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August 18, 2004

William L. Dam
Office of Nuclear Regulatory Regulation
U.S. Nuclear Regulatory Commission
Mail Stop O11F1
Washington, DC 20555

Dear Bill:

Enclosed are printouts of web references cited in the Cook SEIS and a consolidated list of those references. I have also included a CD with revised figures for the SEIS (WordPerfect and tiff formats) and hard copies of those figures. Please contact me if you have any questions regarding the enclosed.

Sincerely,

Kirk E. LaGory, Ph.D.
Ecological and Geographical Sciences

cc: D. Miller

ILLINOIS PLANT INFORMATION NETWORK

ILPIN INFORMATION ON Wolffia braziliensis

CLASS: MONOCOTYLEDENAE
ORDER: ARALES
FAMILY: LEMNACEAE
SCIENTIFIC NAME: Wolffia braziliensis
AUTHORITY: Weddell

COMMON NAMES:
WATER-MEAL

SYNONOMY:
Wolffia papulifera C. H. Thompson

PLANTS CODE: WOPA

NATURAL COMMUNITIES:
- LAKE AND POND
  - POND
  - LAKE
    - NATURAL IMPOUNDMENT
      - SINK HOLE
    - ARTIFICIAL IMPOUNDMN
- STREAM
  - CREEK
    - LOW-GRADIENT

SAF FOREST COVER TYPE:
NO

NATURAL DIVISION: UNAVAILABLE

COUNTIES:

ADAMS	ALEXANDER	FRANKLIN	HANCOCK	HENDERSON
JACKSON	JOHNSON	LAKE	MASSAC	MONROE
ST. CLAIR	UNION	WABASH		

GROWTH FORM: Monocot

TAXONOMIC CHARACTERISTICS:
LEAF TYPE: Simple
LEAF MARGIN: Entire
LEAF SHAPE: Oblong Oval Orbicular Other
INFLORESCENCE: Solitary- few Other
FLOWER STRUCTURE: Incomplete (no petals) (no sepals)
FRUIT: Other

DISTINGUISHING CHARACTERISTIC COMMENTS:
Thallus is flattened above, freely brown-punctate.
Upper side of thallus has one prominent central papilla. At most plant is 1. mm long. Plants have numerous minute brown dots.

GEOGRAPHIC INFORMATION:
ORIGIN: Native

GEOGRAPHIC COMMENTS:
Species is mostly found in Midwest U.S.A.; also throughout Illinois.

POPULATION DYNAMICS:
STATE STATUS: Not listed

FEDERAL STATUS: Not listed
COMMONNESS: Uncommon
ENDEMIC: NOT-ENDEMIC

BIOLOGIC:
HABIT: Forb
LIFE CYCLE: Perennial
REPRODUCTION: Sexual Vegetative
TROPHIC STATUS: Autotrophic
SEX: Unisexual -monoecious

BIOLOGIC COMMENTS:
Plants usually reproduce vegetatively; flowers are rare.

ECODISTRIBUTION COMMENTS:
Species is distributed in sloughs, stagnant waters of ponds; often in organic floating debris of sink-hole ponds.

ENVIRONMENTAL RELATIONSHIPS: No data entered

FUNCTIONAL RELATIONSHIPS: No data entered
HUMAN RELATIONSHIP DATA: No data entered

WILDLIFE AND LIVESTOCK INFORMATION:
FOOD VALUE:
DEER VALUE: Unknown
UPLAND GAME VALUE: Unknown
WATERFOWL VALUE: Unknown
SMALL NON-GAME BIRD VALUE: Unknown
SMALL MAMMAL VALUE: Unknown
AQUATIC MAMMAL VALUE: Unknown
FISH VALUE: Good -Entire plant
COVER VALUE:
DEER: No data WATERFOWL: No data SMALL MAMMAL: No data
FISH: Good SMALL BIRD: No data UPLAND GAME: No data
AQUATIC MAMMAL: No data

WILDLIFE COMMENTS:
This is considered to be good fish food and cover.

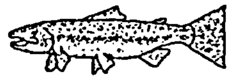
LIVESTOCK PALATABILITY DATA: No data entered

REVEGETATION PLANTINGS: No data entered

REFERENCES:
Mohlenbrock, R. H., ed. 1975. Guide to the vascular flora of Illinois. Southern Illinois University Press, Carbondale. 494 pp.
Steyermark, J. A. 1963. Flora of Missouri. Iowa State University Press, Ames. 1725 pp.
Gleason, H. A. 1952. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. 3 vols. The New York Botanical Garden, New York.

END OF DATA FOR SPECIES Wolffia braziliensis

ILPIN was developed by Louis Iverson*, with data compiled by David Ketzner and Jeanne Karnes
Illinois Natural History Survey, 607 E. Peabody Dr., Champaign, IL 61820
*currently employed by USDA Forest Service, 359 Main Rd., Delaware, OH 43015

FISHING NORTHWEST INDIANA'S LAKE MICHIGAN SHORELINE AND TRIBUTARIES

This packet is a summary of fishing opportunities along Northwest Indiana's shoreline of Lake Michigan and its tributaries. Fish species such as coho salmon, chinook salmon, steelhead trout, brown trout, lake trout, yellow perch, smallmouth bass and various sunfish all contribute to the catch. Fishing opportunities are available to all types of anglers--boat, shoreline and stream.

HISTORY

Lake Michigan is the third largest of the Great Lakes and the sixth largest lake in the world (Beeton 1984). It is the only Great Lake entirely within the United States, but because of fish movement between Lakes Michigan and Huron and its discharge to Huron, the lake is important internationally (Eshenroder, et. al. 1995). Lake Michigan, with a surface area of 57,750 km^2, is divided into:

1) a southern basin, relatively smooth in contour, with a maximum depth of 558ft., and

2) an irregularly shaped northern basin with a maximum depth of 922ft.

Native stocks of lake trout once comprised a great resource in Lake Michigan. However, predation by the parasitic sea lamprey, coupled with intense commercial fishing in the 1940s and 1950s nearly eliminated the lake trout. Sea lampreys, native to the Atlantic Ocean, entered the Great Lakes system in the 1800s through manmade locks and shipping canals. The first observation of the lamprey occurred in Lake Ontario in the 1830's. Through the Welland Canal, a navigational canal connecting Lakes Ontario and Erie, sea lampreys moved into Lake Erie. After spreading throughout Erie, sea lampreys moved to the other Great Lakes, appearing in Lake Michigan in 1936 (Charlebois 1996). By the late 1940's, populations of sea lampreys exploded in all of the upper Great Lakes resulting in the drastic population decline of lake trout. With the Great Lakes top predator in decline, came the next invader, the alewife. Alewives, unintentionally introduced into Lake Michigan in 1949 from the Atlantic Ocean, depleted food sources for themselves and other native fishes. Their high numbers and ability to out-compete fish with similar diets led to depletions and local extinctions of native species. These disruptions in the native fish community and food web, coupled with habitat alterations and degradation, contributed to the decline of important commercial and sport fisheries.

Rehabilitation of the Lake Michigan fish community began in 1960 with the extension of the sea lamprey control program to Lake Michigan, plantings of lake trout and the introduction of coho salmon, chinook salmon, brown trout and steelhead trout. Lake trout planting began in 1965 and coho salmon and chinook salmon were introduced from the Pacific Northwest in 1966 and 1967 (Eshenroder et. al. 1995). Rainbow trout, or steelhead and brown trout were also extensively planted. Of the five major salmonids stocked, only lake trout was released with the main objective being rehabilitation (i.e. to re-establish reproducing populations). The others were stocked to provide angling opportunities and to utilize the overabundance of nonnative alewives, which became a nuisance when vast numbers died and washed up on local beaches.

The Indiana Department of Natural Resources, Division of Fish and Wildlife (DFW) has been stocking salmon and trout along northwest Indiana's shoreline since the late 1960's. The area stocked extends from Michigan City to Whiting, Indiana and includes sites along the St. Joseph River, Trail Creek and the East Branch of the Little Calumet River. The number of trout and salmon stocked in Indiana waters of Lake Michigan from 1982 to 2002 has averaged 1.2 million fish per year (see page 13 for Indiana stocking records).

Indiana was the first Great Lakes state to stock the skamania strain of summer migrating steelhead. The introduction of Pacific Northwest salmonids (coho, chinook, and steelhead) has since produced a more stable and productive fish community.

STOCKING SCHEDULE

The stocking schedule of trout and salmon in Indiana waters of Lake Michigan includes: chinook salmon stocked in early May, coho salmon in November, summer-run steelhead in late March and winter-run steelhead in December. The Pacific salmon and trout spend their adult lives in the Great Lakes in place of their native ocean. When they become sexually mature, they migrate to the stream or lake area where they were stocked in order to spawn. Chinook and coho die after spawning; steelhead may live to spawn in future years. The age of sexual maturity varies among species. Normally, a chinook matures at 2-4 years of age, coho at age 2-3, and steelhead at 3-5 years of age.

These species of Pacific trout and salmon make up the majority of the fish migrating/ returning to Trail Creek, Little Calumet River and Salt Creek.

INTERAGENCY MANAGEMENT

Who manages the Great Lakes and Lake Michigan?

The interagency management of fishery resources in the Great Lakes was formalized in the 1980s when A Joint Strategic Plan for Management of Great Lakes Fisheries (Great Lakes Fishery Commission 1980) was ratified by the heads of federal, state, provincial, and tribal resource agencies (known as the Committee of the Whole, COMW) concerned with these water bodies (Eshenroder et. al. 1995). The Joint Plan implemented a framework for cooperative fishery management under the aegis of the Great Lakes Fishery Commission (GLFC). The Joint Plan established procedures for achieving a consensus approach among Great Lakes fisheries-management agencies. Fish communities in each lake must be managed as a whole. The Joint Plan ensures that each agency has a stake in the entire system and recognizes that the interactions among fish species is important in the overall management of the Lakes' fisheries.

Individual lake committees are responsible for implementing this consensus approach to fish community management. Lake committees are composed of a single representative from each management agency with jurisdiction on a Great Lake. **The Lake Michigan (Lake) Committee (LMC)** has representatives from the states of Illinois, Indiana, Michigan and Wisconsin along with the Chippewa-Ottawa Treaty Fishery

Management Authority. The Lake Michigan biologist stationed in Michigan City is Indiana's representative.

WHERE TO FISH

Indiana's share of Lake Michigan is the smallest of the four states bordering the Lake (approximately 1% of Lake Michigan area), encompassing approximately 43 miles of Lake Michigan shoreline [224 square miles]. Most of the area is highly developed and heavily industrialized, with the exception of the Dunes National Lakeshore and the Indiana Dunes State Park.

Lake There are various sites providing shoreline access and boat launching ramps along the Indiana shoreline of Lake Michigan (see the enclosed Indiana Shoreline map of Lake Michigan).

The Michigan City pier, basin, and adjoining ramp (owned by City of Michigan City), provide access for both shore and boat anglers. Another municipal ramp is located upstream on Trail Creek (Trail Creek Marina). In addition, a public fishing site for shoreline anglers exists adjacently to the Michigan City DNR building (handicap accessible).

A public fishing site for shoreline anglers (handicap accessible) is available at the Port of Indiana. Various private marinas along Burns Waterway (State Road 249; Burns Ditch) provide boat launching facilities.

Hammond, Lake County Parks and Recreation Whihala Beach County Park (Whiting) and East Chicago provide boat launching facilities in addition to access for shoreline anglers (all are handicap accessible).

{ **All previously listed boat ramps from Michigan City west to Hammond charge a launch and/or entrance fee. All previously listed shore access sites, with the exception of the DNR public access site and the Port of Indiana public access site, may charge a parking fee**.}

Stream Trail Creek has six public fishing sites, only one is handicap accessible. These include the access site adjacent to the DNR building; Robert Peo Public Access (located on Liberty Trail); U.S. 35; Trail Creek Forks (U.S. 20); Johnson Road and Creek Ridge Park. Creek Ridge Park (located 5 miles east of U.S. 421 on County Road 400 in Michigan City) is a LaPorte County park that is handicap accessible (Northwest Indiana Steelheaders organization built a handicap-accessible ramp at this park).

The East Branch of the Little Calumet River and Salt Creek provide limited public access sites for fishing opportunities. Salt Creek runs through Imagination Glenn County Park and Haven Hollow Park, both offering angler access. There is one State-managed public fishing site located on Salt Creek, The Chustak Public Fishing Area. Portions of the East Branch of the Little Calumet River flow through the Indiana Dunes National Lakeshore property, which the public can utilize.

Since the majority of the Northwest Indiana tributaries run through private property; **permission** from the landowner to fish is **required** on these private lands.

Discharges Limited access to warm-water discharges is provided by industrial plants located on the shoreline. Due to recent economic downturns and increased security, many areas have either been closed or public access is not being granted.

Mirant Company's State Line Power Plant (formerly known as State Line Generating Station, owned by Southern Energy Company), located on the Indiana/Illinois State Line, BP Oil Company (Amoco) in Whiting, and the Northern Indiana Public Service Company

(NIPSCO) generating station in Michigan City provide fishing opportunities for brown trout, coho, and steelhead in the winter/spring.

Yellow perch, bass and various trout/salmon can be found during the summer months. All discharges previously listed are privately owned and can close these sites at their discretion at any time, i.e., limiting access during adverse weather conditions due to dangers associated with high winds and/or icy conditions.

WINTER OPPORTUNITIES [1]

During the months of January, February and March, fishing activity is limited to the streams and warmwater discharges along the shoreline. All the discharges originate from shoreline property owned by private industry. Three warmwater discharges are available to shore anglers for access.

Mirant Company operates State Line Generating Station, set on the Indiana-Illinois state line. This is open to the public on a limited daily basis for angling opportunities. It has been closed during times when the lake is too treacherous. It is located off 103rd Street in South Chicago, Illinois. BP Oil Company (formerly Amoco) allows day and night fishing at their discharge, located off of 119th Street in Whiting near Whiting Park. Lastly, Northern Indiana Public Service Company (NIPSCO) Michigan City generating station, located just west of the Lake Michigan Fisheries Research Office (100 West Water Street; Michigan City), is open to angling from sunrise to sunset.

This type of warm-water discharge fishing produces good catches of brown trout, with steelhead, coho, and an occasional chinook also contributing. Drum, smallmouth bass, catfish and walleye can also be found at these discharges. Suggested equipment for fishing discharges in the winter includes (not limited to): proper insulated clothing for Northern Indiana's harsh winters; two-three rods for both casting and bait-fishing; 6-10 pound test line rated for fishing in sub-zero to 45 degree temperatures; long-handled net of 8-12 feet (most fishing areas by the discharges are much higher than the water). Best lures/baits include small alewives (frozen, 1½ to 2½ inches); nightcrawlers; spawn bags; small spoons (2/5 to 3/4 oz., such as little cleos; ko-wobblers). Body baits (rapalas-size 7 and 9) and spinners work on occasion. Suggested colors for prior listed lures: silver/green, chrome/green, chrome/orange, chartreuse w/red or black dots; fluorescent orange lures and so forth. Always take along a wide variety of lures/baits because the fish will show preferences on a daily basis.

SPRING OPPORTUNITIES

Coho Salmon

Boat-fishing season along the southern shoreline of Lake Michigan usually begins with the departure of ice around mid-February to April. Between March and mid-May, most of the fishing activity occurs within a two-mile band along the shoreline with coho salmon contributing close to 95% of the catch. Most coho salmon stocked in the lake by Illinois, Michigan, Wisconsin and Indiana will stage in southern Lake Michigan in the spring, due to annual migration patterns. The 3-year-old coho gains weight rapidly, weighing approximately 2 pounds in March and up to 5 pounds in May when they begin moving offshore. Steelhead,

[1] Due to declining electricity demand and the economic downturn in steel and other industries, NIPSCOs Dean Mitchell plant in Gary has ceased operations indefinitely (i.e. no warmwater discharge or public access).

brown trout, chinook salmon, and some larger coho are also taken during this period.

Trolling with thin-fins, rapalas, thunder-sticks (and various other body-baits and spoons), spinners, or dodgers and flies are the fishing methods most frequently used by boat anglers. Casting into warmwater plumes in early spring when the lake temperature is still in the high 30's or low 40's has had some success. Suggested color combinations include blue/white; bright red w/black; solid chartreuse, solid hot pink, solid orange w/silver, chrome or gold.

Shore anglers have found the months of March (and as early as mid-February) through April to be the best for catching coho in the spring. They cast using the same types of artificials as the boat anglers or fish with bait (nightcrawlers, spawn, waxworms or squid, suspending bait off bottom or from 4-6 feet below the surface). Various piers provide fishing access along Indiana's Lake Michigan shoreline.

Rainbow Smelt

Rainbow smelt may be taken by dip net or seine from March 1 through May 30 along Indiana's shoreline of Lake Michigan. The smelt run usually takes place beginning in April to the first half of May; however, the times of the runs are dependent upon environmental variables such as temperature. Peak catches usually occur in mid-April. Smelt are caught by using either dip nets or seines after dusk. Please refer to the Indiana Fishing Regulations Guide for specific requirements.

Sunfish Family

The sunfish family can be divided into three groups:

1) smallmouth and largemouth bass (black bass)

2) the crappies

3) the true sunfish and rock bass

In Lake Michigan, these fish inhabit mostly breakwaters and other areas that are protected from Lake wave action (marina basins). All are spring spawners, with spawning for some extending into the summer months.

Smallmouth Bass

Smallmouth bass, a nearshore species, are confined to reefs and shoal water areas. Prior to development of Indiana's Lake Michigan shoreline, these nearshore waters were relatively shallow, with a consistent sand bottom. Shoreline development (i.e., rip-rap shoreline and structures) has resulted in the creation of suitable smallmouth bass habitat. Smallmouth bass numbers have responded positively to this increase in habitat. As the availability and abundance of smallmouth bass have increased in southern Lake Michigan, so has the interest by anglers targeting smallmouth. Wave energy has a direct influence on smallmouth distribution. Protected areas, such as the land side of breakwaters and inside marinas are areas that produce the best action. Angling methods for bass include bait casting and the use of common live baits (crawlers; minnows). Smallmouth are particularly vulnerable to fishing after dark.

Panfish (bluegill, rock bass, pumpkinseed)

These species are commonly found at all of the shore fishing sites, especially at the marinas (Hammond; Pastrick; Washington Park). Most are sedentary, remaining much of the time near submerged cover or hovering quietly in the shade of an overhanging object. Insects, crustaceans, and small fish are the most important food sources. Feeding occurs at the surface, as well as on the bottom. When fishing for these species, pay particular attention to the marina fishing rules and regulations. Most marinas do not allow fishing inside the marina itself, unless a special area has been opened to marina fishing.

Rock Bass

This fish favors clear, cool to warm waters over a rocky/gravel bottom with some vegetation. They are also found at most of the marina shore access sites, near breakwaters/ stone-armored shorelines. Rock bass utilize a variety of foods, including crayfish, small fish and insects. Adults feed mostly in the evening and morning hours.

SUMMER

Trout and Salmon

The water temperature close to shore increases rapidly in late spring, driving coho and most other salmonids into the deep, colder offshore waters. Between May and the end of July, boat anglers in pursuit of trout and salmon normally fish at depths ranging between 70 and 200 feet of water. This entails traveling a distance of 6-to-20 miles from shore, depending upon the point of departure (these water depths require traveling offshore to Illinois or Michigan waters. If fishing IL or MI waters, a fishing license from the appropriate state is also necessary). Downriggers are used to get the lure down to the temperature zone sought by trout and salmon. Lake trout, coho, chinook, steelhead, and to a lesser extent, brown trout, all contribute to the catch.

Yellow Perch

Yellow perch move closer to the shoreline during these months and are available on a limited basis to shore and boat anglers. Minnows, crayfish tails, frozen shrimp and crab fished at depths less than forty feet July through September have produced the best catches. Shore fishing opportunities also exist throughout the summer months at most of the shoreline fishing sites.

Skamania Steelhead

By mid to late June, depending on water temperatures and water levels in the tributaries, the summer-run skamania will return to Indiana's tributaries where they were planted as fingerlings. The two tributaries the Division of Fish and Wildlife stocks include: The East Branch of the Little Calumet River and Trail Creek.

Most skamania will "stage" in Lake Michigan, with fish rushing upstream--especially after a heavy rainfall to begin the "run". By mid-August (dependent upon tributary temperatures and water levels), good numbers of skamania have entered their home tributary streams; however, skamania will continue to enter the area tributaries throughout the fall and winter months (through March). Skamania spawning activities begin around mid-February through March. The spent steelhead will return to Lake Michigan throughout March and into April. Thus, the summer-run or skamania steelhead provide a year-round fishery.

Sunfish family

See page 5 under the "Spring Opportunities" section.

FALL

The fall sport fishery is a direct product of Indiana's (and the U.S. Fish and Wildlife Service-USFWS) stocking program:

Skamania and Winter-run Steelhead

Adult steelhead (summer run and winter run) return to the streams where they were stocked as fingerlings.

Lake Trout

Lake trout display a spawning pattern close to the Port of Indiana, with a run of lake trout that develops along the shoreline between mid-October and mid-November. The greatest concentration of lake trout occurs at the Port of Indiana, which is close to the major federal stocking site (USFWS).

Chinook and Coho Salmon

Chinook and coho salmon return to streams and spawn from late August to early November. Chinook and coho salmon die after spawning.

The table on page 10 provides a summary of peak angling periods on Lake Michigan.

For stream anglers, the best time of year to fish the trout and salmon is summarized by the following:

Chinook and Coho salmon:
September through mid-November

Skamania (summer) Steelhead:
Mid-June to mid-October
(Also, various winter months from January-March--dependent upon environmental/stream conditions)

Winter Steelhead:
Mid-November to mid-March

Summer-run Skamania steelhead return to streams from July (mid-June) through the winter months and spawn from mid-January to mid/late-February (as late as March); winter-run steelhead return beginning in mid to late October, with the bulk of the return in February and March. Winter-run steelhead spawn from mid-March to mid-April.

All species of salmonids (coho, chinook, steelhead trout, and brown trout) are available to sport anglers during the fall spawning runs (boat/pier anglers as trout and salmon return to their stocking site; stream anglers when trout and salmon are in the tributaries).

SUGGESTED EQUIPMENT FOR TROUT/SALMON FISHING

To fish the trout and salmon, most anglers use a heavy rod with 10-12 pound test line. Medium spoons (cleos/kowobblers), plugs, spinners, and body-baits (rapalas/shadlings) are used for chinook. Smaller spoons and spinners are used for coho. Small spinners or rooster tails work well for steelhead. Nightcrawlers and waxworms are successful at times, especially in summer. Spawn sacks (small clumps of trout or salmon eggs wrapped in mesh bags) are used throughout the year and provide good year-round action. Typical color patterns for trout and salmon include fluorescent orange; chartreuse; red; green/black or any combination of the prior listed colors with silver/chrome.

Anglers report good success with black or brown stonefly patterns, chartreuse flies, green and orange woolyworms, egg sucking leeches, and many others depending upon the time of year and the presentation of the flies to the fish.

EXOTIC SPECIES AND THEIR IMPACTS

Since the early 1800s, 139 non-indigenous aquatic organisms have become established in the Great Lakes basin (Charlebois 1996). This number includes 59 plants, 25 fishes, 24 algae, 14 mollusks, and 6 crustaceans. Unintentional releases from bait buckets, home aquaria, and ships (ballast water) account for 1/3 of these species introductions. Over half of the exotic/introduced species came from Eurasia, with many native to the Atlantic Ocean. Many of these exotic species have had negative impacts to the Lake Michigan ecosystem, including but not limited to: sea lamprey, rainbow smelt, alewife, zebra mussels, round goby and spiny water flea.

Successful invaders, such as the prior species, usually have detrimental effects on native species, their habitats and human activities dependent upon water resources. Once exotic species establish themselves, eradication becomes impossible without further damaging the environment. Not all aquatic species introduced to the Great Lakes have been successful invaders. Species that succeed have characteristics that make them successful, including: hardiness, aggressiveness, prolific breeding, rapid dispersal.

Zebra mussels, introduced to the Great Lakes in 1986, is an excellent example of an exotic species harmful potential. The zebra mussel threatens the entire food web by filtering vast amounts of basic food from the ecosystem. In turn, less food is available to sustain the native species that are dependent on the same food resources. Economic and social consequences have also occurred, with raw water intakes for industry and public drinking water being fouled.

What can anglers do? Anglers play an important role in management strategies for preventing the introduction and spread of nonindigenous species. Tips for reducing the spread of non-native species, such as the round goby, includes:

1) Dumping bait buckets only in areas where they were filled.

2) Anglers should not take unusual species home to put in aquariums (while there may be the temptation to take gobies for a home aquarium or home fish pond; Indiana law prohibits the possession of live gobies and transportation of gobies or other exotic species across state lines is also illegal).

3) Dispose unwanted bait on land.

4) Drain water from your boat, livewell and bilge before leaving a water access

5) Do not dump live fish from one body of water into another.

6) Never dip your bait bucket into a lake or river if it has water in it from another.

7) Weeds that have been removed from fishing hooks and left in the boat or weeds tangled in propellers should be removed and left at the lake where they were collected

8) Washing/drying your boat and equipment to kill harmful species that were not seen at the boat launch is also helpful (esp. for zebra mussels)-- rinse boat/equip. with hot tap water or spray boat/equip. with high pressure water and dry.

9) Learn to identify exotic species – information how to identify them is available on the internet, check out Illinois/Indiana Sea Grant web page at: http://www.iisgcp.org/.

Release of aquarium pets, catches from other waters or live bait into lake and rivers is considered "biological littering" and pollutes our waters, just like dumping chemicals. ***It is illegal to stock any fish without a permit.***

FISH CONSUMPTION ADVISORY

Indiana's fish consumption advisory is similar to the health advice you hear or read about every day regarding diet, exercise or safety. How you use this information to protect your health and enjoy life is a matter of choice.

The purpose of this advisory is to make sure you have the proper information to make those choices.

One common misunderstanding about the advisory is the difference between no consumption and restricted consumption of fish. The advisory is not a ban on eating fish from lakes and streams as some people believe. The fish consumption advisory will help you make the right choice about how much fish to eat and what type of fish to eat. If you follow the advisory, you will minimize the risk from eating fish and maximize you health benefits by using fish as a valuable source of protein.

You should use the advisory to make informed decisions about where to fish, which fish to eat and how much to eat. The advisory should not discourage you from going fishing or eating the fish you catch. The advisory is a source of information that allows you to enjoy your fishing trip and protect your health at the same time.

A statewide fish tissue monitoring program provides data for Indiana's fish consumption advisory. New tissue data is collected every year from new areas or sites previously sampled to keep health information updated. This long term commitment to human health protection also serves as a constant monitor for changes in the environment.

The Indiana Fish Consumption Advisory is issued by the Indiana State Department of Health. Consult the complete advisory for specific information on the body of water you plan to fish.

For a complete copy of the fish consumption advisory or if you have questions concerning the advisory contact:

Indiana State Department of Health
Environmental Epidemiology
2 N. Meridian St., Section 3D
Indianapolis, Indiana 46204
(317) 233-7808

or visit the Indiana State Department of Health web site:
www.IN.gov/isdh/dataandstats/fish/fish_adv_index.htm.

SPECIAL NOTICE TO ANGLERS

Recent changes in the law have resulted in this notice to anglers that the Port of Indiana is CLOSED to all recreational watercraft including fishing from a boat. The area is posted. The following is a summary of the Indiana Administrative Code for this law:

130 IAC 4-1-11 Fishing; swimming; boat launching

Authority: IC 8-10-1-7; IC 8-10-1-9
Affected: IC 8-10-1

Sec. 11 (a) No person shall fish in the port area between sunset and sunrise. Fishing is allowed only within the designated fishing area that is maintained and is under the jurisdiction of the department of natural resources and the commission.

(b) No person shall launch a boat or fish from a boat in the port area.

(c) Swimming is prohibited in the port area. *(Indiana Port Commission; 130 IAC 4-1-11; filed Jun 6, 2002, 11:22 a.m.: 25 IR 3710)*

Literature Cited

Beeton, A.M. 1984. The world's Great Lakes. J. Great Lakes Res. 10(2): 106-113.

Charlebois, Patrice. 1996. Nonindigenous threats continue. The Helm. 13(1): 5-7.

Eshenroder, R.L., M.E. Holey, T.K. Gorenflo, and R.D. Clark, Jr. 1995. Fish-community objectives for Lake Michigan. Great Lakes Fish. Comm. Spec. Pub. 95-3. 56p.

Type of Fish	How to Fish	Best Time of Year	Average Fish Size
Coho Salmon	pier boat stream	mid February/ March thru May Sept./Oct.	 2-4 lbs. 4 lbs.
Chinook Salmon	some pier boat stream	May; mid-July thru September Sept./Oct.	 10-20 lbs. 10-20 lbs.
Steelhead (Skamania)	pier boat stream	mid-June thru mid-Aug. July-February	 10-20 lbs. 10-20 lbs.
Winter-run Steelhead	pier stream	late October- thru March	 8-12 lbs.
Lake Trout	boat	mid June thru August; mid-Oct. to Nov.	 10-20 lbs.
Yellow Perch	pier boat	July to mid-September	 8.0 inches
Smallmouth and other Sunfish species	pier boat	June to September	10-16 inches 6-8 inches

All peak angling opportunities listed are dependent upon environmental variables such as temperature, and may vary (due to local weather conditions).

NOTE

Fishing in offshore areas requires standard and various safety equipment such as life jackets, ship-to-shore radio, a properly compensated compass etc. An auxiliary motor and ship-to-shore radio should be included at all times, especially in emergency situations. Never underestimate the potential for sudden weather changes, possibly severe, on Lake Michigan! Please refer to the pamphlet "Indiana Boating Laws" for a complete listing of boating rules (Indiana boating laws can be accessed through a link provided on the Department of Natural Resources Division of Law Enforcement web page at: http://www.state.in.us/dnr/lawenfor/index.htm)

RULES TO REMEMBER

Lake Michigan is divided into state waters owned by Michigan, Wisconsin, Illinois and Indiana (Michigan DNR http://www.dnr.state.mi.us/ ; Wisconsin DNR http://www.dnr.state.wi.us/ and Illinois DNR http://www.dnr.state.il.us/. Each state requires that sport anglers possess the required license and/or stamp (Indiana requires a trout and salmon fishing stamp in addition to a fishing license when targeting trout/salmon on Lake Michigan an/or it's tributaries, {http://www.state.in.us/dnr/fishwild/ }).

Trout and salmon (Indiana waters):

- A 5-2 daily bag limit for the sport harvest of trout and salmon on Lake Michigan and tributaries (5 fish trout and salmon aggregate bag limit, of which no more than 2 may be lake trout) with a 14" minimum size limit.

You cannot possess more than 5 trout or salmon (Indiana waters of Lake Michigan) while fishing on Lake Michigan, even if you have a fishing license from a neighboring state.

You cannot use a trot line (power line), set line or throw line to take fish from Lake Michigan.

Indiana Yellow Perch (Indiana waters):

The current daily bag limit for the sport harvest of yellow perch on Lake Michigan remains at 15. There is no size limit on yellow perch.

You cannot possess more than 15 yellow perch (Indiana waters of Lake Michigan) while fishing on Lake Michigan, even if you have a fishing license from a neighboring state.

Black Bass (Black bass includes largemouth and smallmouth; Indiana waters):

Daily bag limit of 3 singly or in aggregate; with a 14" minimum size limit.

*Single hooks, including those on artificial baits, cannot exceed ½ inch from point to shank.
*Double and treble hooks on artificial baits cannot exceed 3/8 inch from point to shank.
*Any fish taken from Indiana waters must be hooked in the mouth. Foul-hooked fish must be returned to the water.
*Snagging is strictly prohibited.

Please refer to the 2003 Indiana Fishing Guide for a summary of Indiana fishing regulations (guide can be accessed via links found on the Department of Natural Resources Division of Fish and Wildlife web page at: http://www.state.in.us/dnr/fishwild/). Important regulations include various tributary closings and restrictions along with hook restrictions.

(The fishing guide is designed as a service to anglers and is not intended to be a complete digest of all fishing regulations. Most regulations are subject to change by administrative rule. For a listing of administrative rules, visit: **http://www.state.in.us/legislative/iac/title312.html**)

Indiana Lake Michigan Fishing Hotlines

Lake Michigan Fishing Hotline (219) 874-0009
(Updated weekly March thru December)

St. Joseph River Hotline (574) 257-TIPS
(Updated weekly, mid-Feb. to April; mid-June to mid-Dec.)
The St. Joseph River access guide available by request from the Lake Michigan Fisheries Research Station office. The St. Joseph River, also a tributary of Lake Michigan, is managed by the District 2 Fisheries Biologist, Neil Ledet, (260) 829-6241.

Internet Fishing Report for Lake Michigan and the St. Joseph River can be found on the Division of Fish and Wildlife's web site: http://www.state.in.us/dnr/fishwild

Indiana Lake Michigan Hatcheries

Mixsawbah State Fish Hatchery (Lake Michigan) (219) 369-9591

Bodine State Fish Hatchery (St. Joseph River) (574) 255-4199

Indiana Division of Law Enforcement

District 10 Headquarters (219) 879-5710
(Lake/Porter/LaPorte Counties)

North Region Headquarters (765) 473-9722

Turn-in Poachers/Polluters Hotline (TIP) 1-800-TIP-IDNR (847-4367)
Tips may also be left on the law enforcement web site (http://www.state.in.us/dnr/lawenfor/index.htm)

Additional Numbers/Web-sites of Interest:

LaPorte County Visitor Bureau
(219) 872-0031 or 1-800-634-2650
http://www.harborcountry-in.org/

Porter County Visitor Bureau
(219) 926-2255 or 1-800-283-8687
http://www.info@casualcoast.com/

Lake County Visitor Bureau
1-800-255-5253
http://www.alllake.org/

Indiana Dunes National Lakeshore
(219) 926-7561, ext. 225 or
1-800-727-5847
http://www.nps.gov/indu/

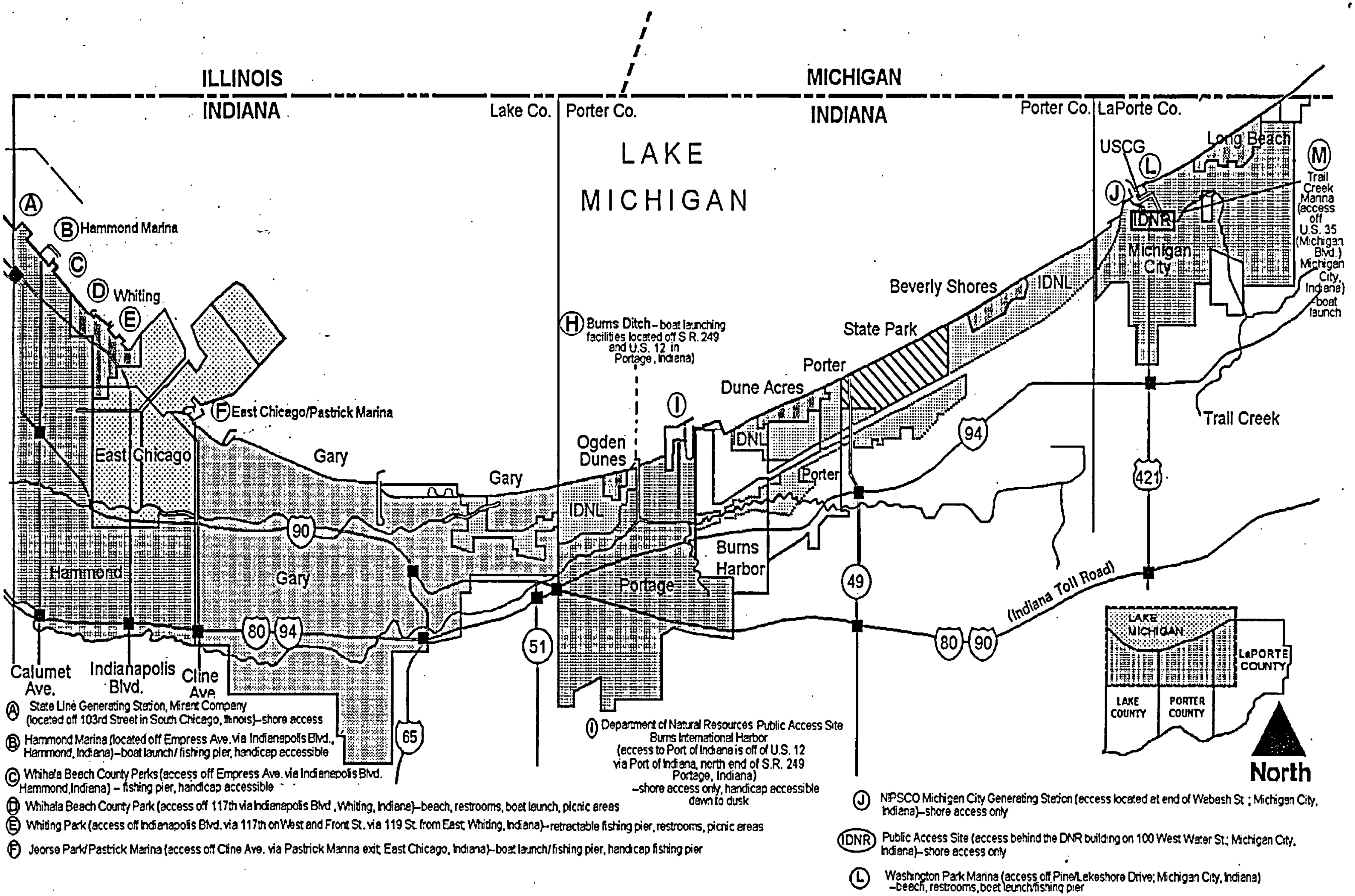
Indiana Dunes State Park
(219) 926-1952
http://www.state.in.us/dnr/parklake/

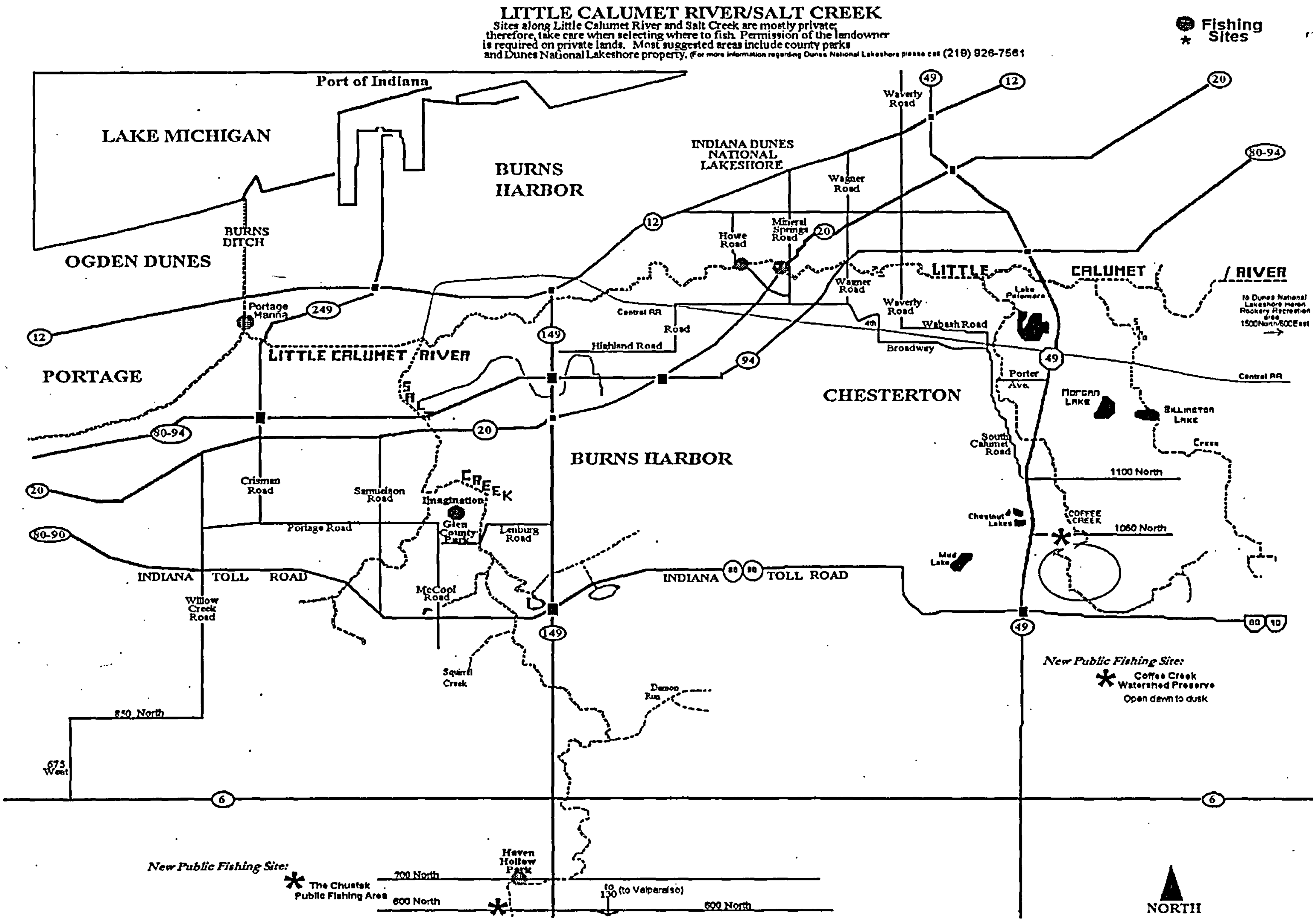
Great Lakes Fisheries Commission
http://www.glfc.org/

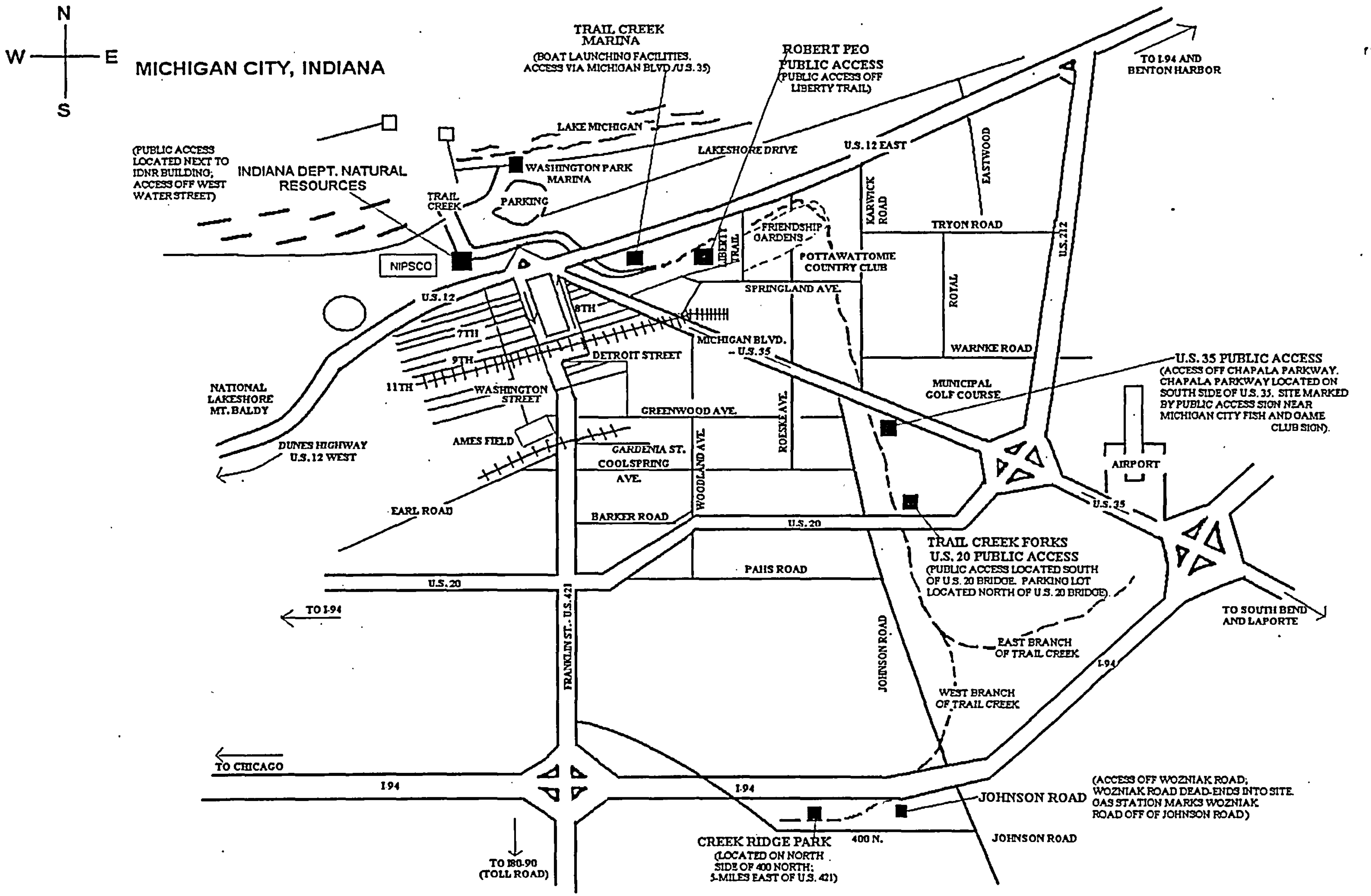
Great Lakes Sport Fishing Council
http://www.great-lakes.org/

TROUT AND SALMON STOCKING RECORDS
Indiana Division of Fish and Wildlife

Lake Michigan					St. Joseph River		
Year	Chinook	Coho	Steelhead	Brown Trout	Chinook	Coho	Steelhead
'82	313,071	160,381	164,111	0	0	0	0
'83	238,383	127,555	283,499	0	0	0	0
'84	405,912	156,304	353,667	0	523,023	0	0
'85	354,740	139,018	282,763	0	407,013	0	226,604
'86	341,726	132,854	346,236	0	355,939	0	259,925
'87	310,745	161,787	286,275	0	258,474	0	224,881
'88	502,311	160,374	243,184	0	377,528	0	226,145
'89	530,561	40,720	289,429	0	186,858	0	214,068
'90	476,646	114,153	317,346	0	153,590	0	221,422
'91	546,084	99,980	271,608	0	148,267	0	221,598
'92	330,453	130,518	315,332	0	173,778	0	230,253
'93	292,464	12,316	295,837	0	166,142	0	180,512
'94	368,026	84,397	378,522	0	168,938	0	172,975
'95	364,182	165,809	301,052	0	190,819	0	188,842
'96	362,162	266,549	312,776	0	209,407	75,980	254,135
'97	279,297	80,817	340,010	0	143,262	0	287,174
'98	386,525	148,320	183,715	0	206,987	0	299,869
'99	264,608	146,882	319,082	0	150,811	0	252,491
'00	267,865	157,208	174,136	0	149,911	0	220,439
'01	297,195	157,048	297,971	0	153,520	0	293,475
'02	253,000	224,797	298,884	35,000	0	0	306,297
Totals	**7,485,956**	**2,867,787**	**6,055,435**	**35,000**	**4,124,267**	**75,980**	**4,281,105**


ILLINOIS
INDIANA
MICHIGAN
INDIANA
Lake Co.
Porter Co.
Porter Co.
LaPorte Co.
LAKE MICHIGAN
Ⓐ
Ⓑ Hammond Marina
Ⓒ
Ⓓ Whiting
Ⓔ
Ⓕ East Chicago/Pastrick Marina
East Chicago
Hammond
Gary
Gary
Gary
Ⓗ Burns Ditch - boat launching facilities located off S.R. 249 and U.S. 12 in Portage, Indiana)
Ⓘ
Ogden Dunes
IDNL
IDNL
IDNL
Dune Acres
Porter
Porter
State Park
Beverly Shores
Burns Harbor
Portage
USCG
Ⓛ
Ⓙ
IDNR
Long Beach
Michigan City
Ⓜ Trail Creek Marina (access off U.S. 35 (Michigan Blvd.) Michigan City, Indiana) -boat launch
Trail Creek
90
80
94
65
51
49
94
421
80
90
(Indiana Toll Road)
Calumet Ave.
Indianapolis Blvd.
Cline Ave.
LAKE MICHIGAN
LaPORTE COUNTY
LAKE COUNTY
PORTER COUNTY
North
Ⓐ State Line Generating Station, Mirant Company (located off 103rd Street in South Chicago, Illinois)–shore access
Ⓑ Hammond Marina (located off Empress Ave. via Indianapolis Blvd., Hammond, Indiana)–boat launch/fishing pier, handicap accessible
Ⓒ Whihala Beach County Perks (access off Empress Ave. via Indianapolis Blvd. Hammond, Indiana) – fishing pier, handicap accessible
Ⓓ Whihala Beach County Park (access off 117th via Indianapolis Blvd, Whiting, Indiana)–beach, restrooms, boat launch, picnic areas
Ⓔ Whiting Park (access off Indianapolis Blvd. via 117th on West and Front St. via 119 St. from East, Whiting, Indiana)–retractable fishing pier, restrooms, picnic areas
Ⓕ Jeorse Park/Pastrick Marina (access off Cline Ave. via Pastrick Marina exit, East Chicago, Indiana)–boat launch/fishing pier, handicap fishing pier
Ⓘ Department of Natural Resources Public Access Site Burns International Harbor (access to Port of Indiana is off of U.S. 12 via Port of Indiana, north end of S.R. 249 Portage, Indiana) –shore access only, handicap accessible dawn to dusk
Ⓙ NIPSCO Michigan City Generating Station (access located at end of Wabash St; Michigan City, Indiana)–shore access only
IDNR Public Access Site (access behind the DNR building on 100 West Water St; Michigan City, Indiana)–shore access only
Ⓛ Washington Park Marina (access off Pine/Lakeshore Drive; Michigan City, Indiana) –beach, restrooms, boat launch/fishing pier


LITTLE CALUMET RIVER/SALT CREEK
Sites along Little Calumet River and Salt Creek are mostly private; therefore, take care when selecting where to fish. Permission of the landowner is required on private lands. Most suggested areas include county parks and Dunes National Lakeshore property.
(219) 926-7561
Fishing Sites
Port of Indiana
LAKE MICHIGAN
BURNS HARBOR
INDIANA DUNES NATIONAL LAKESHORE
BURNS DITCH
OGDEN DUNES
Portage Marina
LITTLE CALUMET RIVER
PORTAGE
CHESTERTON
BURNS HARBOR
Howe Road
Mineral Springs Road
Wagner Road
Waverly Road
Wabash Road
Broadway
Porter Ave.
Central RR
Highland Road
Crisman Road
Samuelson Road
Portage Road
Lenburg Road
Glen County Park
Imagination
CREEK
INDIANA TOLL ROAD
Willow Creek Road
McCool Road
Squirrel Creek
Damon Run
850 North
675 West
South Calumet Road
1100 North
1050 North
COFFEE CREEK
Lake Palomara
Morgan Lake
Billington Lake
Chestnut Lakes
Mud Lake
New Public Fishing Site:
Coffee Creek Watershed Preserve
Open dawn to dusk
Haven Hollow Park
700 North
600 North
to 130 (to Valparaiso)
New Public Fishing Site:
The Chustak Public Fishing Area
NORTH



N
W
E
S
MICHIGAN CITY, INDIANA
TRAIL CREEK MARINA
(BOAT LAUNCHING FACILITIES. ACCESS VIA MICHIGAN BLVD./U.S. 35)
ROBERT PEO PUBLIC ACCESS
(PUBLIC ACCESS OFF LIBERTY TRAIL)
TO I-94 AND BENTON HARBOR
LAKE MICHIGAN
LAKESHORE DRIVE
U.S. 12 EAST
(PUBLIC ACCESS LOCATED NEXT TO IDNR BUILDING; ACCESS OFF WEST WATER STREET)
INDIANA DEPT. NATURAL RESOURCES
WASHINGTON PARK MARINA
TRAIL CREEK
PARKING
EASTWOOD
KARWICK ROAD
TRYON ROAD
FRIENDSHIP GARDENS
LIBERTY TRAIL
POTTAWATTOMIE COUNTRY CLUB
U.S. 212
NIPSCO
U.S. 12
8TH
SPRINGLAND AVE.
ROYAL
7TH
MICHIGAN BLVD. - U.S. 35
WARNKE ROAD
9TH
DETROIT STREET
U.S. 35 PUBLIC ACCESS
(ACCESS OFF CHAPALA PARKWAY. CHAPALA PARKWAY LOCATED ON SOUTH SIDE OF U.S. 35. SITE MARKED BY PUBLIC ACCESS SIGN NEAR MICHIGAN CITY FISH AND GAME CLUB SIGN).
NATIONAL LAKESHORE MT. BALDY
11TH
WASHINGTON STREET
MUNICIPAL GOLF COURSE
GREENWOOD AVE.
ROESKE AVE.
AMES FIELD
DUNES HIGHWAY U.S. 12 WEST
GARDENIA ST.
COOLSPRING AVE.
WOODLAND AVE.
AIRPORT
U.S. 35
EARL ROAD
BARKER ROAD
U.S. 20
TRAIL CREEK FORKS U.S. 20 PUBLIC ACCESS
(PUBLIC ACCESS LOCATED SOUTH OF U.S. 20 BRIDGE. PARKING LOT LOCATED NORTH OF U.S. 20 BRIDGE).
PAHS ROAD
U.S. 20
TO I-94
TO SOUTH BEND AND LAPORTE
JOHNSON ROAD
EAST BRANCH OF TRAIL CREEK
I-94
FRANKLIN ST. - U.S. 421
WEST BRANCH OF TRAIL CREEK
TO CHICAGO
I-94
I-94
(ACCESS OFF WOZNIAK ROAD; WOZNIAK ROAD DEAD-ENDS INTO SITE. GAS STATION MARKS WOZNIAK ROAD OFF OF JOHNSON ROAD)
JOHNSON ROAD
CREEK RIDGE PARK
(LOCATED ON NORTH SIDE OF 400 NORTH; 5-MILES EAST OF U.S. 421)
400 N.
JOHNSON ROAD
TO I80-90 (TOLL ROAD)

List of ENDANGERED, THREATENED AND RARE SPECIES by county

Index (by County Name)

A B C D E F G H J K L M N O P S T U V W

The following lists are in Acrobat Reader format. If you do not have Acrobat Reader installed in your computer, please download it for FREE from http://www.adobe.com.

A					
ADAMS			ALLEN		
B					
BARTHOLOMEW	BENTON	BLACKFORD	BOONE	BROWN	
C					
CARROLL	CASS	CLARK	CLAY	CLINTON	CRAWFORD
D					
DAVIESS	DEARBORN	DECATUR	DEKALB	DELAWARE	DUBOIS

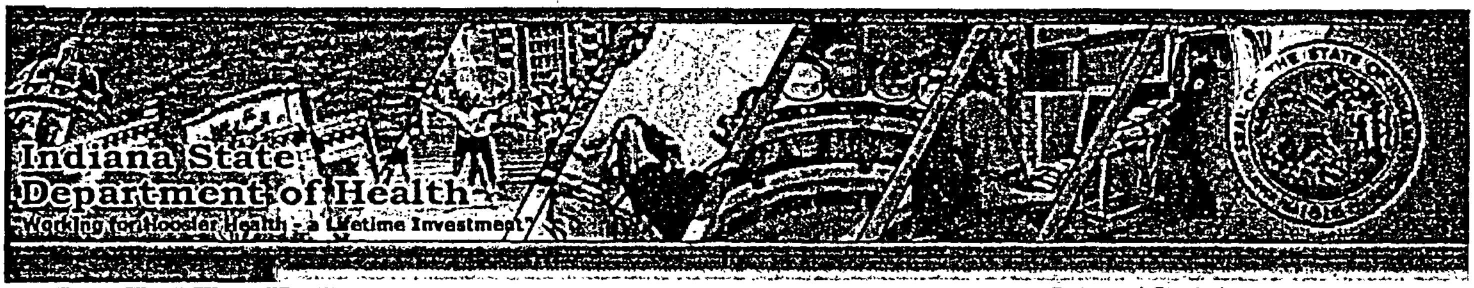
E					
ELKHART					
F					
FAYETTE	FLOYD	FOUNTAIN	FRANKLIN	FULTON	
G					
GIBSON	GRANT	GREENE			
H					
HAMILTON	HANCOCK	HARRISON	HENDRICKS	HENRY	HOWARD
HUNTINGTON					
J					
JACKSON	JASPER	JAY	JEFFERSON	JENNINGS	JOHNSON
K					
KNOX	KOSCIUSKO				
L					
LAGRANGE	LAKE	LAPORTE	LAWRENCE		
M					
MADISON	MARION	MARSHALL	MARTIN	MIAMI	MONROE
MONTGOMERY	MORGAN				
N					
NEWTON	NOBLE				
O					
OHIO	ORANGE	OWEN			
P					
PARKE	PERRY	PIKE	PORTER	POSEY	PULASKI
PUTNAM					
R					
RANDOLPH	RIPLEY	RUSH			
S					
SCOTT	SHELBY	SPENCER	STARKE	STEUBEN	ST JOSEPH
SULLIVAN	SWITZERLAND				
T					
TIPPECANOE	TIPTON				
U					

UNION					
V					
VANDERBURGH		VERMILLION		VIGO	
W					
WABASH	WARREN	WARRICK	WASHINGTON	WAYNE	WELLS
WHITE			WHITLEY		

Back DNR, Nature Preserve's Main Page

Last updated by Raju Maharjan, MIS Manager on November 12, 1999.

No. of visitors to this page since November 16, 1999.--



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- Public Health Programs
- State Laboratories
- Health Care Links
- News Releases
- Calendar Events
- Birth & Death Certs
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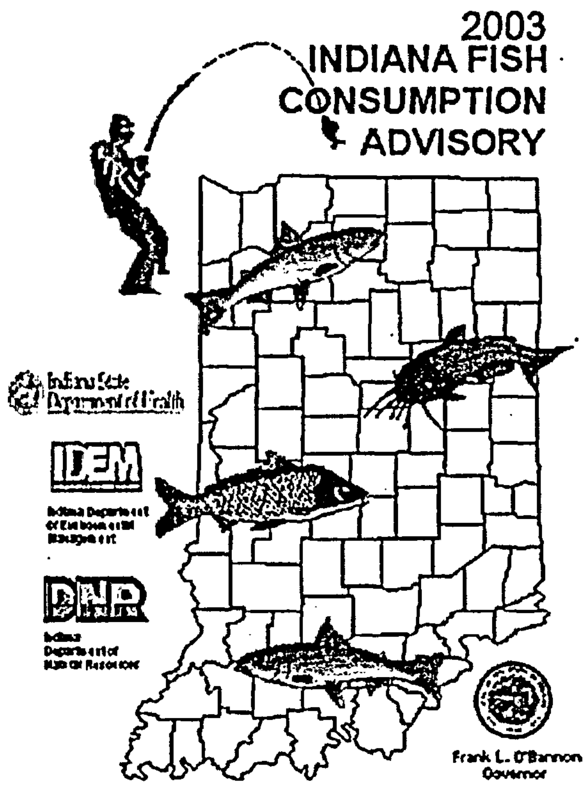
- Español

SEARCH

need help?

Data and Statistics



By Body of Water

By County

Other available resources include:

Mercury information Web site:
http://www.in.gov/idem/mercury/

Mercury fact sheet:
http://www.in.gov/idem/mercury/prevention/mercfact.pdf

Polychlorinated biphenyl (PCB) fact sheet:
http://www.in.gov/idem/macs/factsheets/media/pcbs.html

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Proceedings of The Fifth International Zebra Mussel and Other Aquatic Nuisance Organisms Conference, Toronto, Canada, February 1995

Robotic Removal of Zebra Mussel Accumulations in a Nuclear Power Plant Screenhouse

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Columbia, MD 21045

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Indiana Michigan Power Co./Cook Nuclear Plant
One Cook Place
Bridgman, MI 49106

K.M. Tamms
American Electric Power Service Corporation

ABSTRACT

Zebra mussel accumulations in the power plant intake system have increased over the last four years and have become a maintenance issue. Several treatment methods have been used in combination, including molluscicides, chlorination and mechanical cleaning by divers.

Mechanical cleaning by divers is limited to areas of relatively low flow velocity. Various sections of the screenhouse are not accessible except during an outage or when one of the intake tunnels can be otherwise be blocked and flow reduced. In addition, diver services are relatively costly. For the above reasons, the Indiana Michigan Power Co., Cook Nuclear Plant, contracted with ARD Environmental Inc. to develop and test a robotic system as an alternative to cleaning by divers.

The first phase of this project addressed the requirement to clean the screenhouse floor in all areas, including those with high flow velocity. Subsequent phases will address robotic cleaning of other areas of the intake and the screenhouse structures.

The objectives of the project were to:

1) Demonstrate the ability to deploy and retrieve a modified XT1000 vehicle in the inlet bay and screen bays.

2) Remove the accumulations of zebra mussels and possibly other pumpable material from the floor.

3) Reduce or eliminate the need for diver services and reduce overall cost of removing accumulations of zebra mussels.

4) Critique operations and develop recommendations for further enhancements to the robotic equipment and materials handling system.

Implementation of the operating plan commenced on September 8,1994, and was completed on October 7, 1994. The project demonstrated that robotic techniques are an efficient and cost effective alternative to diver operations for mechanical removal of zebra mussels. In particular, the robotic system was able to operate effectively in the high flow velocity areas including those at the intake tunnels. The ability to operate in the high flow areas means that zebra mussel removal may take place at any time, without affecting normal plant operations.

INTRODUCTION

Initial discussions were held with Cook Nuclear Plant personnel in mid-July 1994. The purpose of these discussions was to define to project requirements, and discuss the approach to be taken by ARD Environmental, Inc. (ARDE), in performing the project. Pursuant to these discussions, ARDE prepared an Operating Plan, which described, in detail, the proposed system and equipment, the methods and procedures to be used, plant support requirements, and safety considerations. The Operating Plan also included a detailed project schedule (Figure 1).

The objectives of the project were to:

1) Demonstrate the ability to deploy and retrieve a modified XT1000 vehicle in the inlet bay and screen bays.

2) Remove the accumulations of zebra mussels and possibly other pumpable material from the floor.

3) Reduce or eliminate the need for diver services and reduce overall cost of removing accumulations of zebra mussels.

4) Critique operations and develop recommendations for further enhancements to the robotic equipment and materials handling system.

The first cleaning effort was performed by ARD Environmental (ARDE) personnel. Subsequent cleanings may also be performed by ARDE personnel, however the overall goal of the project is to develop equipment and a methodology that would permit Cook Nuclear Plant personnel to perform maintenance cleaning and removal of zebra mussel infestations in the inlet bay and semen bays on a routine basis, with minimum support from outside contractors.

This phase of the project consisted of a number of tasks. They included a detailed review of the engineering drawings of the screenhouse, a review of plant operational requirements, design modifications to ARD's XT1000 vehicle to permit insertion in the manways at the plant, design and fabrication of ancillary equipment to support the operation, and development of an operating plan that meshed with plant requirements and activities during a scheduled outage.

The specific cleaning tasks were to remove zebra mussel accumulations from the floor of the screenhouse, in the areas between the traveling screens and trash racks, and west of the trash racks, in the inlet bay and in the triangular trash traps in the comers of the screenhouse (Figure 3).

Operations were required to be conducted on a non-interference basis with other activities being conducted in and around the screenhouse. These included molluscicide treatment of the South Intake tunnel, diver activities in various portions of the screenhouse, and other activities associated with the Unit 2 outage and general operations in the plant.

The robotic system was able to operate in all conditions encountered, although there are improvements that would be incorporated in a production system. Mounds of mussels 8'-10' in height were encountered and successfully removed. Even where there was a large mound where the vehicle was introduced into the screen bay it was capable of working its way through the mound to the bottom, and then maneuver to remove the remainder of the mound.

The next version of the system will incorporate the lessons learned during this project, both in equipment configuration and operating procedures.

PLANT DESCRIPTION AND OPERATING ENVIRONMENT

The Cook Nuclear Plant is shown in plan view in Figure 2. Cooling water for the plant is brought into the screenhouse through three intake tunnels, 16' in diameter, which extend approximately 2300' into Lake Michigan. The screenhouse is a concrete chamber approximately 200' long by 108' wide by 45' deep. The screenhouse is divided into three major areas: The forebay, which is the area between the intake tunnels and the trash racks; the screen bays which are the areas between the trash racks and the traveling screens; and the pump bay which is the area between the traveling screens and the circulating water pump inlets. There are also two trash traps, which are triangular areas on each end of the forebay isolated by baffle walls. The screenhouse layout is shown in Figure 3.

Zebra mussels accumulate on the inside of the intake tunnels and on the intake tunnel cribs and surrounding rip-rap. Inside the screenhouse, they accumulate on the walls, floors and trash racks, except in areas of high flow. Large piles of mussels, which slough off from other areas, accumulate on the screenhouse floor in areas of low flow, and against out-of-service traveling screens. These piles may reach heights in excess of 10'.

The plant was undergoing an outage, with Unit 2 down for refueling. Four circulating water pumps were shut down for most of the operation reducing flow through the screenhouse by 57%. The Unit 2 traveling screens were also shut down for maintenance. The south intake was closed off by a stop log and was undergoing treatment with molluscicide to kill the mussels lining the intake pipe.

Other operations in the screenhouse included traveling screen maintenance, routine operations, and diver operations to clean the screenhouse walls on both sides of the traveling screens.

Lake Michigan was generally calm, although there was a period of thermal inversion and rougher conditions which significantly reduced visibility in the screenhouse for a period of time. No extreme temperature or other weather conditions were experienced.

EQUIPMENT DESCRIPTION

The overall system is shown in the block diagram in Figure 4. The prototype vehicle consists of a tracked, pneumatically-driven platform based on the ARDE XT1000 A four horsepower air motor and 60:1 gearbox are used to drive each track. The motors and gearboxes are modified for use underwater. The prototype vehicle was reduced in size and otherwise reconfigured to permit entry via the screenhouse access points in the Cook Nuclear Plant. In addition, the side plates were cut down to reduce hydrodynamic drag.

A suction head with raising and lowering capability was mounted on the front of the prototype vehicle, and an underwater camera and light assembly with full pan and tilt, was mounted on a folding pedestal on the port side. This camera permitted the operator to navigate in the screen and inlet bays, and to monitor mussel removal. The vehicle is shown in several views in Figure 5.

The umbilical assembly consisted of four supply and return air lines (two for each motor), four small diameter control tubes to raise and lower the suction head and camera, a high-strength buoyant tether, and the suction line from the pump to the prototype vehicle. In addition, a 2" closed hose was added to maintain the umbilical positively buoyant.

The handling equipment consisted of three mobile engine-hoist cranes modified to handle the prototype vehicle and associated equipment. One crane was equipped with an electrically-driven capstan and snatch blocks for handling the prototype vehicle. The second and third cranes were identically equipped with electric winches and snatch blocks to handle the auxiliary camera and to suspend the diver's submersible pump. Aluminum channels were used to span the manways and grates, permitting safe positioning of the cranes over the openings.

The auxiliary camera assembly consisted of a 2' square cage equipped with upper and lower rollers on the back side. An underwater camera, lights and pan and tilt unit was mounted on a plate on the bottom of the cage. The vehicle camera was a color unit, and the auxiliary camera was a black-and-white low light level unit. The purpose of the auxiliary camera was to provide the operator with a means of observing insertion of the prototype vehicle. After the first deployment, the auxiliary camera was considered unnecessary and was not used thereafter.

The operator console consisted of a portable cabinet in which were mounted video monitors, pan and tilt control units, and VCRs for the vehicle and auxiliary cameras. An audio recorder was also installed to permit logging of commentary by the operator. High noise environment sound-powered phones were included to permit communications between the two operators.

The vehicle control console was a separate portable unit, normally used with the XT10000 vehicle, to permit the operator freedom of movement. This was found to be unnecessary for this operation, and the portable console was eventually mounted in front of the video monitors. All pneumatic control valves are electrically operated via the joysticks on the vehicle control console. The pneumatic control assembly contains all of the pneumatic valves, pressure regulators, and exhaust mufflers for the subsystem.

Initially per a request from Cook Nuclear Plant personnel, ARDE used a pump supplied by the divers. This pump was a 4 electrically-powered ABS submersible. Difficulty in priming and lack of sufficient 440 volt outlets required changing the pump. ARDE then rented a 6" diesel-powered Godwin self-priming pump for the remainder of the project.

OPERATIONS

Mobilization commenced on 9/8/94. Training and badging had been conducted previously at the plant, therefore no delays were experienced once ARDE staff arrived at the site. The equipment was unloaded and set up on 9/12 and 9/13, and operations commenced on 9/ 14, in accordance with the schedule in ARDE's Operating Plan.

All equipment with the exception of the air compressor and Godwin pump were located inside. The compressor and pump were placed against the west wall of the screenhouse, in temporary containments in the event of fuel spills. ARDE's truck was also parked outside the screenhouse.

Occasional delays were experienced during the project due to other, higher priority, activities associated with the outage. Some delays were also experienced when the divers were unable to retrieve their pump on request, due to other activities. These delays reduced the overall effectiveness of ARDE's operation in terms of total time on site versus total volume of mussels pumped. This would not be an issue for a future production system operated by plant personnel.

The Operating Plan initially addressed cleaning of all areas of the screen and inlet bays. Based on prior diver reconnaissance, the plan was modified and only selected areas, with significant accumulation of mussels, were entered and cleaned. Table 1 summarizes performance in each area.

No safety or health incidents occurred during the operation, and no support was required from the divers or plant personnel, once the diver's pump was replaced. Operations were completed on 10/6/94, and the equipment was broken down and removed on 10/7, approximately 10 days ahead of the original schedule.

The Operating Plan described several techniques to be used for entering the various areas in the screen and inlet bays. In practice these methods were simplified considerably. Some of the equipment prepared for the project, such as the crane for the pump, was not required. Appendix (A) contains various photographs, taken during the project, showing the equipment and conditions in the screenhouse.

System Performance

Performance of the ARDE system was equivalent to diver performance when equivalent conditions existed. That is, where large mounds of mussels were encountered, and pumping capacity was the same, the rate at which mussels could be removed was equal to diver performance. Although clogging and inability to prime were problems encountered with the ABS submersible electric pump, when it operated properly it was very effective.

The centrifugal trash pump substituted by ARDE was at a disadvantage as it had to overcome a static suction head of about 16'. On the other hand, clogs could easily be cleared by injecting either air or water into the suction hose. Any future system would utilize a hydraulically-driven submersible pump. This would permit clearing of clogs by reversing the pump, as well as water or air injection. Moreover the advantage of reduced total equivalent head would be recovered.

Table 1 lists the area worked, pumping hours, total volume and pumping rate. The forebay areas are west of the trash racks, and the screen bay areas are west of the traveling screens. A memo with additional information and comments is included in the appendix. The bare numbers below do not reflect the advantages that a production system would enjoy which include: Operation at any time and shift; operation in or transit of high flow areas; no confined space entry or other major safety related requirements; cleaning of screen bays with traveling screens in operation; and operation independent of plant status.

Note that the dumpsters used had a maximum capacity of about 24 cubic yards. Since the gravity drain reduced the usable overall height, the dumpsters were only filled to about 80% of maximum capacity (about 20 cubic yards), to permit them to be tilted without spillage during removal.

Adversity Factors

ABS Submersible Pump

Although the ABS pump supplied by the divers had a high delivery rate, it was not the best choice for several reasons.

- Installing or removing the pump required the services of the divers, since it was their pump.

- The pump was electrically-driven by a 440 VAC 3-phase motor, thus it was not reversible, which made it more difficult to clear clogs.
- There was no provision for back flushing either with air or water, which also made it more difficult to clear clogs.
- Clearing a clog required the pump to be pulled from the water and the suction line (and possibly the discharge line) disconnected.
- This type of pump is not capable of clearing air from a loop in the suction line, making start up more difficult.

Visibility

Poor visibility, caused by thermal inversion in the Fall and Spring or storms at any time, prevent the use of the prototype vehicle as it is presently configured. Visibility varied from 10 to 15 feet in clear conditions to less than 1 foot in poor conditions. Poor visibility would also hamper a diver if he had to locate a pile of mussels. However, if he knew where the mussels were, an experienced diver could readily locate and remove them by feel.

Even under ideal conditions, visibility is limited in the large open areas of the inlet bay. This limits direct point-to-point navigation in these areas. However, it does not prevent use of the vehicle as the mussels accumulate against the walls, and the vehicle can always be directed along a wall.

ARDE intends to test an ultrasonic imaging system to determine if this would be a useful adjunct to the video system. Note that although the vehicle is hampered by poor visibility at present, it can be used whenever convenient, thus times of poor visibility can be avoided. Note also, that only about 2 days of operation were affected by poor visibility.

High Flow Conditions

The prototype vehicle was operable in all locations, however the effects of high currents were definitely felt in several areas.

After initial entry into the traveling screen area of Unit 2, which was in a refueling outage, the vehicle was deployed into a number of high flow areas on the operating unit 1 side of the screenhouse to both remove material and demonstrate the ability of the system to be deployed and operate in these areas.

The first high flow deployment was in the forebay area directly across from the center intake. The deployment, initiated from behind the baffle wall, was successful. After removing the accumulations of materials from that area the vehicle was moved around the corner and toward the intake tunnel. After rounding the baffle the vehicle was oriented to face the inlet directly using the baffle wall as a reference. The vehicle was then driven toward the intake. The actual vehicle path was a slow arc toward the north end of the forebay due to the effects of the flow on the discharge and control hoses.

After orienting the vehicle again, a second, successful, attempt was made to reach the intake. As the vehicle approached the intake, flow velocities increased dramatically. The ability of the vehicle to turn and move decreased, as well as the ability of the operator to accurately determine the location of the vehicle, its proximity to structures, and its orientation within the forebay.

Conflicting Operations
Other priority operations, related to management of outage-related activities, resulted in some delays to ARD's activities. Early in the project, when diver support was required to move their pump, some delays were experienced because dive personnel were not always available. A production system, operable by plant personnel at convenient times, would not experience these delays.

Dumpster Configuration
The dumpsters used were standard 20'x8'x4' units with swing-open doors. The dumpsters are designed to handle solid waste material. Each time the dumpster is removed from the site and emptied it must be resealed to provide a proper waterproof seal. This requires approximately 12 tubes of silicone caulk and 30 to 45 minutes of time. The seals achieved by this method are marginal in their ability to keep water from leaking onto the ground.

The current method of material dewatering utilizes a single or dual 8" gravity decant. This system provides adequate flow volume to keep the water level inside of the dumpster. There are a number of disadvantages to this particular system. The 8" decant lines are bulky and difficult to manage when full of water. The final decant of free water following filling of the dumpster is a slow process. A 2" clear tube is used as a siphon which takes approximately 1 hour to finish the decant to a level acceptable for transportation.

Piping and Dumpster Layout
Although there was enough space to lay out all the umbilicals and discharge lines, the presence of other equipment, and other activities made umbilical handling more time consuming and difficult. The placement of the dumpsters required the discharge hose to be disconnected and moved whenever dumpsters were brought in, or other equipment required access to the area.

Umbilical/Discharge Hose Weight
The weight of the hose/umbilical assembly made it difficult for two men to retrieve the system. Retrieval had to stop periodically so the hose/umbilical could be rearranged.

Equipment Malfunctions
Only two malfunctions were experienced during the operation. The first was the inability to lower the vehicle camera for vehicle retrieval. This was traced to a faulty air line connection which most likely occurred during assembly of the system. The air line feeding the retract side of the camera air cylinder was not fully seated in the connector. During operation, the air line pulled loose, preventing the cylinder from lowering the camera. The vehicle was raised as high as possible, and the line was connected by reaching into the manway.

The second malfunction was caused by leaking seals on the camera cylinder. The cylinders installed initially on the camera and suction head were not rated for underwater use. However, because of schedule, and the long lead time for rated cylinders, a decision was made to use off-the-shelf unrated units, and the underwater rated units were ordered at the same time. When the seals started to fail on the camera cylinder, the rated replacements were shipped and arrived the same day. It was installed the next morning with very little loss of operational time.

OBSERVATIONS AND LESSONS LEARNED

A) Mussels continue to accumulate in stagnant areas immediately after they have been cleaned. For any given set of flow conditions these areas are well defined.

B) Accumulations at the base of the traveling screens can be caused by cleaning operations with the screens secured. Restarting the screens can result in significant carry-over of mussels, therefore the screens should be operated continuously while cleaning operations take place.

C) The trash racks tend to accumulate significant growth of mussels about halfway down, yet appear to be clear near the surface and the bottom. This is probably attributable to the vertical flow velocity profile. If necessary the trash racks could be cleaned from the surface.

D) Routine cleaning of areas where large accumulations occur, particularly in the screen bays, would be effective in preventing carry-over and clogged traveling screens.

E) Operations could be made more efficient if the removal process were treated as routine maintenance, rather than a periodic problem to be solved.

F) Increasing vehicle weight, and modifying the attachment points for the umbilical and suction hose would improve handling in high flow areas. A flexible attachment point, which would allow the suction hose and umbilical to swivel around two axes would enable the vehicle to maneuver more freely as the suction hose and umbilical would be better able to align with the flow, regardless of the direction of motion of the vehicle.

G) Improved articulation of the suction head would allow the vehicle to drive straight into the piles of mussels and other debris.

H) Track redesign would aid in deployment by allowing the tracks to come into contact with the screenhouse floor with the vehicle in the vertical position.

I) The temporary and expedient nature of the shell removal piping dumpster configuration, dumpster decant system, and dumpster staging slowed the overall removal rate of the mussels.

With the above improvements, the robotic system represents a cost-effective alternative to the use of divers for screen and inlet bay floors.

RECOMMENDATIONS

The complexity of the zebra mussel problem, coupled with the complexity of power plant operation, suggests that an analysis be done to determine the optimum, cost-effective solution to the problem. It is clear that a combination of techniques are required, each to address a specific problem area. The ongoing nature of the problem suggests that some permanent installations are required, for example, piping and manifolds to carry the mussels to the container site.

Improvements to the vehicle would include reducing its width to permit the vehicle to access the trash traps via the 24"x 24" openings, increasing vehicle weight and modifying the suction hose attachment point to reduce the effects of hydrodynamic drag on vehicle maneuverability. In addition, the pneumatic drive and actuation cylinders would be replaced by hydraulics, and the track profile would be modified to permit easier insertion of the vehicle. Articulation of the suction head would permit the vehicle to be driven straight into the piles of mussels.

Optimizing the equipment operationally would also require a purpose-designed handling system, controllable locally or from the operator's console. The handling system would incorporate power-assist for the umbilical, as well as an improved vehicle winch.

Since zebra mussel removal appears to be a long-term problem, operations in general would be simplified by installing a permanent piping and manifold system in the screenhouse for the pump discharge. Permanent outside piping, and a more convenient site for the dumpsters used to haul the mussels, would also facilitate operations, as would substitution of a decant pump for the gravity decant method currently in use.

COMPARISON OF VEHICLE AND DIVER OPERATIONS

Diver operations and the use of the robotic system were compared for cost and efficiency, and each technique has its merits. Based on experience at the Cook Nuclear Plant, the crew size needed to operate the robotic system under various scenarios, as follows:

Case A: Robotic system operated by contract diving personnel

One diver/ vehicle operator
Two tenders/ laborers

Case B: Robotic system operated by newly trained in-house personnel with contract labor support

Two maintenance mechanics/ operators
Two laborers

Case C: Robotic system operated by experienced in-house personnel with contract labor support

Two maintenance mechanics /operators
One laborer

Case D: Optimized Robotic system operated by experienced in-house personnel with contract labor support

One maintenance mechanics/ operator
One laborer

Case E: Diver removal of mussels by conventional pumping

One diver/ supervisor
One diver
One tender
One laborer

Table 2 is a qualitative pro/ con comparison of the techniques.

CONCLUSIONS

The project goals for this phase were met. The ARDE Robotic system can provide a cost-effective alternative to diver operations for removal of zebra mussels from the screenhouse floor at the Cook Nuclear Plant. The prototype system, a modified ARDE XT1000, incorporating special features for the project, demonstrated the feasibility of the approach.

The experience gained on the project will enable a production system to be designed and built that will meet ongoing needs of the plant on a routine basis. For optimum operational efficiency, some piping and a dedicated hydraulic power unit should be permanently installed in the plant. In addition, the dumpsters and decanting method should be replaced with a more suitable approach.

While divers can be replaced for cleaning the screenhouse floor, they are still needed to clean the walls, and to perform other activities in the plant.

ACKNOWLEDGEMENTS

We thank Mr. William Hannah of the Indiana Michigan Power Company/Cook Nuclear Plant, and his dive crew from RUST Utility Services for their help in staging and retrieval of equipment needed to support this project. Also Messrs. James Ridgely, William Lewis, and Scott Carpenter, of ARD Environmental, Inc., for vehicle operations and suggestions for improved performance. And finally the managements of the American Electric Power Service Corporation, Indiana Michigan Power Co. /Cook Nuclear Plant and ARD Environmental, Inc., for the opportunity to demonstrate telerobotics technology for zebra mussel cleaning and review of this paper.

REFERENCES

Claudi, R. and Spencer, F., "Summary of the Zebra Mussel Research Program at Ontario Hydro", Proceedings of the 1991 AWWA Annual Conference, pp. 215-223.

Demoss, Dennis and Mendelsberg Jeffrey I., "Zebra Mussel Control Strategies", Proceedings of the American Power Conference, v 53 pt 1, 1991, Illinois Institute of Technology, pp. 553-561.

Lawrence, Charles F., "Macrofouling The Design Process in Zebra Mussel Control", Industrial Water Treatment, July/ August 1994, pp. 41-48.

O'Neill, Charles R. Jr. and MacNeill, David B., "The Zebra Mussel (Dreissena Polymorpha): An Unwelcome North American Invader", Coastal Resources Fact Sheet, November 1991, Sea Grant, Cornell Cooperative Extension, State University of New York, pp. 6,7.

Tsou, J.L, et al., "Recent Advances in Zebra Mussel Research", Proceedings of the American Power Conference, v 53 pt 1,1991, Illinois Institute of Technology, pp. 562-570.

Table 1. Performance Summary

AREA WORKED	PUMP HOURS	TOTAL VOLUME CU YDS	PUMPING RATE YDS/HR
2-6,7	3	12	4
2-6,7	3.5	8	2.3
2-2,3	1	2	2
2-2,3	4	8	2
Unit 2 Forebay	2	2	1
Unit 1 Forebay	2.5	5	2
Unit 1 Forebay	2	6	3
1-4,3	2	5	2.5
1-4,3	2	3	1.5
1-4,3	3.5	9	2.6
1-4,3	3.5	7	2
1-2,1	3.5	7	2
1-2,1	3	6	2

Table 2 Comparison of Cleaning Techniques

TECHNIQUE	PRO	CON
DIVING	WIDE CHOICE OF TOOLS/MOST FLEXIBLE	LARGER CREW SIZE
	CLEAN FLOOR OR WALLS	NUMEROUS SAFETY ISSUES
	CAN OPERATE IN POOR VISIBILITY	SECOND DIVER MUST BE READY TO ASSIST IN CASE OF EMERGENCY
		LIMITED ENDURANCE
		CANT WORK IN HIGH FLOW
		MUST SECURE TRAVELING SCREENS FOR SAFETY
		BACKUP SYSTEMS REQUIRED
ARDE ROBOT	SMALLER CREW SIZE	LIMITED CHOICE OF TOOLS/ NOT AS FLEXIBLE
	FEW SAFETY ISSUES	CLEAN FLOOR ONLY
	UNLIMITED ENDURANCE	POSSIBLY LIMITED BY POOR VISIBILITY
	TRAVELING SCREENS CONTINUE TO OPERATE	MAY REQUIRE DIVER RETRIEVAL IN CASE OF MALFUNCTION
	CAN WORK IN HIGH FLOW	
	EQUIPMENT CAN BE LEFT SUBMERGED INDEFINITELY	
	BACKUP SYSTEMS NOT REQUIRED	

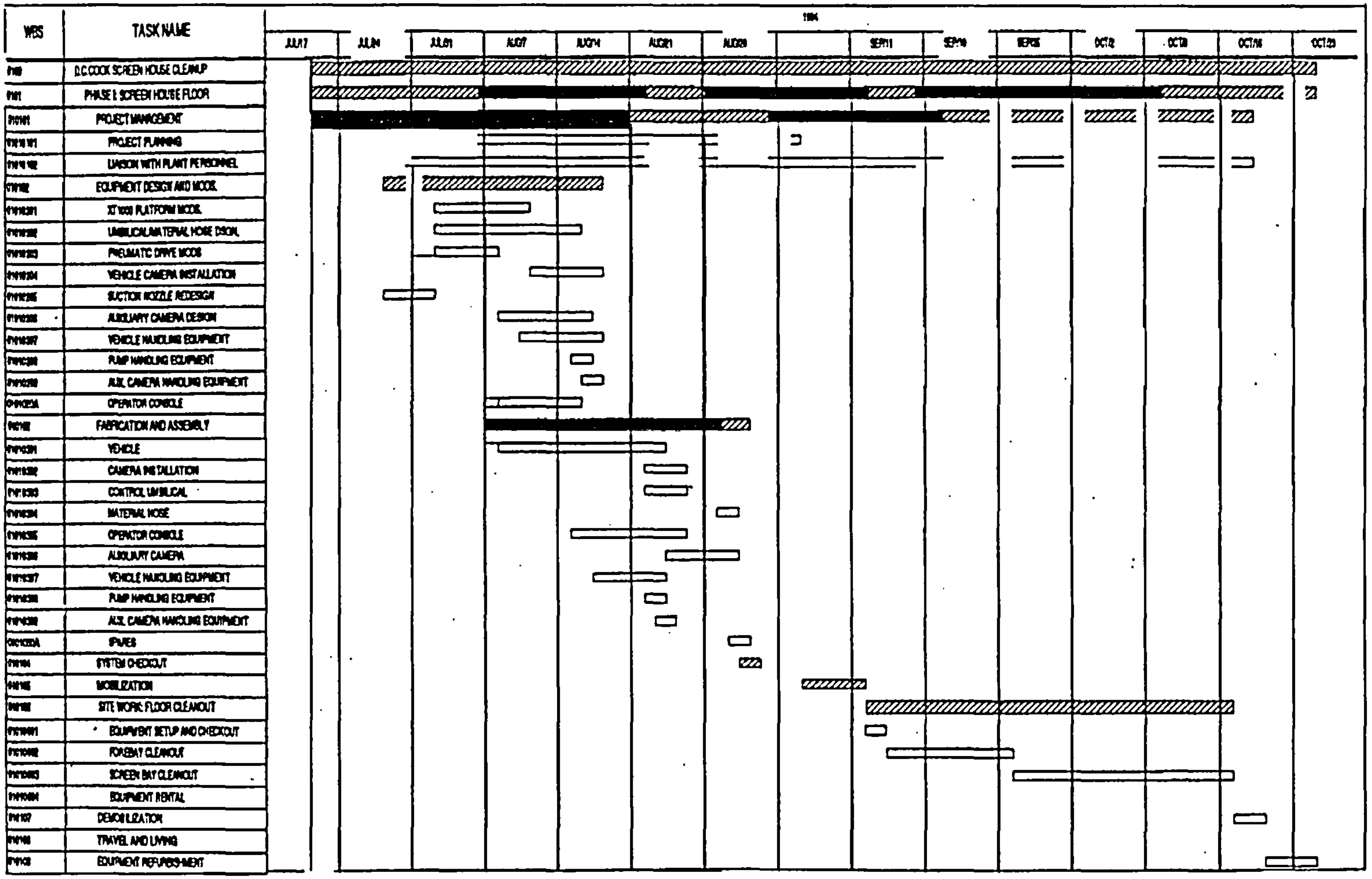

Figure 1. D.C. Cook Phase I: Screenhouse Floor Cleaning Project Schedule

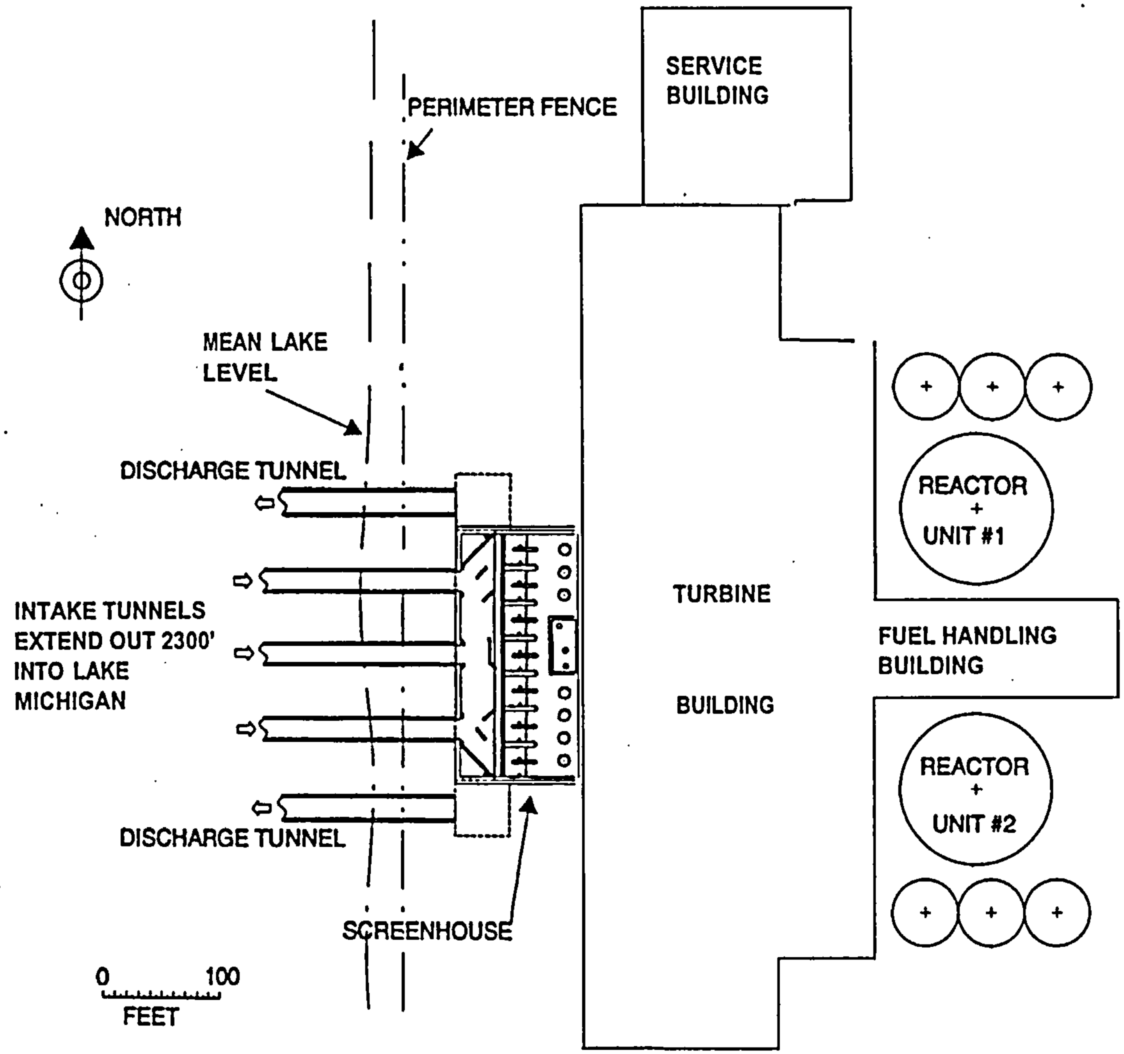

Figure 2. Cook Nuclear Plant

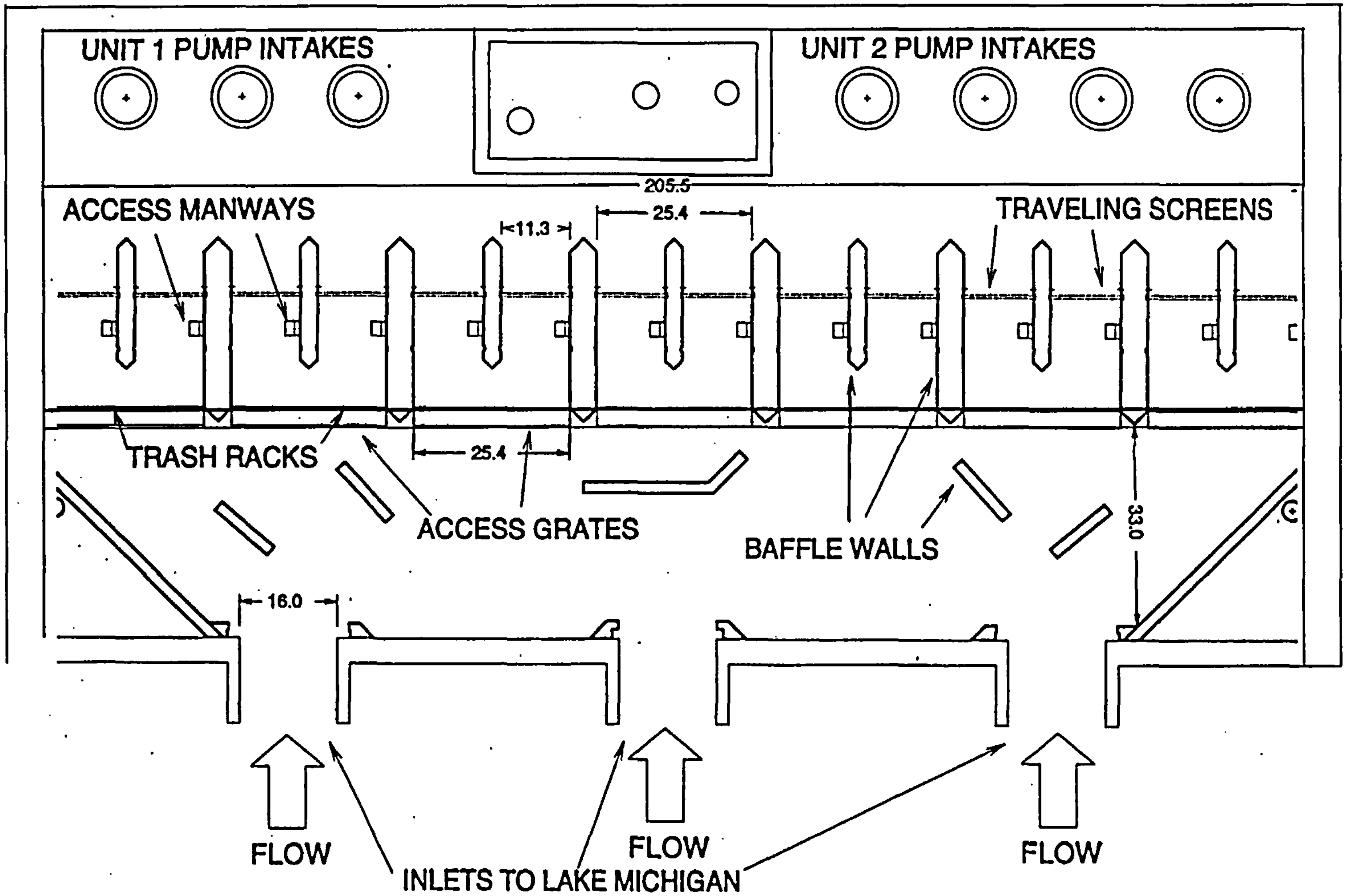

Figure 3. Screenhouse Layout, Cook Nuclear Plant

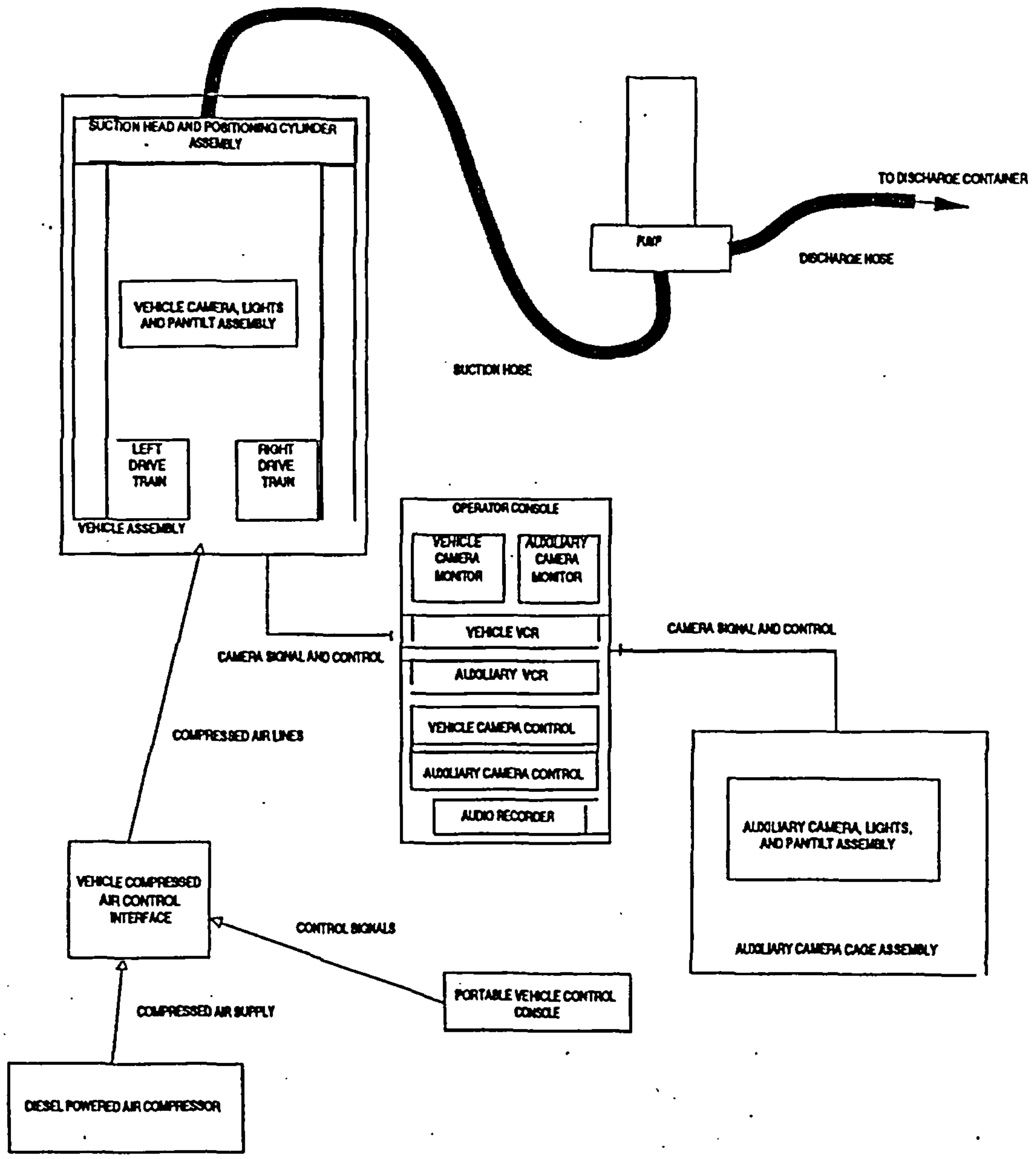

Figure 4. System Block Diagram, Zebra Mussel Removal Equipment, Cook Nuclear Plant

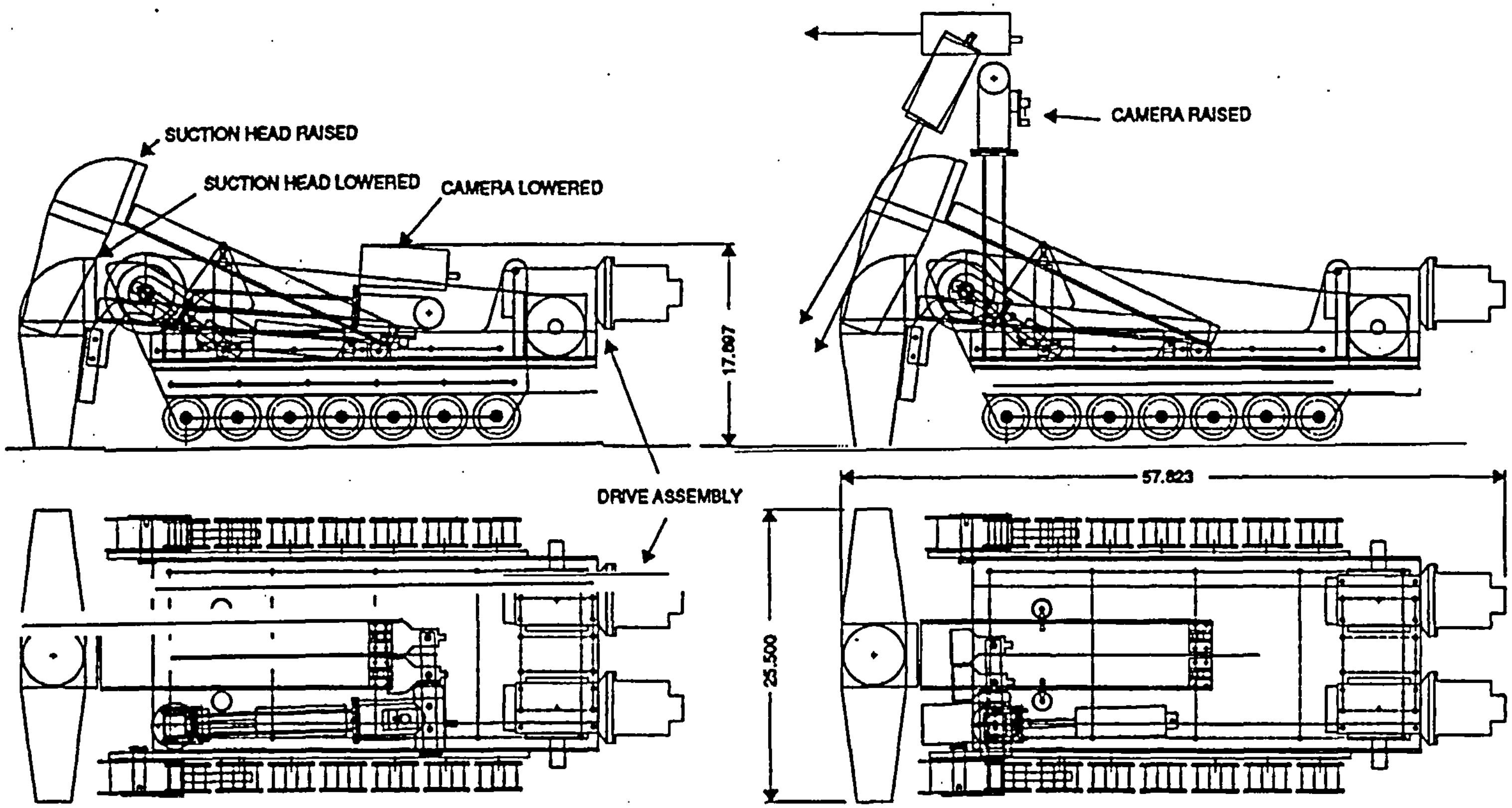

Figure 5. Modified XT1000 for Zebra Mussel Removal Project

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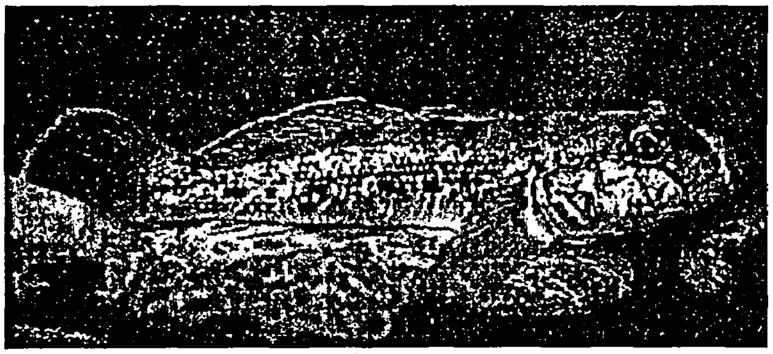
The Round Goby: An Example of the "Perfect" Invader?

The round goby, *Neogobius melanostomus* is the most recent exotic fish (along with its cousin the tubenose goby, *Proterorhinus marmoratus*) to invade the Great Lakes. Introduced from their native range (the Black and Caspian seas) via ballast water, round gobies are small, benthic, soft-bodied fish that look similar to native sculpins, but can be identified by a black spot on their anterior dorsal fin and by fused pelvic fins in the form of a suctorial disc. First discovered in 1990 in the St. Clair River near Detroit, round gobies quickly spread and by 1995 had been reported in all five of the Great Lakes with population numbers reaching high densities in many areas in Lake Erie and Lake Michigan.



The Round Goby, ***Neogobius melanostomus.***

Certain aspects of the round goby's biology provide us with an example of what the "perfect" invader is and why gobies may have been pre-adapted for live transport in ballast water of transoceanic ships. These same qualities will allow for their further expansion in North America, with the potential to threaten not only the Great Lakes aquatic communities but also their tributaries and other connected watersheds as well. The following adaptive features that gobies possess can be useful in determining what makes an invader successful and may predict who else could be a potential invader.

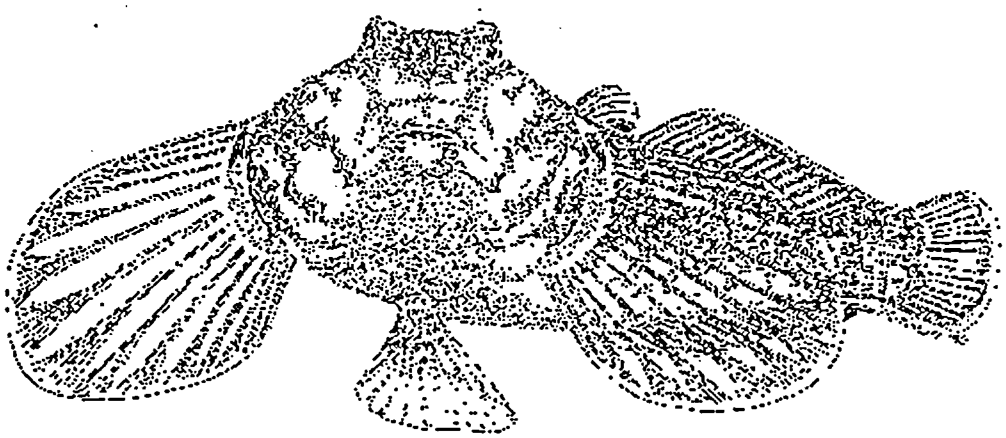
First, the round goby grows up to 10 inches and is a very aggressive, robust fish that is highly territorial and very competitive for food, shelter, and spawning areas. This competitive nature along with its larger size has already allowed it to displace smaller native benthic fish, such as the mottled sculpin (*Cottus bairdi*) and logperch (*Percina caprodes*), from some areas of the Great Lakes. Second, gobies can survive under a wide range of environmental conditions including fresh or salt water (40.5% saline), water with low dissolved oxygen and high levels of pollution, and also water from -1 to 33deg.C. Round gobies can also live in a wide range of habitat types, such as sandy or silty areas and macrophyte habitats, although they prefer rock, cobble, or riprap habitat. Third, gobies are voracious foragers with a very diverse diet comprised mostly of benthic invertebrates including zebra mussels, but may contain smaller fish and fish eggs. The use of zebra mussels in their diet provides gobies with a competitive advantage by giving them a food supply most native fish do not utilize. Round gobies also have a well-developed lateral line system that gives them the ability to feed at night. Finally, gobies spawn every 18-20 days and potentially up to six times during a breeding season. This reproductive pattern gives them an ecological advantage over native species which usually spawn only once.

Characteristics such as propagule pressure, suitability of habitat, and success in previous invasions can be valuable predictors for the success of a particular invasion. Round gobies have demonstrated that they possess these and other important characteristics, such as survivability in unfavorable conditions, adaptability to a new environment, territorial behavior, and other competitive advantages over native species that have allowed them to become an excellent invader. The question is, How far and fast will they spread and what impacts will they have?

Research by Survey scientists shows gobies can survive at least several weeks at temperatures as high as 33deg.C and optimal growth for round gobies occurs near 24deg.C. These results for temperature tolerance are very similar to those of zebra mussels, which are widely distributed and have spread as far south as New Orleans. In addition, with zebra mussels present, gobies are given a preferred food item with suitable habitat already present upon arrival to new areas.

Based on this and temperature tolerance, if gobies are able to spread to the Illinois River from Lake Michigan, their range could potentially expand to the Mississippi River, thus giving them access to much of the interior of North America. It remains to be seen how fast gobies will spread, or if a proposed dispersal barrier in the Chicago Ship and Sanitary Canal will stop round gobies from spreading too far downstream in the Illinois River.

With optimal growth for round gobies occurring near 24deg.C, it is highly possible they will be more successful in streams and rivers, where their greatest impacts on native species could be felt. Since round gobies have already had negative impacts on sculpin and logperch populations in the Great Lakes, biologists fear that similar impacts may occur with darters should gobies continue to spread. Survey scientists have conducted competition experiments among round gobies and both greenside (*Etheostoma blenniodes*) and johnny darters (*E. nigrum*) in artificial streams and enclosures placed into small ponds. Research measuring growth of darters with gobies present or absent indicate trends toward negative impacts on darters by round gobies. Also, results provide evidence that gobies are equal or better competitors than are darters with fellow darters.



Because round gobies reach such high densities and are known to eat the eggs of other fish, researchers are also concerned about possible predation by gobies on eggs of nesting sunfishes during spawning periods. For this reason, experiments were also conducted at the Illinois Natural History Survey in which round gobies were added to large cattle tanks with spawning pumpkinseed (*Lepomis gibbosus*) and green sunfish (*L. cyanellus*). Sunfish nests were then filmed with video equipment to observe if round gobies would eat sunfish eggs or even attempt to do so. The video showed that round gobies will raid nests and successfully prey on sunfish eggs, sometimes even when the guarding male sunfish is present. It is not known from these results how significant an impact gobies could have on overall nesting success of sunfish; however, it appears that guarding the nest successfully comes at a high price energetically for the male sunfish.

There are many other ways in which round gobies could have major impacts on stream and river communities as predators, prey, or as competitors with native species. It is extremely important that more work be done in this area to help understand what impacts round gobies will have as their invasion continues to new areas. Since 1995, round gobies have been found in other areas of the Great Lakes, including a discovery as recently as this summer of large numbers of gobies living in Lake Superior near Superior, Wisconsin. They have also expanded their range to live much farther inland in both the Shiawassee and Flint rivers near Flint, Michigan. Most importantly, perhaps, gobies are now poised to invade the Illinois River system, having been found to exist at least 15 miles inland from Lake Michigan in the Cal-Sag Channel of Chicago. If the round goby and other aquatic invaders, such as the Eurasian ruffe, the sea lamprey, and the zebra mussel, that have similar qualities suited for invasion could be used as a model, we may be able to better predict what invaders will be successful or what other foreign animals could be potential candidates for future invasion, and possibly stop an invasion before it happens.

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The Round Goby Invades Lake Michigan

The latest exotic species to invade the Great Lakes is a diminutive fish from the Black and Caspian seas area. The round goby, which grows to only 10 inches long, was discovered in 1990 in the St. Clair River, which borders the U.S. and Canada near Detroit. For three years they remained within a few miles of their point of introduction, but in January 1993, several gobies were caught by anglers in the Grand Calumet River in Indiana. By 1994 they were found in Calumet and Hammond harbors, IL, South Haven, MI, and Cleveland, OH; and in 1995 gobies were found on the north side of Chicago and in Duluth, MN. This rapid spread was undoubtedly facilitated by the same vector that brought gobies to North America -- ballast water transfer from ocean-going ships in the Great Lakes. The presence of gobies in the Calumet River means that they have direct access to the Illinois and Mississippi river drainages, and thus to a large geographic range.

The reaction of scientists and fisheries managers to the round goby has been different than has been the case with other recent invaders. When zebra mussels were found in Lake St. Clair in 1988, they were immediately recognized as an ecological threat because of their centuries-long history of disrupting native communities and fouling intake pipes as they spread across western Europe. The appearance of European ruffe in Lake Superior near Duluth in 1987 raised similar alarms because ruffe had invaded Loch Lomond in Scotland a decade earlier and nearly wiped out the local populations of yellow perch. In contrast, when the round goby appeared in the St. Clair River, no one paid much attention. Round gobies had not previously spread beyond their native range, so they had no history of causing problems. This has been an unfortunate case of assuming innocence until guilt is proven -- an unwise strategy where exotic species are involved. Many exotic species that have become established in North America (and the rest of the world) have caused significant ecological disruption (consider cockroaches, starlings, Norway rats, dandelions, and the Medfly).

Round gobies are relatively small, benthic, soft-bodied fishes that are easily confused with native sculpin species. Two characteristics may be used to distinguish them from the natives: first, their pelvic fins are fused to form a disk. This pelvic disk is characteristic of the goby family. Second, their bodies are covered with fine, mail-like scales, in contrast to the local native sculpins, which are naked or sparsely covered with prickles. Round gobies also have a distinctive black spot on the spinous (front) dorsal fin, but this character is not diagnostic for gobies because many sculpins have a similar spot in the same location.

Round goby, small but troublesome exotic fish in the Midwest. Photo by Ellen Marsden.

Although there are a few euryhaline (able to tolerate a wide range of saltwater concentrations) marine gobies that are often found in coastal streams, the round goby is the first freshwater goby to proliferate in North America; the tubenose goby, which appeared in the St. Clair River at the same time as the round goby, has not spread widely. Round gobies are more fecund, more aggressive, and have lateral line systems that are more sensitive in still water than those of the native sculpins. Round gobies are natural predators of zebra mussels in their native eastern European range, and a substantial proportion of their diet in the Great Lakes is composed of zebra mussels; sculpins eat few zebra mussels. These features of the goby suggest that round gobies probably will be able to invade many regions of the Great Lakes, and may displace native sculpins by outcompeting them for shared resources of food and habitat.

Another feature that gobies share with sculpins is their ability to deeply penetrate the interstitial spaces in cobble substrates. For sculpins, this behavior makes them an effective predator of lake trout eggs. Lake trout were extirpated in Lake Michigan by the 1950s and are currently the focus of a massive stocking effort with the aim of population rehabilitation. The trout spawn in fall over cobble reefs and their eggs settle deeply into interstitial spaces, where they are mostly protected from storm-generated surges and from predators--except sculpins. Stocked lake trout are just beginning to spawn, in low numbers, in Lake Michigan (see INHS Reports 324); the addition of a new, highly abundant egg predator could mean a significant setback for their rehabilitation.

Gobies have not yet spread into areas where lake trout spawn, though they are within 15 miles of an important lake trout spawning site. However, in our laboratory experiments, which simulated conditions on a lake trout spawning reef, gobies readily retrieved and consumed eggs that had settled into cobble substrates. They also ate newly hatched fry under the same conditions. Gobies as small as 56mm, which are likely only one year old, could break and eat lake trout eggs. The largest gobies tested, which were 100-120mm long, ate over three eggs per day on average. By comparison, sculpins tested under similar conditions ate an average of two eggs per day, as did crayfish. Estimates of sculpin densities in the Great Lakes vary from 1 to 30 per square meter; densities of adult gobies near Calumet Harbor in Lake Michigan vary from 1 to 20 per square meter, and juveniles are present on sandy substrates at 8 to 133 per square meter.

Clearly, gobies have both the potential population densities and the appetite to pose a serious threat to lake trout reproductive success. Whether this threat will be realized depends on how rapidly gobies spread to lake trout spawning areas, and their preference for alternate food sources. Native fish species, including adult lake trout, are likely to prey upon gobies, although the gobies' sensitive lateral line system makes them highly effective at detecting and avoiding predators. For example, sculpins can be easily collected by scuba divers with a dip net, whereas gobies larger than 27mm are extremely difficult to catch. Gobies are only too easy to catch with a rod and reel, however; anglers in the St. Clair River and Calumet Harbor have been frustrated by the gobies' propensity to steal bait.

Like the other exotic species that have invaded the Great Lakes in recent decades, gobies have become a permanent part of the ecosystem; they are too numerous and too widespread to control. A few of their potential impacts are predictable: competition with sculpins, and predation on lake trout eggs and fry and other benthic organisms. Whether they will become a significant nuisance like the ruffe or alewife remains to be seen, and this possibility will be the focus of research by Survey investigators over the next few years.

J. Ellen Marsden and Michael A. Chotkowski, Center for Aquatic Ecology

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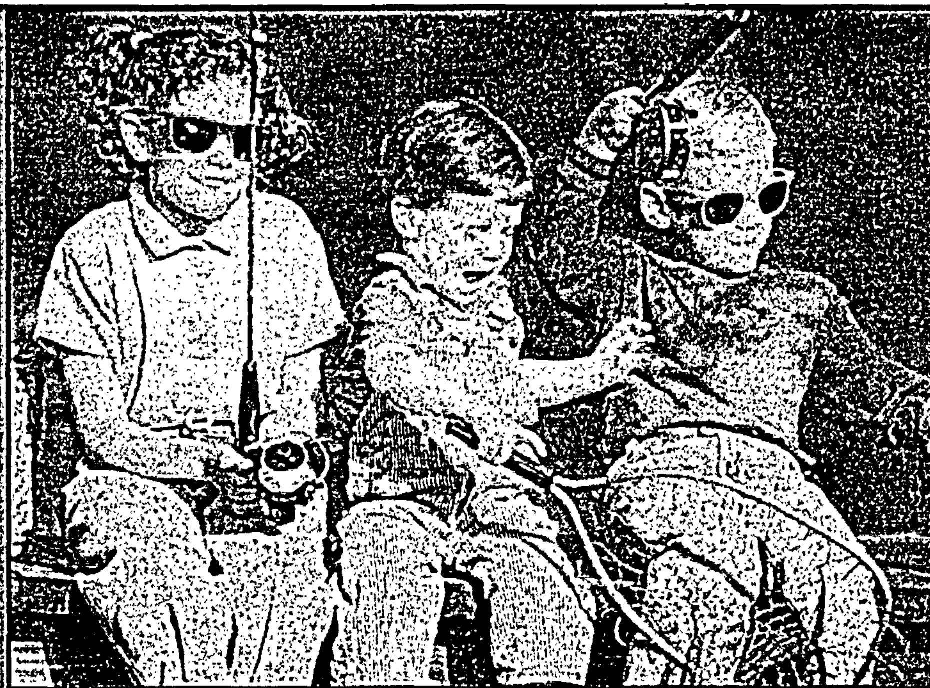

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WHAT WOMEN OF CHILDBEARING AGE SHOULD KNOW ABOUT EATING FISH

General Fish Consumption Advice

The Michigan Department of Community Health advises extra caution about eating Michigan fish for women of childbearing age and children under 15.

Certain kinds and sizes of fish from the Great Lakes and from some of Michigan's lakes and streams contain levels of toxic chemicals that may be harmful if those fish are eaten too often.

The amounts of chemicals found in Michigan fish are not known to cause immediate sickness. But chemicals can collect in the body over time. It may take months or years of regularly eating contaminated fish to build up amounts that are a health concern. Chemicals may eventually affect your health or that of your children. Mothers who eat highly contaminated fish before birth may have children who are slower to develop and learn. A pregnant woman may pass these chemicals to her unborn child and to the new baby through breast milk.

What Can I Do to Reduce My Health Risks from Chemicals in Fish?

- Choose smaller fish. Generally, panfish and fish just over the legal size will have fewer chemicals.
- Choose lean fish. Panfish, brook trout and brown trout that live in streams and rivers tend to be low in fat. Small walleye, northern pike and bass, especially those that are just legal size, also tend to have fewer chemicals. Carp and catfish are higher in fat and usually have more chemicals.
- Choose fish that don't eat other fish. Large predator fish, especially large walleye, northern pike, muskie, bass and lake trout tend to have more chemicals.

For a guide to how often you may eat sport fish and still avoid potential health risks from chemicals, see the charts of specific advisories for the Great Lakes watersheds. The charts start on page 8. They show specific locations, kinds, and sizes of fish, and how often you may eat them.

Trim and cook fish properly to reduce risk. This can remove more than 50 percent of the remaining contaminants in fish. See the separate section on trimming and cooking on page 3.

Advisory on Mercury in Inland Lakes

The Michigan Department of Community Health has issued a special advisory for all inland lakes in Michigan due to mercury. This is a widespread problem throughout the north central United States and Canada.

No one should eat more than one meal a week of these kinds and sizes of fish from any of Michigan's inland lakes:

- Rock bass, perch, or crappie over 9 inches in length
- Any size largemouth bass, smallmouth bass, walleye, northern pike, or muskie

Women of childbearing age and children under age 15 should not eat more than one meal per month of these fish.

More than 200 inland bodies of water have been sampled. For specific advice about these lakes, see the summary of mercury in fish from inland lakes on page 6.

Commercial Fish

The fish you buy from your supermarket can also contain toxic chemicals. There are laws to limit them, but extra caution will help protect unborn and young children.

Women of child bearing age, particularly those who are pregnant or nursing, and children under 15 should not eat these fish due to mercury levels:

• Swordfish • Shark • King Mackerel • Tilefish

COOKING AND CLEANING FISH

Trim & Cook Fish Properly To Reduce Risk

Fish are nutritious and good to eat. When properly prepared, fish provide a diet high in protein and low in saturated fats. Many doctors suggest, based on scientific studies, that eating 2-3 fish meals a week is helpful in preventing heart disease.

Proper preparation reduces the concentration of organic chemicals like PCB even further. By trimming fatty areas before cooking and by cooking fish in ways that allow fat to drip away, more than 50 percent of the contaminants in fish can be eliminated. Methyl mercury is stored in fish flesh. Special trimming and cooking methods do not remove it.

DO

Trim fatty areas before cooking (see drawing). The belly, the top of the back, and the dark meat along the skin side of the fillet are often fatty.

Remove or puncture skin before cooking. This allows fats to drain off and helps remove or reduce fat under the skin.

Cook so fat drips away. Bake, broil or grill on a rack, or poach and do not use the liquid.

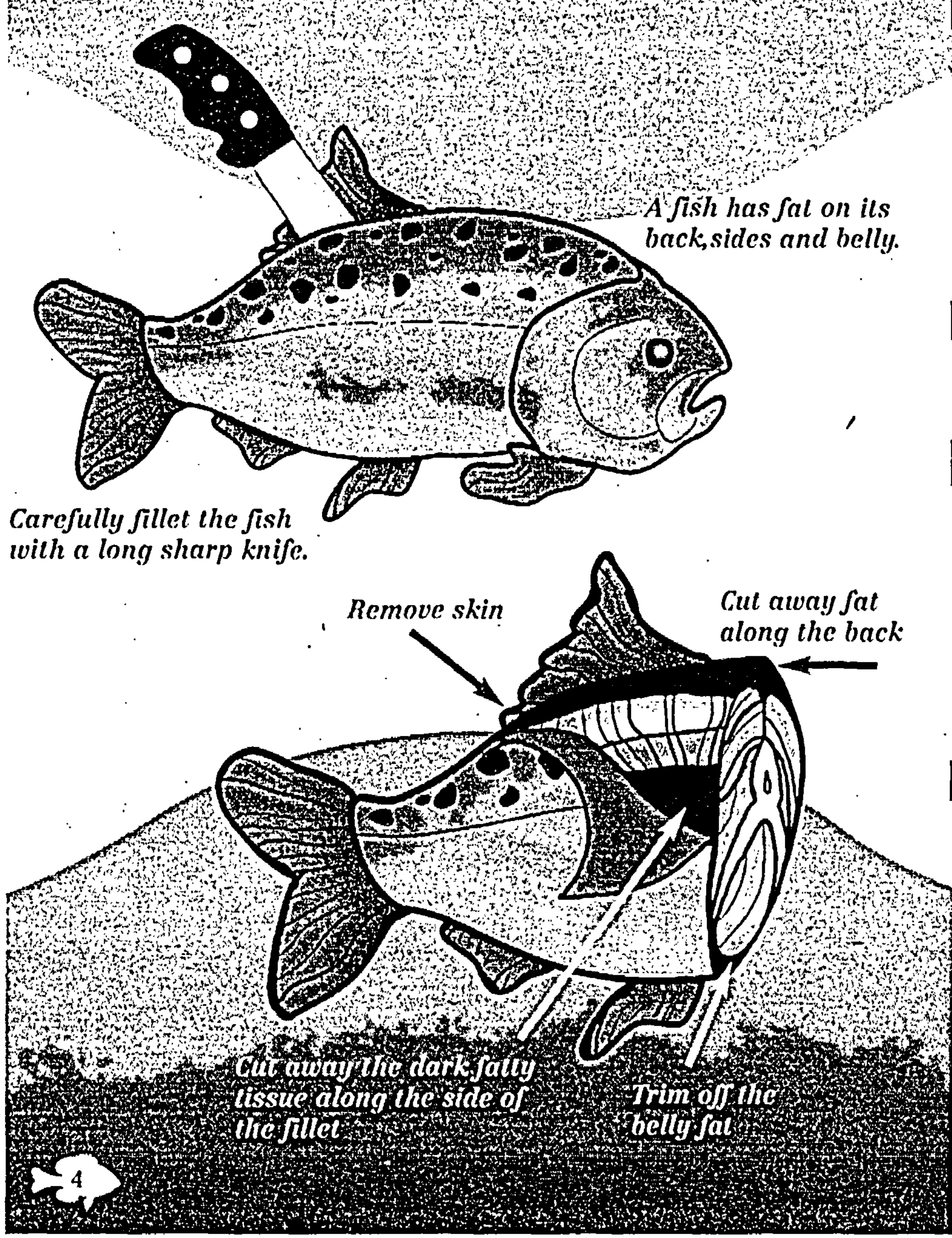
Deep-fry trimmed fillets in vegetable oil. After frying, drain and throw away the oil.

DON'T

Pan-fry in butter or animal fat, and don't make fish soups or chowders. These methods hold in juices that contain fat from the fish.

COOKING AND CLEANING FISH

Important reminders:



CHARTS OF SPECIFIC ADVISORIES

How to Use the Charts – Four Easy Steps

Step One:

In the first column, find the body of water in which you are fishing. The charts are divided into separate listings for each Great Lakes watershed. Within these sections, the Great Lake is listed first, then bays on the lake that have additional advisories, followed by an alphabetical listing of rivers that flow into the lake and inland lakes, reservoirs or impoundments in the watershed.

Step Two:

In the second column, find the kind of fish that you have caught.

Step Three:

Read across the top of the chart to the appropriate category and find the size range of the fish you have caught. The General Population category is for men, boys over the age of 15 and women who are beyond childbearing years. The Women & Children category is for women of childbearing age and children under 15.

Step Four:

Follow the size column down to the line for the species that you found in the previous steps. The symbol on the chart represents the consumption advice, according to the following key:

▲ Unlimited consumption. Eat as much of these fish as you wish.
▼ One meal per week.
● One meal per month.
■ Six meals per year.
◆ Do not eat these fish.

General Advice

If you are fishing in a river or stream that is not listed, keep in mind the following facts:

- Larger and older fish tend to collect more contaminants.
- Fish that eat other fish, such as muskie, northern pike, walleye and bass, tend to collect chemicals such as mercury.
- Fatty fish, such as carp, catfish, lake trout and large salmon, tend to collect PCBs and similar chemicals.
- For salmon and trout on their spawning run into streams, follow the advice for the Great Lake from which they are migrating.

Mercury in fish

Mercury is found in nature. It is also released by burning wastes and coal, and improper disposal of mercury containing products such as thermometers, batteries, and older thermostats. Small amounts can dissolve in water. Bacteria can change it into a more toxic form called methyl mercury.

Fish pick it up as they feed and absorb it from water as it passes over their gills. Larger predator fish accumulate more as they eat other fish. Methyl mercury is stored in fish flesh. Special trimming and cooking methods do not remove it.

Nearly all fish contain very small amounts of methyl mercury. Usually only large fish that eat other fish have levels too high for humans to eat.

Mercury in Michigan Sport Fish

In addition to Great Lakes advisories, these charts represent results of testing for mercury in fish from about 200 inland lakes in Michigan. Only a few kinds of fish were tested in each lake. The charts show only the mercury in the fish that were tested. Other fish in the same lake will probably have similar levels. Large fish such as bass and walleye may have higher levels. Panfish such as bluegill and sunfish may have lower levels. You can also get a copy of the full tables that show species and sizes tested in each lake. Contact the Michigan Department of Community Health Environmental & Occupational Epidemiology Division at 1-800-648-6942.

General Inland Lake Mercury Advisory

For lakes not in these lists, follow this general advisory. Even in the lakes tested that did not have fish consumption advisories due to mercury it is wise to limit meals of large fish.

- No one should eat more than one meal a week of rock bass, yellow perch, or crappie over nine inches in length and bass, walleye, northern pike or muskellunge of any size.
- Women of childbearing age and children under 15 should not eat more than one meal per month of these fish.

Spacing Meals of Sport Fish

It's important to leave enough space between meals of sport fish so you reduce the risks of chemicals in fish.

- If you eat fish that contain mercury, wait until the consumption period is over before having another meal of fish in the same category. For example, if you eat a fish that has a consumption advisory of one meal a month because of mercury contamination, don't eat any more fish that contain mercury for another month.

- It's different with fish that contain other chemicals such as PCBs. You can eat more meals of these fish over a shorter period of time as long as you don't go over the total number of meals you could have in a year. If most of the fish you eat are in the one-meal-a-week category, you could have a total of 52 meals a year. If most of the fish you eat are in the one-meal-a-month group, you could have 12 meals a year. Eating one meal of fish from the one-meal-a-month group is the same as eating four meals of fish from the one-meal-a-week group. If you eat most of your meals of sport fish in four or five months over the summer fishing season, that's okay — but don't eat more than the total number of meals you may have in a year.

Need More Information?

For further information or for the most up-to-date advice, contact the MDCH Environmental & Occupational Epidemiology Division at 1-800-648-6942. This advisory was updated in January, 2002. Determining safe levels of fish consumption is an ongoing process of scientific analysis. Updates may be issued as the Michigan Department of Community Health gets new information.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+
Lake Erie Watershed All other locations refer to general advice on page 6.																				
Lake Erie #	Carp, Catfish	PCBs, Dioxins	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Chinook Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Coho Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Freshwater Drum	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Lake Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			■	■	■	■	■	■	■
	Rainbow Trout (Including Steelhead)	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Smallmouth Bass	PCBs					▲	▲	▲	▲						●	●	●	●	
	Walleye	PCBs				▲	▲	▲	▲	▲	▲				▼	▼	▼	●	●	●
	White Bass	PCBs	▲	▲	▲	▲	▲	▲				●	●	●	●	●	●			
	Whitefish	PCBs, Dioxins	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	White Perch	PCBs	▲	▲	▲	▲						●	●	●	●					
	Yellow Perch	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
Barton Pond* (Huron R.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Belleville Lake* (Huron R.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	■	■
	Gizzard Shad	PCBs	▲	▲	▲	▲	▲	▲				●	●	●	●	●	●			
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	●	●	●	●
	White Suckers	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		●	●	●	●	●	●	●	●	
Black Creek (Lenawee Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
Black River (Sanilac Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Cass Lake* (Oakland Co.)	Smallmouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Walleye	Mercury, PCBs					▼	▼	▼	▼	▼					●	●	●	●	●
Clear Spring Lake* (Macomb Co.)	Largemouth Bass	Mercury, PCBs					▲	▼	▼	▼						▼	●	●	●	

\# Also applies to tributaries into which migratory species enter.

* For species not listed, see general inland lake mercury advisory on page 6.

An empty box in the chart means one of two things:

- On the small end of the size scale, fish in this size range are not of legal size.
- On the large end of the size scale, fish of this type generally do not grow to this size.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	Women & Children Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Erie Watershed All other locations refer to general advice on page 6.																				
Clinton River (Below Yates Dam)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	■	■	■	■
	Rock Bass	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Detroit River	Carp	PCBs, Dioxin	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Freshwater Drum	Mercury, PCBs	▲	▲	▲	▲	▼	▼	▼	▼	▼	●	●	●	●	●	●	●	●	●
	Northern Pike	PCBs							▲	▲	▲							●	●	●
	Redhorse Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		●	●	●	●	■	■	■	■	
	Walleye	PCBs				▲	▲	▲	▲	▲	▲				●	●	●	●	●	●
	Yellow Perch	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
Ford Lake* (Washtenaw Co.)	Black Crappie	PCBs	▲	▲	▲	▲	▲	▲				▼	▼	▼	▼	▼	▼			
	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				▼	▼	●	●	●	●
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	▼	▼	▼	▼
Hudson Lake* (Lenawee Co.)	Carp	Mercury	▲	▲	▲	▲	▲	▲	▲	▼	▼	▲	▲	▲	▲	▲	▲	▲	●	●
	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Kent Lake* (Oakland Co.)	Black Crappie	Mercury, PCBs	▲	▼	▼	▼	▼	▼				▼	●	●	●	●	●			
	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Largemouth and Smallmouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	
	Walleye	Mercury, PCBs					▼	▼	▼	▼	▼					●	●	●	●	●
Lake Orion* (Oakland Co.)	Carp	PCBs, Chlordane	▲	▲	▲	▲	▲	▲	▲	◆	◆	▲	▲	▲	▲	▲	▼	▼	◆	◆
	Largemouth Bass	Mercury					▼	▼	▼	▼						●	●	●	●	
	Northern Pike	Mercury, PCBs							▼	▼	▼							●	●	●

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.	▼ One meal per week.
● One meal per month.	■ Six meals per year.
	◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Erie Watershed All other locations refer to general advice on page 6.																				
Lake St. Clair	Bluegill	PCBs	▲	▲	▲	▲						▼	▼	▼	▼					
	Brown Bullhead	Mercury	▲	▲	▲	▲	▼					▲	▲	▲	▲	●				
	Carp	PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	●	●	●	●	●	●	●	●
	Carpsucker	Mercury	▲	▲	▲	▲	▲	▼	▼	▼	▼	▲	▲	▲	▲	▲	●	●	●	●
	Channel Catfish	PCBs				▲	▲	▲	▼	▼	▼				▼	▼	■	◆	◆	◆
	Largemouth and Smallmouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Northern Pike	Mercury							▲	▼	▼							▲	●	●
	Muskellunge	Mercury, PCBs									◆									◆
	Sturgeon	PCBs									▲									●
	Walleye	Mercury, PCBs				▲	▲	▲	▼	▼	▼				▼	▼	▼	●	●	●
	White Bass	Mercury, PCBs	▲	▲	▲	▼	▼	▼				●	●	●	●	●	●			
	White Perch	Mercury	▲	▲	▼	▼						▲	▲	●	●					
Loon Lake* (Oakland Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Largemouth and Smallmouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Maceday Lake* (Oakland Co.)	Northern Pike	Mercury, PCBs							▼	▼	▼							●	●	●
Norvell Lake (Jackson Co.)	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	▼	▼	▼	
Osmun Lake* (Oakland Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	■	■
	Largemouth Bass	PCBs, Mercury					▼	▼	▼	▼						●	●	●	●	
Ottawa River	All species	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Pine River (St. Clair Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼
Pontiac Lake* (Oakland Co.)	Channel Catfish	Mercury, PCBs				▲	▲	▲	▼	▼	▼				▼	▼	▼	●	●	●
River Raisin (Above Monroe Dam)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
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Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Erie Watershed All other locations refer to general advice on page 6.																				
River Raisin, (Below Monroe Dam) **and Plum Creek**	Black Buffalo	PCBs	▲	▲	▲	▲	◆	◆	◆	◆	◆	■	■	■	■	◆	◆	◆	◆	◆
	Carp	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Channel Catfish	PCBs				◆	◆	◆	◆	◆	◆				◆	◆	◆	◆	◆	◆
	Freshwater Drum	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Smallmouth Bass	PCBs					▼	▼	▼	▼						■	■	■	■	
	White Bass	PCBs	▲	▲	▼	◆	◆	◆				■	■	■	◆	◆	◆			
River Raisin, South Branch	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Northern Pike	PCBs							▲	▲	▲							●	●	●
	Redhorse Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		▼	▼	▼	●	●	●	●	●	
Rouge River (Main or Upper Branch above M-153/Ford Road)	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Rouge River (Phoenix Lake)	Bluegill	PCBs	▲	▲	▲	▲						▼	▼	▼	▼					
	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	●	●	●	●
	Northern Pike	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	●
Rouge River (Newburgh Lake)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	■	■
	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				●	●	●	●	●	●
	Largemouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	
Rouge River (Middle Branch below Newburgh Lake and Main Branch below M-153/Ford Road)	Carp, Catfish	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Largemouth and Smallmouth Bass	PCBs					◆	◆	◆	◆						◆	◆	◆	◆	
	Northern Pike	PCBs							◆	◆	◆							◆	◆	◆
	White Suckers	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	■	■	■	■	■
	All other species	PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆
Rouge River Lower Branch	Carp, Suckers	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Terry Lake* (Oakland Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	●	●	●	●

*For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Erie Watershed All other locations refer to general advice on page 6																				
St. Clair River	Carp	Mercury, PCBs	▲	▲	▲	▲	▲	▲	▼	▼	◆	▲	▲	▲	▼	●	●	■	◆	◆
	Freshwater Drum	Mercury, PCBs	▲	▲	▲	▲	▼	▼	▼	▼	▼	▲	▲	▲	▲	●	●	●	●	●
	Gizzard Shad	Mercury, PCBs	▲	▲	▼	▼	▼	▼				▼	●	◆	◆	◆	◆			
	Walleye	PCBs				▲	▲	▲	▲	▲	▲				●	●	●	●	●	●
Stony Creek Impoundment* (Macomb Co.)	Northern Pike	Mercury, PCBs							▼	▼	▼							●	●	●
Unnamed Lake* (Washtenaw Co., T3S, R7E, S26)	Bullhead	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
	Largemouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
Walled Lake* (Oakland Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	●	●	●
	Northern Pike	Mercury, PCBs							▼	▼	▼							●	●	●
Whitmore Lake* (Livingston Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼
Woodland Lake* (Livingston Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼
	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
All inland lakes, reservoirs, and impoundments (mercury advisory)	Crappie	Mercury	▲	▼	▼	▼	▼	▼				▲	●	●	●	●	●			
	Largemouth and Smallmouth Bass	Mercury					▼	▼	▼	▼						●	●	●	●	
	Muskellunge	Mercury									▼									●
	Northern Pike	Mercury							▼	▼	▼							●	●	●
	Rock Bass	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				
	Walleye	Mercury					▼	▼	▼	▼	▼					●	●	●	●	●
	Yellow Perch	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				

* For species not listed, see general inland lake mercury advisory on page 6.

Symbol	Meaning
▲	Unlimited consumption.
●	One meal per month.
▼	One meal per week.
■	Six meals per year.
◆	Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+	Women & Children Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+
Lake Huron Watershed All other locations refer to general advice on page 6.																				
Lake Huron #	Brown Trout	PCBs			▲	▲	▲	▼	▼	▼	▼			●	●	●	◆	◆	◆	◆
	Burbot	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Chinook Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Coho Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Lake Trout	PCBs, Chlordane, Dioxins			▼	▼	▼	▼	◆	◆	◆			◆	◆	◆	◆	◆	◆	◆
	Rainbow Trout (Including Steelhead)	PCBs, Dioxins			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Whitefish	PCBs, Dioxins	▲	▲	▲	▲	▲	▼	◆	◆	◆	▼	▼	▼	▼	▼	◆	◆	◆	◆
Saginaw Bay # (Also follow **Lake Huron** advisories above)	Carp	PCBs, Dioxins	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Channel Catfish	PCBs, Dioxins				▼	▼	◆	◆	◆	◆				◆	◆	◆	◆	◆	◆
	Northern Pike	PCBs							▲	▲	▲							▼	●	●
	Walleye	Mercury, PCBs					▲	▲	▼	▼	▼					▼	●	●	●	●
	White Bass	PCBs	▼	▼	▼	▼	▼	▼				■	■	■	■	■	■			
	White Perch	PCBs	▲	▲	▲	▲						●	●	●	●					
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	●	●	●	●	●
	Yellow Perch	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
Thunder Bay # (Also follow **Lake Huron** advisories above)	Carp	PCBs, Dioxins	▲	▲	▲	▲	▲	◆	◆	◆	◆	▼	▼	▼	▼	▼	◆	◆	◆	◆
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	▼	●	●	●
Au Sable River (At Oscoda)	Carp	PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Walleye	Mercury, PCBs					▲	▲	▲	▼	▼					▼	●	●	●	●
Au Sable River (Middle Branch)	Walleye	Mercury					▼	▼	▼	▼	▼					●	●	●	●	●
Bad River	Channel Catfish	PCBs				▼	▼	▼	▼	▼	▼				●	●	■	◆	◆	◆
	Northern Pike	PCBs							▲	▲	▲							▼	▼	▼
Burt Lake (Cheboygan County)	Walleye	Mercury					▲	▼	▼	▼	▼					▲	●	●	●	●
Caro Impoundment* (Cass River)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼

Also applies to tributaries into which migratory species enter.

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Lake Huron Watershed

All other locations refer to general advice on page 6.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Cass River (Below Bridgeport)	Carp	Dioxins	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Channel Catfish	PCBs, Mercury Dioxins				◆	◆	◆	◆	◆	◆				◆	◆	◆	◆	◆	◆
	Northern Pike	PCBs							▲	▲	▲							▼	●	●
Cass River (Above Bridgeport)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Northern Pike	Mercury							▲	▼	▼							▲	●	●
Cheboyganing Creek	Carp	PCBs	▲	▲	▲	▲	▲	▼	◆	◆	◆	▼	▼	▼	●	●	■	◆	◆	◆
	Northern Pike	PCBs							▲	▲	▲							●	●	●
Chippewa River (Midland Co.)	Redhorse Suckers	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Flint River (Below Flint)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	◆	●	●	●	●	●	●	●	●	◆
	Smallmouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	
Holloway Reservoir* (Genessee Co.)	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				●	●	●	●	●	●
Kawkawlin River	Carp	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Northern Pike	PCBs							▲	▲	▲							●	●	●
Kearsley Reservoir* (Genesee County)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	●	●
	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Pine River* (Alma Impoundment)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	●	●
Pine River* (Downstream of Alma dam)	All Species	PBBs, DDT	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Lake Ponemah* (Genesee Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	●	●	●
	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Rifle River	Redhorse Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		▼	▼	▼	▼	▼	▼	▼	▼	
	Rock Bass	PCBs	▲	▲	▲	▲	▲					▲	▼	▼	▼	▼				
Saginaw River (Entire Length)	Carp, Catfish	PCBs, Dioxins	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	White Bass	PCBs	▼	▼	▼	▼	▼	▼				■	■	■	■	■	■			
	All other species	PCBs, Dioxins	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	●	●	●	●	●	●	●	●

* For species not listed, see general inland lake mercury advisory on page 6.

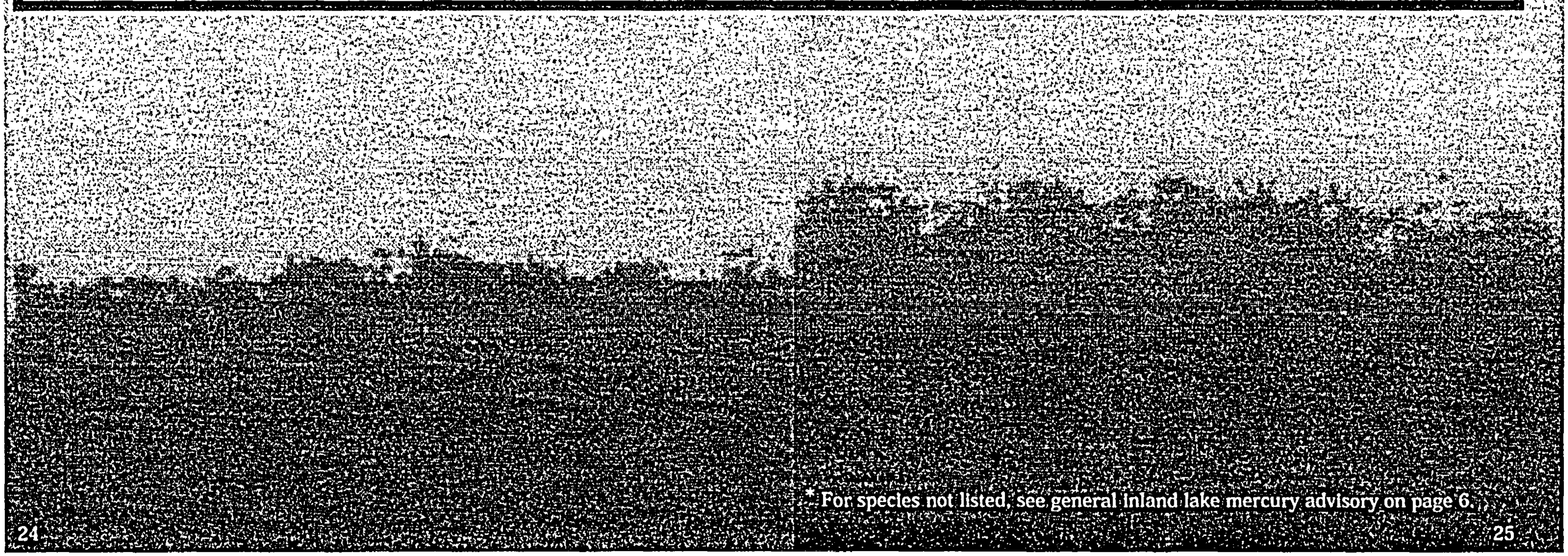
▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Huron Watershed All other locations refer to general advice on page 6.																				
Sanford Lake* (Midland Co.)	Black Crappie		▲	▲	▲	▲	▲	▲				▲	▲	▲	▲	▲	▲			
	Channel Catfish	Mercury, PCBs				▲	▲	▲	▲	▼	▼				▼	▼	▼	▼	●	●
	Rock Bass		▲	▲	▲	▲	▲					▲	▲	▲	▲	▲				
St. Mary's River	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Northern Pike	PCBs							▲	▲	▲							▲	▼	▼
	Walleye	Mercury, PCBs					▲	▲	▼	▼	▼					▼	▼	●	●	●
Sebawaing River	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	●	●	●	●	●
	Northern Pike	PCBs							▲	▲	▲							▼	▼	▼
Shiawassee River (Below Owosso)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	●	●	●
	Rock Bass	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
	Smallmouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	
Shiawassee River (Byron to Owosso)	Carp	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Northern Pike	PCBs							▲	▲	▲							●	●	■
	Smallmouth Bass	PCBs					▲	▲	▲	▲						●	●	●	●	
Shiawassee River S. Br. (M-59 to Byron)	All species	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Tawas River	Northern Pike	PCBs							▲	▲	▲							▼	▼	▼
Thompson Lake* (Livingston Co.)	Black Crappie	Mercury, PCBs	▲	▼	▼	▼	▼	▼				●	●	●	●	●	●			
	Carp	PCBs	▲	▲	▲	▲	▲	▼	◆	◆	◆	▼	▼	▼	●	●	■	◆	◆	◆
Thread Creek and Thread Creek Impoundment (Genesee Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
Tittabawassee River (Below Midland)	Carp, Catfish	PCBs, Dioxins	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Smallmouth Bass	PCBs, Dioxins					▼	▼	▼	▼						◆	◆	◆	◆	
	White Bass	PCBs, Dioxins	◆	◆	◆	◆	◆	◆				◆	◆	◆	◆	◆	◆			
	All other species	PCBs, Dioxins	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	●	●	●	●	●	●	●	●

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Huron Watershed All other locations refer to general advice on page 6.																				
Tobico Wetland* (Bay Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Northern Pike	PCBs							▲	▲	▲							▲	▼	▼
Van Etten Lake* (Iosco Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				●	■	■	■	■	■
	Walleye	Mercury, PCBs					▼	▼	▼	▼	▼					●	●	●	●	●
***All Inland lakes, reservoirs, and impoundments** (mercury advisory)	Crappie	Mercury	▲	▼	▼	▼	▼	▼				▲	●	●	●	●	●			
	Largemouth and Smallmouth Bass	Mercury					▼	▼	▼	▼						●	●	●	●	
	Muskellunge	Mercury									▼									●
	Northern Pike	Mercury							▼	▼	▼							●	●	●
	Rock Bass	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				
	Walleye	Mercury					▼	▼	▼	▼	▼					●	●	●	●	●
	Yellow Perch	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				



*For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Lake Michigan Watershed

All other locations refer to general advice on page 6.

Water body	Species	Contaminant(s)	General Population Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+	Women & Children Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+
Lake Michigan North of Frankfort #	Brown Trout	PCBs			▲	▲	▲	▲	◆	◆	◆			●	●	●	●	◆	◆	◆
	Burbot	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼
	Carp	PCBs	▼	▼	▼	▼	▼	▼	▼	◆	◆	■	■	■	■	■	■	■	◆	◆
	Catfish	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Chinook Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	■	■
	Coho Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	■
	Lake Trout	PCBs, Chlordane			▲	▲	▲	▲	▲	◆	◆			●	●	●	●	■	◆	◆
	Rainbow Trout (Including Steelhead)	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	●	●	●	●
	Smelt	PCBs	▲	▲	▲	▲						▼	▼	▼	▼					
	Sturgeon	PCBs									◆									◆
	Walleye	Mercury, PCBs					▲	▲	▼	▼	▼					▼	●	●	■	■
	Whitefish	PCBs, Dioxin	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Yellow Perch	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
Lake Michigan South of Frankfort #	Brown Trout	PCBs			▲	▲	▲	▲	◆	◆	◆			●	●	●	●	◆	◆	◆
	Carp, Catfish	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Chinook Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	■	■
	Coho Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	■
	Lake Trout	PCBs, Chlordane			▲	▲	▲	▼	◆	◆	◆			●	●	●	●	◆	◆	◆
	Rainbow Trout (Including Steelhead)	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	●	●	●	●
	Smelt	PCBs	▲	▲	▲	▲						▼	▼	▼	▼					
	Sturgeon	PCBs, Chlordane DDT, Dioxin									◆									◆
	Walleye	Mercury, PCBs					▲	▲	▼	▼	▼					▼	●	●	■	■
	Whitefish	PCBs, Chlordane Dioxin	▲	▲	▲	▲	▲	▲	◆	◆	◆	●	●	●	●	●	●	◆	◆	◆
	Yellow Perch	PCBs	▲	▲	▲	▲	▲					▲	▼	▼	▼	▼				

Also applies to tributaries into which migratory species enter

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	Women & Children Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Michigan Watershed All other locations refer to general advice on page 6.																				
Green Bay # (S. of Cedar River. Applies to Michigan waters including Menominee and Cedar rivers below first dam. See also **Lake Michigan-North of Frankfort**)	Brown Trout	PCBs			▼	▼	▼	◆	◆	◆	◆			●	●	■	◆	◆	◆	◆
	Burbot	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼
	Carp	PCBs	▼	▼	▼	▼	▼	▼	▼	◆	◆	■	■	■	■	■	■	■	◆	◆
	Channel Catfish	PCBs				▼	▼	▼	▼	▼	▼				■	■	■	■	■	■
	Chinook Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Lake Trout	PCBs			▲	▲	▲	▲	▼	▼	▼			●	●	●	●	●	■	■
	Longnose Sucker	PCBs	▼	▼	▼	▼	▼	▼	▼			■	■	■	■	■	■	■		
	Northern Pike	PCBs							▲	▲	▲							●	●	●
	Rainbow Trout (Including Steelhead)	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Smallmouth Bass	Mercury, PCBs					▲	▼	▼	▼						●	●	●	●	
	Splake	PCBs			▼	▼	▼	◆	◆	◆	◆			●	●	■	◆	◆	◆	◆
	Sturgeon	PCBs									◆									◆
	Walleye	Mercury, PCBs					▲	▼	▼	◆	◆					●	■	■	◆	◆
	White Bass	PCBs	◆	◆	◆	◆	◆	◆				◆	◆	◆	◆	◆	◆			
	Whitefish	PCBs, Dioxins	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	White Perch	PCBs	◆	◆	◆	◆						◆	◆	◆	◆					
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Yellow Perch	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
Little Bay de Noc # (See also Lake Michigan North of Frankfort)	Burbot	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼
	Carp	PCBs	▼	▼	▼	▼	▼	▼	▼	◆	◆	■	■	■	■	■	■	■	◆	◆
	Longnose Sucker	PCBs	▼	▼	▼	▼	▼	▼	▼			●	●	●	●	■	◆	◆		
	Northern Pike	PCBs							▲	▲	▲							●	●	■
	Smallmouth Bass	Mercury, PCBs					▲	▼	▼	▼						●	●	●	●	
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
Barton Lake* (Kalamazoo Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼

Also applies to tributaries into which migratory species enter.
* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+	Women & Children Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+
Lake Michigan Watershed All other locations refer to general advice on page 6.																				
Battle Creek River	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	●	●	●
	Smallmouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	
Bear Lake* (Muskegon Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▼	◆	●	●	●	●	●	●	●	◆	◆
	Largemouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Northern Pike	PCBs							▲	▲	▲							▼	●	●
	Walleye	Mercury, PCBs					▲	▼	▼	▼	▼					●	●	■	■	■
Black Creek (Muskegon Co.)	Carp, White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
Black River (Below S. Br. and S. Br. below Bangor)	Carp	PCBs, Chlordane	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Northern Pike	PCBs							▲	▲	▲							●	●	●
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Boyne River	Brown Trout	PCBs		▲	▲	▲	▲	▲	▲	▲	▲		▼	●	●	●	●	●	●	●
Constantine Impoundment* (St. Joseph R.; St. Joseph Co.)	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				▼	▼	▼	▼	▼	▼
Crystal Lake* (Benzie Co.)	Brown Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	●	●	●	●
	Lake Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	▼	●	●	●
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Dowagiac River	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Elk Lake* (Antrim Co.)	Lake Trout	Mercury, PCBs			▲	▲	▲	▲	▲	▼	▼			▼	▼	▼	▼	●	●	●
Fawn River	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	●	●	●
Flat River	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Rock Bass	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
Fenner Lake* (Allegan Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	●	●	●
Galien River	Carp	PCBs, Chlordane	▲	▲	▲	▲	▲	▲	◆	◆	◆	▲	▲	▲	▼	●	●	◆	◆	◆
Glen Lake* (Leelanau Co.)	Lake Trout	Mercury, PCBs, Chlordane			▲	▲	▲	▲	▼	▼	◆			▼	▼	▼	●	●	●	◆

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+	Women & Children Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+
Lake Michigan Watershed All other locations refer to general advice on page 6.																				
Goose Lake* (Marquette Co.)	Northern Pike	PCBs							▲	▲	▲							●	●	●
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	▼	▼	▼	▼
	Yellow Perch	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
Grand River (Above Webber Dam)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				▼	▼	●	●	●	●
	Northern Pike	PCBs							▲	▲	▲							▼	▼	▼
	Redhorse Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		●	●	●	●	●	●	●	●	
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	▼	▼	▼	▼
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Grand River (Below Webber Dam)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				▼	▼	●	●	●	●
	Northern Pike	PCBs							▲	▲	▲							▼	▼	▼
	Redhorse Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		●	●	●	●	●	●	●	●	
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	●	●	●	●
Greenwood Reservoir* (Escanaba River, Marquette Co.)	Northern Pike	Mercury							▼	▼	◆							●	●	◆
Gull Lake* (Kalamazoo Co.)	Northern Pike	Mercury, PCBs							▲	▼	▼							▼	●	●
Hess Lake* (Newago Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼
Higgins Lake* (Roscommon Co.)	Lake Trout	Mercury, PCBs, Chlordane			▲	▲	▲	▲	▲	▲	◆			●	●	●	●	●	●	◆
Houghton Lake* (Roscommon Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼
Kalamazoo River (Ceresco Impoundment, Calhoun Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
Kalamazoo River (From Battle Creek to Morrow Pond Dam)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Channel Catfish	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Smallmouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Michigan Watershed* All other locations refer to general advice on page 6.																				
Kalamazoo River (From Morrow Dam to Allegan Dam) and	Carp	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Catfish, Suckers	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Largemouth and Smallmouth Bass	PCBs PCBs					◆	◆	◆	◆						◆	◆	◆	◆	
	All other species	PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆
Kalamazoo River (Below Allegan Dam)	Carp, Catfish	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Largemouth and Smallmouth Bass	PCBs					▼	▼	▼	▼						◆	◆	◆	◆	
	Northern Pike	PCBs							◆	◆	◆							◆	◆	◆
	All other species	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
Klinger lake (St. Joseph Co.)	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Lake Charlevoix* (Charlevoix Co.)	Brown Trout	PCBs			▲	▲	▲	▲	▼	▼	▼			●	●	●	●	■	■	■
	Lake Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
Lake Macatawa* (Ottawa Co.)	Carp	PCBs, Chlordane	▲	▲	▲	▲	▲	▼	◆	◆	◆	▼	▼	▼	▼	●	●	◆	◆	◆
	Walleye	PCBs					▲	▲	▲	▲	▲					●	●	●	●	●
Lake Paradise (Emmet Co.)	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
	Smallmouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Long Lake (St. Joseph Co.)	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Manistee Lake* (Manistee Co.)	Black Crappie	Mercury, PCBs	▲	▼	▼	▼	▼	▼				▼	●	●	●	●	●			
	Bluegill	PCBs	▲	▲	▲	▲						▼	▼	▼	▼					
	Largemouth and Smallmouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Walleye	Mercury, PCBs					▼	▼	▼	▼	▼					●	●	●	●	●
Manistique River (Below M-94/ Old U.S. 2)	Carp	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Channel Catfish	PCBs				▲	▲	▲	▲	▲	▲				●	●	■	■	■	■
Manistique River (Upstream from dam at Manistique)	Northern Pike	Mercury							▼	▼	▼							●	●	●

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption. ▼ One meal per week.
● One meal per month. ■ Six meals per year.
◆ Do not eat these fish.

Lake Michigan Watershed

All other locations refer to general advice on page 6.

Water body	Species	Contaminant(s)	General Population – Length (inches)* 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	Women & Children – Length (inches)* 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Menominee River (Below Quinnesec. Dickinson Co.)	Carp	Mercury, PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	●	●	●	●	●	●	●	■
	Redhorse Sucker	Mercury, PCBs	▲	▲	▲	▲	▼	▼	▼	▼		▲	▲	▲	▲	●	●	●	●	
	Sturgeon	Mercury, PCBs									▼									●
	Walleye	Mercury, PCBs					▲	▼	▼	▼	▼					▲	●	●	●	●
	White Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Michigamme River System* (Including Lake Michigamme, Michigamme Reservoir, Peavy Pond, and Paint River Pond)	Burbot	Mercury	▲	▲	▲	▲	▲	▲	▼	▼	▼	▲	▲	▲	▲	▲	▲	●	●	●
	Northern Pike	Mercury							▼	▼	▼							●	●	●
	Walleye	Mercury					▼	▼	▼	▼	▼					●	●	●	●	●
	White Sucker	Mercury	▲	▲	▲	▲	▲	▼	▼	▼	▼	▲	▲	▲	▲	▲	●	●	●	●
Mona Lake* (Muskegon Co.)	Carp	PCBs	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Smallmouth Bass	PCBs					▲	▲	▲	▲						●	●	●	●	
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	●	●	●	●
Morrison Lake* (Ionia Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		▲	▲	▲	▲	▲	▲	▲	▼	●
	Largemouth Bass						▲	▲	▲	▲						▲	▲	▲	▲	
Muskegon Lake* (Muskegon Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▼	◆	●	●	●	●	●	●	●	◆	◆
	Largemouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Northern Pike	PCBs							▲	▲	▲							▼	●	●
	Smallmouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Walleye	Mercury, PCBs					▲	▼	▼	▼	▼					●	●	■	■	■
Muskegon River (Below Croton Dam)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▼	◆	●	●	●	●	●	●	●	◆	◆
	Redhorse Sucker	Mercury, PCBs	▲	▲	▲	▲	▲	▼	▼	▼		▲	▲	▲	▲	▲	●	●	●	
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	●	●	■	■
Net River (Iron Co.)	Northern Pike	Mercury							▼	▼	▼							●	●	●
	Walleye	Mercury					▼	▼	▼	▼	▼					●	●	●	●	●
Palmer Lake (St. Joseph Co.)	Largemouth Bass	Mercury					▲	▼	▼	▼						▲	●	●	●	
Pere Marquette Lake* (Mason Co.)	Northern Pike	Mercury, PCBs							▼	▼	▼							●	●	●
	Redhorse Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		●	●	●	●	●	●	●	●	

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Michigan Watershed All other locations refer to general advice on page 6.																				
Pere Marquette River	Brown Trout	Mercury, PCBs		▲	▲	▲	▼	▼	▼	▼	▼		▼	▼	▼	●	●	●	●	●
	Redhorse Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲		●	●	●	●	●	●	●	●	
Portage Creek (Monarch Pond)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Portage Creek (Below Monarch Mill Pond, Kalamazoo Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	●	●	●	●	●
	Channel Catfish	PCBs				◆	◆	◆	◆	◆	◆				◆	◆	◆	◆	◆	◆
	Largemouth Bass	PCBs					◆	◆	◆	◆						◆	◆	◆	◆	
	Smallmouth Bass	PCBs					◆	◆	◆	◆						◆	◆	◆	◆	
	All other species	PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆
Portage Lake* (Manistee Co.)	Largemouth and Smallmouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Northern Pike	Mercury, PCBs							▼	▼	▼							●	●	●
Randall Lake Chain* (Branch Co.)	Northern Pike	Mercury, PCBs							▼	▼	▼							●	●	●
Red Cedar River	Carp	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	●	●	●	●
	Northern Pike	PCBs							▲	▲	▲							▲	▲	▲
Reed's Lake* (Kent Co.)	Largemouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	
	Northern Pike	PCBs							▲	▲	▲							▼	▼	▼
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	▼	▼	▼	▼
Ruddiman Creek Lagoon (Muskegon Co.)	Carp	PCBs	▲	▲	▲	▲	▲	▲	▼	◆	◆	●	●	●	●	●	●	●	◆	◆
	Largemouth Bass	PCBs					▲	▲	▲	▲						▼	▼	▼	▼	
Round Lake* (Marquette Co.)	Northern Pike	Mercury							◆	◆	◆							◆	◆	◆
Selkirk Lake* (Allegan Co.)	Yellow Bullhead	Mercury	▲	▲	▼	▼	▼					▲	▲	●	●	●				
St. Joseph River (Below Berrien Springs)	Carp	PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Smallmouth Bass	PCBs					▲	▲	▲	▲						●	●	●	●	
	Walleye	PCBs					▲	▲	▲	▲	▲					▼	▼	▼	▼	▼
St. Joseph River (Including **Chapin Lake*** above Berrien Springs, Berrien Co.)	Carp	PCBs	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Smallmouth Bass	PCBs					▲	▲	▲	▲						●	●	●	●	
St. Joseph River	Walleye	PCBs					▲	▲	▲	▲	▲					▼	▼	▼	▼	▼

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+
Lake Michigan Watershed All other locations refer to general advice on page 6.																				
Stanley Lake (Iron Co.)	Walleye	Mercury					▲	▲	▲	▲	▲					▲	▲	▲	▲	▲
Torch Lake* (Antrim Co.)	Brown Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	●	●	●	●
	Lake Trout	Mercury, PCBs, Chlordane			▲	▲	▲	▲	▼	◆	◆			▼	▼	●	●	●	◆	◆
	Lake Whitefish	PCBs, Dioxin	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼	◆	◆	◆	◆
	Smallmouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Yellow Perch	Mercury	▲	▲	▲	▼	▼					▲	▲	▲	●	●				
Union Lake* (St. Joseph R., Branch Co.)	Carp, Catfish	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Unnamed Lake* (Baraga Co., T49N, R31W, S35)	Nothern Pike	Mercury							◆	◆	◆							◆	◆	◆
	Walleye	Mercury					▼	▼	◆	◆	◆					●	●	◆	◆	◆
	Yellow Perch	Mercury	▲	▼	◆	◆	◆					▲	●	◆	◆	◆				
Walloon Lake* (Charlevoix Co.)	Rock Bass	Mercury	▲	▲	▲	▲	▲					▲	▲	▲	▲	▲				
	Yellow Perch	Mercury	▲	▲	▲	▲	▲					▲	▲	▲	▲	▲				
West Branch Lakes, SE and SW* (Alger Co., T48N, R14W, S31)	Northern Pike	Mercury							◆	◆	◆							◆	◆	◆
	Walleye	Mercury					▼	▼	◆	◆						●	●	◆	◆	
	Yellow Perch	Mercury	▲	▼	◆	◆	◆					▲	●	◆	◆	◆				
White Lake (Muskegon Co.)	Carp	PCBs, Chlordane	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
	Smallmouth Bass	Mercury, PCBs					▼	▼	▼	▼						●	●	●	●	
	Walleye	Mercury, PCBs					▲	▲	▲	▼	▼					▼	●	●	●	●
***All inland lakes, reservoirs, and impoundments** (mercury advisory)	Crappie	Mercury	▲	▼	▼	▼	▼	▼				▲	●	●	●	●	●			
	Largemouth and Smallmouth Bass	Mercury					▼	▼	▼	▼						●	●	●	●	
	Muskellunge	Mercury									▼									●
	Northern Pike	Mercury							▼	▼	▼							●	●	●
	Rock Bass	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				
	Walleye	Mercury					▼	▼	▼	▼	▼					●	●	●	●	●
	Yellow Perch	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				

* For species not listed, see general inland lake mercury advisory on page 6.

▲ Unlimited consumption.
● One meal per month.
▼ One meal per week.
■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches)									Women & Children Length (inches)								
			6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +	6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30 +
Lake Superior Watershed All other locations refer to general advice on page 6.																				
Lake Superior #	Brown Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	▼	▼	▼	▼
	Chinook Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			●	●	●	●	●	●	●
	Ciscowet	Chlordane PCBs, Dioxin			▲	▲	▲	◆	◆	◆	◆			●	●	●	◆	◆	◆	◆
	Coho Salmon	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	▼	▼	▼	▼
	Lake Herring	PCBs	▲	▲	▲	▲	▲					▼	▼	▼	▼	▼				
	Lake Trout	PCBs, Chlordane			▲	▲	▲	▼	▼	▼	◆			▼	▼	▼	◆	◆	◆	◆
	Longnose Sucker	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Whitefish	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Au Train Lake* (Alger Co.)	Northern Pike	Mercury							▲	▲	▼							▲	▲	●
Boston Pond* (Houghton Co.)	Yellow Perch	Mercury	▲	▲	▲	▲	▲					▲	▲	▲	▲	▲				
Carp River (Downstream of Deer Lake, Marquette Co.)	Brook Trout	Mercury	▲	▲	▲	▲	▲	▲	▲	▲		▲	▲	▲	▲	▲	▲	▲	▲	
	Northern Pike	Mercury							▼	▼	▼							●	●	●
	All other species	Mercury	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Carp Creek (Upstream of Deer Lake, Marquette Co.)	Brook Trout	Mercury	▲	▲	▲	▲	▲	▲	▲	▲		▲	▲	▲	▲	▲	▲	▲	▲	
	All other species	Mercury	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Chaney Lake* (Gogebic Co.)	Northern Pike	Mercury							▼	◆	◆							●	◆	◆
	Yellow Perch	Mercury	▲	▲	▲	▲	▲					▲	▲	▲	▲	▲				
Cisco Lake Chain* (Gogebic Co.)	Walleye						▲	▲	▲	▲	▲					▲	▲	▲	▲	▲
Deer Lake (Marquette Co.)	All species	Mercury	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Duck Lake* (Gogebic Co.)	Walleye	Mercury					▲	▼	▼	▼	▼					▲	●	●	●	●
Lake Independence* (Marquette Co.)	Northern Pike	Mercury							▲	▲	▼							▲	▲	●
Langford Lake* (Gogebic Co.)	Walleye	Mercury					▲	▲	◆	◆	◆					▲	▲	◆	◆	◆
Pomeroy Lake* (Gogebic Co.)	Walleye	Mercury					▲	▼	▼	▼	▼					▲	●	●	●	●

* For species not listed, see general inland lake mercury advisory on page 6.
# Also applies to tributaries into which migratory species enter.

▲ Unlimited consumption. ▼ One meal per week.
● One meal per month. ■ Six meals per year.
◆ Do not eat these fish.

Water body	Species	Contaminant(s)	General Population Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+	Women & Children Length (inches) 6-8	8-10	10-12	12-14	14-18	18-22	22-26	26-30	30+
Lake Superior Watershed All other locations refer to general advice on page 6																				
Portage Lake* (Houghton Co.)	Brown Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			▲	▲	▼	▼	●	●	●
	Walleye	Mercury, PCBs					▲	▲	▼	▼	▼					▲	▲	●	●	●
Siskiwit Lake* (Isle Royale)	Lake Trout	PCBs			▲	▲	▲	▲	▲	▲	▲			▼	▼	▼	▼	▼	▼	▼
	Lake Whitefish	PCBs	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	▼	▼
Thousand Island Lake* (Gogebic Co.)	Walleye	Mercury					▲	▼	▼	▼	▼					▲	●	●	●	●
Torch Lake* (Houghton Co.)	Northern Pike	Mercury, PCBs							▲	▲	▼							▼	▼	●
	Smallmouth Bass	Mercury, PCBs					▲	▼	▼	▼						▼	●	●	●	
	Walleye	Mercury, PCBs					▲	▲	▼	▼	▼					▼	▼	●	●	●
***All inland lakes, reservoirs, and impoundments** (mercury advisory)	Crappie	Mercury	▲	▼	▼	▼	▼	▼				▲	●	●	●	●	●			
	Largemouth and Smallmouth Bass	Mercury					▼	▼	▼	▼						●	●	●	●	
	Muskellunge	Mercury									▼									●
	Northern Pike	Mercury							▼	▼	▼							●	●	●
	Rock Bass	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				
	Walleye	Mercury					▼	▼	▼	▼	▼					●	●	●	●	●
	Yellow Perch	Mercury	▲	▼	▼	▼	▼					▲	●	●	●	●				

\# Also applies to tributaries into which migratory species enter.

* For species not listed, see general inland lake mercury advisory on page 6.

A. When multiple contaminants are listed, each chemical was analyzed separately for the appropriate advisory and the most protective advisory selected.

Updated May 2003. Advisory updates may be issued at any time upon receipt of significant new findings or changes in advisory criteria. For further information or the most up-to-date advice contact the Michigan Department of Community Health Environmental & Occupational Epidemiology Division at 1-800-648-6942.

Overview of Michigan's Fish Hatchery System

The State of Michigan operates six hatcheries and five permanent salmonid egg take stations (click here for map). Two hatcheries are in the Upper Peninsula (Marquette and Thompson State Fish Hatcheries). Four hatcheries are in the Lower Peninsula and all are located on the westside of the peninsula. All of these hatcheries were located in areas with the best water supplies, in particular groundwater supplies.

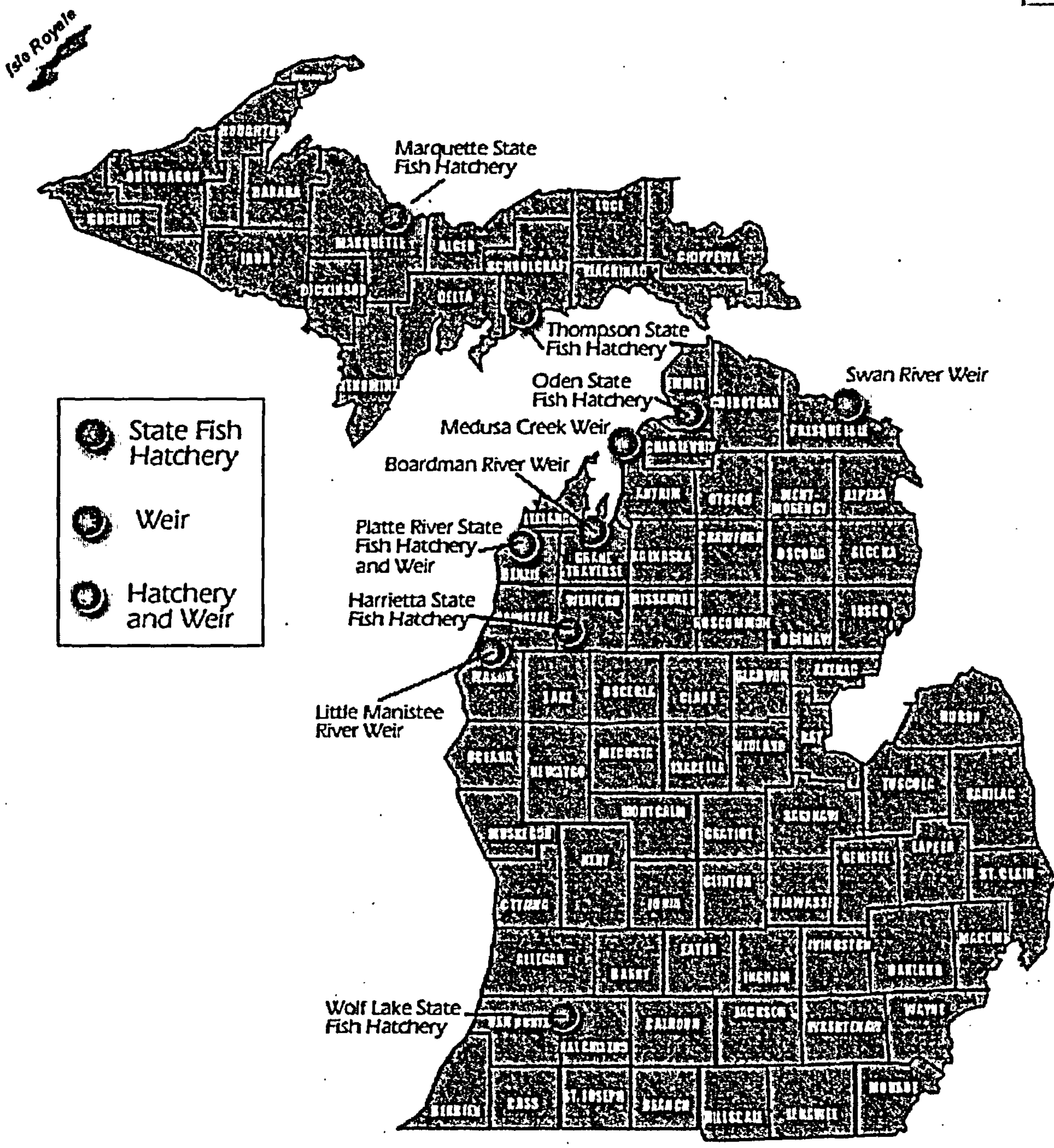
In order to operate a hatchery system, it is critical that you have reliable egg and sperm sources for species that you can not hold as captive broodstock. Fisheries Division operates six permanent salmonid egg take stations for chinook salmon, coho salmon and steelhead trout (a migratory form of rainbow trout). All are located in the Lower Peninsula with four on Lake Michigan tributary streams and one on a Lake Huron tributary stream. The Swan River (near Rogers City), Medusa Creek (near Charlevoix), Boardman River (Traverse City), and the Little Manistee Weirs are used in the fall for chinook salmon egg takes. The Platte River State Fish Hatchery Weir is used in the fall for coho salmon egg takes and infrequently for chinook salmon egg takes. The Little Manistee Weir is the only weir used for steelhead egg takes in the spring. Each of these sites that is a salmon egg take station receives large stockings from our hatcheries to ensure sufficient fish return for egg take purposes. We do not stock steelhead for our egg takes needs and strictly use the wild produced fish from the Little Manistee River.

In addition to the permanent egg take stations, we use natural spawning runs of walleye for egg sources from the Muskegon River near Newaygo, Tittabawassee River near Midland and Little Bay de Noc near Rapid River. Similarly, we use natural spawning runs of lake sturgeon for egg and fry sources from the Sturgeon River (Baraga County), Black River (Cheboygan County) and the Menominee River (Menominee County). We also maintain broodstocks of northern muskie in Thornapple Lake (Barry County) and Lake Hudson (Lenawee County). We use electrofishing boats and trap nets to collect fish from the wild spawning runs.

Related Content
> State Fish Hatchery and Weir Map
> Michigan's Fish Production Program – Summary for 2002
> Why We Have Hatcheries

Department of Natural Resources

Michigan.gov



Michigan's Special Animals

This list presents the Endangered (E), Threatened (T), and Probably Extirpated (X) animal species of Michigan, which are protected under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act). The current list became effective on March 20, 1999, after extensive review by technical advisors to the Michigan Department of Natural Resources and the citizenry of the state.

Also included in this list are animal species of Special Concern (SC). While not afforded legal protection under the Act, many of these species are of concern because of declining or relict populations in the state. Should these species continue to decline, they would be recommended for Threatened or Endangered status. Protection of Special Concern species now, before they reach dangerously low population levels, would prevent the need to list them in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Some other potentially rare species are listed as Special Concern pending more precise information on their status in the state; when such information becomes available, they could be moved to threatened or endangered status or deleted from the list.

This list was produced by the Endangered Species Program of the Michigan Department of Natural Resources and the Michigan Natural Features Inventory. English names in common usage or from published sources have been incorporated, when possible, to facilitate public understanding of and participation in the Endangered Species Program. To comment on the list or request additional copies, or for information on the Endangered Species Program, contact the Endangered Species Coordinator, Wildlife Division, Michigan Department of Natural Resources, P.O. Box 30028, Lansing, MI 48909 (517-373-1263). To report occurrences of these species, please contact us.

The special animals list is also available as a PDF document.

Jump to:
Amphibians Birds Fish Insects: Beetles Insects: Butterflies and Moths Insects: Cicadas and Hoppers
Insects: Dragonflies and Damselflies Insects: Grasshoppers and Crickets Mammals Mussels Reptiles Snails

Amphibians

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Acris crepitans blanchardi	Blanchard's cricket frog	Hylidae		SC	G5T5	S2S3	View
Ambystoma opacum	Marbled salamander	Ambystomatidae		T	G5	S1	
Ambystoma texanum	Smallmouth salamander	Ambystomatidae		E	G5	S1	
Pseudacris triseriata maculata	Boreal chorus frog	Hylidae		SC	G5T5	S1	

Birds

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Accipiter cooperii	Cooper's hawk	Accipitridae		SC	G5	S3S4	View

Accipiter gentilis	Northern goshawk	Accipitridae		SC	G5	S3	View
Ammodramus henslowii	Henslow's sparrow	Emberizidae		T	G4	S2S3	View
Ammodramus savannarum	Grasshopper sparrow	Emberizidae	(PS)	SC	G5	S3S4	
Asio flammeus	Short-eared owl	Strigidae		E	G5	S1	View
Asio otus	Long-eared owl	Strigidae		T	G5	S2	
Botaurus lentiginosus	American bittern	Ardeidae		SC	G4	S3S4	
Buteo lineatus	Red-shouldered hawk	Accipitridae		T	G5	S3S4	View
Charadrius melodus	Piping plover	Charadriidae	(LE,LT)	E	G3	S1	View
Chlidonias niger	Black tern	Laridae		SC	G4	S3	View
Chondestes grammacus	Lark sparrow	Emberizidae		X	G5	SX	
Circus cyaneus	Northern harrier	Accipitridae		SC	G5	S3	View
Cistothorus palustris	Marsh wren	Troglodytidae		SC	G5	S3S4	
Coturnicops noveboracensis	Yellow rail	Rallidae		T	G4	S1S2	View
Cygnus buccinator	Trumpeter swan	Anatidae		T	G4	S3	
Dendroica cerulea	Cerulean warbler	Parulidae		SC	G4	S3	View
Dendroica discolor	Prairie warbler	Parulidae		E	G5	S1	View
Dendroica dominica	Yellow-throated warbler	Parulidae		T	G5	S1	
Dendroica kirtlandii	Kirtland's warbler	Parulidae	LE	E	G1	S1	View
Falcipennis canadensis	Spruce grouse	Phasianidae		SC	G5	S2S3	
Falco columbarius	Merlin	Falconidae		T	G5	S1S2	View
Falco peregrinus	Peregrine falcon	Falconidae		E	G4	S1	
Gallinula chloropus	Common moorhen	Rallidae		SC	G5	S3	
Gavia immer	Common loon	Gaviidae		T	G5	S3S4	
Haliaeetus leucocephalus	Bald eagle	Accipitridae	(PS:LT,PDL)	T	G4	S4	
Ixobrychus exilis	Least bittern	Ardeidae		T	G5	S2	
Lanius ludovicianus migrans	Migrant loggerhead shrike	Laniidae		E	G5T3Q	S1	View
Nycticorax nycticorax	Black-crowned night-heron	Ardeidae		SC	G5	S2S3	
Pandion haliaetus	Osprey	Accipitridae		T	G5	S4	
Phalaropus tricolor	Wilson's phalarope	Scolopacidae		SC	G5	N	
Picoides arcticus	Black-backed woodpecker	Picidae		SC	G5	S2	View
Protonotaria citrea	Prothonotary warbler	Parulidae		SC	G5	S3	
Rallus elegans	King rail	Rallidae		E	G4G5	S1	View
Seiurus motacilla	Louisiana waterthrush	Parulidae		SC	G5	S2S3	
Spiza americana	Dickcissel	Cardinalidae		SC	G5	S3	

Sterna caspia	Caspian tern	Laridae		T	G5	S2	View
Sterna forsteri	Forster's tern	Laridae		SC	G5	S2	View
Sterna hirundo	Common tern	Laridae		T	G5	S2	View
Sturnella neglecta	Western meadowlark	Icteridae		SC	G5	S4	
Tympanuchus phasianellus	Sharp-tailed grouse	Phasianidae		SC	G4	S3S4	
Tyto alba	Barn owl	Tytonidae		E	G5	S1	
Wilsonia citrina	Hooded warbler	Parulidae		SC	G5	S3	
Xanthocephalus xanthocephalus	Yellow-headed blackbird	Icteridae		SC	G5	S2	

Fish

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Acipenser fulvescens	Lake sturgeon	Acipenseridae		T	G3	S2	View
Ammocrypta pellucida	Eastern sand darter	Percidae		T	G3	S1S2	
Clinostomus elongatus	Redside dace	Cyprinidae		E	G4	S1S2	View
Coregonus artedi	Cisco or lake herring	Salmonidae		T	G5	S3	
Coregonus bartlettii	Siskiwit lake cisco	Salmonidae		SC	GHQ	S1	
Coregonus hubbsi	Ives lake cisco	Salmonidae		SC	G1Q	S1	
Coregonus johannae	Deepwater cisco	Salmonidae		X	GX	SX	
Coregonus kiyi	Kiyi	Salmonidae		SC	G3	S3	
Coregonus nigripinnis	Blackfin cisco	Salmonidae		X	GXQ	SX	
Coregonus reighardi	Shortnose cisco	Salmonidae		X	G1	SH	
Coregonus zenithicus	Shortjaw cisco	Salmonidae		T	G2	S2	
Cottus ricei	Spoonhead sculpin	Cottidae		SC	G5	S3	
Erimyzon oblongus	Creek chubsucker	Catostomidae		E	G5	S1S2	View
Etheostoma zonale	Banded darter	Percidae		SC	G5	S1	View
Fundulus dispar	Starhead topminnow	Cyprinodontidae		SC	G5	S2	
Hiodon tergisus	Mooneye	Hiodontidae		T	G5	S2	
Hybopsis amblops	Bigeye chub	Cyprinidae		X	G5	SH	
Ictiobus niger	Black buffalo	Catostomidae		SC	G5	S3	
Lepisosteus oculatus	Spotted gar	Lepisosteidae		SC	G5	S2S3	View
Macrhybopsis storeriana	Silver chub	Cyprinidae		SC	G5	S2S3	
Moxostoma carinatum	River redhorse	Catostomidae		T	G4	S1	View
Notropis anogenus	Pugnose shiner	Cyprinidae		SC	G3	S3	

Notropis chalybaeus	Ironcolor shiner	Cyprinidae		X	G4	S1	
Notropis photogenis	Silver shiner	Cyprinidae		E	G5	S1	View
Notropis texanus	Weed shiner	Cyprinidae		X	G5	S1	
Noturus miurus	Brindled madtom	Ictaluridae		SC	G5	S2S3	
Noturus stigmosus	Northern madtom	Ictaluridae		E	G3	S1	View
Opsopoeodus emiliae	Pugnose minnow	Cyprinidae		E	G5	S1	View
Percina copelandi	Channel darter	Percidae		E	G4	S1S2	View
Percina shumardi	River darter	Percidae		E	G5	S1	View
Phoxinus erythrogaster	Southern redbelly dace	Cyprinidae		E	G5	S1	View
Polyodon spathula	Paddlefish	Polyodontidae		X	G4	SX	
Stizostedion canadense	Sauger	Percidae		T	G5	S1	
Stizostedion vitreum glaucum	Bluepike	Percidae		X	G5TX	SX	
Thymallus arcticus	Arctic grayling	Salmonidae	(PS)	X	G5	SX	

Insects: Beetles

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Brychius hungerfordi	Hungerford's crawling water beetle	Haliplidae	LE	E	G1	S1	View
Dryobius sexnotatus	Six-banded longhorn beetle	Cerambycidae		SC	G?	SH	
Liodessus cantralli	Cantrall's bog beetle	Dytiscidae		SC	G?	S1S3	
Lordithon niger	Black lordithon rove beetle	Staphylinidae		SC	G1	SH	
Nicrophorus americanus	American burying beetle	Silphidae	LE	E	G2G3	SH	
Stenelmis douglasensis	Douglas stenelmis riffle beetle	Elmidae		SC	G1G3	S1S2	

Insects: Butterflies and Moths

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Acronicta falcula	Corylus dagger moth	Noctuidae		SC	GU	S2S3	
Atrytonopsis hianna	Dusted skipper	Hesperiidae		T	G4G5	S2S3	
Basilodes pepita	Gold moth	Noctuidae		SC	G4	S1S2	
Battus philenor	Pipevine swallowtail	Papilionidae		SC	G5	S1S2	
Boloria freija	Freija fritillary	Nymphalidae		SC	G5	S3S4	
Boloria frigga	Frigga fritillary	Nymphalidae		SC	G5	S3S4	
Brachionycha borealis	Boreal brachionyncha	Noctuidae		SC	G4	S1S2	

Calephelis mutica	Swamp metalmark	Riodinidae		SC	G3G4	S1S2	
Catocala amestris	Three-staff underwing	Noctuidae		E	G4	S1	
Catocala dulciola	Quiet underwing	Noctuidae		SC	G3	S1S2	
Catocala illecta	Magdalen underwing	Noctuidae		SC	G5	S2S3	
Catocala robinsoni	Robinson's underwing	Noctuidae		SC	G4	S2S3	
Chlosyne gorgone carlota	Gorgone checkerspot	Nymphalidae		SC	G5T5	S2S3	
Eacles imperialis pini	Pine imperial moth	Saturniidae		SC	G5T3	S2S3	
Erebia discoidalis	Red-disked alpine	Nymphalidae		SC	G5	S2S3	
Erora laeta	Early hairstreak	Lycaenidae		SC	G3G4	S2S3	
Erynnis baptisiae	Wild indigo duskywing	Hesperiidae		SC	G5	S2S3	
Erynnis persius persius	Persius duskywing	Hesperiidae		T	G5T2T3	S3	
Euchloe ausonides	Large marble	Pieridae		SC	G5	S1S2	
Euphyes dukesi	Dukes' skipper	Hesperiidae		T	G3	S1	
Euxoa aurulenta	Dune cutworm	Noctuidae		SC	G5	S1S2	View
Fixsenia favonius ontario	Northern hairstreak	Lycaenidae		SC	G4T4	S1	
Hemileuca maia	Barrens buckmoth	Saturniidae		SC	G5	S2S3	
Hesperia ottoe	Ottoe skipper	Hesperiidae		T	G3G4	S1S2	View
Heterocampa subrotata	Small heterocampa	Notodontidae		SC	G4G5	S1S2	
Heteropacha rileyana	Riley's lappet moth	Lasiocampidae		SC	G4	S1S2	
Incisalia henrici	Henry's elfin	Lycaenidae		SC	G5	S2S3	
Incisalia irus	Frosted elfin	Lycaenidae		T	G3	S2S3	
Lycaeides idas nabokovi	Northern blue	Lycaenidae		T	G5TU	S2	View
Lycaeides melissa samuelis	Karner blue	Lycaenidae	LE	T	G5T2	S2	View
Merolonche dolli	Doll's merolonche	Noctuidae		SC	G3G4	S1S2	
Meropleon ambifusca	Newman's brocade	Noctuidae		SC	G2G4	S1S2	
Neonympha mitchellii mitchellii	Mitchell's satyr	Nymphalidae	LE	E	G1G2T1T2	S1	View
Oarisma poweshiek	Poweshiek skipperling	Hesperiidae		T	G2	S1S2	
Oeneis macounii	Macoun's arctic	Nymphalidae		SC	G5	S2S3	
Oncocnemis piffardi	3-striped oncocnemis	Noctuidae		SC	G4	S1S2	
Pachypolia atricornis	Three-horned moth	Noctuidae		SC	G3G4	S1S2	
Papaipema aweme	Aweme borer	Noctuidae		SC	GH	SH	
Papaipema beeriana	Blazing star borer	Noctuidae		SC	G3	S1S2	View
Papaipema cerina	Golden borer	Noctuidae		SC	G4	S1S2	
Papaipema maritima	Maritime sunflower borer	Noctuidae		SC	G4	S1S2	

Papaipema sciata	Culvers root borer	Noctuidae		SC	G3G4	S2S3	View
Papaipema silphii	Silphium borer moth	Noctuidae		T	G3G4	S1S2	View
Papaipema speciosissima	Regal fern borer	Noctuidae		SC	G4	S2S3	
Phyciodes batesii	Tawny crescent	Nymphalidae		SC	G4	S4	
Polygonia gracilis	Hoary comma	Nymphalidae		SC	G5	S3	
Proserpinus flavofasciata	Yellow-banded day-sphinx	Sphingidae		SC	G4	S2S3	
Pygarctia spraguei	Sprague's pygarctia	Arctiidae		SC	G3G4	S2S3	
Pyrgus wyandot	Grizzled skipper	Hesperiidae		SC	G2	S1S2	
Schinia indiana	Phlox moth	Noctuidae		E	GU	S1S2	
Schinia lucens	Leadplant flower moth	Noctuidae		E	G4	S1	
Spartiniphaga inops	Spartina moth	Noctuidae		SC	G3G4	S1S2	
Speyeria idalia	Regal fritillary	Nymphalidae		E	G3	SH	

Insects: Cicadas and Hoppers

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Dorydiella kansana	Leafhopper	Cicadellidae		SC	G?	S1S2	
Flexamia delongi	Leafhopper	Cicadellidae		SC	G?	S1S2	
Flexamia huroni	Huron river leafhopper	Cicadellidae		SC	G?	S1	
Flexamia reflexus	Leafhopper	Cicadellidae		SC	G?	S1	
Lepyronia angulifera	Angular spittlebug	Cercopidae		SC	G3	S1S2	
Lepyronia gibbosa	Great plains spittlebug	Cercopidae		T	G3G4	S1S2	
Philaenarcys killa	Spittlebug	Cercopidae		SC	G?	S1S2	
Prosapia ignipectus	Red-legged spittlebug	Cercopidae		SC	G4	S2S3	View

Insects: Dragonflies and Damselflies

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Cordulegaster erronea	Tiger spiketail	Cordulegasteridae		SC	G4	S1S2	
Gomphus lineatifrons	Splendid clubtail	Gomphidae		SC	G4	S2S3	
Gomphus quadricolor	Rapids clubtail	Gomphidae		SC	G3G4	S2S3	View
Ophiogomphus anomalus	Extra-striped snaketail	Gomphidae		SC	G3	S1	
Ophiogomphus howei	Pygmy snaketail	Gomphidae		SC	G3	S1	
Somatochlora hineana	Hine's emerald dragonfly	Corduliidae	LE	E	G2G3	S1	View
Somatochlora incurvata	Incurvate emerald dragonfly	Corduliidae		SC	G4	S1S2	View

Stylurus amnicola	Riverine snaketail	Gomphidae		SC	G4	S1S2	
Stylurus laurae	Laura's snaketail	Gomphidae		SC	G4	S1S2	
Stylurus notatus	Elusive snaketail	Gomphidae		SC	G3	S1S2	
Stylurus plagiatus	Russet-tipped clubtail	Gomphidae		SC	G5	S1S2	
Tachopteryx thoreyi	Grey petaltail	Petaluridae		SC	G4	S1S3	
Williamsonia fletcheri	Ebony boghaunter	Corduliidae		SC	G3G4	S1S2	

Insects: Grasshoppers and Crickets

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Appalachia arcana	Secretive locust	Acrididae		SC	G2G3	S2S3	View
Atlanticus davisi	Davis's shield-bearer	Tettigoniidae		SC	G?	S2S3	
Melanoplus flavidus	Blue-legged locust	Acrididae		SC	G4	S1S3	
Neoconocephalus lyristes	Bog conehead	Tettigoniidae		SC	G?	S1S3	
Neoconocephalus retusus	Conehead grasshopper	Tettigoniidae		SC	G?	S1	
Oecanthus laricis	Tamarack tree cricket	Gryllidae		SC	G1G2	S1S2	
Oecanthus pini	Pinetree cricket	Gryllidae		SC	G?	S1S2	
Orchelimum concinnum	Red-faced meadow katydid	Tettigoniidae		SC	G?	S2S3	
Orchelimum delicatum	Delicate meadow katydid	Tettigoniidae		SC	G?	S1S3	
Paroxya hoosieri	Hoosier locust	Acrididae		SC	G?	S2S3	
Scudderia fasciata	Pine katydid	Tettigoniidae		SC	G?	S1S3	
Trimerotropis huroniana	Lake huron locust	Acrididae		T	G2G3	S2S3	View

Mammals

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Alces alces	Moose	Cervidae		SC	G5	S4	
Canis lupus	Gray wolf	Canidae	(PS:LE,LT,XN)	T	G4	S3	
Cryptotis parva	Least shrew	Soricidae		T	G5	S1S2	
Felis concolor	Cougar	Felidae	(PS)	E	G5	SH	
Felis lynx	Lynx	Felidae	PS:LT	E	G5	S1	
Microtus ochrogaster	Prairie vole	Muridae		E	G5	S1	
Microtus pinetorum	Woodland vole	Muridae		SC	G5	S3S4	View
Myotis sodalis	Indiana bat or indiana myotis	Vespertilionidae	LE	E	G2	S1	
Pipistrellus subflavus	Eastern pipistrelle	Vespertilionidae		SC	G5	S2	

Sorex fumeus	Smoky shrew	Soricidae		SC	G5	S1	

Mussels

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Alasmidonta marginata	Elktoe	Unionidae		SC	G4	S2S3	View
Alasmidonta viridis	Slippershell mussel	Unionidae		SC	G4G5	S2S3	View
Anodonta subgibbosa	Lake floater	Unionidae		T	G?	S1	
Cyclonaias tuberculata	Purple wartyback	Unionidae		SC	G5	S2S3	
Dysnomia sulcata	Catspaw	Unionidae	(LE)	E	G1	SH	
Epioblasma obliquata perobliqua	White catspaw	Unionidae	LE	E	G1T1	SH	View
Epioblasma torulosa rangiana	Northern riffleshell	Unionidae	LE	E	G2T2	S1	View
Epioblasma triquetra	Snuffbox	Unionidae		E	G3	S1	View
Lampsilis fasciola	Wavy-rayed lampmussel	Unionidae		T	G4	S2	View
Leptodea leptodon	Scaleshell	Unionidae	PE	SC	G1	SU	
Obovaria olivaria	Hickorynut	Unionidae		SC	G4	S2S3	
Obovaria subrotunda	Round hickorynut	Unionidae		E	G4	S1	View
Pleurobema clava	Clubshell	Unionidae	LE	E	G2	S1	View
Pleurobema coccineum	Round pigtoe	Unionidae		SC	G4	S2S3	
Simpsonaias ambigua	Salamander mussel	Unionidae		E	G3	S1	View
Toxolasma lividus	Purple lilliput	Unionidae		E	G2	S1	View
Venustaconcha ellipsiformis	Ellipse	Unionidae		SC	G3G4	S2S3	
Villosa fabalis	Rayed bean	Unionidae		E	G1G2	S1	View
Villosa iris	Rainbow	Unionidae		SC	G5	S2S3	

Reptiles

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Clemmys guttata	Spotted turtle	Emydidae		T	G5	S2	View
Clonophis kirtlandii	Kirtland's snake	Colubridae		E	G2	S1	
Cnemidophorus sexlineatus	Six-lined racerunner	Teiidae		SC	G5	SU	
Elaphe obsoleta obsoleta	Black rat snake	Colubridae		SC	G5T5	S3	
Elaphe vulpina gloydi	Eastern fox snake	Colubridae		T	G5T3	S2	View
Emys blandingii (Emydoidea blandingii)	Blanding's turtle	Emydidae		SC	G4	S3	View

Glyptemys insculpta (Clemmys insculpta)	Wood turtle	Emydidae		SC	G4	S2S3	View
Nerodia erythrogaster neglecta	Copperbelly watersnake	Colubridae	(PS:LT)	E	G5T2T3	S1	
Sistrurus catenatus catenatus	Eastern massasauga	Viperidae	C	SC	G3G4T3T4	S3S4	View
Terrapene carolina carolina	Eastern box turtle	Emydidae		SC	G5T5	S2S3	View

Snails

Help with Codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	Abstract
Acella haldemani	Spindle lymnaea	Lymnaeidae		SC	G3	S3	
Anguispira kochi	Banded globe	Discidae		SC	G?	SU	
Appalachina sayanus (Mesodon sayanus)	Spike-lip crater	Polygyridae		SC	G4G5	SU	View
Catinella exile	Land snail	Succineidae		SC	G1G2	SU	
Discus patulus	Domed disc	Discidae		SC	G5	SU	
Euconulus alderi	Land snail	Helicarionidae		SC	G?	S2	
Fontigens nickliniana	Watercress snail	Hydrobiidae		SC	G5	SU	
Gastrocopta holzingeri	Land snail	Pupillidae		SC	G4G5	S1	
Guppya sterkii	Land snail	Helicarionidae		SC	G4G5	S1	
Hendersonia occulta	Cherrystone drop	Helicinidae		T	G4	S1	View
Mesodon elevatus	Proud globe	Polygyridae		SC	G5	SU	
Mesomphix cupreus	Copper button	Zonitidae		SC	G5	SU	
Philomycus carolinianus	Carolina mantleslug	Philomycidae		SC	G5	SU	
Planogyra asteriscus	Eastern flat-whorl	Valloniidae		SC	G?	S3	
Planorbella multivolvis	Acorn ramshorn	Planorbidae		E	GX	SX	
Planorbella smithi	Aquatic snail	Planorbidae		SC	G?	S2	
Pomatiopsis cincinnatiensis	Brown walker	Pomatiopsidae		SC	G4	SU	
Pupilla muscorum	Land snail	Pupillidae		SC	G4	SU	
Pyrgulopsis letsoni	Gravel pyrg	Hydrobiidae		SC	G5	SU	
Stagnicola contracta	Deepwater pondsnail	Lymnaeidae		T	G1	S1	
Stagnicola petoskeyensis	Petoskey pondsnail	Lymnaeidae		E	GH	SH	
Vallonia albula	Land snail	Valloniidae		SC	G?Q	S1	
Vallonia gracilicosta albula	Land snail	Valloniidae		SC	G?T?	S1	
Vertigo bollesiana	Land snail	Pupillidae		SC	G3	S2	
Vertigo cristata	Land snail	Pupillidae		SC	G?	S3	

Vertigo elatior	Land snail	Pupillidae	SC	G?	S3
Vertigo hubrichti	Land snail	Pupillidae	SC	G2	S2
Vertigo modesta	Land snail	Pupillidae	SC	G5	S1
Vertigo modesta parietalis	Land snail	Pupillidae	SC	G5T?	S1
Vertigo morsei	Land snail	Pupillidae	SC	G?	S2
Vertigo nylanderi	Land snail	Pupillidae	SC	G?	S1
Vertigo paradoxa	Land snail	Pupillidae	SC	G2G4	S3
Vertigo pygmaea	Land snail	Pupillidae	SC	G4	SU
Xolotrema denotata	Velvet wedge	Polygyridae	SC	G5	SU

Michigan's Special Plants

This list presents the Endangered (E), Threatened (T), and Probably Extirpated (X) plant species of Michigan, which are protected under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act). The current list became effective on March 20, 1999, after extensive review by technical advisors to the Michigan Department of Natural Resources and the citizenry of the state.

Also included in this list are plant species of Special Concern. While not afforded legal protection under the Act, many of these species are of concern because of declining or relict populations in the state. Should these species continue to decline, they would be recommended for Threatened or Endangered status. Protection of Special Concern species now, before they reach dangerously low population levels, would prevent the need to list them in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Some other potentially rare species are listed as of Special Concern pending more precise information on their status in the state; when such information becomes available, they could be moved to threatened or endangered status or deleted from the list.

This list was produced by the Endangered Species Program of the Michigan Department of Natural Resources and the Michigan Natural Features Inventory. English names in common usage or from published sources have been incorporated, when possible, to promote public understanding of and participation in the Endangered Species Program. To comment on the list or request additional copies, or for information on the Endangered Species Program, contact the Endangered Species Coordinator, Wildlife Division, Michigan Department of Natural Resources, P.O. Box 30028, Lansing, MI 48909 (517-373-1263). To report occurrences of these species, please contact us.

The special plants list is also available as a PDF document.

Sort by (•) Scientific Name ( ) Common Name

Help with codes

Scientific Name	Common Name	Family	US Status	State Status	Global Rank	State Rank	More Information Abstract	Reference
Adlumia fungosa	Climbing fumitory	Fumariaceae		SC	G4	S3		View
Agalinis gattingeri	Gattinger's gerardia	Scrophulariaceae		E	G4	S1		View
Agalinis skinneriana	Skinner's gerardia	Scrophulariaceae		E	G3	S1		View
Agoseris glauca	Prairie or pale agoseris	Asteraceae		T	G5	S2	View	View
Agrimonia rostellata	Beaked agrimony	Rosaceae		SC	G5	S1S2		View
Agropyron spicatum	Bluebunch wheatgrass	Poaceae		X	G5	SX		View
Allium schoenoprasum	Wild chives	Liliaceae		T	G5	S2		View
Amerorchis rotundifolia	Round-leaved orchis	Orchidaceae		E	G5	S1	View	View
Amorpha canescens	Leadplant	Fabaceae		SC	G5	S3		View
Androsace occidentalis	Rock-jasmine	Primulaceae		E	G5	SH		View
Angelica venenosa	Hairy angelica	Apiaceae		SC	G5	S3		View
Antennaria parvifolia	Pussy-toes	Asteraceae		SC	G5	S1		View

Antennaria rosea	Rosy pussytoes	Asteraceae		T	G4G5	SH		View
Arabis missouriensis var deamii	Missouri rock-cress	Brassicaceae		SC	G4G5QT3?Q	S2		View
Arabis perstellata sensu lato	Rock cress	Brassicaceae		T	G5	S1		View
Arenaria macrophylla	Big-leaf sandwort	Caryophyllaceae		T	G4	S1		View
Aristida dichotoma	Shinner's three-awned grass	Poaceae		X	G5	SX		View
Aristida longespica	Three-awned grass	Poaceae		T	G5	S2		View
Aristida tuberculosa	Beach three-awned grass	Poaceae		T	G5	S1		View
Aristolochia serpentaria	Virginia snakeroot	Aristolochiaceae		T	G4	S2	View	View
Armoracia lacustris	Lake cress	Brassicaceae		T	G4?	S2		View
Arnica cordifolia	Heart-leaved arnica	Asteraceae		E	G5	S1		View
Artemisia ludoviciana	Western mugwort	Asteraceae		T	G5	S1		View
Asclepias hirtella	Tall green milkweed	Asclepiadaceae		T	G5	S2	View	View
Asclepias ovalifolia	Dwarf milkweed	Asclepiadaceae		E	G5?	S1		View
Asclepias purpurascens	Purple milkweed	Asclepiadaceae		SC	G4G5	S3	View	View
Asclepias sullivantii	Sullivant's milkweed	Asclepiadaceae		T	G5	S2	View	View
Asplenium montanum	Mountain spleenwort	Aspleniaceae		X	G5	SH		View
Asplenium rhizophyllum	Walking fern	Aspleniaceae		T	G5	S2S3	View	View
Asplenium ruta-muraria	Wall-rue	Aspleniaceae		E	G5	S1		View
Asplenium scolopendrium var americanum	Hart's-tongue fern	Aspleniaceae	LT	E	G4T3	S1	View	View
Asplenium trichomanes-ramosum	Green spleenwort	Aspleniaceae		T	G4	S2S3		View
Aster furcatus	Forked aster	Asteraceae		T	G3	S1		View
Aster modestus	Great northern aster	Asteraceae		T	G5	S1		View
Aster praealtus	Willow aster	Asteraceae		SC	G5	S3		View
Aster sericeus	Western silvery aster	Asteraceae		T	G5	S2		View
Astragalus canadensis	Canadian milk-vetch	Fabaceae		T	G5	S1S2		View
Astragalus neglectus	Cooper's milk-vetch	Fabaceae		SC	G4	S3		View
Baptisia lactea	White or prairie false indigo	Fabaceae		SC	G4Q	S3		View
Baptisia leucophaea	Cream wild indigo	Fabaceae		E	G4G5	S1		View
Bartonia paniculata	Panicled screw-stem	Gentianaceae		T	G5	S2	View	View
Beckmannia syzigachne	Slough grass	Poaceae		T	G5	S2		View
Berula erecta	Cut-leaved water-parsnip	Apiaceae		T	G4G5	S2		View
Besseya bullii	Kitten-tails	Scrophulariaceae		T	G3	S1S2		View

Betula murrayana	Murray birch	Betulaceae	SC	G1Q	S1		View
Botrychium acuminatum	Acute-leaved moonwort	Ophioglossaceae	E	G1	S1	View	View
Botrychium campestre	Prairie moonwort	Ophioglossaceae	T	G3	S2	View	View
Botrychium hesperium	Western moonwort	Ophioglossaceae	T	G3	S2	View	View
Botrychium mormo	Goblin moonwort	Ophioglossaceae	T	G3	S2	View	View
Botrychium pallidum	pale moonwort	Ophioglossaceae	SC	G2G3	S3		View
Bouteloua curtipendula	Side-oats grama grass	Poaceae	T	G5	S1S2		View
Braya humilis	Low northern rock-cress	Brassicaceae	T	G5	S1		View
Bromus pumpellianus	Pumpelly's brome grass	Poaceae	T	G4Q	S2	View	View
Buchnera americana	Blue-hearts	Scrophulariaceae	X	G5?	SX		View
Cacalia plantaginea	Prairie indian-plantain	Asteraceae	SC	G4G5	S3	View	View
Calamagrostis lacustris	Northern reedgrass	Poaceae	T	G3Q	S1		View
Calamagrostis stricta	Narrow-leaved reedgrass	Poaceae	T	G5	S1		View
Callitriche hermaphroditica	Autumnal water-starwort	Callitrichaceae	SC	G5	S2		View
Callitriche heterophylla	Large water-starwort	Callitrichaceae	T	G5	S1		View
Calypso bulbosa	Calypso or fairy-slipper	Orchidaceae	T	G5	S2	View	View
Camassia scilloides	Wild-hyacinth	Liliaceae	T	G4G5	S2		View
Carex albolutescens	Greenish-white sedge	Cyperaceae	T	G5	S2		View
Carex assiniboinensis	Assiniboia sedge	Cyperaceae	T	G4G5	S2	View	View
Carex atratiformis	Sedge	Cyperaceae	T	G5	S2		View
Carex concinna	Beauty sedge	Cyperaceae	SC	G4G5	S3		View
Carex conjuncta	Sedge	Cyperaceae	T	G4G5	S1		View
Carex crus-corvi	Raven's-foot sedge	Cyperaceae	T	G5	SH		View
Carex davisii	Davis's sedge	Cyperaceae	SC	G4	S3		View
Carex decomposita	Log sedge	Cyperaceae	X	G3	SX		View
Carex festucacea	Fescue sedge	Cyperaceae	SC	G5	S1		View
Carex frankii	Frank's sedge	Cyperaceae	SC	G5	S2S3		View
Carex gravida	Sedge	Cyperaceae	X	G5	SX		View
Carex haydenii	Hayden's sedge	Cyperaceae	X	G5	SX		View
Carex heleonastes	Hudson bay sedge	Cyperaceae	E	G4	S1		View
Carex lupuliformis	False hop sedge	Cyperaceae	T	G4	S2		View
Carex media	Sedge	Cyperaceae	T	G5?	S2S3		View
Carex nigra	Black sedge	Cyperaceae	E	G5	S1		View
Carex novae-angliae	New england sedge	Cyperaceae	T	G5	S1		View

Carex oligocarpa	Eastern few-fruited sedge	Cyperaceae		T	G4	S2		View
Carex platyphylla	Broad-leaved sedge	Cyperaceae		T	G5	S1		View
Carex richardsonii	Richardson's sedge	Cyperaceae		SC	G4	S3S4	View	View
Carex rossii	Ross's sedge	Cyperaceae		T	G5	S2		View
Carex scirpoidea	Bulrush sedge	Cyperaceae		T	G5	S2		View
Carex seorsa	Sedge	Cyperaceae		T	G4	S2		View
Carex squarrosa	Sedge	Cyperaceae		SC	G4G5	S1		View
Carex straminea	Straw sedge	Cyperaceae		E	G5	SH		View
Carex tincta	Sedge	Cyperaceae		SC	G4G5	S?		View
Carex trichocarpa	Hairy-fruited sedge	Cyperaceae		SC	G4	S2		View
Carex typhina	Cat-tail sedge	Cyperaceae		T	G5	S1		View
Carex wiegandii	Wiegand's sedge	Cyperaceae		T	G3	S2		View
Castanea dentata	American chestnut	Fagaceae		E	G4	S1S2		View
Castilleja septentrionalis	Pale indian paintbrush	Scrophulariaceae		T	G5	S2S3		View
Ceanothus sanguineus	Redstem ceanothus or wild lilac	Rhamnaceae		T	G4G5	S2		View
Celtis tenuifolia	Dwarf hackberry	Ulmaceae		SC	G5	S3		View
Chamaerhodos nuttallii var keweenawensis	Keweenaw rock-rose	Rosaceae		E	G5T1Q	S1		View
Chasmanthium latifolium	Wild-oats	Poaceae		T	G5	S1		View
Chelone obliqua	Purple turtlehead	Scrophulariaceae		E	G4	S1		View
Cirsium hillii	Hill's thistle	Asteraceae		SC	G3	S3	View	View
Cirsium pitcheri	Pitcher's thistle	Asteraceae	LT	T	G3	S3	View	View
Clematis occidentalis	Purple clematis	Ranunculaceae		SC	G5	S3		View
Collinsia parviflora	Small blue-eyed mary	Scrophulariaceae		T	G5	S2		View
Commelina erecta	Slender day-flower	Commelinaceae		X	G5	SX		View
Coreopsis palmata	Prairie coreopsis	Asteraceae		T	G5	S2		View
Corydalis flavula	Yellow fumewort	Fumariaceae		T	G5	S2		View
Crataegus douglasii	Douglas's hawthorn	Rosaceae		SC	G5	S3S4		View
Cryptogramma acrostichoides	American rock-brake	Pteridaceae		E	G5	S2		View
Cryptogramma stelleri	Slender cliff-brake	Pteridaceae		SC	G5	S3S4		View
Cuscuta campestris	Field dodder	Cuscutaceae		SC	G5	SH		View
Cuscuta glomerata	Rope dodder	Cuscutaceae		SC	G5	SH		View
Cuscuta indecora	Dodder	Cuscutaceae		SC	G5	SH		View
Cuscuta pentagona	Dodder	Cuscutaceae		SC	G5	SH		View

Cuscuta polygonorum	Knotweed dodder	Cuscutaceae	SC	G5	S2		View
Cyperus acuminatus	Nut-grass	Cyperaceae	X	G5	SX		View
Cyperus flavescens	Yellow nut-grass	Cyperaceae	SC	G5	S2S3		View
Cypripedium arietinum	Ram's head lady's-slipper	Orchidaceae	SC	G3	S3	View	View
Cypripedium candidum	White lady-slipper	Orchidaceae	T	G4	S2	View	View
Cystopteris laurentiana	Laurentian fragile fern	Dryopteridaceae	SC	G3	S1S2		View
Dalea purpurea	Purple prairie-clover	Fabaceae	X	G5	SX		View
Dalibarda repens	False-violet	Rosaceae	T	G5	S1S2	View	View
Danthonia compressa	Flat oat grass	Poaceae	SC	G5	S1		View
Danthonia intermedia	Wild oat-grass	Poaceae	SC	G5	S1S2		View
Dasistoma macrophylla	Mullein foxglove	Scrophulariaceae	T	G4	S1S2		View
Dennstaedtia punctilobula	Hay-scented fern	Dennstaedtiaceae	X	G5	S?		View
Dentaria maxima	Large toothwort	Brassicaceae	T	G5Q	S1S2	View	View
Diarrhena americana	Beak grass	Poaceae	T	G4?	S2	View	View
Digitaria filiformis	Slender finger-grass	Poaceae	X	G5	SX		View
Disporum hookeri	Fairy bells	Liliaceae	E	G5	S1	View	View
Disporum maculatum	Nodding mandarin	Liliaceae	X	G3G4	SX		View
Disporum trachycarpum	northern fairy bells	Liliaceae	T	G5	S1		View
Dodecatheon meadia	Shooting-star	Primulaceae	E	G5	S1		View
Draba arabisans	Rock whitlow-grass	Brassicaceae	SC	G4	S3		View
Draba cana	Ashy whitlow-grass	Brassicaceae	T	G5	S1		View
Draba glabella	Smooth whitlow-grass	Brassicaceae	E	G4G5	S1		View
Draba incana	Twisted whitlow-grass	Brassicaceae	T	G5	S1		View
Draba nemorosa	Whitlow-grass	Brassicaceae	X	G5	SX		View
Draba reptans	Creeping whitlow-grass	Brassicaceae	T	G5	S1		View
Drosera anglica	English sundew	Droseraceae	SC	G5	S3	View	View
Dryopteris celsa	Log fern	Dryopteridaceae	T	G4	S2		View
Dryopteris filix-mas	Male fern	Dryopteridaceae	SC	G5	S3		View
Dryopteris fragrans	Fragrant cliff woodfern	Dryopteridaceae	SC	G5	S3	View	View
Echinacea purpurea	Purple coneflower	Asteraceae	X	G4	SX		View
Echinodorus tenellus	Dwarf burhead	Alismataceae	E	G5?	S1		View
Eleocharis atropurpurea	Purple spike-rush	Cyperaceae	E	G4G5	S1		View
Eleocharis caribaea	Spike-rush	Cyperaceae	T	G4G5	S1		View
Eleocharis compressa	Flattened spike-rush	Cyperaceae	T	G4	S2		View

Eleocharis engelmannii	Engelmann's spike-rush	Cyperaceae	SC	G4?	S2S3		View
Eleocharis equisetoides	Horsetail spike-rush	Cyperaceae	SC	G4	S3		View
Eleocharis melanocarpa	Black-fruited spike-rush	Cyperaceae	SC	G4	S3		View
Eleocharis microcarpa	Small-fruited spike-rush	Cyperaceae	E	G5	S1		View
Eleocharis nitida	Slender spike-rush	Cyperaceae	E	G3G4	S1		View
Eleocharis parvula	Dwarf spike-rush	Cyperaceae	T	G5	S1		View
Eleocharis radicans	Spike-rush	Cyperaceae	X	G5	SX		View
Eleocharis tricostata	Three-ribbed spike-rush	Cyperaceae	T	G4	S2		View
Elymus glaucus	Blue wild-rye	Poaceae	SC	G5	S3		View
Elymus mollis	American dune wild-rye	Poaceae	SC	G5	S3	View	View
Empetrum nigrum	Black crowberry	Empetraceae	T	G5	S2		View
Equisetum telmateia	Giant horsetail	Equisetaceae	X	G4G5	SX		View
Eragrostis capillaris	Love grass	Poaceae	SC	G5	SH		View
Eragrostis pilosa	Small love grass	Poaceae	SC	G4	SH		View
Erigeron acris	fleabane	Asteraceae	SC	G5	SR		View
Erigeron hyssopifolius	Hyssop-leaved fleabane	Asteraceae	T	G5	S1		View
Eryngium yuccifolium	Rattlesnake-master	Apiaceae	T	G5	S2		View
Euonymus atropurpurea	Wahoo	Celastraceae	SC	G5	S3		View
Eupatorium fistulosum	Hollow-stemmed joe-pye-weed	Asteraceae	T	G5?	S1		View
Eupatorium sessilifolium	Upland boneset	Asteraceae	T	G5	S1		View
Euphorbia commutata	Tinted spurge	Euphorbiaceae	T	G5	S1		View
Euphrasia hudsoniana	Eyebright	Scrophulariaceae	T	G5?	S?		View
Euphrasia nemorosa	Common eyebright	Scrophulariaceae	T	G5	S1		View
Festuca scabrella	Rough fescue	Poaceae	T	G5	S2S3	View	View
Filipendula rubra	Queen-of-the-prairie	Rosaceae	T	G4G5	S2		View
Fimbristylis puberula	Chestnut sedge	Cyperaceae	X	G5	SX		View
Fraxinus profunda	Pumpkin ash	Oleaceae	T	G4	S2		View
Fuirena squarrosa	Umbrella-grass	Cyperaceae	T	G4G5	S2		View
Galearis spectabilis	Showy orchis	Orchidaceae	T	G5	S2	View	View
Galium kamtschaticum	Bedstraw	Rubiaceae	T	G5	S1		View
Gentiana flavida	White gentian	Gentianaceae	E	G4	S1		View
Gentiana linearis	Narrow-leaved gentian	Gentianaceae	T	G4G5	S2		View
Gentiana puberulenta	Downy gentian	Gentianaceae	E	G4G5	S1		View
Gentiana saponaria	Soapwort gentian	Gentianaceae	X	G5	SX		View

Gentianella quinquefolia	Stiff gentian	Gentianaceae		T	G5	S2		View
Geum triflorum	Prairie-smoke	Rosaceae		T	G5	S2S3	View	View
Geum virginianum	Pale avens	Rosaceae		SC	G5	S1S2		View
Gillenia trifoliata	Bowman's root	Rosaceae		T	G4G5	S1		View
Glyceria acutiflora	Manna grass	Poaceae		X	G5	SX		View
Gnaphalium sylvaticum	Cudweed	Asteraceae		T	G5	S1		View
Gratiola aurea	Hedge-hyssop	Scrophulariaceae		T	G5	S1S2		View
Gratiola virginiana	Round-fruited hedge hyssop	Scrophulariaceae		T	G5	S1		View
Gymnocarpium jessoense	Northern oak fern	Dryopteridaceae		E	G5	S1		View
Gymnocarpium robertianum	Limestone oak fern	Dryopteridaceae		T	G5	S2	View	View
Gymnocladus dioicus	Kentucky coffee-tree	Fabaceae		SC	G5	S3S4		View
Hedyotis nigricans	Hedyotis	Rubiaceae		X	G5	SX		View
Hedysarum alpinum	Alpine sainfoin	Fabaceae		E	G5	S1		View
Helianthus hirsutus	Whiskered sunflower	Asteraceae		SC	G5	S3		View
Helianthus microcephalus	Small wood sunflower	Asteraceae		X	G5	SX		View
Helianthus mollis	Downy sunflower	Asteraceae		T	G4G5	S2		View
Hemicarpha micrantha	Dwarf-bulrush	Cyperaceae		SC	G4	S3		View
Hibiscus laevis	Smooth rose-mallow	Malvaceae		SC	G5	SH		View
Hibiscus moscheutos	Swamp rose-mallow	Malvaceae		SC	G5	S3S4		View
Hieracium paniculatum	Panicled hawkweed	Asteraceae		SC	G5	S2		View
Houstonia caerulea	bluets	Rubiaceae		SC	G5	S?		View
Huperzia appalachiana	mountain fir-moss	Lycopodiaceae		E	G4G5	S?		View
Huperzia selago	Fir clubmoss	Lycopodiaceae		SC	G5	S3		View
Hybanthus concolor	Green violet	Violaceae		SC	G5	S3		View
Hydrastis canadensis	Goldenseal	Ranunculaceae		T	G4	S2	View	View
Hymenoxys herbacea	Lakeside daisy	Asteraceae	LT	E	G2	S1	View	View
Hypericum gentianoides	Gentian-leaved st. john's-wort	Clusiaceae		SC	G5	S3		View
Hypericum sphaerocarpum	Round-fruited st. john's-wort	Clusiaceae		T	G5	S1		View
Ipomoea pandurata	Wild potato-vine	Convolvulaceae		T	G5	S2		View
Iris lacustris	Dwarf lake iris	Iridaceae	LT	T	G3	S3	View	View
Isoetes engelmannii	Appalachian quillwort	Isoetaceae		E	G4	S1		View
Isotria medeoloides	Smaller whorled pogonia	Orchidaceae	LT	E	G2	S1		View
Isotria verticillata	Whorled pogonia	Orchidaceae		T	G5	S2		View
Jeffersonia diphylla	Twinleaf	Berberidaceae		SC	G5	S3		View

Juncus brachycarpus	Short-fruited rush	Juncaceae	T	G4G5	S1S2		View
Juncus militaris	Bayonet rush	Juncaceae	T	G4	S1		View
Juncus scirpoides	Scirpus-like rush	Juncaceae	T	G5	S2		View
Juncus stygius	Moor rush	Juncaceae	T	G5	S1S2		View
Juncus vaseyi	Vasey's rush	Juncaceae	T	G5?	S1S2		View
Justicia americana	Water-willow	Acanthaceae	T	G5	S2		View
Kuhnia eupatorioides	False boneset	Asteraceae	SC	G5	S2		View
Lactuca floridana	Woodland lettuce	Asteraceae	T	G5	S2		View
Lactuca pulchella	Blue lettuce	Asteraceae	T	G5	SH		View
Lechea minor	Least pinweed	Cistaceae	SC	G5	SH		View
Lechea pulchella	Leggett's pinweed	Cistaceae	T	G5	S1S2		View
Lechea stricta	Erect pinweed	Cistaceae	SC	G4?	S1		View
Lemna valdiviana	Pale duckweed	Lemnaceae	X	G5	SX		View
Lespedeza procumbens	Trailing bush-clover	Fabaceae	X	G5	SX		View
Leucospora multifida	conobea	Scrophulariaceae	SC	G5	S?		View
Liatris punctata	Dotted blazing-star	Asteraceae	X	G5	SX		View
Liatris squarrosa	Blazing-star	Asteraceae	X	G5	SX		View
Linum sulcatum	Furrowed flax	Linaceae	SC	G5	S2S3		View
Linum virginianum	Virginia flax	Linaceae	T	G4G5	S2		View
Liparis liliifolia	Purple twayblade	Orchidaceae	SC	G5	S3		View
Listera auriculata	Auricled twayblade	Orchidaceae	SC	G3	S2S3		View
Lithospermum incisum	Narrow-leaved puccoon	Boraginaceae	X	G5	SX		View
Lithospermum latifolium	Broad-leaved puccoon	Boraginaceae	SC	G4	S2		View
Littorella uniflora	American shore-grass	Plantaginaceae	SC	G5	S2S3		View
Lonicera involucrata	Black twinberry	Caprifoliaceae	T	G4G5	S2		View
Ludwigia alternifolia	Seedbox	Onagraceae	SC	G5	S3		View
Ludwigia sphaerocarpa	Globe-fruited seedbox	Onagraceae	T	G5	S1		View
Luzula parviflora	Small-flowered woodrush	Juncaceae	T	G5	S1		View
Lycopodiella margueriteae	northern prostrate clubmoss	Lycopodiaceae	T	G2	S2		View
Lycopodiella subappressa	Northern appressed clubmoss	Lycopodiaceae	SC	G2	S2	View	View
Lycopus virginicus	Virginia water-horehound	Lamiaceae	T	G5	S2		View
Lygodium palmatum	Climbing fern	Schizaeaceae	E	G4	S1		View
Lysimachia hybrida	Swamp candles	Primulaceae	SC	G5	S2		View
Mertensia virginica	Virginia bluebells	Boraginaceae	T	G5	S2		View

Mikania scandens	Mikania	Asteraceae		X	G5	SX		View
Mimulus alatus	Wing-stemmed monkey-flower	Scrophulariaceae		X	G5	SX		View
Mimulus glabratus var michiganensis	Michigan monkey-flower	Scrophulariaceae	LE	E	G5T1	S1	View	View
Mimulus guttatus	Western monkey-flower	Scrophulariaceae		SC	G5	S1		View
Monarda didyma	Oswego tea	Lamiaceae		X	G5	SX		View
Morus rubra	Red mulberry	Moraceae		T	G5	S2		View
Muhlenbergia cuspidata	Plains muhly	Poaceae		X	G4	SX		View
Muhlenbergia richardsonis	Mat muhly	Poaceae		T	G5	S2	View	View
Myriophyllum alterniflorum	Alternate-leaved water-milfoil	Haloragaceae		SC	G5	S2S3		View
Myriophyllum farwellii	Farwell's water-milfoil	Haloragaceae		T	G5	S2		View
Nelumbo lutea	American lotus	Nelumbonaceae		T	G4	S2		View
Nuphar pumila	Small yellow pond-lily	Nymphaeaceae		E	G4G5	S1S2		View
Nymphaea tetragona	pygmy water-lily	Nymphaeaceae		E	G5	S1		View
Onosmodium molle	Marbleweed	Boraginaceae		X	G4G5	SX		View
Ophioglossum vulgatum	Southeastern adder's tongue	Ophioglossaceae		T	G5	S1		View
Oplopanax horridus	Devil's-club	Araliaceae		T	G4G5	S2		View
Opuntia fragilis	Fragile prickly-pear	Cactaceae		E	G4G5	S1		View
Orobanche fasciculata	Fascicled broom-rape	Orobanchaceae		T	G4	S2	View	View
Oryzopsis canadensis	Canada rice-grass	Poaceae		T	G5	S2		View
Osmorhiza depauperata	Sweet cicely	Apiaceae		T	G5	S2		View
Oxalis violacea	Violet wood-sorrel	Oxalidaceae		T	G5	S1		View
Panax quinquefolius	Ginseng	Araliaceae		T	G3G4	S2S3	View	View
Panicum leibergii	Leiberg's panic-grass	Poaceae		T	G5	S2		View
Panicum longifolium	Long-leaved panic-grass	Poaceae		T	G4	S2		View
Panicum microcarpon	Small-fruited panic-grass	Poaceae		SC	G5T5	S2		View
Panicum polyanthes	Round-seed panic grass	Poaceae		E	G5T5	S1		View
Panicum verrucosum	Warty panic-grass	Poaceae		T	G4	S1		View
Parnassia palustris	Marsh grass-of-parnassus	Saxifragaceae		T	G5	S2	View	View
Paronychia fastigiata	Low-forked chickweed	Caryophyllaceae		SC	G5	SH		View
Pellaea atropurpurea	Purple cliff-brake	Pteridaceae		T	G5	S2		View
Penstemon calycosus	Smooth beard tongue	Scrophulariaceae		T	G5	S2		View
Penstemon gracilis	Slender beard-tongue	Scrophulariaceae		E	G5	S1		View

Penstemon pallidus	Pale beard tongue	Scrophulariaceae		SC	G5	S3		View
Petasites sagittatus	Sweet coltsfoot	Asteraceae		T	G5	S1S2	View	View
Phacelia franklinii	Franklin's phacelia	Hydrophyllaceae		T	G5	S1		View
Phaseolus polystachios	Wild bean	Fabaceae		SC	G4	SH		View
Phleum alpinum	Mountain timothy	Poaceae		X	G5	SX		View
Phlox bifida	Cleft phlox	Polemoniaceae		T	G5?	S1		View
Phlox maculata	Wild sweet william or spotted phlox	Polemoniaceae		T	G5	S1		View
Pinguicula vulgaris	Butterwort	Lentibulariaceae		SC	G5	S3		View
Piperia unalascensis	Alaska orchid	Orchidaceae		SC	G5	S2S3		View
Plantago cordata	Heart-leaved plantain	Plantaginaceae		E	G4	S1		View
Platanthera ciliaris	Orange or yellow fringed orchid	Orchidaceae		T	G5	S2		View
Platanthera leucophaea	Prairie fringed orchid	Orchidaceae	LT	E	G2	S1	View	View
Poa alpina	Alpine bluegrass	Poaceae		T	G5	S1S2		View
Poa canbyi	Canby's bluegrass	Poaceae		E	G4G5	S1		View
Poa paludigena	Bog bluegrass	Poaceae		T	G3	S2		View
Polemonium reptans	Jacob's ladder or greek-valerian	Polemoniaceae		T	G5	S2		View
Polygala cruciata	Cross-leaved milkwort	Polygalaceae		SC	G5	S3		View
Polygala incarnata	Pink milkwort	Polygalaceae		X	G5	SX		View
Polygonatum biflorum var melleum	Honey-flowered solomon-seal	Liliaceae		X	G5TH	SX		View
Polygonum careyi	Carey's smartweed	Polygonaceae		T	G4	S1S2		View
Polygonum viviparum	Alpine bistort	Polygonaceae		T	G5	S1S2		View
Polymnia uvedalia	Large-flowered leafcup	Asteraceae		T	G4G5	S1		View
Polytaenia nuttallii	Prairie-parsley	Apiaceae		X	G5	SX		View
Populus heterophylla	Swamp or black cottonwood	Salicaceae		E	G5	S1		View
Potamogeton bicupulatus	Waterthread pondweed	Potamogetonaceae		T	G4?	S2		View
Potamogeton confervoides	Alga pondweed	Potamogetonaceae		SC	G4	S3		View
Potamogeton hillii	Hill's pondweed	Potamogetonaceae		T	G3	S2		View
Potamogeton pulcher	Spotted pondweed	Potamogetonaceae		T	G5	S2		View
Potamogeton vaseyi	Vasey's pondweed	Potamogetonaceae		T	G4	SH		View
Potentilla paradoxa	Sand cinquefoil	Rosaceae		T	G5	SU		View
Potentilla pensylvanica	Prairie cinquefoil	Rosaceae		T	G5	S1		View
Proserpinaca pectinata	Mermaid-weed	Haloragaceae		E	G5	S1		View

Prunus alleghaniensis var davisii	Alleghany or sloe plum	Rosaceae	SC	G4T3Q	S3		View
Psilocarya scirpoides	Bald-rush	Cyperaceae	T	G4	S2		View
Pterospora andromedea	Pine-drops	Monotropaceae	T	G5	S2	View	View
Pycnanthemum muticum	Mountain-mint	Lamiaceae	T	G5	S1		View
Pycnanthemum pilosum	Hairy mountain-mint	Lamiaceae	T	G5	S2		View
Pycnanthemum verticillatum	Whorled mountain-mint	Lamiaceae	SC	G5	S2		View
Quercus shumardii	Shumard's oak	Fagaceae	SC	G5	S2		View
Ranunculus ambigens	Spearwort	Ranunculaceae	T	G4	SH		View
Ranunculus cymbalaria	Seaside crowfoot	Ranunculaceae	T	G5	S1		View
Ranunculus lapponicus	Lapland buttercup	Ranunculaceae	T	G5	S1S2	View	View
Ranunculus macounii	Macoun's buttercup	Ranunculaceae	T	G5	S1		View
Ranunculus rhomboideus	Prairie buttercup	Ranunculaceae	T	G4	S2		View
Rhexia mariana var mariana	Maryland meadow-beauty	Melastomataceae	T	G5T5	S1S2		View
Rhexia virginica	Meadow-beauty	Melastomataceae	SC	G5	S3	View	View
Rhynchospora globularis	Globe beak-rush	Cyperaceae	E	G5	S1		View
Rhynchospora macrostachya	Tall beak-rush	Cyperaceae	SC	G4	S3S4		View
Ribes oxyacanthoides	Northern gooseberry	Grossulariaceae	SC	G5	S3		View
Rotala ramosior	Tooth-cup	Lythraceae	SC	G5	S3		View
Rubus acaulis	Dwarf raspberry	Rosaceae	E	G5	S1		View
Rudbeckia subtomentosa	Sweet coneflower	Asteraceae	X	G5	S?		View
Ruellia humilis	Hairy ruellia	Acanthaceae	T	G5	S1		View
Ruellia strepens	Smooth ruellia	Acanthaceae	T	G4G5	S1		View
Rumex occidentalis	Western dock	Polygonaceae	E	G5	S?		View
Ruppia maritima	Widgeon-grass	Ruppiaceae	T	G5	S1		View
Sabatia angularis	Rose-pink	Gentianaceae	T	G5	S2		View
Sagina nodosa	Pearlwort	Caryophyllaceae	T	G5	S2		View
Sagittaria montevidensis	Arrowhead	Alismataceae	T	G4G5	S1S2		View
Salix pellita	Satiny willow	Salicaceae	SC	G5	S2		View
Salix planifolia	Tea-leaved willow	Salicaceae	T	G5	SH		View
Sanguisorba canadensis	Canadian burnet	Rosaceae	T	G5	S1		View
Sarracenia purpurea ssp heterophylla	Yellow pitcher-plant	Sarraceniaceae	T	G5T1T2Q	S1	View	View
Saxifraga paniculata	Encrusted saxifrage	Saxifragaceae	T	G5	S1		View
Saxifraga tricuspidata	Prickly saxifrage	Saxifragaceae	T	G4G5	S2		View
Scirpus clintonii	Clinton's bulrush	Cyperaceae	SC	G4	S3		View

Scirpus hallii	Hall's bulrush	Cyperaceae		T	G2	S2	View	View
Scirpus olneyi	Olney's bulrush	Cyperaceae		T	G4	S1		View
Scirpus torreyi	Torrey's bulrush	Cyperaceae		SC	G5?	S2S3		View
Scleria pauciflora	Few-flowered nut-rush	Cyperaceae		E	G5	S1		View
Scleria reticularis	Netted nut-rush	Cyperaceae		T	G3G4	S2		View
Scleria triglomerata	Tall nut-rush	Cyperaceae		SC	G5	S3		View
Scutellaria elliptica	Hairy skullcap	Lamiaceae		SC	G5	S3		View
Scutellaria incana	Downy skullcap	Lamiaceae		X	G5	SX		View
Scutellaria nervosa	Skullcap	Lamiaceae		T	G5	S1		View
Scutellaria ovata	Heart-leaved skullcap	Lamiaceae		X	G5	SX		View
Scutellaria parvula	Small skullcap	Lamiaceae		T	G4	S2		View
Senecio congestus	Marsh-fleabane	Asteraceae		X	G5	SX		View
Senecio indecorus	Rayless mountain ragwort	Asteraceae		T	G5	S1		View
Silene stellata	Starry campion	Caryophyllaceae		T	G5	S2		View
Silene virginica	Fire pink	Caryophyllaceae		T	G5	S1		View
Silphium integrifolium	Rosinweed	Asteraceae		T	G4G5	S2		View
Silphium laciniatum	Compass-plant	Asteraceae		T	G5	S1S2		View
Silphium perfoliatum	Cup-plant	Asteraceae		T	G5	S2		View
Sisyrinchium atlanticum	Atlantic blue-eyed-grass	Iridaceae		T	G5	S2		View
Sisyrinchium farwellii	Farwell's blue-eyed-grass	Iridaceae		X	GHQ	SX		View
Sisyrinchium hastile	Blue-eyed-grass	Iridaceae		X	GUGHQ	SX		View
Sisyrinchium strictum	Blue-eyed-grass	Iridaceae		SC	G2Q	S2		View
Smilax herbacea	Smooth carrion-flower	Smilacaceae		SC	G5	S3		View
Solidago bicolor	White goldenrod	Asteraceae		SC	G5	S3		View
Solidago houghtonii	Houghton's goldenrod	Asteraceae	LT	T	G3	S3	View	View
Solidago missouriensis	Missouri goldenrod	Asteraceae		T	G5	S?		View
Spiranthes ochroleuca	Yellow ladies'-tresses	Orchidaceae		SC	G4	S3		View
Spiranthes ovalis	Lesser ladies'-tresses	Orchidaceae		T	G5?	S1		View
Sporobolus clandestinus	Dropseed	Poaceae		SC	G5	S1		View
Sporobolus heterolepis	Prairie dropseed	Poaceae		SC	G5	S3	View	View
Stellaria crassifolia	Fleshy stitchwort	Caryophyllaceae		T	G5	S1S2		View
Stellaria longipes	Stitchwort	Caryophyllaceae		SC	G5	S2		View
Strophostyles helvula	Trailing wild bean	Fabaceae		SC	G5	S3		View
Subularia aquatica	Awlwort	Brassicaceae		E	G5	S1		View

Tanacetum huronense	Lake huron tansy	Asteraceae	T	G4G5Q	S3	View	View
Thalictrum venulosum var confine	Veiny meadow-rue	Ranunculaceae	SC	G5T4?Q	S3		View
Tipularia discolor	Cranefly orchid	Orchidaceae	T	G4G5	S1		View
Tofieldia pusilla	False asphodel	Liliaceae	T	G5	S2		View
Tomanthera auriculata	Eared false foxglove	Scrophulariaceae	X	G3	SX		View
Tradescantia bracteata	Long-bracted spiderwort	Commelinaceae	X	G5	SX		View
Tradescantia virginiana	Virginia spiderwort	Commelinaceae	SC	G5	S2		View
Trichostema brachiatum	False pennyroyal	Lamiaceae	T	G4G5	S1		View
Trichostema dichotomum	Bastard pennyroyal	Lamiaceae	T	G5	S2		View
Trillium nivale	Snow trillium	Liliaceae	T	G4	S2		View
Trillium recurvatum	Prairie trillium	Liliaceae	T	G5	S2S3		View
Trillium sessile	Toadshade	Liliaceae	T	G4G5	S2S3		View
Trillium undulatum	Painted trillium	Liliaceae	E	G5	S1S2	View	View
Trillium viride	Green trillium	Liliaceae	X	G4G5	SX		View
Triphora trianthophora	Three-birds orchid	Orchidaceae	T	G3G4	S1		View
Triplasis purpurea	Sand grass	Poaceae	SC	G4G5	S2		View
Trisetum spicatum	Downy oat-grass	Poaceae	SC	G5	S2S3		View
Utricularia inflata	Floating bladderwort	Lentibulariaceae	E	G5	S1		View
Utricularia subulata	Zigzag bladderwort	Lentibulariaceae	T	G5	S1	View	View
Vaccinium cespitosum	Dwarf bilberry	Ericaceae	T	G5	S1S2	View	View
Vaccinium uliginosum	Alpine blueberry	Ericaceae	T	G5	S2		View
Vaccinium vitis-idaea	Mountain-cranberry	Ericaceae	E	G5	S1		View
Valeriana edulis var ciliata	Edible valerian	Valerianaceae	T	G5T3	S2		View
Valerianella chenopodiifolia	Goosefoot corn-salad	Valerianaceae	T	G5	S1		View
Valerianella umbilicata	Corn-salad	Valerianaceae	T	G3G5	S2		View
Viburnum edule	Squashberry or mooseberry	Caprifoliaceae	T	G5	S2S3		View
Viburnum prunifolium	Black haw	Caprifoliaceae	SC	G5	S3		View
Viola epipsila	Northern marsh violet	Violaceae	T	G4	SH		View
Viola novae-angliae	New england violet	Violaceae	T	G4Q	S2		View
Viola pedatifida	Prairie birdfoot violet	Violaceae	T	G5	S1		View
Vitis vulpina	Frost grape	Vitaceae	T	G5	S1S2		View
Wisteria frutescens	Wisteria	Fabaceae	T	G5	S1		View
Wolffia papulifera	Water-meal	Lemnaceae	T	G4	S1		View
Woodsia alpina	Northern woodsia	Dryopteridaceae	T	G4	S1		View

Woodsia obtusa	Blunt-lobed woodsia	Dryopteridaceae	T	G5	S1S2		View
Woodwardia areolata	Netted chain-fern	Blechnaceae	X	G5	SX		View
Zizania aquatica var aquatica	Wild-rice	Poaceae	T	G5T5	S2S3	View	View
Zizia aptera	Prairie golden alexanders	Apiaceae	T	G5	S1S2		View

For assistance with this site, email mnfiweb@msue.msu.edu

Biomass and Biofuels

Mac users: Please note that this map program works best with Microsoft Internet Explorer.

This map provides county-level estimates of biomass resources available for biofuels production or biomass power stations. The map includes only those resources available from crop and forest residues. It does not include managed crop or forest resources, or urban residues.

The biomass resource data were derived from several sources. One of the sources was an NREL contracted study of crop residue for 36 eastern states. The data are based on a three-year average of corn and wheat residue available for energy, taking into account tillage practices rainfall erosion deterrence. The units for the original data were in dry tons per county. These were converted to total kilowatts per county by assuming that one dry ton is equivalent to 1100 kw-hr/yr at a 65% plant capacity factor and a 35% plant conversion efficiency. This study only included the eastern 36 states where data was available. For a few of these 36 states, county level data were missing for a few counties. The report is in draft form, titled "Corn Stover and Wheat Straw Removal Analysis" by Richard G. Nelson.

The forest residue data were derived from the forest inventory and analysis unit of the USDA forest service Timber Product Output Database Retrieval System Web site. The data used from this site were county level data for the conterminous United States. The 1996 data included were logging and mill residues, and other removals (pre-commercial thinnings, land clearing, timber stand improvements, etc.). The logging residue and other removals data were converted into potential kilowatts per county from thousand cubic feet. This was done by assuming that one thousand cubic feet of residue is equivalent to 14 dry tons, and a dry ton is equivalent to 1100 kw-hr/yr at a a 65% plant capacity factor and a 35% plant conversion efficiency. The mill residue was converted directly from thousand dry tons into potential kilowatts per county.

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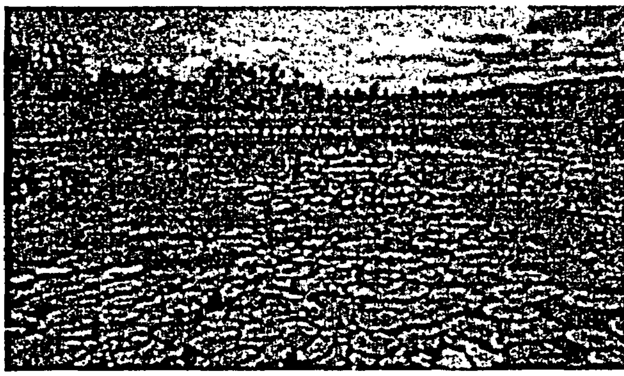

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Species Index

Northwest Power Supply Adequacy/Reliability Study Phase 1 Report

Northwest Power Planning Council

Paper Number 2000-4

March 6, 2000

Summary

Background

Approximately a year ago, Bonneville Power Administration Administrator Judi Johansen met with the Council to share her concerns about the evolving power supply situation in the Northwest. She cited Bonneville's annual White Book analysis, which showed that in the 2000-2001 operating year, 80 percent of the Septembers (out of the historical record of 50 water years) show deficits.[1] The average energy deficit in those years is equal to almost 2,500 average megawatts. Similarly, 36 percent of the Februarys show energy deficits that average 3,800 average megawatts. Problems in meeting the 50-hour sustained peak were also identified. Most of the supply-demand imbalance occurs on non-federal systems. Ms. Johansen noted the relative lack of new power plant construction taking place in the Northwest and questioned whether the competitive generation market would result in sufficient new development in the near term to avoid power supply problems. She encouraged the Council to undertake a review of the issue.

Objectives of the Council Analysis

Bonneville's White Book analysis is very valuable in terms of signaling the need for concern. However, there are several assumptions that could result in the White Book analysis painting an overly bleak picture. First, the analysis does not account for imports beyond existing firm contracts. In reality, the Northwest is part of a Western system with a good deal of seasonal diversity in loads that makes a certain degree of reliance on imports a cost-effective choice. Second, the White Book analysis does not reflect how the hydroelectric system can frequently (but not always) be operated to manage through relatively short-term supply problems. Finally, the White Book chooses not to speculate about possible new resource development. This is probably a prudent decision but it does seem likely that the operation of the power market will induce some level of new resource development.

In light of these limitations, the first phase of the Council's analysis attempts to answer the following questions:

- Is there a power supply adequacy problem for the Northwest over the next few years (5) taking into account flexible hydro operations; availability of imports; and known new resource development?

- If so, what is the nature of the problem in terms of its character (energy, capacity), magnitudes and probabilities? It is necessary to describe the situation in probabilistic terms taking into account hydro and temperature-induced load variability and forced generation outages.

- What are the interactions between operating the hydro system for reliability and meeting critical fish and wildlife targets for flows, reservoir levels, etc?

- What level of new resource additions is required to achieve typical industry reliability standards?

[1] 1998 Pacific Northwest Loads and Resources Study (White Book), Bonneville Power Administration, September, 1998. http://www.bpa.gov/power/pgp/whitebook/1998/index.shtml

- Is it likely the restructured/restructuring electricity industry will develop or maintain sufficient power supplies to address residual adequacy problems?

- If not, what are the options for addressing these problems?

The second phase of the study is intended to further refine key areas of the Phase 1 analysis and to evaluate the options for addressing adequacy problems.

Key Findings

There is a problem

Over each of the next few winters (the months of December, January, and February), with no new resources added to the system beyond those already under construction, there is a relatively high probability of one or more "generation insufficiency events" in which generation supply is not adequate to meet loads. Such events can be relatively small – tens of megawatts for an hour or a few hours. Or, such events can be quite large – several thousand megawatts for a few days. Both types of events are possible. The probability of a generation shortfall reaches approximately 24 percent by 2003. This means an almost one in four chance of one not getting through the winter without a supply interruption. These events are typically the result of some combination of poor hydro conditions, higher than normal demand due to weather conditions, and unplanned generation outages.

The kinds of problems experienced may be due to either capacity or energy shortfalls. Capacity problems occur when there is insufficient generating machine capability on the system to meet electrical demand during the peak hours of any given day.[2] Energy problems occur when, even if there is sufficient machine capability to meet peak hour demand, the capability of the system to deliver energy over a period of one or more days is less than the average demand over that time period. Capacity problems are typically associated with systems whose predominant generation is thermal, while energy problems are typically associated with principally hydroelectric systems. Historically, energy reliability has been the primary concern in the Northwest, but in the last few years concerns have been expressed about capacity, and this analysis indicates that the Northwest power system is transitioning to a state where a mix of potential capacity and energy problems exists.

The Council believes that a 24-percent probability of supply inadequacy is unacceptably large. There are a number of different reliability measures used in the electricity industry, but the 24 percent falls into a category called Loss of Load Probability (LOLP), which is the probability of some generation shortfall over a specified period of time. The traditional utility standard for generation LOLP in the U.S. is 5 percent, or one event in 20 years. The results of this study show a likelihood of interruption almost five times higher than this traditional standard. In order to meet that standard, we estimate that it would require almost 3,000 megawatts of new generating resources by 2003. New resources could, however, be some combination of new generating capacity and voluntary load reduction. It is not clear whether additional generating capacity and load reduction are substitutable one for one. We are planning further

[2] The analysis here assumes that the aggregate level of operating reserves specified by the WSCC is met at all times. Curtailments can occur even if there is unloaded generation capacity, if use of that capacity would violate reserve requirements. Reserve requirements in any hour are equal to five percent of hydro generation plus seven percent of thermal generation, or the single largest contingency, whichever is larger. Reserves are to be maintained at these levels to prevent the transmission system from becoming unstable and causing widespread disruptions. Utilities are required to restore reserves to the specified levels in a short period of time and, if unable to do so, are required to shed loads. Consequently, we believe it is not justifiable to count use of operating reserves toward meeting demand.

analysis of this question. However, given the lead times for the development of substantial amounts of new generating capacity, it seems clear that much of this new capacity will have to be met through voluntary load reduction where reducing load makes sense for both the end-user and the system. The alternative is involuntary load reduction, where system operators are forced to allocate supply shortfalls through mechanisms like rolling brownouts or blackouts at the substation level without regard to the value different customers place on maintaining service.

The Region is Heavily Dependent on Imports

This analysis also highlights the importance of power imports, particularly over the next few years before substantial new resources can be added to the system. These imports are necessary both to serve loads and to help restore the hydroelectric system after it has been necessary to temporarily draft the system below non-power constraints to address adequacy problems. These non-power constraints are typically reservoir elevation requirements for salmon and resident fish mitigation. The level of imports is heaviest in fall and early winter, with average purchases approaching 2,500 average megawatts, primarily from California and the Desert Southwest. Individual years with poor water conditions would see higher levels of imports continuing though the winter. The addition of new resources within the Northwest reduces the levels of imports significantly.

This extensive use of imports is not unreasonable. The Northwest has been transitioning from a standard of regional self-sufficiency under critical water conditions for a number of years. It is more efficient for the region to take advantage of the seasonal diversity in loads that exist between the Northwest and the Southwest than to try to be self-sufficient in resources. Generating capacity used to meet high summer loads in the Southwest is often available to help meet fall and winter needs in the Northwest.

The high degree of reliance on imports does mean, however, that we are highly dependent on the interties and their reliability. Our analysis has not incorporated the effects of unplanned outages on the interties on our ability to meet Northwest loads.

The Region Will Have to Make Significant Use of the Flexibility of the Hydro System

There have been significant constraints placed on the operation of the Pacific Northwest hydroelectric system in recent years for the purposes of salmon recovery and mitigation of resident fish problems. Nonetheless, on a short-term basis (periods of a week or less), the system still retains a high degree of operating flexibility. System operators can, if necessary, temporarily take additional energy (water) out of the system to help meet supply problems. In periods of very high demand, after all available Northwest generation and imports have been used, it may still be necessary to draft reservoirs in the system below levels that would ordinarily be constraints, and use this emergency generation to meet demand. That water is replaced as soon as possible by reducing hydro system generation, continuing high levels of regional thermal operation and purchasing additional imports. This kind of emergency operation during cold snaps is explicitly recognized in the current Biological Opinion.[3]

Our analysis indicates that over the next few years, before significant new resources are added to the system, there is a high likelihood this flexibility will have to be used. Under most circumstances, this flexibility can be used without significantly affecting factors that are important to salmon recovery and healthy resident fish populations – reservoir levels and stream flows. The analysis showed relatively little

[3] 1994-1998 Biological Opinion on the Operation of the Federal Columbia River System, National Marine Fisheries Service, Seattle, WA, Issued March 2, 1995; Supplement Issued, May 1998.

effect on flows but somewhat lower reservoir levels in dry years. In the near term, absent alternatives, this is something that the region may have to live. However, if, in the longer term, we do not add resources to the system, we would be forced to push the system harder and harder. This would lead to unacceptable impacts.

Market-Driven Generation Development May Not be Sufficient for Reliability

One of the more difficult aspects of this study has to do with how much of the generation needed for reliability purposes is likely to be brought on line over the next few years in response to market forces. The utility industry is in a new world compared to what existed just a few years ago. As a matter of national policy, the generation market has been opened up to competition. Development is being undertaken primarily by independent developers, many of whom are unregulated affiliates of utilities. These independent developers do not have monopoly service territories. They cannot count on being able to recover the fixed costs of new generating units from a secure customer base. They must be able to recover their costs and make a profit on the basis of what a plant can earn at market prices.

Adequately capturing the decision process of developers and their financial backers is difficult. We have used a commercial model, the AURORA™ Electric Market Model, to estimate the development of new, market-driven development.[4] AURORA uses an iterative process to forecast market prices and the viability of new (and existing) resources at those prices. The analysis is extremely data intensive, and many of the data requirements, like forecast fuel prices, technological advances, and price of load curtailment are open to argument. In addition, such an analysis cannot hope to capture the details of specific situations that might make particular projects more or less viable.

With those caveats, what the analysis suggests, first of all, is that even if the market would support it, the lead times for new development are such that it is not possible for significant amounts of new generation to come on line before 2002 at the earliest. Beyond that, the model indicates steady development of new generation in the Northwest beginning (coming on line) about 2004. However, this is not soon enough, nor in sufficient quantity to avoid the kinds of infrequent, relatively short-duration supply problems that this study identifies. The generation units that are added are primarily gas-fired combined-cycle combustion turbines.

We are not completely confident in these results. It may be that very high prices during periods of short supply could result in more development or development of a different type than our analysis suggests. It may also be that the market for ancillary services may have an effect on development that our analysis is not capturing. Moreover, it is certain that the modeling cannot capture the specifics of individual developer and project decisions.

There is the possibility that new mechanisms can be established to pay for new or existing capacity for reliability purposes. There is the risk, however, of giving unfair market advantage to some parties at the expense of others, thereby distorting the competitive marketplace. These questions need further analysis.

It's Time for Serious Discussion

The bottom line of this study is the Council thinks the Northwest needs to start serious discussions about how it can assure an adequate power supply during this transitional period in the electricity industry.

[4] AURORA Electric Market Model, EPIS Inc., 18813 Willamette Dr., West Linn, OR 97068, www.epis.com

The supply side needs to be an important component of these discussions. Does the region need to take special steps to support the development of generation for reliability purposes? If so, how? What is the cost? And what effects will this intervention in the competitive generation market have?

Given the impending potential supply problems, the demand-side needs to be addressed as well. Doing so may also be more economical than a pure supply-side approach. Many believe that as more end-users see market prices directly on a real-time basis, loads will automatically be reduced during periods of short supply and very high prices. We believe that will, in fact, be the case. Industrial and large commercial customers are most likely to see market prices and are probably most able to respond to price signals with load reductions or by shifting loads to off-peak periods. However, it is not clear how long it will take before real-time market prices will make it through to a large number of these end-users. Nor is it clear how long it will take for these end-users to implement procedures for load reduction or shifting in response to these prices.

In the near term, the region may have to look to other mechanisms by which the demand-side can participate in achieving load-resource balance. There are a variety of mechanisms that one could envision. They range from technological means of reducing and/or shifting loads to contracts for shedding loads or perhaps establishing a market for load reductions. Whatever the specific approach, there are criteria that should be met. The mechanism should be voluntary on the part of the end-user. Otherwise, we might as well rely on rolling blackouts. The mechanism should make economic sense for the end-user and the power system. And the mechanism must be reliable. The load reduction must be there when called upon. Otherwise, it cannot contribute to the overall reliability of the system.

Next Steps

Phase 2 of the Adequacy/Reliability Study has two components. The first is to explore the options for addressing the power supply adequacy problems this analysis has identified. These options are described below. The second is to further refine the analysis that has already been done. The steps to be taken there are described under "Results."

Options for ensuring an adequate power supply

Our analysis has indicated the need for substantial new resource development and/or voluntary (but dispatchable) economic load reduction in order to avoid power supply adequacy problems. The analysis also suggests that the market, as currently structured, may not be up to the task of ensuring adequate supplies. The market price signals to power plant developers do not appear to be sufficient to ensure adequate generation resources for the kinds of infrequent but potentially severe problems identified in this analysis. At the same time, relatively few end-use consumers see real-time prices that would allow them to make the trade-off between price and consumption that could mitigate supply shortfalls. The number of customers seeing real-time pricing is likely to increase over time but it is far from clear how quickly and to what extent that will happen.

The question is what to do about it. There seem to be two possible approaches:

Stand back and let the market develop

There is a school of thought that the best plan is no plan. Real-time pricing seems likely to become more prevalent with time, perhaps to an extent sufficient to mitigate supply shortfalls. If we do experience periods of inadequate power supply, system operators would manage through such situations. First they would purchase power wherever they could and at whatever price. If that proved insufficient, system operators would shed load, probably through rolling blackouts on the substation level so as to maintain the stability of the system as a whole. Those consumers who value uninterrupted service very highly might find it in their interest to invest in stand-by generation. The suppliers responsible for meeting load will see the high wholesale price of power during periods of tight supplies and also might find themselves subject to damages when they are unable to meet load. Those costs might be sufficient to encourage those suppliers to enter into interruptible contracts with some customers, invest in load shifting or load shaving technology and/or invest in standby generation. Emerging distributed generation technologies may help address local; distribution system reinforcement needs as well as help power supply adequacy. However, if the cost of avoiding interruption exceeds the cost of the interruption, from an economic standpoint, avoidance actions shouldn't be undertaken. This would all take some time to work out, but it would probably happen.

Jump-start the response.

Even if you believe the market will develop as described above, there are reasons why the region might want to begin looking at ways to mitigate supply shortfalls before they happen. Letting the market develop is inherently messy. The public is relatively tolerant of power interruptions that can be attributed to acts of God. They may be less tolerant of interruptions that they might attribute to a failure of trusted institutions to carry out their responsibilities. Their reaction might include a backlash that delays or even reverses the general movement toward a more competitive and efficient power system. It may be prudent to take steps to facilitate the development of responses to possible supply inadequacies before they happen. Some of the possibilities include:

- Find a way to pay the fixed costs of sufficient generation capacity to address adequacy problems. This capacity could either be new generation or older, less efficient generation that would otherwise not be available for use (however, little or no capacity in the Northwest fits this description). The regulatory approach is to require suppliers to maintain a planning reserve (of which operating reserves are a subset) adequate to achieve an acceptable loss of load probability. There are a number of different ways in which a reserve requirement might be implemented, some more and some less market-oriented.[5] The cost of maintaining that reserve margin inevitably flows through to the consumer in a way that does not distinguish between different consumers' cost of curtailment. The consumer pays the same whether uninterrupted service is very valuable or only modestly valuable. On the other hand, this inefficiency may be a minor factor in most consumers' consideration. As noted above, emerging distributed generation technologies might play a deal role in addressing local distribution system reinforcement needs as well as providing additional power supply.

- The other alternative is to find a way for the end-user to participate *voluntarily*. There are several ways in which this might happen.

    - Real-time pricing -- economic theory indicates that if consumers see the actual price of the power, they might choose to reduce their use in periods of extreme high prices. This is, of course; a highly charged issue. Many consumers may not wish to face volatile prices. On the other hand, it is not necessary to fully embrace retail open access to get some benefit out of real-time pricing. Some consumers may well be able to handle the volatility and welcome the opportunity to manage their electricity use in response to real-time price signals. These are most likely large industrial and, perhaps, commercial consumers. Reductions in those loads could have a significant effect on the adequacy of power

[5] See Hirst, Eric; Brendan Kirby and Stan Hadley, "Generation and Transmission Adequacy in a Restructuring U.S. Electric Industry," Prepared for the Edison Electric Institute, 701 Pennsylvania Av NW, Washington, DC 20004-2696, June, 1999, pp. 7-16.

supplies. How end-users would choose to respond to high prices could take any number of directions, ranging from reducing or stopping operations, investing conservation of demand management or investing in self-generation.

- Increased use of contracts for load reduction. In the absence of direct price signals to consumers, those responsible for serving loads might find it attractive to enter into contracts for load reduction with end-users. Theoretically, suppliers could pay up to the difference between the market price of power and their tariffed rate. These could be contracts for curtailment or load reduction between a utility and its customers or even with other power suppliers who might find it economic to meet reserve needs in this way. Some activities might offer opportunities for such load reductions are processes that, for a price, can discontinue operation temporarily. Candidates might be some of the Direct Service Industries, air separation, rock crushing, and other industrial processes. Some might be able to use backup generation. The rapid development and penetration of digital communications and control technologies should make it increasingly feasible to achieve controllable demand reduction.

- Demand-side bids to provide reserves. This would involve the same physical actions but a different market mechanism that once established could be more flexible and have lower transaction costs. Markets for load reduction are being established.[6] End-users get paid to reduce loads or take loads off the system with the payment based on the difference between the market price of power and the rate paid by the end-user.

- For other applications, it may be possible to employ Demand- Side Management technologies that can reduce the peak level of use, for example, reducing lighting levels in commercial buildings or water heaters that can be controlled remotely to reduce the coincident use of power for water heating. Again, as digital communications and control technologies evolve, the opportunities might be expected to expand. In each of these instances, at least a contractual relationship and perhaps the investment in some technology will be required.

- "Conventional" conservation. The Northwest has a long and successful history in implementing end-use efficiency improvements. Conservation is a resource that will reduce loads. While not as targeted at periods of critical supply constraints as some of the other options, conservation can clearly contribute. When assessing the value of conservation opportunities, their contribution to addressing power supply adequacy problems should be included.

What finally evolves will probably be some mix of the approaches depending on timing, economics and political feasibility. It may be that many of the demand-side actions turn out to be attractive economically. Phase 2 of the study will focus on working with parties in the region to evaluate the different options. What is clear is that there needs to be a focus on making something other than the involuntary curtailment option happen and happen soon.

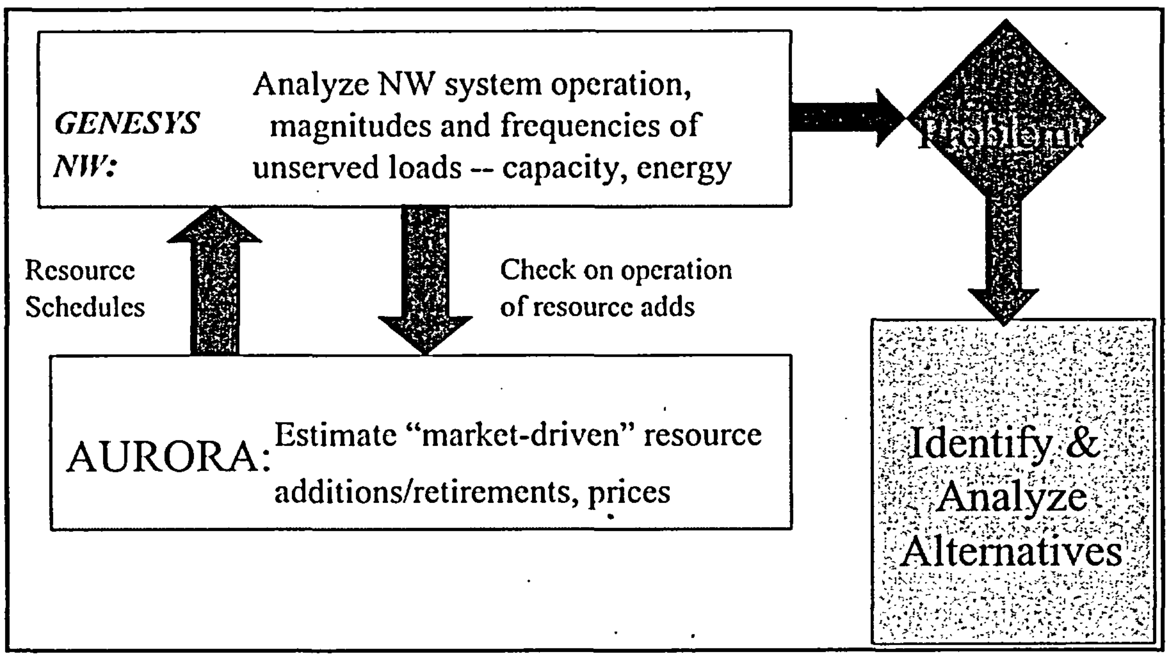
[6] Capage, Adam, Ron Davis and William Le Blanc, "The Dawning of Market-Based Load Management," E Source Report ER-99-18, E Source, 4755 Walnut St., Boulder, CO 80301-2537 pp. 9-10.

Analytical Approach

The analysis relies on two models of the Northwest and Western power systems -- *GENESYS* and AURORA. Their relationship is diagramed in Figure 1.

Figure 1

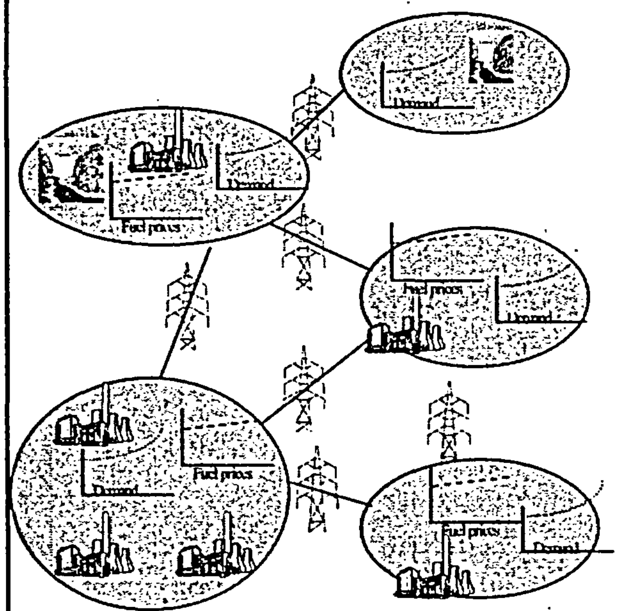
Overall Analytical Approach



AURORA

AURORA is a commercial proprietary model developed by EPIS, Inc. AURORA is used to provide *GENESYS* with schedules for the market-driven development of new resources and the retirement of existing resources and estimates of the availability of resources from other regions. A schematic of AURORA is shown on figure 2.

Figure 2
AURORA Schematic



15 load - resource areas
- transmission interconnections
- individual generating units (>2000)
- load forecast
- fuel price forecast
- portfolio of new resource options

Hourly market clearing prices
- by area and trading hub
- most expensive resource required to meet load for that hour

Resource retirements
- uneconomic going forward costs

Resource additions
- positive net present value

AURORA simulates the operation and expansion of the entire West Coast power system. AURORA is very data intensive. It operates off a data base containing the characteristics of existing and committed generating resources in the West, transmission capacity and costs between sub-regions, fuel price and demand growth forecasts, new generating resource characteristics (costs, efficiency), the cost of curtailing loads and a number of other factors. It incorporates a simplified representation of the operation of the hydroelectric generation in the West. The model runs multiple iterations to estimate market prices, the development of new resources and the retirements of existing resources until forecast market prices converge on stable values. Roughly stated, the decision rule is that those new resources that can cover their full costs and earn an acceptable return on their investment are built. Those that cannot are not built. If existing plants cannot recover their fixed and variable operating costs, they are retired, otherwise, they continue to operate. The model implicitly assumes perfect knowledge about the future – demands, fuel prices, what other plants are built and so on. That, of course, is a condition that cannot exist.

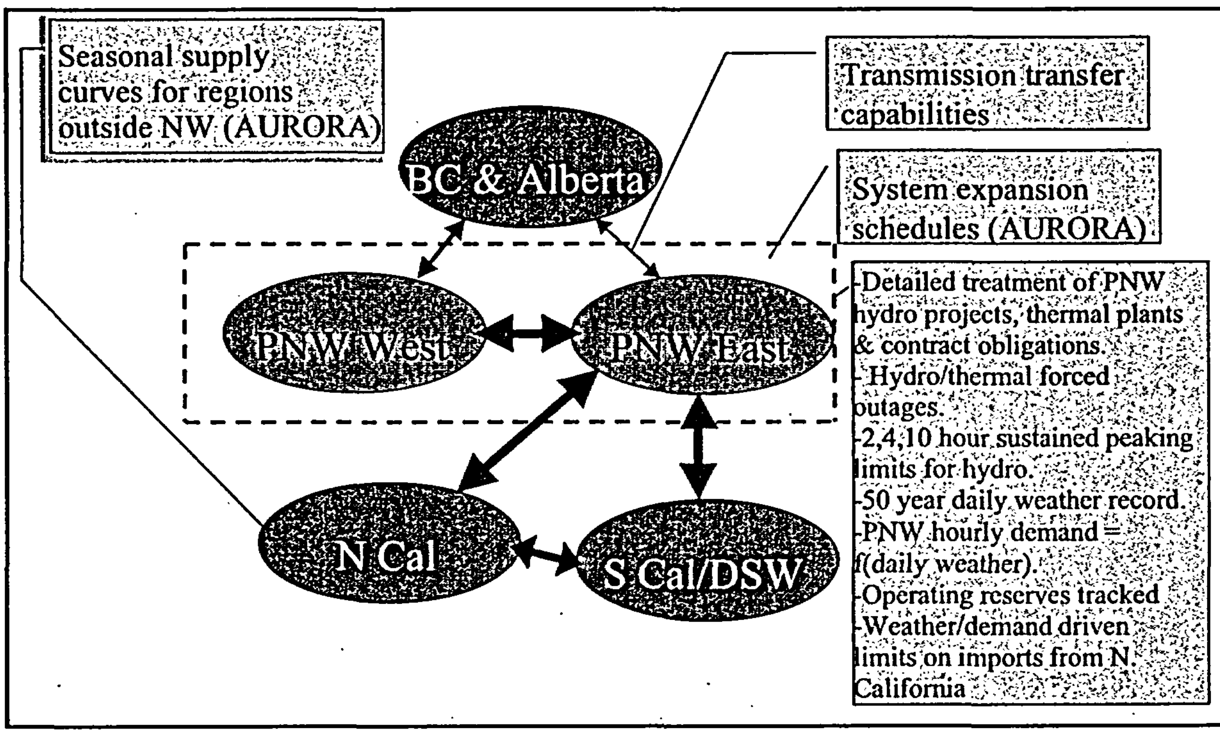
Because of computational limitations, it is necessary to make an assumption about hydro conditions when using AURORA in the resource expansion mode. For now, the assumption we have made is that developers would make their build decisions based on average hydro conditions. In poorer water years, a plant would make more money, in better water years it would make less. The assumption of average water was intended to represent a balancing of this uncertainty that developers face. However, prices are not entirely symmetrical around average water. We are investigating whether "slightly dry" water conditions should be used in subsequent analysis. In this respect and in others, the model cannot hope to fully capture how individual developers would make the build decision or the details of "deals" that might make a specific project go or not go.

GENESYS

GENESYS is the model used in this study for evaluation of power supply adequacy. It focuses on the Pacific Northwest region as defined by the Northwest Power Act. This includes the states of Idaho, Oregon, Washington and Montana west of the Continental Divide. The Pacific Northwest region is divided into a Western section and an Eastern section. This allows the capture of the possible effects of transmission transfer limits east to west and to model limitations on the transfer capability from Northern California to the Northwest as a function of demand and generation on the west side of the Cascades. The structure of *GENESYS* is highlighted in Figure 3.

Figure 3

GENESYS Area Structure



One of the roles of *GENESYS* is to represent the important sources of uncertainty in generation supply, allowing their effect on the adequacy of power supply to be captured probabilistically. This is done in *GENESYS* through a technique known as Monte Carlo simulation. In *GENESYS*, a single simulation is performed by taking samples for uncertain variables from defined probability distributions, and then simulating the operation of the power system under those conditions. Hundreds of simulations (or games) are run with different observations for these uncertain variables to evaluate the full range of impact on the ability of the system to meet load. The primary uncertain variables in *GENESYS* are Pacific Northwest stream flows, Pacific Northwest demand and generating unit forced outages. The variation in stream flow is captured through incorporation of the 50-year (1929–1978) Pacific Northwest streamflow record. Uncertainty in demand is captured through use of a weather-driven demand model. *GENESYS* incorporates an hourly demand model for the Pacific Northwest that uses observed daily average temperatures to calculate hourly demands. Here, the daily temperature record corresponding to the 50-year stream flow record is used. The temperature record can either be run in lockstep with the streamflow record (i.e., 1929 water and 1929 temperatures go together) or the temperature record can be sampled independently from streamflows. On average, this analysis assumes loads in the region grow at a rate of 1.5 percent per year. Finally, forced (unplanned) outages of thermal and hydro generating units are also a major source of uncertainty. The model samples the outage states of individual generating units according to their defined forced outage rates.

Another important role of *GENESYS* is to achieve a realistic representation of operation of the Pacific Northwest hydroelectric system. Hydro projects provide about 75 percent of the Northwest's electricity generation, and modeling realistic limits to hydro generation in emergency situations is critical to assessing system reliability. There is significant short-term flexibility in how the hydro system is operated, and a static treatment of Northwest hydro generation, as used in AURORA and other models, is insufficient for a power supply adequacy study for the Northwest. Energy generation at specific projects is discretionary within limits, and the capacity availability and duration (how long the system can generate at a given capacity) is a function of reservoir contents at any given time, releases at individual projects, the states of individual generators and a number of other factors. A detailed multi-project hydro-regulator is needed to track the system and determine the generation capability at any observed state. *GENESYS* incorporates the current version of HYDSIM, the hydro-regulation model used by the Bonneville Power Administration. Use of a multi-project hydro-regulator also provides the ability to evaluate the trade-offs between operating the system for reliability and strict adherence to fish and wildlife constraints. Finally, the relationship between daily average hydro energy generation and sustained peaking capability for each of 2, 4, and 10-hour duration limits is modeled using functions developed through the trapezoidal approximation linear program. This methodology is described in the Technical Appendix of the Council's Fourth Northwest Power Plan.[7]

In addition to draft of U.S. projects, Bonneville also has seasonal access to generation from storage in Canadian projects through non-treaty storage and provisional draft agreements. The use (and restoration) of this storage is modeled in *GENESYS*.

In the reliability analysis, transfer limits on the interties into the Northwest are generally held constant, with two exceptions: first, the south-to-north capacity of the California-Oregon Intertie, connecting the Pacific Northwest and Northern California, is an inverse function of net demand (load minus generation) on the west side of the Cascades. When net west-side demand exceeds 11,000 megawatts, the transfer limit begins to drop from a maximum of 3,705 megawatts and if demand continues to rise, the line may be derated to as low as 1,300 megawatts. This relationship is modeled in *GENESYS*, using data supplied by Bonneville.

Second, it was found that there are circumstances when both the Northwest and Northern California are experiencing colder than normal weather simultaneously. When it gets cold in Northern California, the potential for imports through Northern California is reduced because of increased load there and natural gas supply constraints. Based on discussion with California Energy Commission and Pacific Gas & Electric staff, it was estimated that when temperatures in Northern California fall to 50 degrees, the availability of imports out of Northern California begins to fall, reaching zero at a Northern California temperature of 40 degrees. A temperature record for Northern California parallel to the record for the Northwest was incorporated in the model and import availability from Northern California is adjusted based on the observed daily temperature there.

[7] Northwest Power Planning Council *Fourth Northwest Conservation and electric Power Plan*, Volume II Technical Appendices, Appendix H2, July, 1998.

To determine generation sufficiency for the region, *GENESYS* performs a chronological, multi-area, transmission-constrained dispatch. This dispatch is carried out on a subdaily basis down to hourly if desired. As mentioned above, Pacific Northwest resources and loads are modeled at a high level of detail. Contract export obligations of the Northwest are always met, and it is likewise assumed that contractual imports from other areas are always supplied. For this analysis, individual resources outside the region (Northern California, Southern California and the Desert Southwest, British Columbia and Alberta) are not modeled in detail. Surplus generation from these areas, that would be available for import to the Northwest, is represented by a set of supply curves (amounts of power available at a given price) that are differentiated seasonally and by time of day. The results from AURORA runs were used to estimate these supply curves. When necessary, generation in the other regions is used first to offset any firm export obligations from the Northwest (counter-scheduling) and then for imports to the Northwest.

In the results presented here, the full flexibility of the hydro system is used to meet load if required. If necessary to meet Pacific Northwest demand, reservoirs are drafted below non-power constraints. These are typically reservoir levels at particular times of the year established to ensure the ability to provide desired flows for downstream migration of salmonids. This flexibility is used only as a last resort after hydro above fish constraints, thermal generation, imports, hydro from non-treaty storage, and provisional draft of Canadian reservoirs (Arrow). This water is restored as soon as possible by running thermal units more than normal and by making additional imports. The cost of these operations is not estimated.

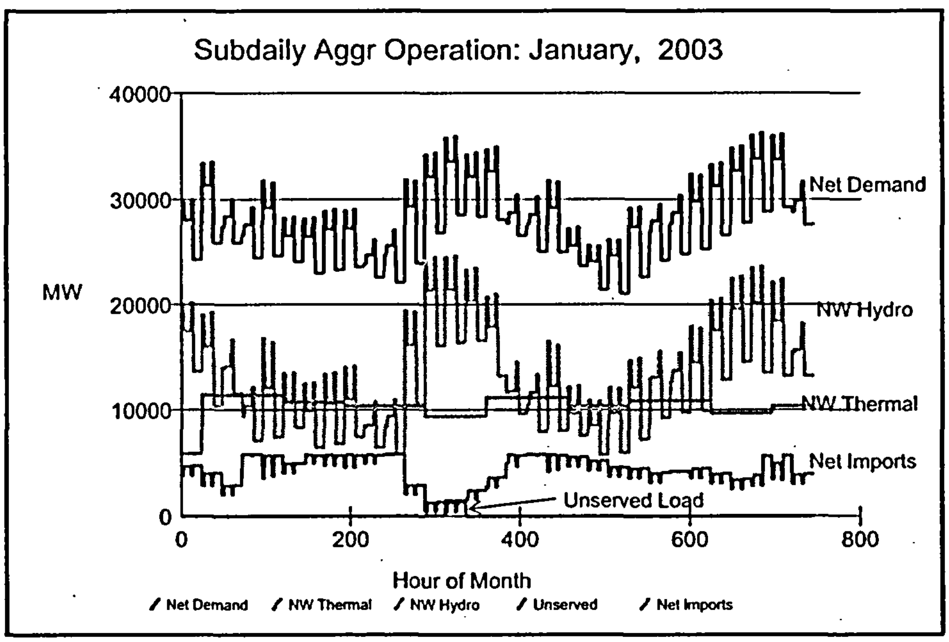
Results

Power Supply Adequacy

Initial analysis found that if problems of power supply adequacy were to occur, they would occur during the winter months when Northwest loads peak. Consequently; the analysis focused on the months of December, January and February. As noted earlier, *GENESYS* is a Monte Carlo simulation where many individual simulations or "games" are run in which the uncertain variables – stream flows, temperatures, and forced outages – are sampled according to their probability distributions. In this study, the model was run on a daily time step over each winter season, with each day broken into four demand segments – a morning peak, a mid-day period, an evening peak and a night-time off-peak period. For this part of the analysis, no additional generating capacity was assumed for the region beyond the Klamath Falls cogeneration units (536 megawatts) that are already under construction.

Figure 4 illustrates of one such game for January in 2003. In this particular game, the stream flow and temperature conditions correspond to 1932 water and 1950 weather conditions respectively. This is a poor streamflow year and a weather year in which two cold snaps occur in January.

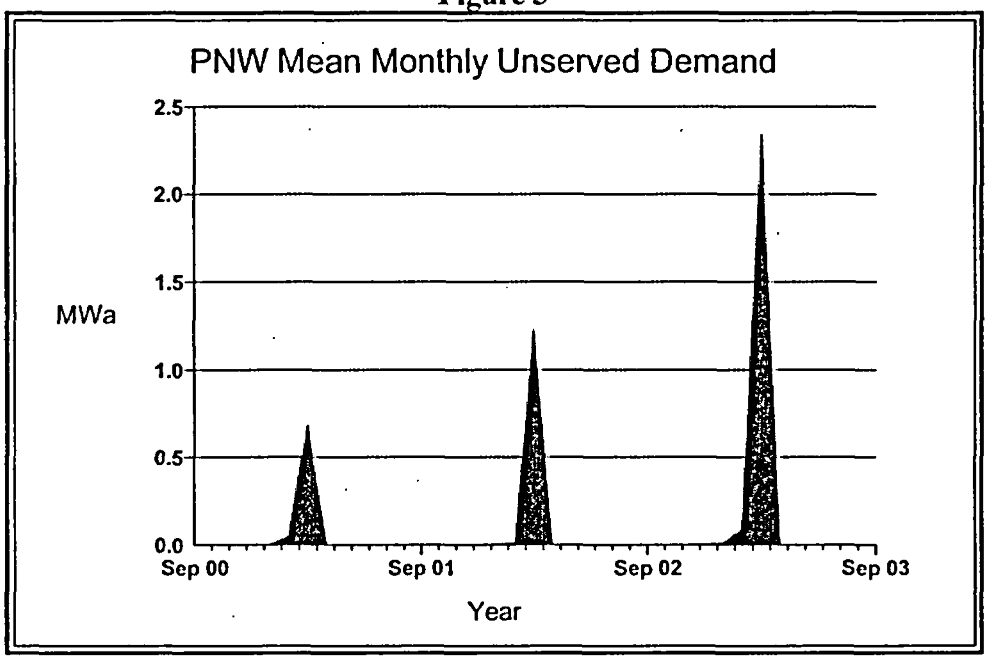
Figure 4
Subdaily Aggregate Operation for January, 2003
1932 Stream Flows and 1950 Temperatures



The top line shows the variation of net demand over the month, with two distinct periods of high demand (cold temperatures) occuring just before mid-month and toward the end of the month. The second line down shows the output from Northwest hydro. This clearly illustrates how hydro is used to follow daily variations in load, and a heavier use of hydro during the cold-snaps. The third line down shows the operation of Northwest thermal units. This is a month when regional generation supplies are tight, and all thermal units are running if not on forced outage. The dips in the thermal line correspond to forced outages on some of these units. The fourth line down shows net imports. This shows that for much of this month, use of imports is on the order of 6,000 megawatts. During the first cold snap, imports fall off sharply. This corresponds to coincident cold snaps in the Northwest and Northern California which limit the availability of imports. Hydro picks up much of the swing, but even with use of non-treaty storage and provisional draft from Canadian projects, not all demand can be met. During this period, the Northwest experiences unserved load (the bottom line) on the order of 1,000 to 1,500 megawatts for a period of approximately a day. During the demand surge later in the month, there is no corresponding cold snap in Northern California and the level of imports is maintained and there is no unserved load.

Figure 4 shows the results for a single game for a single month. Figure 5 shows the ***mean*** unserved demand for 500 games for the operating years beginning September 2000 through September 2003. In these games, water years and temperature years were selected sequentially from the historical record and run in lockstep mode.

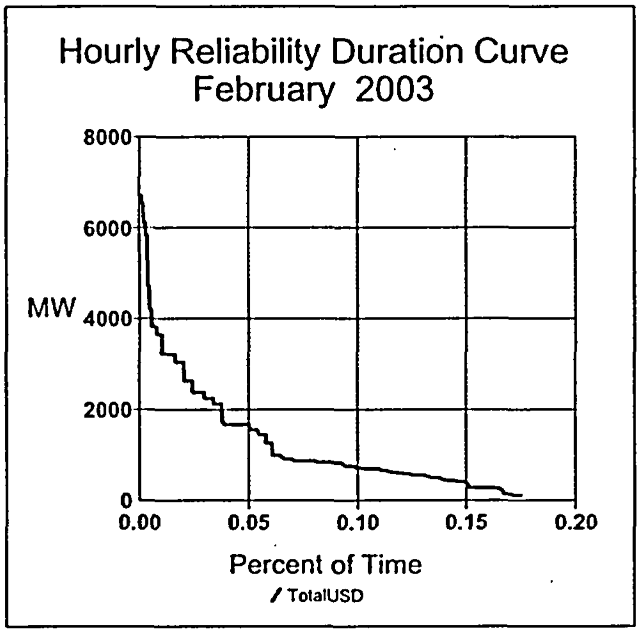
Figure 5



As Figure 5 shows, on an average basis, the problems appear to be quite small. The mean unserved demand in February 2003 is under 2.5 average megawatts for a monthly average demand of over 20,000 average megawatts. Use of the mean is very misleading, however, because it includes the results for over 330,000 hours simulated in each month, the vast majority of which have zero unserved demand. This masks the magnitude of the relatively small number of individual reliability events that occur in February.

A graphic that provides better insight into the generation reliability problem is shown in Figure 6. This is a duration curve of the hourly unserved demand events for all hours simulated in February 2003. All of the reliability events recorded in the simulation are sorted from high to low and plotted against their cumulative probability. The chart provides an indication of both the magnitude and probability of unserved demand events. The figure shows that for over 99.8 percent of the 336,000 hours examined there was no reliability problem detected. However, for almost 0.2 percent of the hours there was some level of unserved load. For approximately .01 percent of the hours there was unserved load of 4,000 megawatts or more.[8]

Figure 6
Duration Curve of Unserved Demand



Loss of Load Probability

While the data of Figure 6 give a more detailed look at the simulation results, they can be difficult to interpret. Another way to express generation reliability is through a measure called "loss of load probability" (LOLP). This is a measure that has been commonly used by electric utilities historically. It represents the probability of any generation supply shortfall, regardless of magnitude, over some defined period of time, typically a peak day or peak season. We have chosen to look at an LOLP for the Pacific Northwest for the months of December through February. This asks the straightforward question: "What is the probability of a generation shortfall, of any size, across the winter months?" The determination of winter loss of load probability is illustrated on Figure 7.

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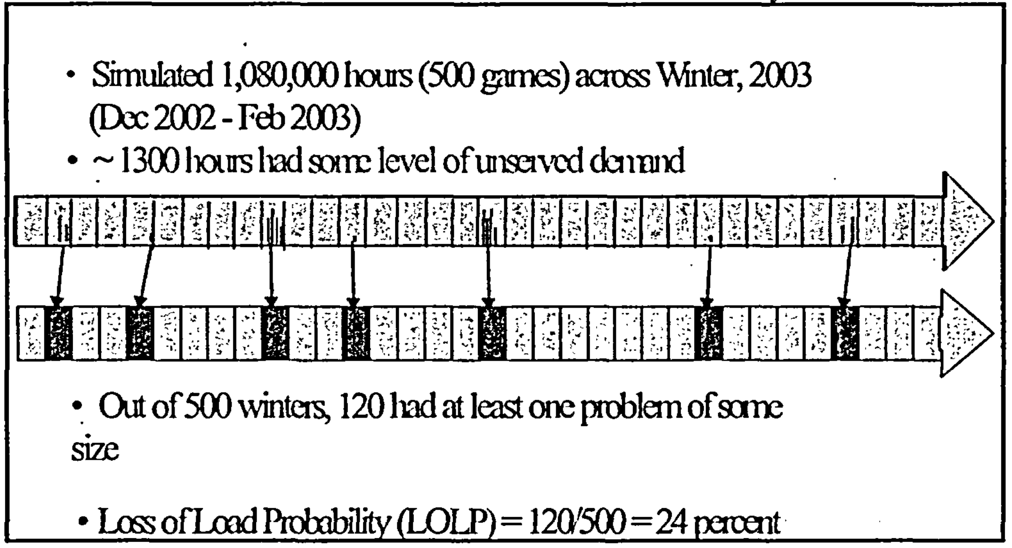
[8] The flat spots on the curve in Figure 5 typically result from a day (24 hours) where there is insufficient energy available to meet average daily demand.

Figure 7
Determination of Loss of Load Probability



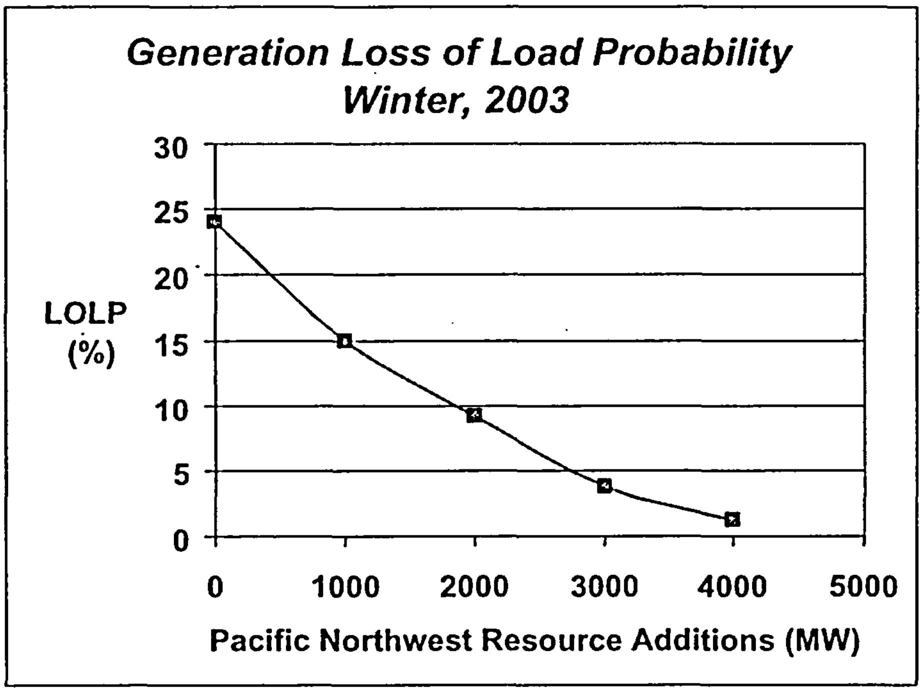
In 500 games, the *GENESYS* simulation examined over a million hours across the winter months of 2003. In approximately 1,300 of those hours there was some level of unserved demand. However, it would be incorrect to interpret that as a 0.12 percent probability of unserved load. Instead, think of each of the segments in the top arrow of Figure 7 as representing a winter. Within that winter, there might be one or more events in which resources were insufficient to meet load or there might be none at all. Such events are indicated by the "tics" within a winter. The events could be large in magnitude and/or duration or they might be small. If there is one or more event within a winter, that winter is counted as a "problem" winter, as indicated by the solid segments in the lower arrow. Out of 500 winters simulated, 120 had one or more events. The loss of load probability is then 120/500 or approximately 24 percent. This translates into an almost one in four chance of supply interruption in any given winter.

New Resource Needs

As mentioned earlier, the council believes a loss of load probability of 24 percent is unacceptably high. The next step in the analysis was to determine the amount of new resources necessary to reduce the loss of load probability to a more acceptable level. We have chosen a figure of 5 percent or essentially a one-winter-in-20 chance of losing load due to inadequate resources. This is a standard that has been used historically by utilities and their regulators.

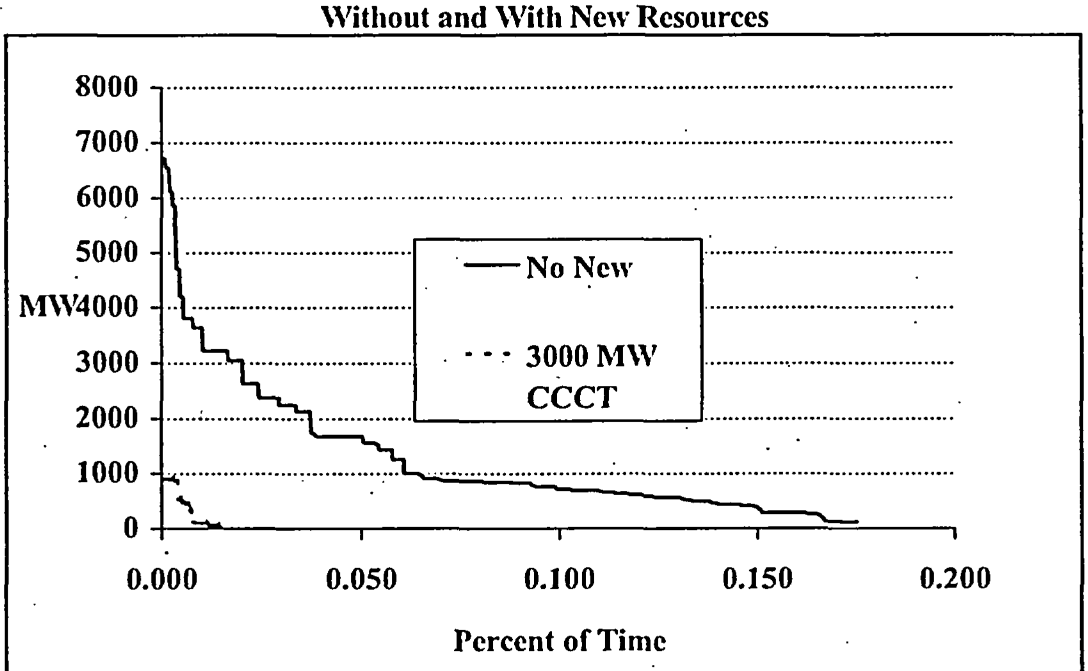
To assess the amount of new resource capacity required, additional amounts of capacity were added to the system incrementally and the probability of loss of load was reassessed. The resources added were all gas-fired combined cycle plants. The results are shown on figure 8. The analysis indicates that approximately 2,800 megawatts of generating new resource capacity would be required to bring the probability of loss of load down to 5 percent. We have not yet assessed the degree to which generation and load reduction are interchangeable. Generation capacity, which can be run at times other than when a supply shortfall is imminent, probably helps keep the hydro system up and may have greater effect on reducing the LOLP than an equivalent amount of load reduction. This relationship will be investigated in Phase 2.

Figure 8



The effect of adding 3,000 megawatts of combined cycle on the hourly duration curve of unserved load for February, 2003 is illustrated in Figure 9. The chart on the left is a repeat of Figure 6. The chart on the right shows the effect of the resource additions. The new resources reduce both the probability and the magnitude of curtailment by roughly an order of magnitude.

Figure 9
Comparison of Hourly Unserved Load Duration Curve
Without and With New Resources



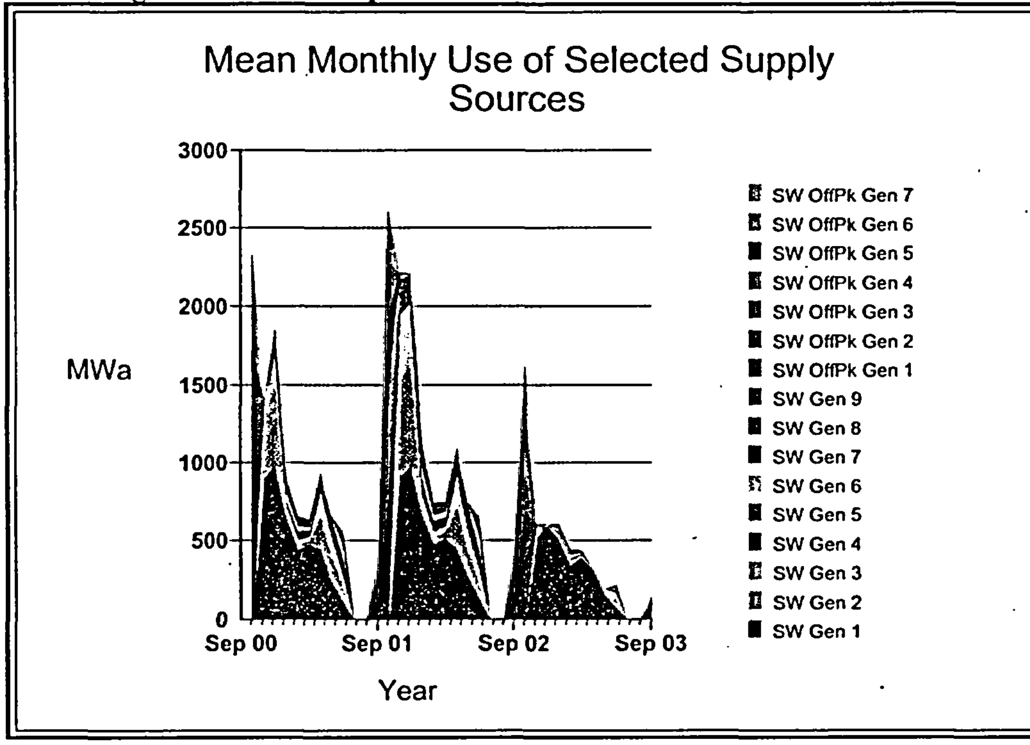
Imports

The region is heavily dependent on imports, primarily from California and the Desert Southwest, both for meeting load and for helping restore water in the hydro system after it has been necessary to draft below fish and wildlife targets to meet loads. The assumptions for import availability in GENESYS were developed through the area specific load and resource data we used in AURORA, including the effect of expected thermal maintenance and forced outage. The period during which imports into the region are most likely to be needed runs from September through March. In September, it is likely that only off-peak capacity would be available from the Southwest. Based on the AURORA data we've estimated that 7,000 megawatts are available in September off-peak hours. However, from October through March, there appears to be significant energy available around the clock, over 9,000 average megawatts available from the combined areas of the Desert Southwest, Southern California and Northern California. This is typically enough surplus to counter-schedule out of any Northwest contractual exports to the South, and still load the interties to their northbound transfer limits. So effectively, the limit on imports from the Southwest during the late fall and winter is the transfer capability of the interties. (However, as described earlier, the transfer capability of the AC is dynamically constrained by demand west of the Cascades, and/or cold snaps in Northern California.) A similar analysis for British Columbia and Alberta yields much smaller import capability. We have assumed surplus available from Canada equal to 380 and 290 average megawatts in September and October respectively. The analysis shows no availability in the winter months.

Figure 10 illustrates the average use of imports from the Southwest over the period September 2000 to August of 2003. The different shades represent blocks of power available at different prices, on and off peak. These results incorporate the effects of the addition of 3,000 megawatts of new generating capacity beginning in September of 2002 (the beginning of the 2003 operating year).

As this figure shows, imports are used heavily in the fall and again in the early spring to restore reservoir levels. The addition of the 3,000 megawatts of generation in Operating Year 2003 significantly diminishes the use of imports but does not eliminate it. It should also be emphasized that these are *average* levels. During periods of poor water conditions, exports are much higher and continue through most of the winter. Conversely, during wet years imports are less.

Figure 10
Average Reliance on Imports from California and the Desert Southwest



It should also be noted that the effect of new resources on the level of imports will depend on what kinds of new resources we are talking about and, more to the point, their cost relative to the cost of imports. Figure 10 incorporates the effects of 3,000 megawatts of new gas-fired combined cycle combustion turbine capacity beginning in operating year 2003. The cost of power from these units will displace more expensive imports. If some or all of the new resources were priced higher than some of the import blocks, then the imports would continue to be used.

In any event, imports are important to the region and will remain so. This is not a bad thing. It is merely the consequence of rational economic choices. It does, however, point out the importance of the interties. We have not incorporated any consideration of forced outages on the intertie in our assessment of power supply adequacy. There have been circumstances over the past decade that have reduced the transfer capability of the intertie, sometimes for extended periods.

Simulating February 1989

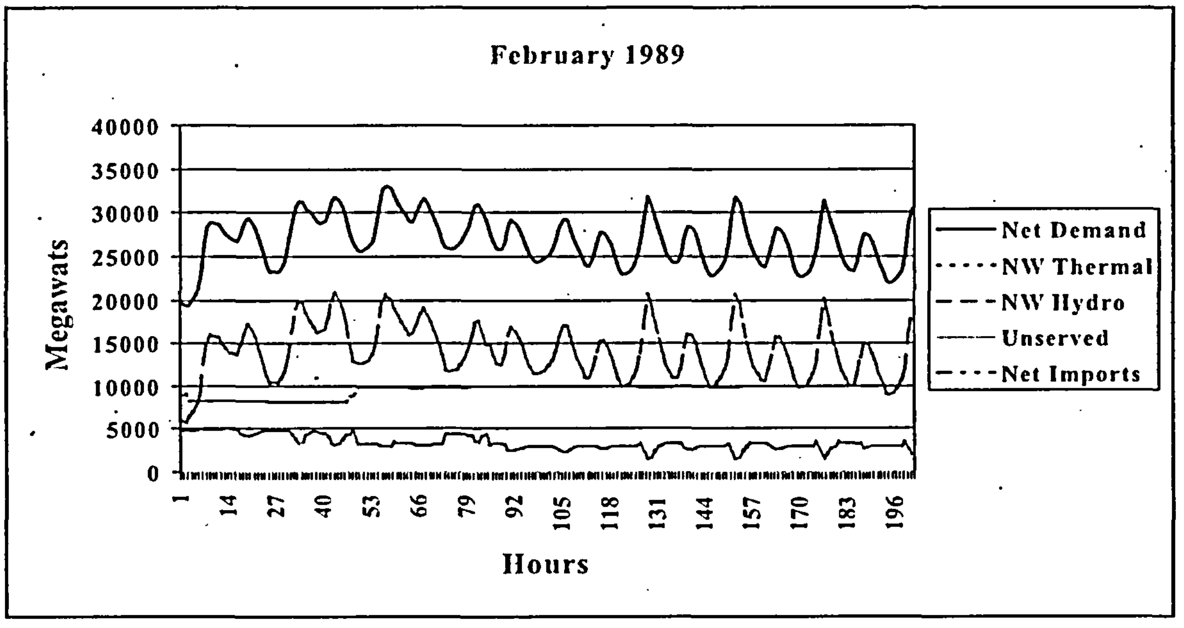
AS a test of *GENESYS*, a "backcast" of February 1989 was carried out. February of '89 was chosen because it is the most recent really severe situation that the region has faced. Although now more than a decade has passed, this event seems quite fresh in the memories of system operators. In the first few days of February '89, the region experience several days in which temperatures were quite low – 30 degrees F below normal in the region's load centers. Weather this cold has approximately a one in ten chance of occurring each winter.[9] Moreover, the cold was widespread throughout the region. Peak demand for the Northwest Power Pool exceeded the previous record by 5400 megawatts. In addition, reservoirs were quite low as a result of low stream flows and earlier operating decisions. The DC intertie was down beginning February 4. Finally, the month began with two major thermal units, WNP-2 and

[9] "Lessons Learned from the Cold Snap of February, 1989," Division of Power Supply, Bonneville Power Administration, April 26, 1989.

Colstrip 3, off line until the evening of February 2. The region made it through this event, but with a slender margin over operating reserve requirements. For the area modeled by *GENESYS*, the margin was approximately 300 megawatts.[10]

To test *GENESYS*, the model was run with actual February '89 loads and the 1989 resources from the 1989 Pacific Northwest Utilities Conference Committee Northwest Regional Forecast. The reservoirs were started where they were on January 31 and actual thermal unit outages were "hardwired" in the model. The operation of the hydro system was as modeled by *GENESYS.* The results are shown on Figure 11A for the first 200 hours of the month. Figure 11A shows that the region gets through the period with no unserved load.

Figure 11A



To see how close to the margin the simulation was, it was re-run with the loads incremented by an average of 500 megawatts over the month. The results are shown in Figure 11B.

[10] "Northwest Power Pool Operations During February 1989 Arctic Cold Weather Conditions," Northwest Power Pool Coordinating Group, march, 1989.

Figure 11B

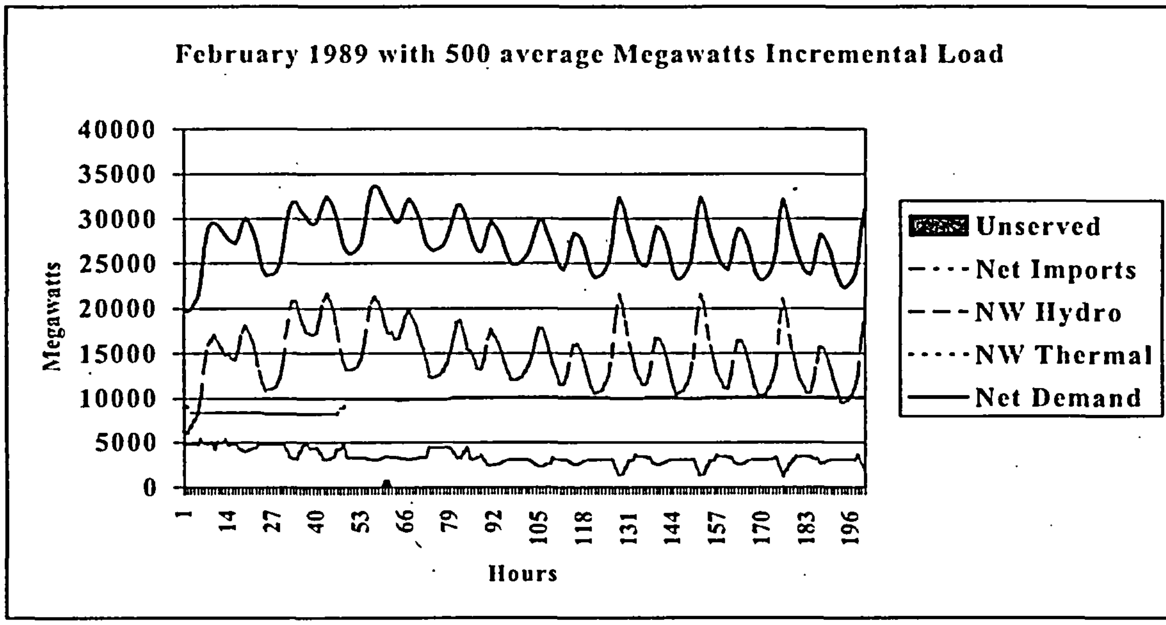


Figure 11B shows a short period of unserved peak load during the third say of the month amounting to a few hundred megawatts. This agrees quite well with the level of operating reserves available on that day.

February '89 Conditions Projected onto 2001

What would the situation be if we experience 1989 temperatures and water conditions with today's loads and resources? To test this, actual February '89 hourly loads were scaled up to 2001 with an average annual growth rate of 1.36 percent. Resources were updated to account for the resource additions and retirements that have occurred. For example, the Trojan nuclear power plant has been retired, the firm energy capability of the hydro system has been reduced as a result of fish requirements and several combined cycle combustion turbines and some renewable resources have been added to the system. The same forced outages of thermal units experienced in '89 were simulated as were the January 31 '89 reservoir conditions. Because of reinforcement of the DC intertie, it was assumed that the intertie would stay in service throughout the period. The results are shown on Figure 12.

Figure 12

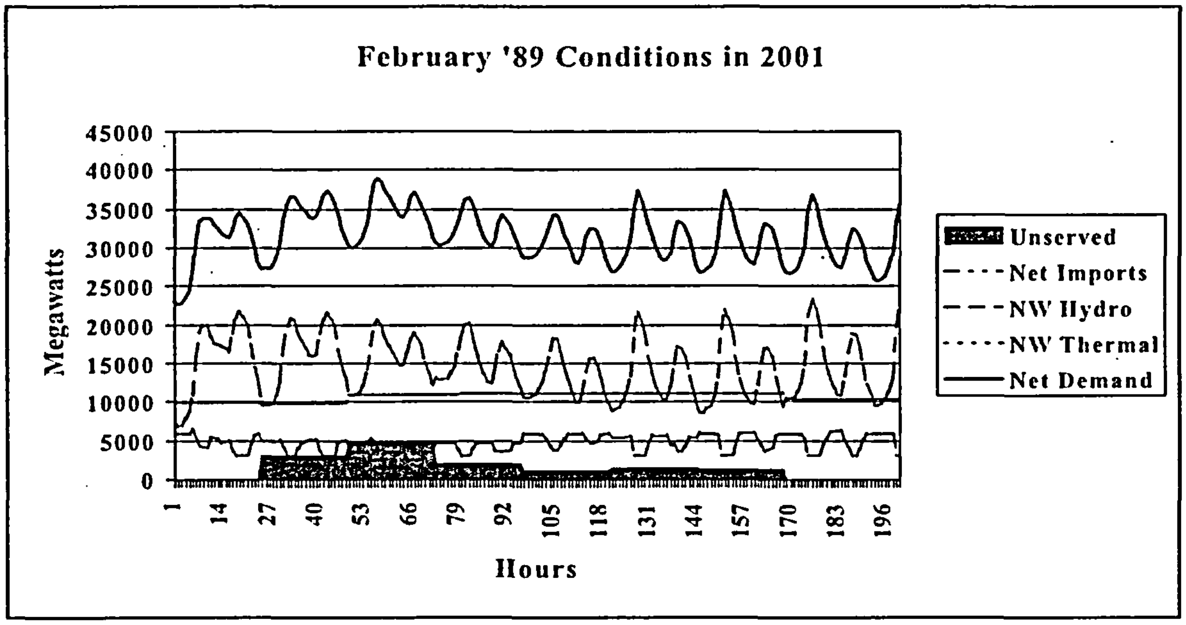
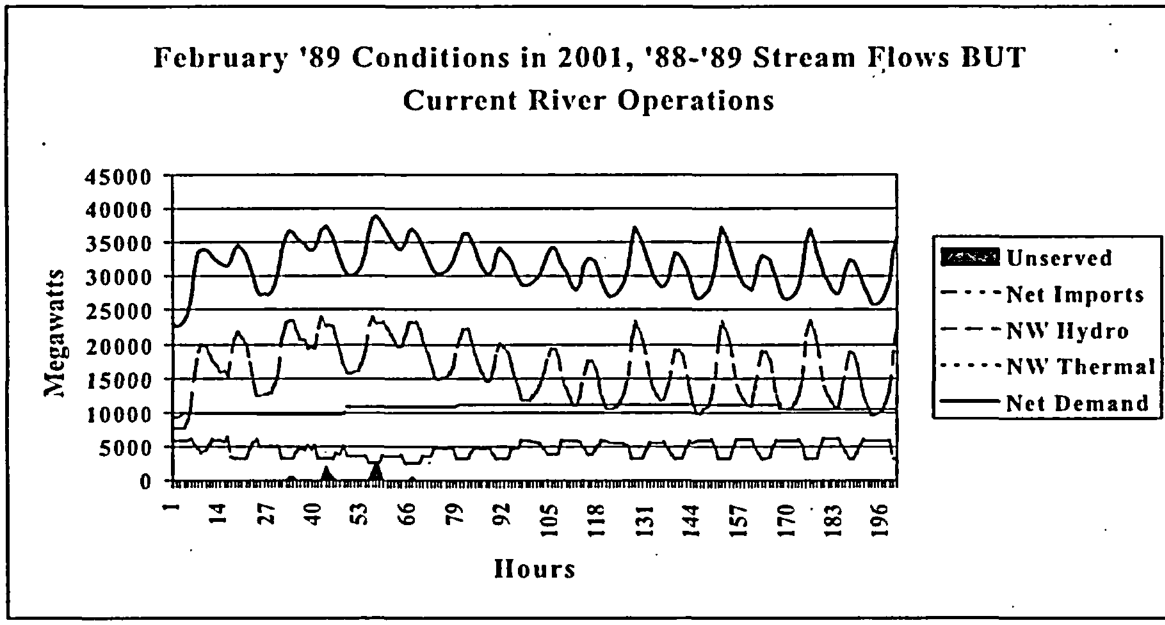


Figure 12 shows that if the same conditions were imposed on today's system, we would experience a significant and prolonged energy shortfall. The net addition of approximately 2000 megawatts since 1989 would be overwhelmed by the growth in loads.

However, this situation is probably unrealistic given the requirements of today's river operations. Because of the requirement to provide summer flows for salmon, we think it is unlikely that today's operators would allow reservoirs to be drafted as low as they were in in the fall of 1988 and early winter of 1989. The targets in the current Biological Opinion are for reservoirs to be at flood control throughout the winter, To achieve this in a year with low stream flows, operators would run thermal plants harder and made additional purchases of imports throughout the fall and early winter. To test this hypothesis, we ran the previous simulation, beginning the opeating year with the reservoirs as thery were at the end of August of 1988. We used '88-'89 stream flows with the current operations of the hydro system. The results are shown on Figure 13.

Figure 13



As this figure shows, the amount of hydro generation that we get during the period of highest demand, is approximately 4000 megawatts greater than shown on Figure 12, As a result, the severe energy deficit observed in Figure 12 is transformed into a couple of significant but much smaller peaking problems. There is, of course, a cost to this operation that we have not evaluated. However, in this instance, there is also a significant benefit to the power system.

Questions Requiring Further Analysis

We have fairly high confidence that the analysis is giving a reasonable representation of potential power supply adequacy problems. There are, however, factors that deserve further analysis that could alter the results to some degree. These questions will be addressed during Phase 2 of the study. They include:

- Cross-Cascades transmission transfer capability – We have estimated that during a winter event, the East-to-West cross-Cascades transfer capability would not be limiting. If, on further analysis, it turns out to be a limiting factor, the frequency and magnitude of supply problems would be larger.
- Intra-month stream flows – The analysis uses monthly average natural stream flows (the shortest time step currently available in the hydro-regulation model) and does not include the effects of reduced unregulated side flows into the reservoirs during extreme cold events within a month. This could exacerbate problems during extreme cold events.
- Availability of imports from Canada – We have assumed that during cold events, British Columbia and Alberta will also be experiencing increased demand and will not have significant exports available for our use. If there were emergency operations that could make Canadian power available, it would reduce the magnitude and frequency of supply problems here.

- Hydro generating unit forced outages and maintenance – While *GENESYS* has the capability of simulating hydro forced outages, further work needs to be done to separate the effects of forced outages on hydro units from deferrable maintenance. This study used an average availability for hydro units, based on the combined effect of forced outage rates and expected maintenance. To the extent that hydro unit maintenance is deferrable, it could be delayed if a cold snap were forecast, and would improve the reliability results in this study. On the other hand, full simulation of hydro unit forced outages would tend to decrease reliability. It is not clear at this time what the direction of the net effect would be. Work is ongoing to separate the effect of hydro unit forced outage and deferrable maintenance.

- Effect of additional generation versus load reduction in reducing LOLP – As noted earlier, our assessment of the amount of new resources needed to reduce the loss of load probability to 5 percent assumed the addition of combined cycle combustion turbines. It is likely that demand reduction or, for that matter, other generating technologies with different characteristics would interact with the hydroelectric system differently. As a consequence, it may not be possible to mix demand reduction and different kinds of generation on a megawatt for megawatt basis and achieve the same effect on LOLP.

In the longer term, there are a number of enhancements to *GENESYS* that will make it a more useful tool for the analysis of power supply adequacy. In approximate order of priority, they are as follows:

- Enhanced economics – At present, *GENESYS* incorporates only a relatively rough representation of the economics of operation of the Northwest power system including its interaction with other areas of the WSCC. To adequately evaluate the economics of different system operation alternatives will require simulating demands and resources not only in the Northwest, but also in the connected areas of the WSCC. This simulation does not need to be as detailed as exists in models like AURORA but is essential if the economics of various operational alternatives are to be evaluated.

- Shorter time periods – At present, *GENESYS* simulates hydro conditions over 14 periods in a year (the months of April and August are split, the rest of the months are whole). The stream flow data exists to allow simulating over 24 periods. This would yield a better representation of hydro generation.

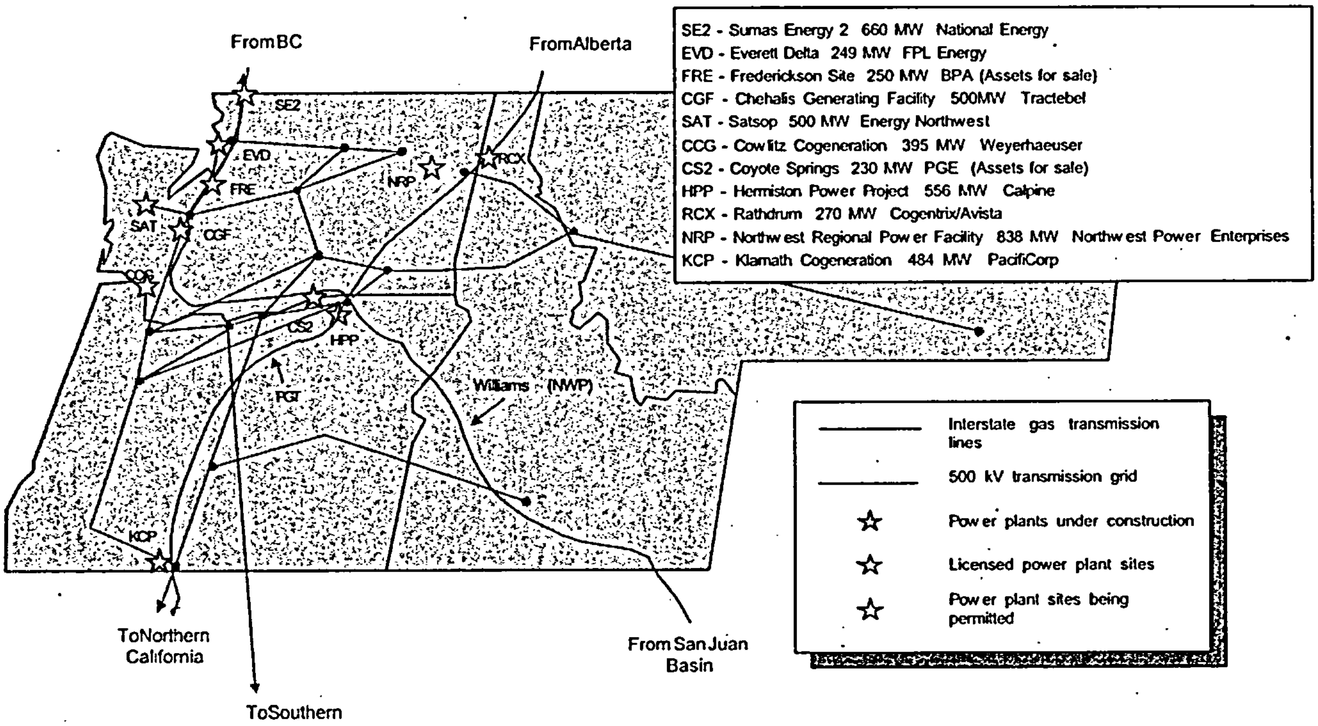
- Random water – *GENESYS* currently treats year-to-year variations in hydro conditions by going through the 50 years of the historical record sequentially multiple times. That is, the first game begins with 1929 water and proceeds through the record in sequence. The second game will begin with 1930 water and proceed through the record in sequence, and so on until the simulation has begun with each of the years in the record several times. Because there is relatively little correlation in water conditions from year to year, it would be preferable to be able to treat water conditions randomly. This will require some enhancements including determining the operation of Canadian dams dynamically.

New Power Plant Development

As the foregoing analysis shows, significant amounts of new resources are required to bring the loss of load probability down to a level consistent with our interpretation of industry standards. We now have a competitive generation market in which new generation development is typically undertaken by independent (non-regulated) developers. We would expect some part of the needed new resources to be supplied by new generation developed in response to market forces. The question is how much?

The Council maintains an inventory of existing generating projects and new project proposals. This provides us with an understanding of the type, location and size of new projects that could be constructed in the Pacific Northwest. What is uncertain is how many of these projects might be built and when they might enter service. Figure 14 shows the location of proposed projects in relation to the major natural gas pipelines and the transmission grid. All of the proposals are for natural gas-fired, combined-cycle combustion turbines, and range in size from about 250 to over 800 megawatts. Of these projects, only one is actually under construction – the 484 megawatt Klamath Falls Cogeneration Project in southern Oregon. Construction permits have been secured for the rest, save one. These permitted sites are capable of accommodating about 3,700 megawatts of new capacity. A site certificate for a 660 megawatt project is being sought for the remaining site.

Figure 14
Proposed Northwest Power Plants



As described earlier, we have used AURORA™, an electricity market model of the western North America power system developed by EPIS, Inc., to forecast market-driven resource retirements and additions. AURORA was developed primarily to forecast wholesale electric power prices. Because wholesale electricity prices are expected to drive development (and retirement) of generation in an increasingly deregulated generation market, AURORA can also be used to forecast the development (and retirement) of generating resources.

We modeled the Western Systems Coordinating Council (WSCC) electricity system as 15 geographic load-resource areas. These load-resource areas are generally defined by transmission constraints. Each area is characterized by an inventory of its existing generating units, fuel price forecasts, a load forecast, and a portfolio of new resource options. Transmission interconnections between the areas are characterized by transfer capacity, losses and wheeling costs.

Because we are interested in where in the Northwest development might take place, not just how much and when, we have chosen to model the Pacific Northwest as four load-resource areas. For this analysis, we have divided AURORA's standard single Washington/Oregon area into two areas – West of the Cascades and East of the Cascades. This was done in anticipation of the possibility that transmission across the Cascades could be constraining. The remaining two Northwest load-resource areas are southern Idaho and Montana.

AURORA forecasts hourly market clearing prices by dispatching generating units to meet forecast load-resource area loads. Unit dispatch is based on the variable cost of unit operation. Area loads may be served by native generation, or, if economic considering transmission capability, units located in other areas. Hourly electricity prices are established for each load-resource area by the variable cost of the most expensive resource dispatched to meet that area's load.

A forecast of generating unit retirements and additions is developed through an iterative process, in which the present value of candidate resource additions and retirements is calculated for each year over the study period. Existing resources are retired if market prices are insufficient to meet future maintenance and operation costs. New resources are added if forecast market prices are sufficient to cover the fully allocated costs of resource development, maintenance and operation, including a return on the developer's investment.

Key Assumptions

Because independent generating companies are the primary developers of new generating resources, we assume that future projects will be developed under financial conditions representative of this type of developer. These financial assumptions are described in Appendix A. We assume that projects currently under construction are completed as scheduled, and that proposed retirements reported by WSCC occur as scheduled. These scheduled additions and retirements are listed in Appendix A. Additional project development and retirements are market-driven, as forecast by AURORA.

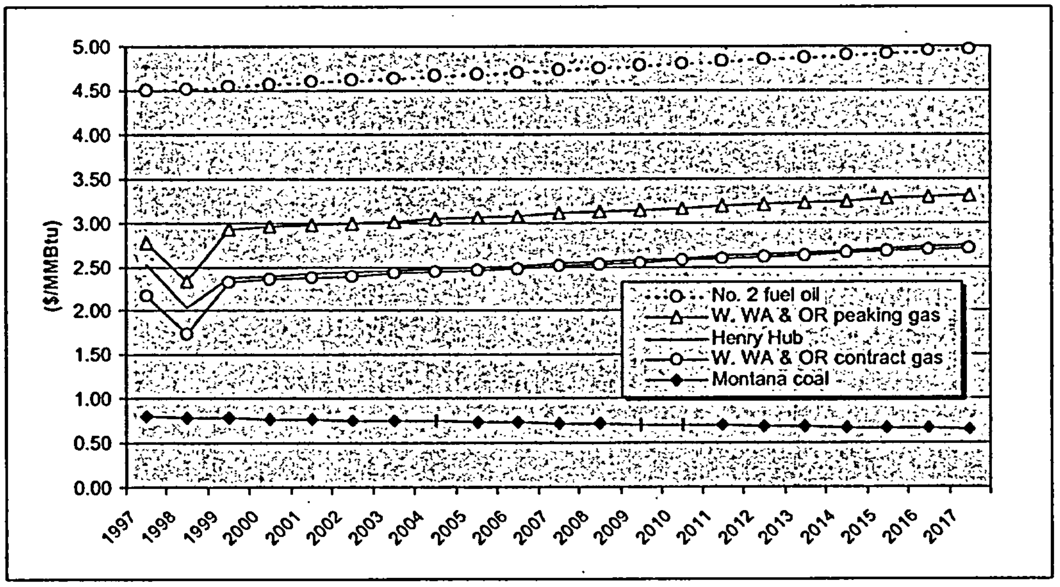
The findings described in this report are based on average water conditions from 1929 through 1978. Hydropower conditions can strongly affect wholesale electricity prices. It appears that the relationship is somewhat asymmetrical because price increases during poor water conditions are greater than the decline in prices under good water conditions of equal probability. However, this effect may be offset by greater price volatility observed in several good water years. Because long-term system expansion analysis using stochastic modeling of water conditions is very time consuming in AURORA, we are exploring the magnitude of price asymmetry and whether "slightly dry" water conditions should be used when forecasting wholesale prices.

Loads are also treated deterministically, using average load shapes and load growth. The forecast growth rate averages 1.5 percent per year for the WSCC as a whole. Load growth forecasts for the individual load-resource areas are provided in Appendix A. High loads, like poor hydropower conditions may have a disproportionate effect on prices. We plan to further explore the effect of load variation on prices.

One of the most significant drivers of power prices and, as a consequence, new generation development, is the price of natural gas. Our natural gas price forecasts have been revised upward to reflect recent trends. Natural gas prices in AURORA are referenced to the price at Henry Hub, Louisiana. The Henry Hub gas price for 2000, for example, used for this study is $2.40/MMBtu, compared to $2.05/MMBtu for the Council's 1998 Bonneville costs and revenues study[11].

The Henry Hub base price is adjusted to account for regional differences. For example, in the past Northwest gas prices have been low relative to the rest of the West because of our access to gas from Alberta and British Columbia and the relative lack of competition for that gas. The recent extension of the Northern Border pipeline to the Chicago area has eroded that price advantage. Completion of the Alliance pipeline to Midwest markets is expected to sustain the higher prices now seen for western Canadian gas. This price increase is reflected in our current forecasts of Northwest gas prices (Figure 15). Also shown are the price forecasts for gas at Henry Hub, Montana coal and distillate fuel oil. Additional information regarding fuel prices is provided in Appendix A.

Figure 15
Selected Fuel Price Forecasts



The new resource alternatives considered in this study include simple and combined-cycle combustion turbines fired by natural gas, wind, landfill gas energy recovery, advanced coal-fired power plants and central-station solar photovoltaic plants. Natural gas combined-cycle combustion turbine power plants are currently the generating technology of choice, and are likely to comprise the majority of new baseload capacity brought into service over the period of interest in this study. Simple-cycle gas-fired combustion turbines may be the economic choice for peaking applications. There is great interest in promoting the development of generation using renewable resources, and it is likely that various renewable resource incentives such as production tax credits and green power marketing programs will continue through the period of interest. We used a production credit of 1.5 cents/kWh for new renewable resources, extending through 2010 as a proxy for various renewable resource incentives. In the longer-term, it is possible that distributed generation such as packaged small-scale cogeneration units using

[11] Northwest Power Planning Council. Analysis of the Bonneville Power Administration Potential Future Costs and Revenues (Document 98-11). June 1998.

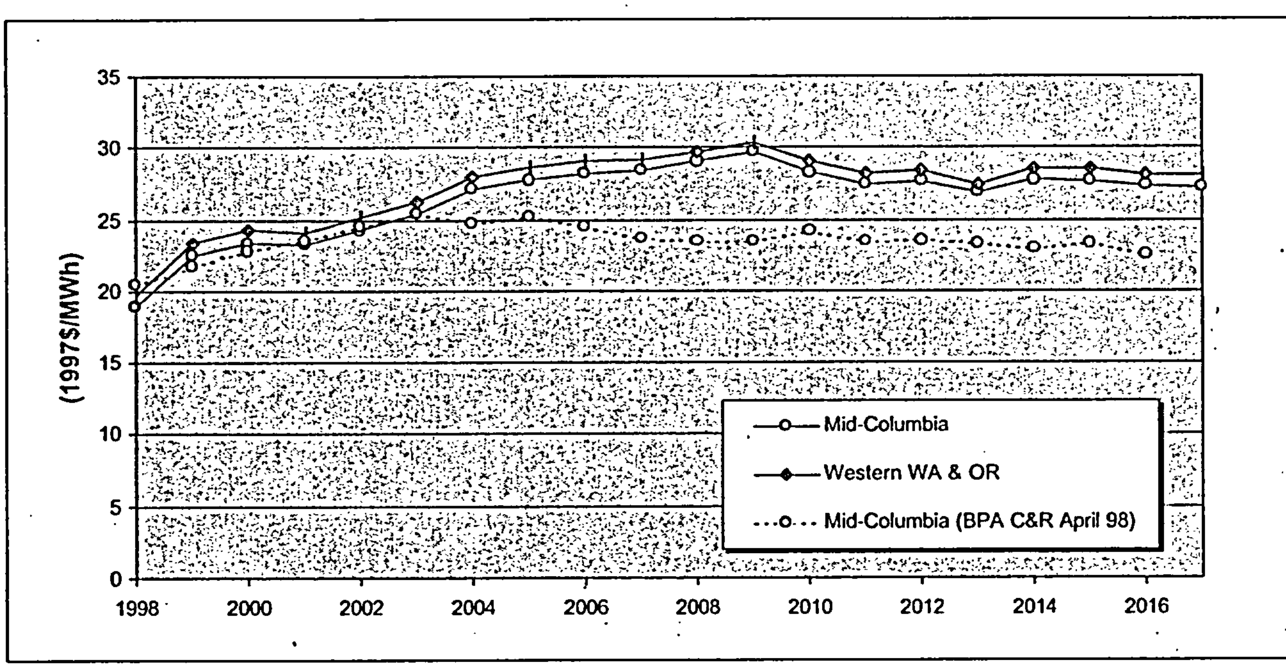
microturbine or fuel cell technologies will begin to penetrate the market. These, however, have not been specifically modeled. The new resource alternatives used in these studies are further described in Appendix A.

Finally, assume that some load could be voluntarily curtailed if economic compensation were available. When resources are insufficient to meet load, the price of this curtailed load determines the market price. Our estimates for the supply curve of unserved load rely on work done as part of the Council's 1998 study of Bonneville future costs and revenues. Based on limited information from Florida and California load curtailment programs, we assume that up to 25 percent of load is available for voluntary curtailment. For modeling purposes, this 25 percent is divided into five, 5 percent blocks. These curtailment blocks are priced at $50, $100, $150, $250 and $500 per Megawatt-hour. AURORA's system expansion results are sensitive to this parameter, and it is one subject to considerable uncertainty.

Forecast Electricity Prices

AURORA forecasts wholesale electricity prices for the 15 load-resource areas and for the major WSCC trading hubs. Prices are forecast over a 20-year period to allow the cost-effectiveness of generating resource for the 2000 - 2006 period of interest to be more accurately assessed. Forecast average annual Pacific Northwest prices are shown in Figure 16. Mid-Columbia prices are representative of eastside Pacific Northwest, whereas the Western Washington and Oregon prices are representative of westside. The Mid-Columbia forecast developed for the Council's 1998 assessment of Bonneville's future costs and revenues is shown for comparison.

Figure 16
Forecast Annual Average Mid-Columbia Electricity Prices



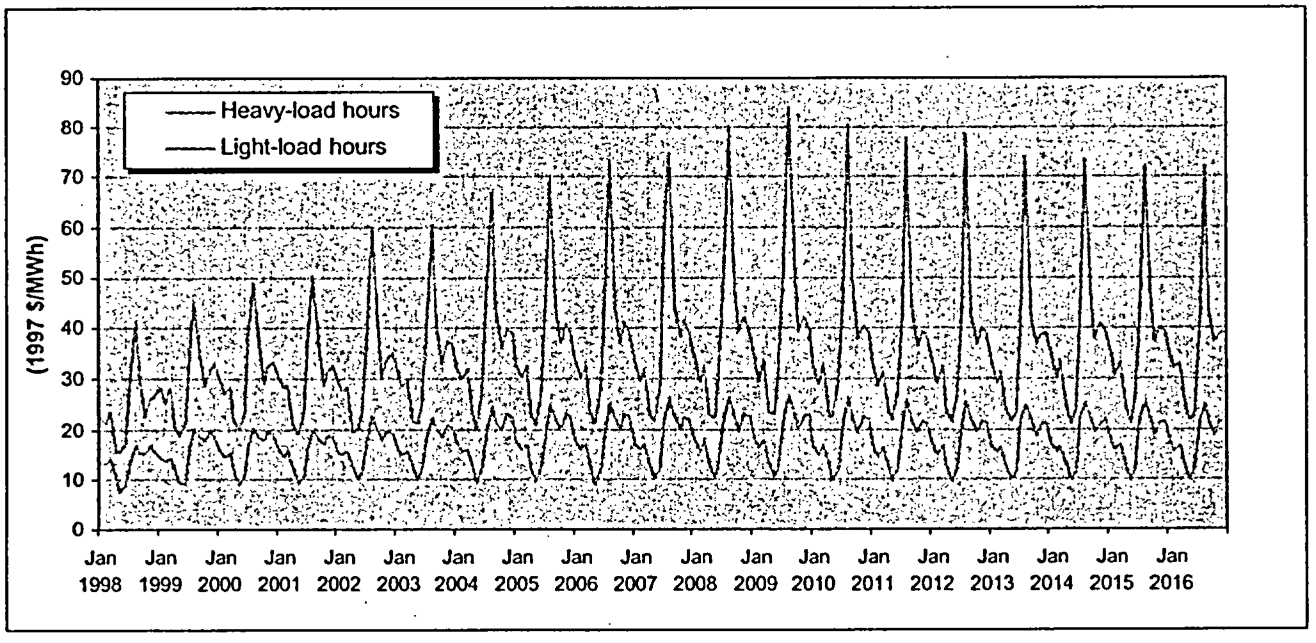
The overall form of the price forecast is very consistent between studies. Prices gradually increase through the early years of the study period as loads grow. Increasing loads force the dispatch of more costly, less efficient units to meet peak period loads. As prices approach the fully allocated cost of new generating resources (primarily gas-fired combined-cycle units), new units are added. Average prices level off at the fully allocated cost of these new resources. Because forecast increases in the efficiency and reduction in cost of new plants largely offset forecast increases in gas prices, prices remain fairly stable in real terms once reaching the fully allocated cost of new plants. Further real price increases would not be expected unless gas price escalation exceeded the offsetting effects of efficiency improvements and capital and operating cost reduction.

The West Side area forecast prices exceed the Mid-Columbia prices by an average of $0.80/MWh over the study period. This results from the persistent West Side capacity deficit and the transmission losses between the West Side and exporting areas, particularly the East Side. (This study assumed no trans-Cascades wheeling or congestion charges.)

While agreeing closely with the base case forecast prepared in 1998 for the Council's assessment of future BPA costs and revenues (lower curve) during early years of the study period, the current forecast ranges up to 25 percent higher during the later years. Higher fuel price forecasts and corrected hydropower energy characteristics appear to be the principle reason for higher long-term prices. Other revisions to assumptions and the model also contribute to the difference between the electricity price forecasts.

The annual average prices of Figure 16 obscure the increasingly evident shorter-term volatility of wholesale power prices. Figure 17 shows monthly average prices for heavy and light load hours. While off-peak prices remain relatively stable, increasingly strong peaks are forecast for late summer months. These are produced by the influence of daily air-conditioning loads in California and the Southwest. As these loads grow, increasingly less efficient and costly generating capacity (or economic curtailment) is dispatched, increasing peak period prices. While we think of the Northwest as a winter peaking system, we are part of an interconnected western market and market prices in this region reflect that fact.

Figure 17
Mid-Columbia Heavy and Light Load Hour Monthly Average Prices



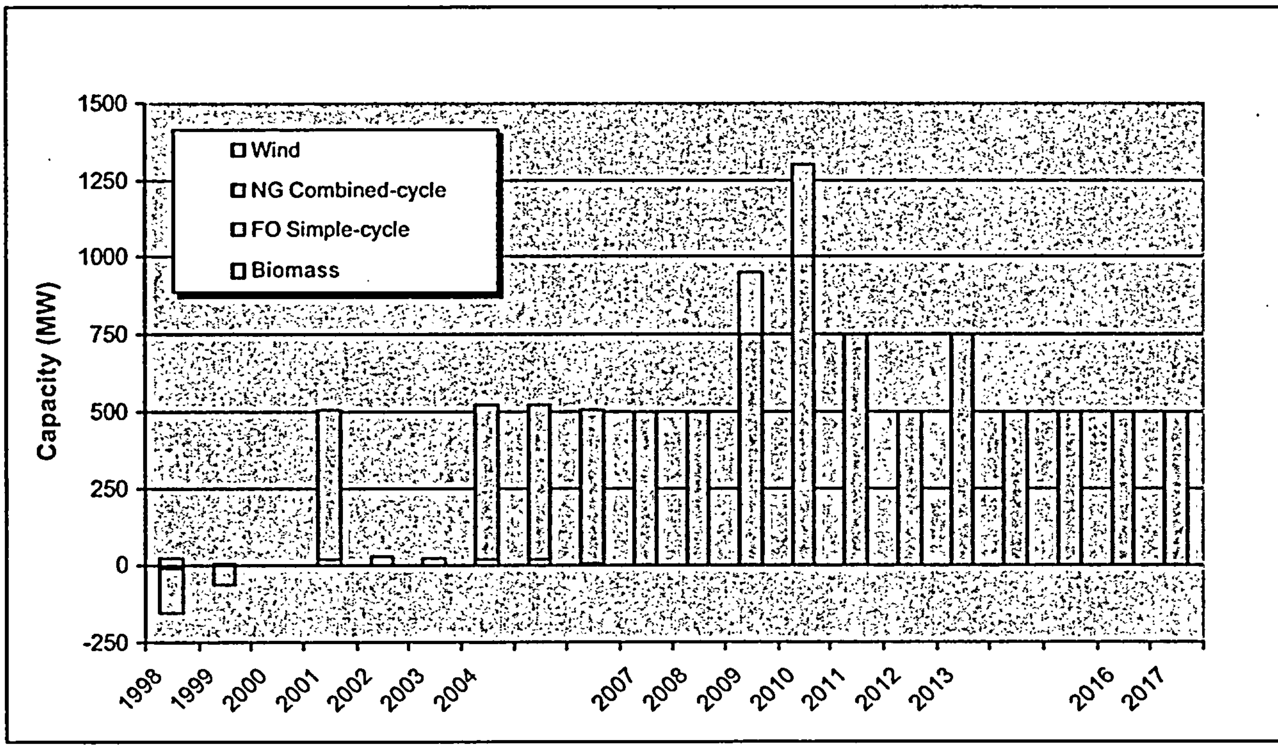
As loads grow and prices increase, wholesale prices will reach a point where the development of new generating capacity becomes economic. This point will be when future prices are sufficient to recover the fully allocated costs of constructing and operating new capacity.

AURORA forecasts net addition of about 9,000 megawatts of capacity for the four Pacific Northwest load-resource areas from 1998 through 2017. These additions are shown by resource type in Figure 18. Several older oil-fired gas turbines and a biomass unit are retired in early years (these retirements have occurred). Early-year additions include the Vansycle wind project in 1998, the Klickitat landfill gas-to-energy facility in 1999 and the 484 megawatts Klamath Falls combined-cycle project in 2001. These units are "forced" into the model as they are already completed or under construction. The recently completed Wyoming Wind Project, though owned by utilities operating in the Pacific Northwest, is not shown on this chart because it is physically located outside the Northwest.

All other additions are market-driven. Gas-fired combined-cycle units dominate new resource development. Beginning in 2004, gas-fired combined-cycle units are forecast to be added at the rate of 500 to 1,000 megawatts per year. In addition, the renewable production credit (as a proxy for an array of renewables incentives) results in the development of a moderate amount of renewables. Small-scale biomass units are added through 2006. At that time the estimated inventory of this resource is exhausted. Small blocks of wind turbines are added in 2009 and 2010, after which the assumed renewable production incentive expires. (The energy contribution of the new wind capacity is somewhat less significant than suggested by the capacity figures of Figure 18. Wind turbines typically operate at about a 30- to 35-percent capacity factor, compared to the 90- to 95-percent capacity factor of a gas-fired combined-cycle plant).

The important finding is that in none of the base studies did market-driven development of large amounts of new capacity in the Pacific Northwest occur prior to 2004, despite continuing load growth and substantial capacity deficit west of the Cascades. This reflects the transition from regulated resource development driven by very conservative (critical period) hydro criteria, to the market-driven resource development simulated in this study. Poor water conditions occur too infrequently to motivate the level of market-driven development needed to maintain previous reliability standards.

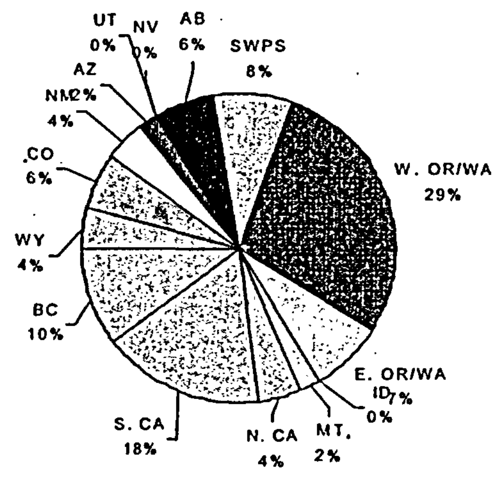
Figure 18
Pacific Northwest Market Driven Resource Development



Most of the forecast resource additions shown in Figure 18 occur in the Western Washington and Oregon load resource area (Figure 19). The western Washington and Oregon area is currently severely resource-deficit, has much larger loads than other Northwest areas and is likely to experience continuing load growth. Other factors favoring west side resource development include reasonable transmission access to seasonally complementary southwestern loads and relatively lower gas prices than southwestern areas.[12]

[12] The model treats the western Oregon/Washington area as a single area and does not incorporate any transmission constrains within that area. In reality, there are transmission constraints that could restrict transmission to the Southwest for resources located in the northern part of the western Oregon/Washington area.

Figure 19
Forecast Resource Development by Load-resource Area



Sensitivity Analyses

In forecasting future resource development we have tried to capture the issues that a project developer would most likely consider in assessing future market conditions. In addition to the factors described above, other less certain factors may influence future wholesale prices and hence a developer's decision to proceed with a project. Among these factors are the effects of a prolonged wet climate period in the Pacific Northwest and possible carbon dioxide mitigation policies. The effect of possible removal of federal dams to support fisheries restoration efforts will be analyzed in Phase 2 of the study.

Pacific Decadal Oscillation

There is evidence that a shift to a cool-wet climatic regime occurred in the late 1990's. If so, we can expect generally cooler and wetter conditions in the Northwest for the next 20 to 30 years. The resulting augmentation of hydropower production would tend to depress wholesale electricity prices and further defer the time by which new capacity additions would be economic.

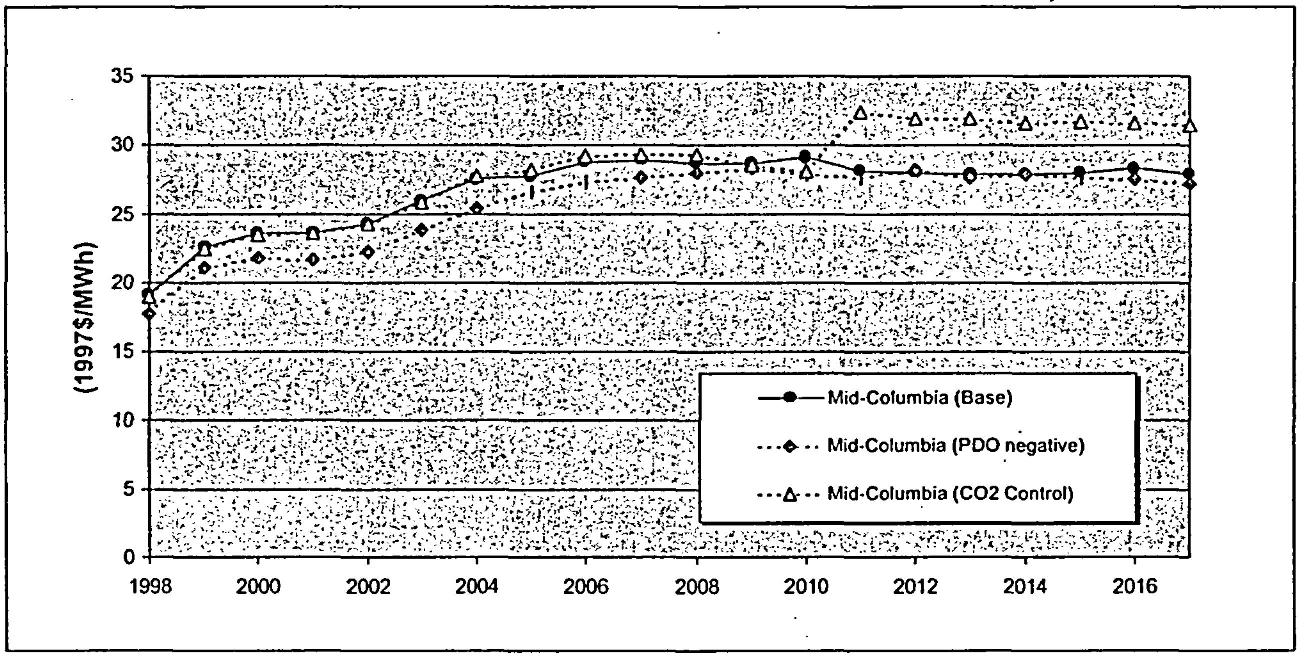
Two main patterns of climatic variation that significantly affect the Pacific Northwest are the El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO)[13]. ENSO, which recurs irregularly on a two- to seven-year time scale, produces warm, dry (El Nino) conditions or cold, wet (La Nina) conditions. PDO, likewise, can produce warm, dry conditions (PDO positive) or cool, wet conditions (PDO negative). The PDO regimes appear to persist for 20 to 30 years and appear to shift abruptly. PDO and ENSO effects are additive, so warm, dry years, for example, can occur during a cool, wet PDO cycle. Nonetheless, the predominant weather during a PDO phase will be that characteristic of the current phase.

The effect of a cool, wet PDO phase on power prices and capacity additions was simulated by substituting average 1946 through 1976 water conditions for the average water conditions of the base case. The years 1946 through 1976 constitute a cool, wet PDO regime for which complete water records

[13] Additional information concerning Pacific Northwest climate variability can be obtained from the Pacific Northwest Climate Impacts Group at the University of Washington. The group's website is http://tao.atmos.washington.edu/PNWimpacts/main.html.

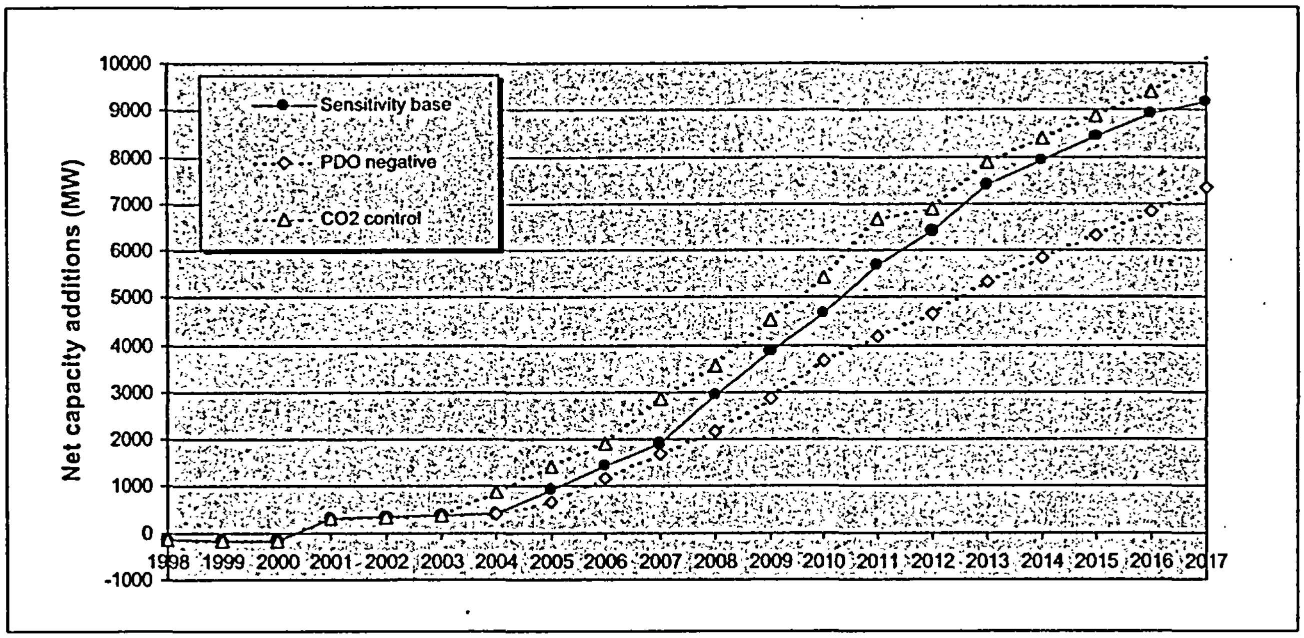
are available. As expected, cool-wet PDO conditions depress prices. As shown in Figure 20, Mid-Columbia prices average 4 percent lower than in the base case (The base case of this and the following sensitivity analyses differs slightly from the principal case described above. The relative effects of the sensitivity analyses should be consistent). The price effects of the cool-wet PDO are most pronounced in the earlier years of the study period when the additional hydro energy curtails dispatch of more expensive peaking units, depressing prices. This effect largely disappears following 2011, once prices have leveled at the fully allocated cost of new resources.

Figure 20
Effects of Sensitivity Analyses on Mid-Columbia Prices



As expected, cool-wet conditions retard the time for which market-driven resource development becomes economic. Initial-year service of market-driven new combined-cycle plants is one unit (250 megawatts) rather than two (500 megawatts). Moreover, as shown in Figure 21, the subsequent rate of development is slower than under base conditions. Clearly, consideration by developers of the possible effects of a prolonged cool-wet climate phase would reduce the rate of market-driven resource development below the rate described earlier. However, if better water conditions actually occur, the probability of failing to meet load would not necessarily increase. The effects of a cold-wet PDO phase on system reliability depend upon the probability of periodic El Nino-driven poor water conditions during the generally wet climate phase.

Figure 21
Effects of Sensitivity Analyses on Pacific Northwest net Resource Additions



Carbon Dioxide Mitigation

Increasing evidence of global climate change from human activity[14] may lead to incentives to reduce carbon dioxide production from fossil fuel combustion. A developer may consider the possible effect of future mandatory carbon dioxide control measures when assessing the financial viability of proposed generating capacity. The possibility of such measures cannot be discounted. Oregon currently requires developers to offset a portion of their carbon-dioxide production, and such efforts are likely to spread if the evidence of human-induced climate change continues to mount.

The effects of carbon-control measures on new resource development are not intuitively obvious. On one hand, generation of power from any fossil-fired plant, including gas-fired combined-cycle units, would become more expensive. This might suppress development of new fossil-fueled generating capacity and reduce energy demand through price elasticity. On the other hand, because of the relatively low carbon content of natural gas compared to other fossil fuels, and the high thermal efficiency of combined-cycle plants, replacement of existing coal or oil-fired units with new combined-cycle units may become economic.

Possible future carbon control measures were simulated by a fuel carbon tax of $10/ton carbon dioxide equivalent. The tax is assumed to take effect in 2011, following expiration of the renewables production incentive. As expected, wholesale prices increase abruptly by about $4.00/MWh (about 14-percent) with introduction of the tax in 2011 (Figure 20). Also, prices are higher, by roughly $0.5/MWh from 2005 through 2008, possibly from accelerated development of higher-cost, low-CO2 resources during this period.

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[14] Wigley, Tom M. L. The Science of Climate Change: Global and U.S. Perspectives. Pew Center on Global Climate Change. June 1999. Also see www.pewclimate.org.

In the Pacific Northwest, the earliest market-driven development of new combined-cycle plants shifts forward by about a year (Figure 21). Combined-cycle plant development continues on the West Side at the maximum rate allowed in these studies (500 megawatts per year) through the study period. Wind development in the Northwest increases from 500 to 1,000 megawatts, but still ceases when the renewables production incentive transitions to a carbon tax in 2011 (wind development continues in areas with more favorable wind regimes).

Because of the uncertainties associated with future carbon dioxide regulation, it seems unlikely that developers would advance development schedules on the anticipation of later enhanced returns on a project. However, these results suggest that the effects of possible future carbon control measures should not discourage developers of gas-fired combined-cycle power plants.

Conclusions

Because of construction lead-time requirements, it is unlikely significant new capacity could be placed in service in the Northwest prior to the winter of 2001-2002. Simple-cycle units, requiring about a year of construction could be in service by that time. However, none of the currently licensed Northwest sites are permitted for simple-cycle capacity. Not only has there been little apparent recent interest in the development of new simple-cycle capacity, but also several older simple-cycle units have recently been retired.

This assessment suggests that the development of new generating capacity by independent developers is unlikely to be economical prior to about 2004. Following that time, it appears that the wholesale market will support relatively constant development of new capacity in the region at the rate of 500 to 1000 megawatts per year. This capacity would be predominantly gas-fired combined-cycle units, preferentially located west of the Cascade Range. Under the assumption that development incentives for renewables continue for the next decade, we could also see development of land-fill gas energy recovery, several hundred megawatts of wind capacity and possibly other types of relatively low-cost renewables.

Though these findings are very consistent throughout model runs performed for this assessment, it would not be unrealistic to expect one or two new combined-cycle projects (beyond the Klamath Cogeneration Project) prior to 2004. Because of the large number of assumptions required for this forecast and the complexity of the modeling process, we are less certain of this forecast than we are of other elements of this study. The wholesale price forecasts, and in turn, the forecasts of market-driven resource development, are particularly sensitive to assumptions regarding load curtailment and fuel prices. The cost and availability of voluntary load curtailment is poorly understood, and fuel price forecasts are inherently uncertain.

On one hand, our estimates of new generation costs may be pessimistic. Developers may be able to secure better deals on fuel, equipment or financing than assumed here, allowing them to proceed with development earlier than forecast. Some developers may have sufficient financial resources to carry them through early years of low market prices in anticipation of higher payoffs in the longer term. Moreover, new project development is likely to be cyclical, with periods of optimistic development followed by periods of surplus. A development cycle could be stimulated by a cyclic upswing in market prices. These factors are not easily captured in Aurora, a model that seeks perfect economic timing of new projects.

Other factors weigh against earlier development than forecast here. Project development opportunities abound in North America. Over two hundred simple- and combined-cycle projects have been announced in North America within the past two years. Many of these projects are located in regions having more predictable prices than the Pacific Northwest. Most project developers are national or international businesses and will generally direct their investments to the projects with the most certain returns, other factors being equal. This same abundance of proposed projects has shifted the "heavy duty" turbine business from a buyer's to a seller's market. Delivery times for new equipment orders are reported to be three years. Though a large-scale developer might shift a couple of advanced-order turbines to a Northwest project, delivery constraints may limit the availability of many new heavy-duty machines prior to 2004. The aeroderivative turbine market remains weak due to slow aircraft orders, however these units are not well suited for combined-cycle applications.

A final point is that AURORA is a less-than-perfect tool for this kind of analysis. It essentially tells us what, when and where a "rational actor" developer would build to serve base loads. Not surprisingly, AURORA primarily chooses to develop combined cycle units whose relatively high thermal efficiency and resulting low operating costs will allow them to operate a relatively large percentage of the time. The kind of problem we are trying to address is a situation of potentially significant but relatively short and infrequent periods of supply inadequacy during which wholesale prices could be expected to be quite high. For such a situation, a generating resource with lower capital costs and higher operating costs such as a simple cycle combustion turbine might make more sense.

To evaluate such a situation, a model needs to be able to capture the variation in hydro generation and loads. Optimally, this would be done using stochastic modeling of hydropower conditions. AURORA does have the capability to be run in a Monte Carlo mode with variations in hydro corresponding to the 50-year historical record. However, for a resource expansion analysis, the run time is prohibitive. We are trying to simulate the price effect of year-to-year hydro variability by using somewhat drier than average water conditions approximating the condition that would yield expected prices over the long term. Aurora's stochastic modeling capabilities can, however, be used relatively efficiently to evaluate the economics of a specified resource schedule. Staff is working on an analysis where single-cycle units are substituted for some of the combined cycle units and their starting dates are moved up in time to see if the market would support such development. We are, however, unaware of any developers in the Northwest who are actively considering the development of single cycle units.

In conclusion, although there are shortcomings to our analysis, as a practical matter, it would be very difficult to bring 3,000 megawatts of new generation on-line in the Northwest by 2003. Though a new project or two may see service in the Northwest by 2003, it is highly unlikely that the market will deliver the 2,500 to 3,000 megawatts of new capacity required to resolve the reliability issue by 2003.

Operation of the Hydroelectric System and Impacts to Fish and Wildlife

During times when all available resources are generating electricity and available imports are being used and the region is still unable to meet its demand, the hydroelectric system can be pushed a little harder, over short periods of time, to help out. This is often called using hydro flexibility for emergency conditions. The term "hydro flexibility" refers to the additional energy that can be generated when some operating constraints of the hydro system are temporarily violated. Any additional water used would be replaced as soon as possible through additional power imports or thermal generation at a later date so as to be able to meet critical fish recovery standards for reservoir levels and flows. The use of such flexibility for winter cold snap reliability is acknowledged in the current Biological Opinion on Hydropower Operations.

Some level of use of flexibility is inevitable. We have treated the use of hydro flexibility as a last resort, after additional imports, use of non-treaty hydro storage and provisional drafting of Canadian reservoirs. Over the next couple of years, before new resources or voluntary load reduction can be added to the system, it could be necessary to use hydro flexibility quite heavily to avoid involuntary curtailment.

The preliminary results of this reliability study, with regard to the operation of the hydroelectric system and fish and wildlife concerns, can be summarized as follows:

Practically speaking, it will not be possible to add any significant amount of new generating capacity in the Northwest for at least a few years. Beyond that period, it is not clear that the market will result in sufficient development to assure adequate supplies. This means that over the next few years, there is a higher probability that reservoirs will be drafted to lower elevations during the winter months to maintain service to customers. In years when this occurs, less water will be available for spring and summer flow augmentation to aid anadromous fish migration. In the near term, the effect on flows is not that great. In the longer term, without new resources, the result could be significant.

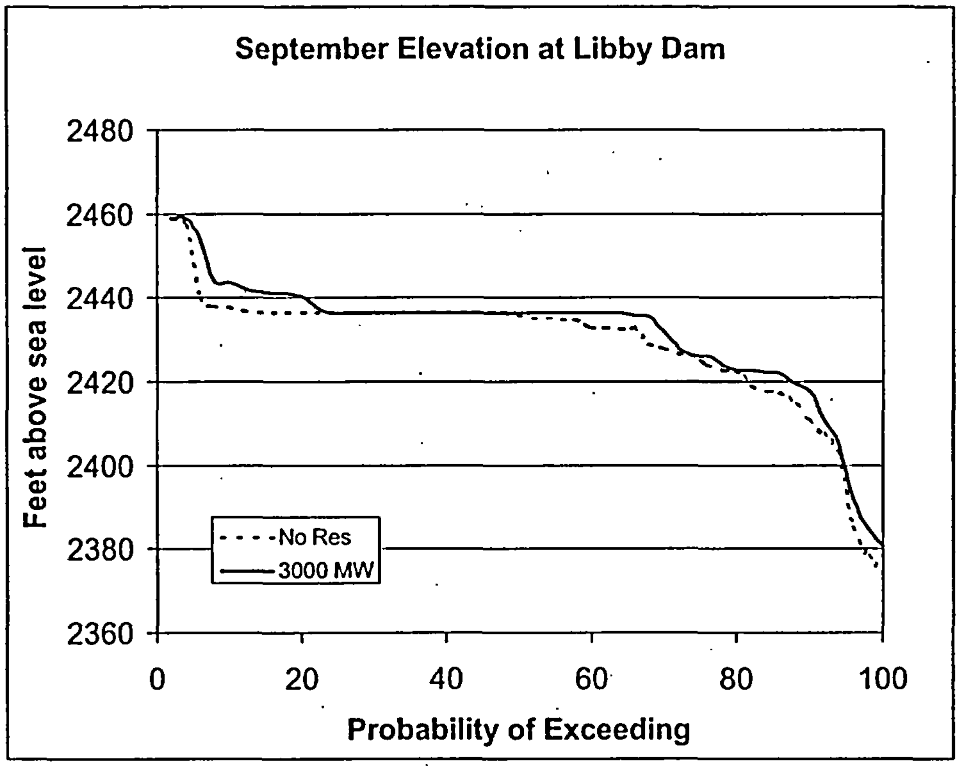
To illustrate the effects of using hydro flexibility we examined two cases. In each case hydro flexibility is used when needed. In the first case, no new resources come online until after 2003. In the second case, 3,000 megawatts of new generating capacity is on-line by 2003. We chose to observe impacts at Libby Dam in 2003 simply as an example of how all the major reservoirs will be affected. While impacts will vary by reservoir, the results at Libby are a fair representation of what would occur at other projects.

The next six figures display what are commonly called "duration" curves. These types of graphs indicate the likelihood that some parameter will be at or above a certain level. In Figure 22, below, for example, the curves show the likelihood of Libby Dam's reservoir being at or above a certain elevation in September of 2003.

Libby's elevation duration curve for each of the two cases mentioned earlier is shown in the figure below. The first curve (dashed line) represents the scenario with no new resource development in the Northwest. The second case (solid line) is a scenario in which 3,000 megawatts of newly installed generating resources are online by 2003.

As an example of how to read the chart, examine the solid line. As you follow its descent from an elevation of 2,460 feet on the left to about 2,380 on the right, you will notice that it drops away from the 2,460 level at about the 4-percent mark on the horizontal axis. This means that there is a 4-percent probability that Libby's reservoir will be at 2,460 feet (full) in September of 2003.

Figure 22

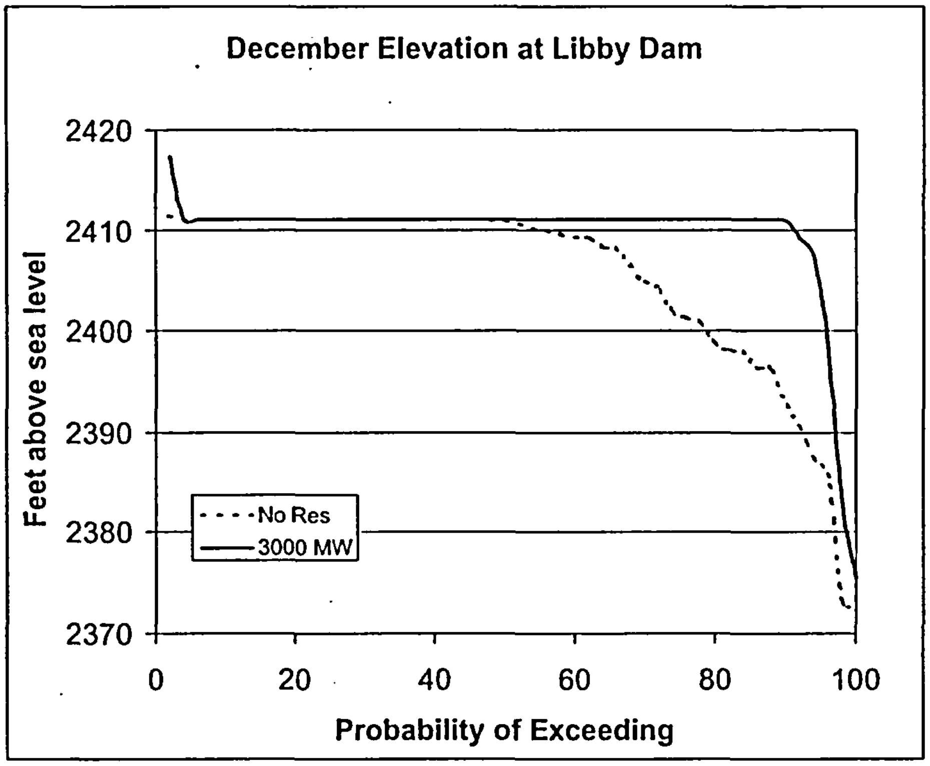


By observing the curves in Figure 22, we conclude that there is about a 70-percent chance that Libby will be at a lower elevation in September of 2003 under the "no new resource" scenario (about 70 percent of the time, the dashed line is below the solid line). In years when Libby is lower, it will be about four feet lower on average. The difference in elevation ranges from one to seven feet in all but one case (in the worst case, the difference was 14 feet).

Figure 23 presents the December elevation probability curves for Libby in 2003. Although the scale in this figure is different from the one in the previous chart, it should be obvious that the impacts of not including new resources are more severe than in September. This is true because demand for electricity in the Northwest normally peaks sometime between December and February and, if hydro flexibility is going to be used, it will more likely be used in these months.

It is about 50 percent more likely under the "no new resource" scenario that Libby will be lower in December. In years when Libby is lower, it will be about eight feet lower on average. In the worst case, it could be as much as 20 feet lower. The Corps of Engineers would like Libby's reservoir to be no lower (and no higher) than 2,411 feet by the end of December. With new resources in place, that occurs over 90 percent of the time. Without new resources, about 50 percent of the time Libby's elevation will be below that level. Not having Libby at 2,411 feet by the end of December reduces the likelihood that it will reach its desired elevation for anadromous fish considerations by mid-April.

Figure 23



The more severe drafts in winter months under the "no new resource" scenario can often be made up by mid-April when the salmon migration typically begins. (Water is restored by reducing flows and importing energy from out of region or from in-region non-hydro resources).

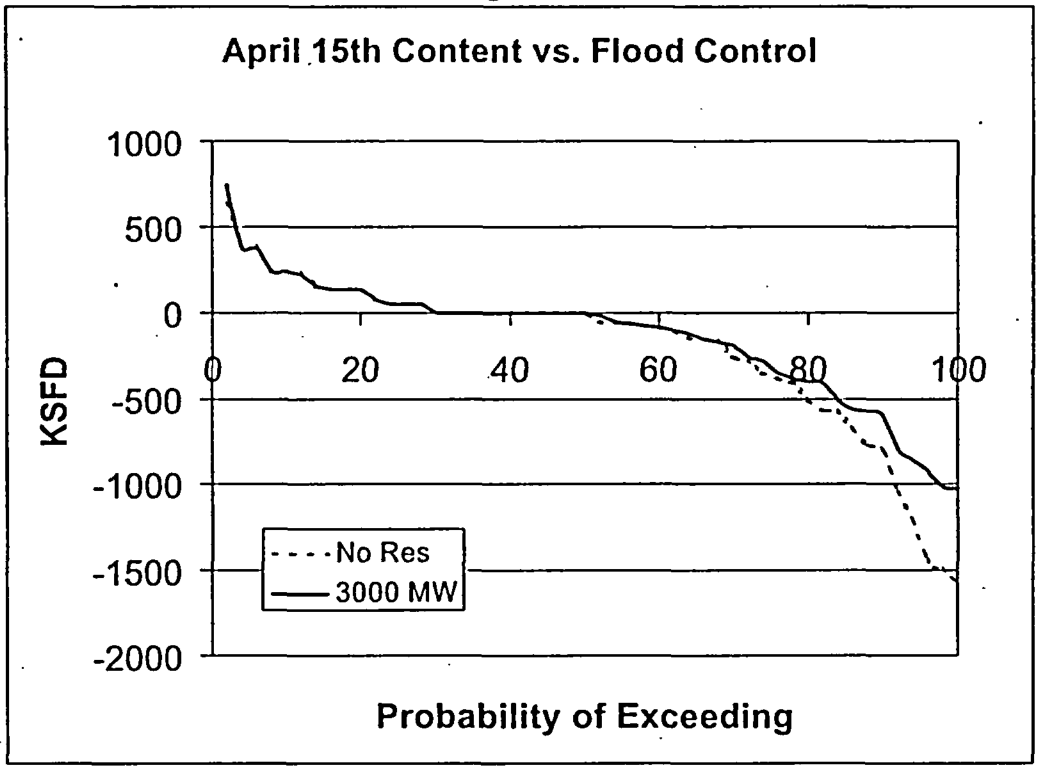
Figure 24 below is also a probability chart, but unlike the previous charts it presents the likelihood that Libby will be "as full as possible" by mid-April. The curves in this figure indicate how much volume of water (vertical axis is volume in units of thousand second-foot days, or KSFD) above or below flood control is likely to be in the Libby reservoir on April 15th in 2003. When Libby's elevation is exactly at the flood control level, the curve will be at zero.

Flood control elevation is normally the highest elevation that a reservoir can be operated to. In wet years, the flood control elevation tends to be lower. This is intended to provide a space for the expected snowmelt runoff and protect against flooding.

In Libby's case, the reservoir elevation can sometimes be higher than flood control due to an agreement with Canada regarding the elevation at Kootenay Lake (which is downstream from Libby). This effect can be seen on the left-hand side of the graph where the curves are above zero. About 30 percent of the time, Libby will be above its flood control elevation by mid-April.

About 44 percent of the time, Libby will have less volume in its reservoir under the "no new resource" scenario. On average, the shortage will be about 300,000 acre-feet. In the worst case, the shortage is about one million acre-feet.

Figure 24

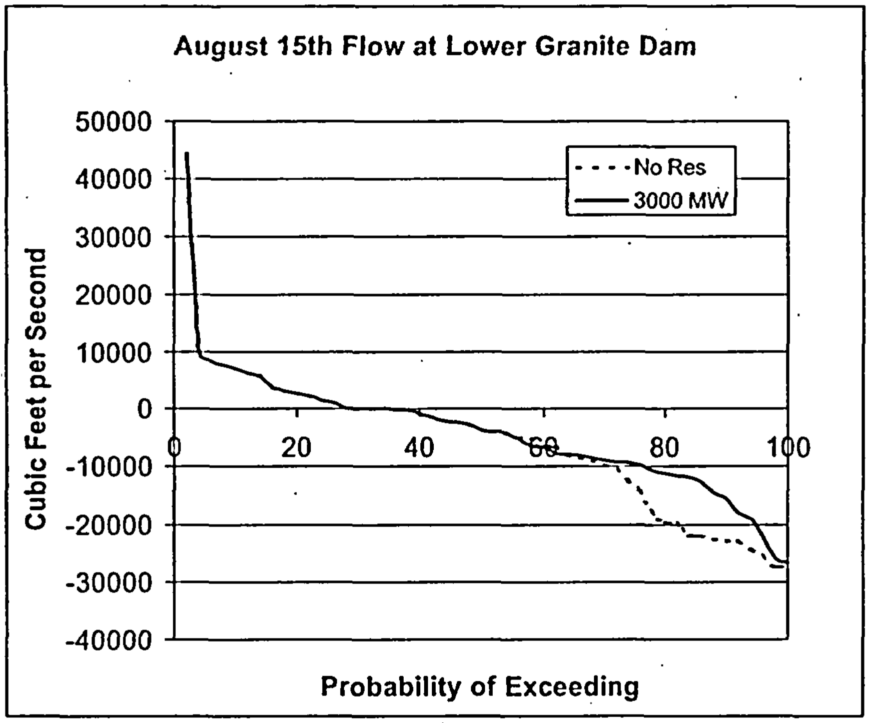


River flows are important for anadromous fish migration. The migration period usually runs from mid-April through August. The average runoff volume during that time period is about 92 million acre-feet. U.S. reservoirs can store about 20 million acre-feet. Under the National Marine Fisheries Service's current Biological Opinion, about 12 million acre-feet can be used to augment flows.

About half the time under the "no new resource" scenario, U.S. reservoirs will have less water by mid-April. In these cases, the average shortage is about 1.1 million acre-feet or about 10 percent of the controllable volume for flow augmentation. Typically, the shortfalls will occur in dry years when the runoff volume is low.

The impacts of this shortage appear in Figure 25 below, which shows the flow probability (relative to the target flow) at Lower Granite Dam in the first half of August in 2003. (We chose to show this month because, typically, the volume of controllable water is not used up until late July or August. Thus differences in flows between the two scenarios we are examining will most often appear in this time period.) Under each scenario there is about a 30-percent probability that August flows at Lower Granite will be equal to or greater than the target level. (The target flow at Lower Granite in this month is 50,000 cubic feet per second). About 40 percent of the time, flows are lower at Lower Granite Dam under the "no new resource" scenario. In years when flows are lower (typically drier years), they average about 4,500 cubic feet per second lower. During these years, the flow at Lower Granite averages between 30,000 and 40,000 cubic feet per second. In the worst case, the flow is nearly 10,000 cubic feet per second lower.

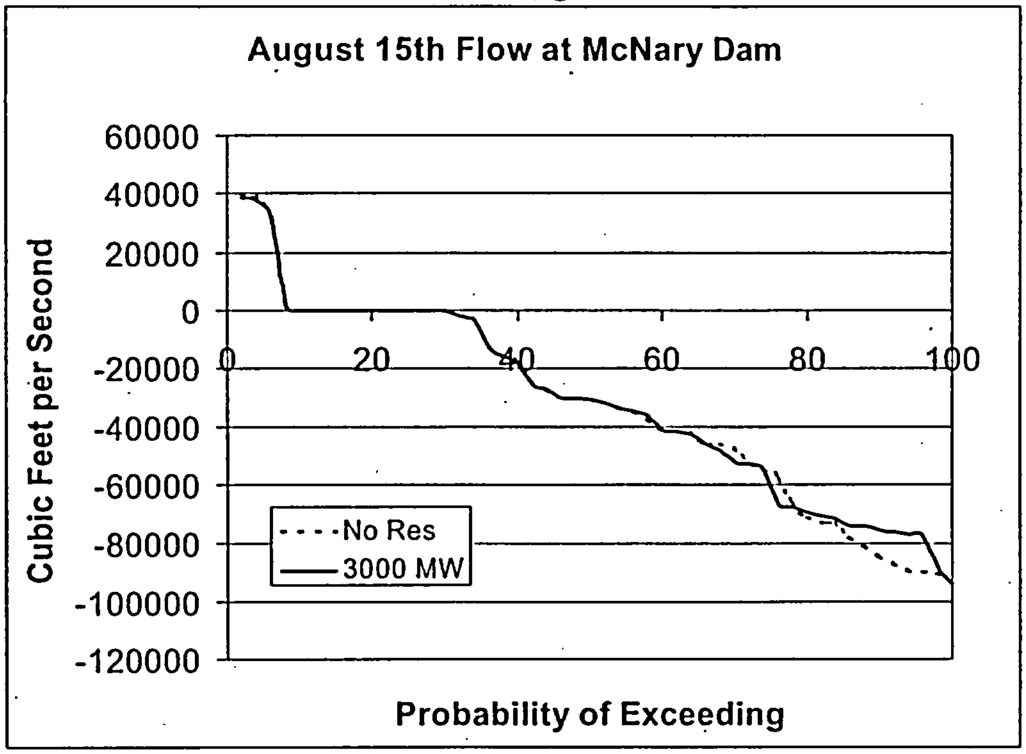
Figure 25



In looking at the flow probability curves at McNary Dam, in Figure 26 below, we observe the impacts of actions on both the Snake and Columbia rivers. Again we see that about 30 percent of the time, under each scenario, flows at McNary are equal to or greater than the target level. (The Biological Opinion flow target at McNary for this period is 200,000 cubic feet per second).

About 22 percent of the time (the dashed line is below the solid line about 22 percent of the time), flows are likely to be lower in the "no new resource" scenario at McNary in the first half of August, 2003. In years when flows are lower (again, typically dry years), they average about 6,000 cubic feet per second lower. In the worst case, the flow is nearly 13,000 cubic feet per second lower.

Figure 26



Although this result is not good for migrating salmon, it is not as bad as it could be. Converting the 6,000 cubic feet per second average shortfall into units of volume yields about 200,000 acre-feet. This volume is much less than the average shortfall of flow augmentation water in April, which was about 1.1 million acre-feet. So where did the extra water come from? The answer is from reservoirs drafting below the Biological Opinion flow augmentation limits to meet power needs. Figure 27 helps illustrate what is going on.

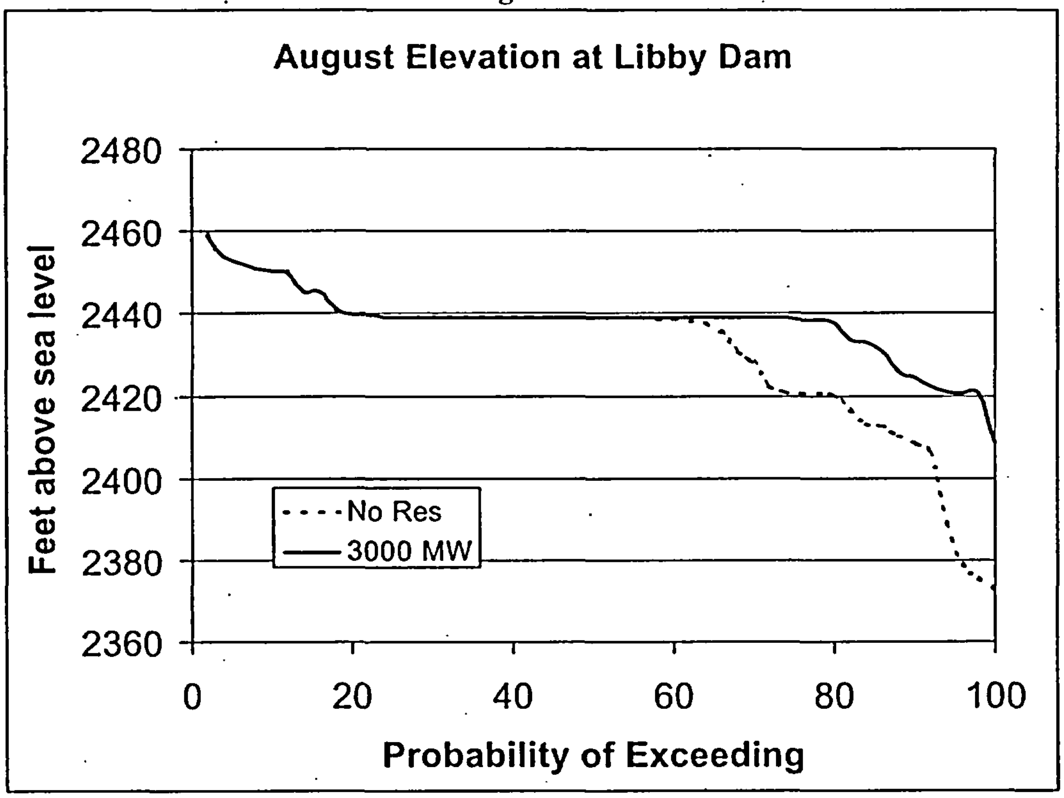
This chart (similar to the first two) shows the elevation probability at Libby Dam for the end of August in 2003. About 44 percent of the time, Libby will be lower in the "no new resource" scenario. In years when it is lower, it will be 17 feet lower on average. In the worst case, Libby is 45 feet lower.

The Biological Opinion draft limit for flow augmentation for anadromous fish at Libby is 2,440 feet (or 20 feet down from full). As can be seen in the chart below, the solid line is on or above 2,440 feet about 80 percent of the time. The remaining 20 percent of the time, Libby is drafted below this limit to help maintain flows for sturgeon or for power needs.

In the "no new resource" scenario (dashed line), Libby is below the Biological Opinion draft limit nearly 40 percent of the time, twice as often as in the "new resource" case. It is safe to assume that every time the dashed line is below the solid line, that Libby was used for power needs and not for flow augmentation. And, whenever Libby is drafted for power needs, it is coincidentally increasing river flows, which help migrating salmon. This effect tends to mitigate the shortfall of flow augmentation water (Figure 24) under the "no new resource" scenario.

Impacts to other federal reservoirs will vary but in general are similar to those for Libby. By not developing new resources and, therefore, relying heavily on the hydro system to maintain reliability results in what many would interpret to be unacceptable operations at federal hydro projects. The impacts show a higher probability that reservoirs will be at lower-than-desired elevations in the winter months and that less volume of flow augmentation water will be available by mid-April. Flows are not affected as much as one might think because reservoirs are likely to be drafted deeper than the Biological Opinion limits in the summer for power needs. In the longer run, if sufficient new generation and voluntary economic load reduction is added to the system, the use of hydro flexibility should be modest, although there will always be some level of reliance on it. However, failure to address resource needs would, over time, force greater and greater reliance on flexibility with possibly unacceptable results for fish recovery.

Figure 27



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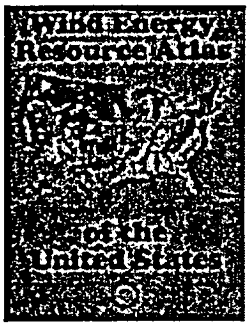

Wind Energy Resource Atlas of the United States

Table of Contents

Chapter 2 The National Wind Resource

Chapter 3: Regional Summaries

This chapter presents a summary of the United States wind energy resource on a region-by-region basis. The regions are identified on the map shown in Map 3-1; the numbers on the map indicate the order in which the regional information is presented. For each region, major wind resource areas are described that have been estimated to have suitable wind energy potential for wind turbine applications (class 3 or greater annual average wind power).

The regional summaries are accompanied by regional and state maps. The regional maps display major cities, mountain ranges, and geographic features. The state maps show the geographic distribution of annual average wind power and depict prominent wind energy areas and other geographic features. Chapter 1 gives information on interpreting the wind power maps.

A latitude-longitude grid is superimposed on each state map to facilitate locating specific places on the maps. The grid cells are 1/4° latitude by 1/3° longitude for states in the contiguous United States. This corresponds to grid cells that are approximately 25 by 25 km (15 by 15 mi). For Alaska, grid cells are 1/2° latitude by 1° longitude. For Hawaii, Puerto Rico, and the U.S. Virgin Islands, grid cells are 1/8° latitude by 1/8° longitude.

Some of the larger states (i.e., Alaska, California, and Texas) are subdivided for the purpose of presenting the analyses more clearly. Some of the smaller states (i.e., Massachusetts, Connecticut, and Rhode Island; Vermont and New Hampshire; and Maryland and Delaware) are combined as a set of states on one map.

The Northwest Region

The Northwest region consists of Idaho, Montana, Oregon, Washington, and Wyoming. Almost half of the region's people live in western Washington and Oregon, where the region's two largest cities—Seattle and Portland—are located. The major cities, rivers, mountain ranges, and national parks are shown in Map 3-2.

The topography varies dramatically throughout the Northwest, which is dissected by the Cascade Range in the western part of the region and by the Rocky Mountains in the central and eastern parts of the region. Over one-third of the region's terrain is hilly and mountainous. Much of the mountainous terrain, and western Washington and Oregon, are heavily forested.

Areas of good wind energy potential are dispersed throughout the Northwest. Some notable areas where wind energy developments have occurred are the Columbia River corridor along the Oregon-Washington border between Portland and Boardman, Oregon, 275 km (170 mi) to the east of Portland; the Ellensburg corridor in central Washington; the Oregon coast; southern Wyoming (especially around Medicine Bow); and the Livingston corridor in southwestern Montana. Goodnoe Hills, located approximately 200 km (120 mi) east of Portland, is the site of three MOD-2 wind turbines currently being monitored by DOE. Medicine Bow, in southeastern Wyoming, has also served as a field test location for several large wind turbines. DOE sponsored measurement programs at seven sites in the Northwest region: Livingston, Montana; Boardman and Cape Blanco, Oregon; Augsburger Mountain, Diablo Dam, and Goodnoe Hills, Washington; and Bridger Butte, Wyoming. The Bonneville Power Administration has taken wind measurements at numerous sites throughout the western part of the Northwest region. The Bureau of Reclamation and Western Area Power Administration, among others, have also been active in selecting sites and measuring the wind resource for potential wind turbine applications.

Considerable amounts of new data have been collected throughout the Northwest region since the completion of the regional atlas (Elliott and Barchet 1980). Analyses of these new data have resulted in some significant changes in the wind energy analysis from the previous analysis.

Major areas in the Northwest region with class 3 or greater annual average wind power are described below. Maps of annual average wind power are presented as Maps 3-3 through 3-7 for Idaho, Montana, Oregon, Washington and Wyoming.

Oregon and Washington Coast

The estimated annual average wind power for exposed coastal areas of Oregon and Washington is class 4 at 50 m (164 ft). Specific sites that experience terrain-induced acceleration of the wind may have greater than class 4 power. The abrupt increase in surface roughness inland from the coastline, because of vegetation and topography, rapidly attenuates the wind resource landward. During winter, the season of maximum wind power at sites well-exposed to the prevailing south and southeasterly winds, high wind speeds are usually associated with storms and fronts moving in from the Pacific Ocean. However, during the summer, wind power is high along the central and southern Oregon coast at sites well-exposed to northerly winds and is associated with the strong surface pressure gradients created by the cold water and relatively warm interior.

Columbia River Corridor

The Columbia River wind corridor straddles the Oregon-Washington state border from just east of Portland, Oregon, to Boardman, Oregon (which is about 70 km or 40 mi west of Pendleton, Oregon). Goodnoe Hills, the site of three MOD-2 wind turbines, is located on a ridge in the eastern part of the Columbia River corridor.

The Columbia River gorge provides a low-elevation connection between continental air masses in the interior of the Columbia Basin east of the Cascade Range and the maritime air of the Pacific coast. Especially strong pressure gradients develop along the Cascades and force the air to flow rapidly eastward or westward through the gorge. Summer winds blow eastward from the cool, dense maritime air west of the Cascades to the hot, less dense air in the Columbia Basin. In winter, the comparatively cold air in the Columbia Basin frequently blows westward through the gorge.

Although the Columbia River corridor is generally an area of high wind resource, terrain variations cause considerable local variability in the wind resource. The wind resource has been measured at numerous sites throughout the Columbia River corridor, and the annual average wind resource at exposed areas ranges from class 3 to class 6. Spring and summer are the seasons of maximum wind power, except for the extreme west end where the maximum resource is in winter.

Central Washington Corridor

Near Ellensburg, Washington, another breach occurs in the Cascade Range, which separates maritime and continental air. Unlike the Columbia River gorge, the central Washington corridor consists of relatively low mountain passes leading into a broad valley corridor to the east. In winter, the cold, dense air to the east of the passes occasionally becomes deep enough to spill westward into the Puget Sound. However, in late spring and summer the cool, marine air over western Washington is often deep enough to flow eastward over the passes and through this valley corridor into the Columbia Basin.

Data from several sites throughout the central Washington corridor indicate that exposed areas have class 4 to 5 annual average wind resource, with class 6 resource during the spring and summer seasons. This high wind resource area extends eastward over the low ridges to Wanapum Dam on the Columbia River, about 50 km (30 mi) east of Ellensburg.

Northwestern Montana Plains

Areas of class 4 and 5 annual average wind power exist over the plains of northwestern Montana from near the Rocky Mountains eastward to Cut Bank and Great Falls. The highest wind energy occurs from October to April, when strong westerly to southwesterly winds frequently occur in association with intense surface pressure gradients. The seasonal average wind resource varies from a maximum of class 6 in winter to a minimum of class 2 and 3 in summer. New data collected at several sites throughout this region indicate that the highest wind resource exists in the northern part of the region, east of Glacier National Park in the vicinity of Browning and Cut Bank.

Southwestern Montana and Northwestern Wyoming Corridors

Areas with up to class 6 annual average wind resource, are found in several valley wind corridors in southwestern Montana. Three such areas that have been identified are located in the vicinities of Livingston, Whitehall, and Harlowton-Judith Gap. Another valley corridor of high wind resource (class 4) is located in northwestern Wyoming in the vicinity of Cody. Strong winds in these corridors are often associated with strong surface pressure gradients. The channeling effect of the valleys and the local terrain intensifies the winds set in motion by the pressure gradients. Prevailing strong winds at Livingston, Whitehall, and Cody are primarily from the southwest quadrant, in alignment with the orientation of the valley corridors. However, the Harlowton-Judith Gap area experiences frequently strong northerly winds caused by channeling of flow between the Little Belt and Big Snowy mountains.

All of these wind corridors have pronounced seasonal variations in wind power density, with a maximum power density in the winter. Neighboring valleys and basins lacking the appropriate orientation show a significantly reduced wind resource.

Wind data have been collected at several new sites throughout southwestern Montana and northwestern Wyoming since the late 1970s. These data indicate that considerable local variability exists in the wind resource in the vicinity of these wind corridors, although well-exposed sites can have up to class 6 to 7 annual wind power. The only known site where winds have been measured up to heights near 50 m (164 ft) above ground was the DOE candidate site at Livingston, where class 6 annual wind resource was measured.

Southern Wyoming Corridor

An area of high wind energy extends across southern Wyoming from the Utah border on the west to the Nebraska border on the east. This zone of high wind energy can be attributed to a major gap, about 150 km (90 mi) wide, in the north-south barrier of the Rocky Mountains. Prevailing westerly and southwesterly winds blow with little resistance through this gap across the relatively high plains and uplands of southern Wyoming. As a result, this is the largest region of non-mountainous terrain in the Northwest with a high wind energy resource.

Wind measurements taken throughout the extent of this high wind corridor in southern Wyoming indicate that exposed areas have class 4 to 6 annual average wind resource. Areas of highest wind resource occur where there is enhanced channeling by the terrain (e.g., between two mountain ranges) and/or where there is terrain-induced flow acceleration (e.g., over hilltops, uplands, or low ridges). One large area of exceptionally good wind energy potential occurs from near Rawlins eastward to Medicine Bow and the Laramie Mountains and southward along the Laramie Mountains divide to the Colorado border. Several large wind turbines have been installed in the Medicine Bow area.

Wind measurements from a DOE candidate site at Bridger Butte, in extreme southwestern Wyoming near Fort Bridger, showed class 6 annual average wind power at heights to 50 m (164 ft). Aircraft measurement (Dawson and Marwitz 1981) and surveys of eolian land forms (Marrs and Kopriva 1978) throughout southern Wyoming also indicate areas of very high wind energy potential. However, considerable variability in the wind resource exists in certain areas, especially where there are local terrain influences.

Winter is the season of maximum wind power, with class 7 power in the best areas. In summer, the season of minimum wind power, class 3 power can be expected in the best areas.

Plains and Uplands of Eastern Montana and Northeastern Wyoming

Class 3 and 4 annual average wind resource occurs over the open plains and upland areas throughout eastern Montana and northeastern Wyoming. There are relatively few wind measurement sites in this vast area, aside from airfield stations near the larger towns and cities. New data from the uplands area east of Circle, Montana, indicate class 4 wind energy potential.

Exposed Mountain Ridges and Summits

At least class 3 or higher wind power is estimated for most of the exposed mountain summits and ridge crests throughout the Northwest except for some of the lower, forested summits of Oregon and Washington. Average wind speeds may vary significantly from one ridge-crest site to another and are primarily influenced by the height and slope of the ridge, orientation to the prevailing winds, and the proximity of other mountains and ridges. Winter is the season of highest wind power over most mountain summits and ridge crests in the Northwest because mean upper-air wind speeds are highest during this season. However, severe icing, access problems, and damaging storm winds severely restrict the suitability of wind energy development for many of the higher mountain summits and ridge crests in the Northwest.

The North Central Region

The North Central region, (Map 3-8), consists of Iowa, Minnesota, Nebraska, North Dakota, and South Dakota. Two-thirds of the residents live in Iowa and Minnesota. The region is largely rural.

The topography of the region is generally flat plains to rolling hills and uplands, with the exception of the mountainous Black Hills area of western South Dakota. Topographic features in the North Central region, especially in the eastern Dakotas, Minnesota, and parts of Iowa, are largely the result of glaciation, with flat areas that are the beds of ancient lakes. Consequently, a large fraction of the land area is well exposed to the wind.

Class 3 and higher wind energy potential exists at exposed areas throughout the North Central region except for portions of eastern Minnesota, southeastern Iowa and the Missouri River lowlands along the Nebraska-Iowa border. As a result of new measurement programs beginning in the late 1970s and early 1980s, several areas in the North Central region, notably in North Dakota, indicate significantly greater wind energy potential than previously estimated (although higher wind power was speculated) in the regional atlas (Freeman et al. 1981). These new measurements indicate that the annual average wind resource is class 5, and possibly class 6, in certain areas.

Very strong nocturnal shear is evident from data collected at a DOE-installed meteorological tower near Finley, North Dakota, such that the average annual wind shear increases at a rate much greater than that predicted by a 1/7 power law. Thus, data collected near 10 m (33 ft) may not provide a realistic indication of the wind power and diurnal variation at 50 m (164 ft). However, at other areas in the North Central region, such as Huron, South Dakota, the nocturnal wind speeds at 50 m (164 ft) are substantially less than those at Finley, North Dakota. Finley, located on an upland above an escarpment, is slightly elevated with respect to its regional terrain environment, whereas Huron, located in the James River plain, is slightly lower than the uplands to the east and west of the river plain.

Thus, minor variations in elevation appear to have a very significant influence on the wind energy resource in the northern Great Plains. Additional data are needed to evaluate the nature of the low-level nocturnal jet in this region and its effect on the spatial and temporal variation of the wind energy resource with respect to minor variations in elevation. Major areas with class 3 or greater annual average wind power are described below. Maps of annual average wind power are presented as Maps 3-9 through 3-13 for Iowa, Minnesota, Nebraska, and North and South Dakota.

Canadian Wind Corridor and the Red River Valley

The Canadian wind corridor is a wide, flat area that comprises most of the central part of the North Central region. It is characterized by low relief and low surface roughness and is, thus, well-exposed to the strongest winds, which are mostly northerly to northwesterly in all seasons except summer. This area appears to have a significant effect in channeling cold arctic air from the Canadian interior southeastward into the United States during the winter. Strongest winds occur in conjunction with the passage to the east of migratory low-pressure systems that originate in the lee of the Rocky Mountains. This entire area is estimated to have class 4 annual average wind power.

Within this general area is the Red River valley. The Red River forms much of the boundary between North Dakota and northern Minnesota. This valley slopes downward to the north as the Red River flows northward into Lake Winnipeg. Data from stations near the Red River indicate some channeling effect, with prevailing winds being split between north and south directions. Data from Pembina and Grand Forks indicate annual wind power averages that are near the borderline between class 4 and class 5.

Missouri and Pembina Escarpments and Turtle Mountains

The Missouri Escarpment is an area of abrupt east-to-west rise of about 200 m (600 ft) in the otherwise flat terrain of eastern and central North Dakota and eastern South Dakota.

Left by receding glaciers, this feature is near the approximate western boundary of the Canadian wind corridor. The Pembina Escarpment is similar to the Missouri Escarpment and is located west of the Red River, forming the approximate western boundary of that valley. The Turtle Mountains are located on the Canadian border in north-central North Dakota, with elevations about 200 m (600 to 700 ft) higher than the flat terrain to the south.

Wind measurements from new sites located on hilltops and uplands at the top of these escarpments indicate that these areas have class 5 annual average wind resource at 50 m (164 ft), with class 6 possible in some places. Almost 2 years of data from the DOE-installed site at Finley, North Dakota, located above the Pembina Escarpment, indicate class 6 at 50 m (164 ft) with maximum wind power at night. Class 4 power was measured at 10 m (33 ft), and the diurnal variation at 10 m (33 ft) was completely reversed from that at 50 m (164 ft). Data from another DOE-installed site located south of Minot, North Dakota, at the top of the Missouri Escarpment, indicate class 5 wind power. New site data collected near 10 m (33 ft) above ground by Bureau of Reclamation and Western Area Power Administration indicate class 4 and 5 power in the upland areas of the Missouri Coteau, located between the Missouri Escarpment and the Missouri River.

Maximum wind power occurs in spring, with class 6 to 7 power at 50 m (164 ft). The new data at Finley and Minot show very strong nocturnal wind shear during the summer and surprisingly high wind energy potential at 50 m (164 ft), class 6 and 4, respectively, for the summer season. Previous estimates of the summer wind resource in the regional atlas were only class 2 for these areas. However, longer-term data at 50 m (164 ft) are needed to verify the higher summer resource measured at Finley and Minot, which is based on only two summers' data.

Prairie Coteau and Lake Traverse Area

The Prairie Coteau is a basin-like plateau, rising about 200 to 250 m (656 to 820 ft) above the surrounding flat terrain, and containing numerous small moraine lakes. It is bounded on the east by an extension of the Missouri Escarpment and on the west by a similar though lower ridge. Sloping downward to the south, its north end appears on topographic maps as a wedge pointed north into the Canadian wind corridor.

To the east of the Prairie Coteau, near the Minnesota-South Dakota border formed by Lake Traverse, is an area that forms a divide between the Red River and Minnesota River drainages. New data collected near 10 m (33 ft) indicate class 4 power over these areas; however, class 5 is possible at 50 m (164 ft) if strong nocturnal shear occurs over these areas. No data at 50 m (164 ft) are available to verify this estimate.

Missouri Plateau and Sand Hills

New site data collected near 10 m (33 ft) from hilltops and uplands of the Missouri Plateau of the western Dakotas and the Sand Hills of northwestern Nebraska that are well exposed indicate class 4 to 5 wind power. Several instrumented sites near an upland divide in southwestern North Dakota measured class 5 wind power. Class 5 wind power was also measured over an elevated area in north-central South Dakota. Most other exposed sites of Missouri Plateau and Sand Hills measured class 4 power.

Many of the valleys and drainages in the Missouri Plateau are frequently sheltered from prevailing winds. These valleys have a lower wind power class, especially in winter and autumn when these valleys tend to fill with cold air. The resulting high stability restricts vertical mixing so that winds in these valleys are not as strong as on the uplands and better exposed areas. Examples of this are Bismarck and Williston, North Dakota, which are located in sheltered areas of the Missouri River valley.

Black Hills Ridge Crests

Exposed ridge crests and summits in the Black Hills are estimated to have at least class 4 annual average wind power. Average speed at any particular location depends on the elevation, orientation with respect to strong westerly winds, and proximity to other ridges and mountains. Wind power should be greatest at high elevations of the Black Hills that have wide-open exposure.

Open Hills and Plains of Southern Minnesota and Iowa

Exposed elevated sites in southern Minnesota and northwestern Iowa are estimated to have class 4 wind power, although no data from 30 to 50 m (98 to 164 ft) above ground were identified in these areas and surface data are very limited. Data from the Rochester Airport, located on an exposed ridge in southeastern Minnesota, indicate class 4 wind power. Limited data from northwestern Iowa and southwestern Minnesota also indicate class 4 power for exposed uplands. Class 3 wind power is estimated for exposed areas throughout the rest of Iowa, except for the extreme southeastern and southwestern parts of the state. Lower and more sheltered locations will have significantly less wind power, especially in winter and autumn when stable air in these lowlands restricts vertical mixing, causing wind speeds to be less than at higher locations.

Mesabi Range and Lake Superior Shore

In northeastern Minnesota, the Mesabi Range and Lake Superior shore are estimated to have class 3 annual average wind power. The Mesabi Range, which is oriented perpendicular to the strongest winds in the area, is estimated to have class 3 because of acceleration of winds blowing over this ridge. However, there were no data to verify this estimate.

The Lake Superior shore is exposed to the strong easterly winds from Lake Superior. Data from Duluth Airport indicate that strong easterly winds in this area may penetrate inland up to 25 km (15 mi). Thus, class 3 wind resource is estimated to extend inland up to 25 km (15 mi) from the shore.

The Great Lakes Region

The Great Lakes region consists of Illinois, Indiana, Michigan, Ohio, and Wisconsin. The major cities, lakes, rivers, and geographical features are shown in Map 3-14.

The topography of the region, relative to western sections of the United States, is not complex. The entire area is almost all glaciated; terrain ranges from flat in Indiana and Illinois to gently rolling in central and northern Wisconsin. The two exceptions are southeastern Ohio and extreme southwestern Wisconsin, where terrain is rugged and unglaciated. Areas near the Great Lakes have sandy bluffs and marshes. Glacial lakes are prevalent in Wisconsin and Michigan where the terrain is more hilly.

In the Great Lakes region, class 3 or higher wind energy potential is estimated for exposed coastal and offshore areas of Lakes Erie, Huron, Michigan, and Superior, hilltops and ridges in southwestern Wisconsin and in the upper part of Michigan's lower peninsula, and upland plains in west-central Illinois. Areas of highest wind energy potential in the region are the exposed coastal and offshore areas and islands of the Great Lakes. At least class 5 wind power can be expected over offshore areas of all the Great Lakes, with maximum wind power in the winter (class 6) and minimum wind power in the summer (class 3). Over offshore areas, prevailing strong winds are mostly from the northwest-to-southwest directions. Exposed coastal points along the eastern shore of Lake Michigan and along the northern and western part of Keweenaw Peninsula in Lake Superior are estimated to have class 5 wind power, because these areas are well exposed to the prevailing strong winds with a long fetch over the open waters.

Major wind resource areas in the Great Lakes region are described below in greater detail. Maps of annual average wind power are presented in Maps 3-15 through 3-19 for Illinois, Indiana, Michigan, Ohio and Wisconsin.

Lake Michigan

The annual average wind power for exposed coastal and offshore areas of Lake Michigan is estimated to range from class 3 to class 5. The abrupt increase in surface roughness inland from the coastline, because of vegetation and topography, rapidly attenuates the wind resource landward.

Areas of highest wind energy potential are the exposed offshore areas, islands and exposed capes, and points along the eastern shore of Lake Michigan. Class 5 wind power is estimated for these areas, with maximum wind power in the winter (class 6) and minimum wind power in the summer (class 3). Over the offshore areas, prevailing strong winds are mostly from the northwest-to-southwest directions. Exposed coastal points along the eastern shore of Lake Michigan are well exposed to these prevailing strong winds, which have a long fetch over the open water. The class 5 estimate for exposed coastal points along the eastern shore of Lake Michigan is verified by approximately two years of wind measurements at 30 and 46 m (98 to 151 ft) on a DOE-installed tower at Big Sable Point.

The western shore of Lake Michigan forms the eastern edge of Wisconsin and has an annual average wind power of class 3. This reduced wind power on the western shore reflects the prevailing westerly winds. Eastward-moving storm systems during the winter and late autumn are responsible for the easterly winds that flow off the lake. Thus, on the annual average, the wind power on the western shore is less than on the eastern shore but still reflects the influence of Lake Michigan. Lake breezes, which are maximized in the spring, also enhance the wind power potential along this shoreline.

Lake Huron

Like the Wisconsin shore of Lake Michigan, the Lake Huron shoreline was estimated to have class 3 annual average wind power with class 4 possible at some of the most prominent capes. Offshore, wind power increases to class 5.

The average prevailing winds are westerly. In addition to lake breeze effects in spring, during the storm season (late fall through early spring) northeasterly and easterly winds frequently blow off the water. Because the low surface friction of the lake surface does not reduce the wind velocity, the annual average wind power along the coast is higher than inland. The abrupt increase in surface roughness inland from the coastline, because of vegetation and topography, rapidly attenuates the wind resource landward.

Lake Erie

The coastal region of extreme northern Ohio has an estimated annual wind power of class 3, increasing to class 5 over offshore areas of Lake Erie. Prevailing northerly and westerly winds have a long, smooth fetch across Lake Erie, resulting in powerful winter and spring winds, especially along the coastal areas of northeastern Ohio. The shape of the coastline is such that exposed coastal sites can also experience strong onshore winds from the northeastern quadrant.

Lake Superior

The annual average wind power along Lake Superior shorelines is estimated to range from class 3 to class 5, with class 5 existing at exposed areas along the northern Keweenaw Peninsula, Isle Royale, and offshore areas of Lake Superior. In some areas, class 3 and 4 wind powers are estimated to occur at exposed sites 15 to 35 km (10 to 20 mi) inland from the shoreline. In the western part of Michigan's upper peninsula, the class 3 and 4 wind power areas represent exposed sites along the coast and in the Gogebic, Porcupine, and Huron mountains, where the wind power estimates are representative only of well-exposed sites on the higher elevations.

Hilltops and Uplands of Michigan's Lower Peninsula

In the northern part of Michigan's lower peninsula, exposed sites on elevated terrain features are estimated to have class 3 annual average wind power. These elevated terrain features comprise the higher mountains, hilltops, and uplands in this region.

Hilltops and Ridges in Southwestern Wisconsin

Exposed hilltops and ridges in southwestern Wisconsin are estimated to reach class 3 annual average wind power. Although representative data from well-exposed sites have not been identified in southwestern Wisconsin, long-term data are available from a well-exposed airport site (Rochester, Minnesota) located on a ridge in extreme southeastern Minnesota. Based on the data from this site, similarly well-exposed sites on hilltops and ridges in southwestern Wisconsin were estimated to have class 3 wind power.

West Central Illinois

Uplands of west-central Illinois from Quincy to Springfield are estimated to reach class 3 annual average wind power, slightly higher wind energy potential than other inland areas of Illinois. Long-term data from the Springfield Airport gave the highest annual average wind power of any airport site in Illinois. No 50-m (164 ft) data were identified in this area of Illinois (Paton et al. 1980).

The Northeast Region

The Northeast region consists of Connecticut, Massachusetts, Rhode Island, Maine, New Hampshire, Vermont, New Jersey, New York, and Pennsylvania. The region's total population in 1980 of 49,136,000 represents approximately one-fourth of the nation's population. A large percentage of the people in the Northeast live in the corridor between Boston and Philadelphia, while large areas of northern Maine and upstate New York are quite sparsely populated. The major cities, rivers, lakes, and mountain ranges are shown in Map 3-20.

The topography varies dramatically throughout the Northeast. The Appalachian Mountains extend in a bank from northern Maine beyond the southern border of Pennsylvania. To the east of the mountains lie piedmont and coastal plain regions. West of the mountains the land becomes flatter as one approaches the Great Lakes. A large portion of the land area of the Northeast is composed of either hills and mountains or open hills and mountains, while large areas of

Massachusetts, Rhode Island, Maine, and New York are plains containing hills. The only area of tablelands in the Northeast extends in an arc from the Hudson River valley, across central New York, and into northwestern Pennsylvania. Central and southern New Jersey contain the only true plains in the region.

Areas of class 3 or higher wind energy potential occur throughout much of the Northeast region. The primary areas of good wind energy resource are the Atlantic coast, the Great Lakes, and exposed hilltops, ridge crests, and mountain summits from Pennsylvania to Maine. Areas of highest wind energy potential (class 5 and 6) are the outer coastal areas such as Cape Cod and Nantucket Island, offshore areas of Lake Ontario and Lake Erie, and the higher mountain summits of the Appalachians. Winter is the season of maximum wind power throughout the Northeast region. During this season, all except the most sheltered areas have class 3 or better wind resource, and exposed coastal areas and mountain summits can expect class 6 or 7 wind resource. In summer, the season of minimum wind power, class 3 wind resource can be found only on the outer coastal areas and highest mountain summits.

Major areas of wind resource in the Northeast region are described below. Maps of annual average wind power are presented in Maps 3-21 through 3-26 for Connecticut, Massachusetts and Rhode Island (displayed on one map), Maine, New Hampshire and Vermont (displayed on one map), New Jersey, New York, and Pennsylvania.

Atlantic Coastal Areas

The annual average wind power for exposed Atlantic coastal and offshore islands of the Northeast is primarily class 4, 5, and 6. Class 4 is found immediately along the coast, while class 6 exists along the outer capes and islands such as Cape Cod and Nantucket Island. Semi-enclosed bodies of water, such as Long Island Sound and Delaware Bay, have a lower wind resource (class 3).

When onshore flow occurs, the abrupt change in surface roughness inland from the coastline, because of vegetation and topography, rapidly attenuates the wind resource landward. The strongest onshore flow on the synoptic scale occurs most frequently in the winter and early spring and is associated with strong pressure gradients occurring with coastal storms.

Wind measurements up to 46 m (150 ft) above ground have been taken at four DOE-installed tower sites along the northeastern Atlantic coast—Nantucket Island and Provincetown, Massachusetts; Montauk Point, New York; and Block Island, Rhode Island. Long-term data (5 yr) from both Block Island and Montauk Point indicated class 4 annual average wind power at 50 m (164 ft) for those areas. Limited data (2 yr) from Nantucket Island and Provincetown indicated that these outer areas could have class 6 or better annual average wind power at 50 m (164 ft). At 10 m (33 ft), the annual average wind power varied considerably among these four sites and was only class 2 at Block Island and Provincetown. These data provide excellent examples of how local roughness features such as vegetation and buildings can reduce the wind power at levels near the ground and how near surface (10-m or 33 ft) data may not provide a realistic indication of the wind power at 50 m (164 ft).

Hills and Mountains of Vermont, New Hampshire, Maine, Massachusetts, and Connecticut

An extensive area, including most of Vermont and New Hampshire, as well as much of Maine, Massachusetts, and Connecticut, has annual average wind power of class 3 or higher on exposed locations. Highest powers (class 5 and 6) occur on the best-exposed mountain and ridge tops in Vermont's Green Mountains, New Hampshire's White Mountains, and Maine's Longfellow Mountains. The remainder of the hilltops and mountain tops in this area that are outside of these major ranges have class 3 or 4 wind power. At the highest elevations this wind power increases to class 6 and 7 in the winter. Average wind speeds may vary significantly from one ridge crest to another and are primarily influenced by the height and slope of the ridge, orientation to the prevailing winds, and the proximity of other mountains and ridges. For example, the White Mountains are indicated to have class 6 wind power, but Mount Washington, at 1,917 m (6,288 ft) elevation, is known to have considerably greater wind power as a result of terrain-induced acceleration as the air passes over the mountain.

Adirondack Mountains

Wind power of class 3 and higher is estimated for the high elevations of the Adirondack Mountains of northeastern New York. Two of the highest mountains, Mt. Marcy and Whiteface Mountain, have at least class 6 wind power. As in the case of Mount Washington, wind measurements on Whiteface Mountain indicate higher than class 6 power because of local acceleration effects. Mean upper-air wind speeds appear to be about the same over the Adirondack Mountains as they are over the mountains of northern New Hampshire and Vermont.

Hills and Mountains of Northern Pennsylvania, Southern New York, and Northwestern New Jersey

Class 3 and higher wind power is estimated for exposed hilltops, ridge crests, and mountain summits in Pennsylvania, southern New York, and northwestern New Jersey. The highest wind power, class 5, exists in southeastern New York on the higher summits of the Catskill Mountains. Other major mountains or mountain ranges included in this resource area are Bald Eagle Mountain, North Mountain, the Pocono Mountains, and the Allegheny Mountains. The wind power in much of this area increases to class 5 and 6 in the winter.

Lake Ontario and Lake Erie

Annual average wind power of class 3 or 4 is found along the coastal areas of both Lake Erie and Lake Ontario as the smooth, overwater fetch allows strong near-surface winds to develop. Class 5 is estimated to exist in the central part of both lakes. Existing data indicate that class 3 wind power may extend 30 to 40 km (20 to 25 mi) inland from the eastern shore of Lake Ontario (Pickering et al. 1980).

The East Central Region

The East Central region consists of Delaware, Kentucky, Maryland, North Carolina, Tennessee, Virginia, and West Virginia. North Carolina, Virginia, and Maryland account for nearly 60% of the region's population, of which most reside in the Mid-Atlantic Lowlands. The major cities, rivers, mountain ranges, and national parks are shown in Map 3-27.

The region's topography varies from rolling hills in the west to forested mountain ridges in the central portion to relatively flat coastal plains in the east. The mountain ridges are generally oriented in a northeast-southwest direction.

Areas of class 3 annual average wind power are found along exposed coastal areas from Delaware southward to Cape Lookout, North Carolina, including much of Delaware Bay, Chesapeake Bay, and Pamlico Sound. Seasonal average wind power along the coastal areas ranges from class 4 in the winter and spring to class 2 in the summer. Class 3 to 6 annual average wind resource is estimated for exposed mountain summits and ridge crests of the Appalachians. Over 4 years' data collected at a DOE wind turbine site on a 1,347 m (4419 ft) mountain summit near Boone, North Carolina, indicated class 4 annual average wind power at 50 m (164 ft). Seasonal average wind power ranged from a maximum of class 7 in winter to a minimum of class 2 in summer at this site.

Aside from the coastal areas and exposed mountains and ridges of the Appalachians, there is little wind energy potential in the remainder of the East Central region for current wind turbine applications (Brode et al. 1980).

Major areas of wind resource in the East Central region are described below. Maps of annual average wind power are presented in Maps 3-28 through 3-33 for Delaware and Maryland (displayed on one map), Kentucky, North Carolina, Tennessee, Virginia, and West Virginia.

Atlantic Coastal Areas

The annual average wind power for exposed coastal areas of Delaware, Maryland, Virginia, and North Carolina is estimated to be class 3. South of Cape Lookout, North Carolina, wind power decreases to class 2. There is a steep gradient in the estimated wind power within several kilometers of the coastline because of the abrupt change in surface roughness between the land and open water, even though relatively flat, smooth plains extend far inland along the entire length of the East Central region's coastline. While most of the coastline is oriented such that the prevailing wind direction (from the southwest across most of the region) is offshore, there is considerable variation in the orientation from one area to another.

Winter and spring are the seasons of maximum power for the coastal areas of the region, with class 4 wind power from Cape Hatteras northward. In summer, wind power decreases to a minimum of class 1 and 2 along the coastal areas.

Chesapeake and Delaware Bays

Much of the Chesapeake and Delaware bays are estimated to have class 3 wind power. Areas of highest wind resource are expected where there is a large fetch over open water for the prevailing strong winds, which come from the west through north directions. The complexity of the Chesapeake Bay shoreline, with its many islands and inlets, suggests a high variability of wind power in this area.

Exposed Mountain Ridges and Summits

Class 3 or higher wind power is estimated for exposed mountain summits and ridge crests in western North Carolina, eastern Tennessee, eastern West Virginia, western Maryland, and portions of Virginia. Average wind speeds may vary considerably from one ridge-crest site to another and are primarily influenced by the height and slope of the ridge, orientation to the prevailing winds, and the proximity and relative height of other mountains and ridges. Most of the ridges in Virginia, West Virginia, and western Maryland are oriented perpendicular to the prevailing westerly winds. As a result, the higher ridges may experience wind power that is considerably enhanced by a venturi speed-up effect - wind flows are compressed as they are forced over the ridges. Winter is the season of maximum wind power over the mountain summits and ridge crests of the East Central region because mean upper-air wind speeds are highest during this season. In contrast to valley and plain locations, the daily maximum wind speed for mountain summits and ridge crests generally occurs at night; this situation occurs because the frictional boundary layer is more shallow as a result of the absence of solar heating and associated vertical mixing.

The Southeast Region

The Southeast region consists of Alabama, Florida, Georgia, Mississippi, and South Carolina. The region's total population in 1980 of 24,746,000 represents approximately one-tenth of the nation's population. Nearly three-quarters of the people in the Southeast live on the East Coast from South Carolina to Florida. The major cities, rivers, mountain ranges, and geographical features of the Southeast are shown in Map 3-34.

With the exception of the north-central portion of the Southeast region and a few scattered areas, the topography is relatively low and flat. Roughly 41% of the topography in the Southeast is irregular plains, 41% is flat and smooth plains, and only 18% is tableland, hills, and low mountains, which lie in the north-central part of the Southeast. The northern half of Alabama, the northern part of Georgia, and the far northwestern corner of South Carolina have the most complex terrain of the region, with tablelands, hills, and low mountains.

There is little wind energy potential in the Southeast region for existing wind turbine applications (Zabransky et al. 1981). Even along coastal areas, existing data from exposed sites indicate at best only class 2 at 50 m (164 ft) above ground. The only places in the Southeast region estimated to have class 3 or higher annual average wind resource are the exposed ridge crests and mountain summits confined to northeastern Georgia and extreme northwestern South Carolina, as described below. Maps of annual average wind power are presented in Maps 3-35 through 3-39 for Alabama, Florida, Georgia, Mississippi, and South Carolina.

Mountains of South Carolina and Georgia

The exposed ridge crests and mountaintops of the southern Appalachians in extreme northwestern South Carolina and northeastern Georgia have annual average wind power densities of class 3 to class 5. This area is highly confined and represents an extremely small percentage of exposed land in the Southeast region.

The South Central Region

The South Central region, consisting of Arkansas, Kansas, Louisiana, Missouri, Oklahoma, and Texas, is about the same size as Alaska and equal to one-fifth the area of the 48 contiguous states. Texas has 45% of the area and slightly more than 45% of the region's population. Over 40% of the people in the South Central region live in the six metropolitan areas that have over one million inhabitants each. In order of decreasing population, these are Dallas-Fort Worth, Texas; Houston, Texas; St. Louis, Missouri; Kansas City, Kansas; Kansas City, Missouri; New Orleans, Louisiana; and San Antonio, Texas. The major cities, rivers, mountains, and national parks of the South Central region are shown in Map 3-40.

The South Central region extends from the interior plains to the coastal plains with a few interior highlands in the east-central part. The Mississippi River makes up most of the eastern boundary of the region as it flows south to the Gulf of Mexico. The only major portions of the region that are mountainous are the western tip of Texas, and parts of Arkansas, Missouri, and extreme eastern Oklahoma.

A substantial portion of the South Central region has class 3 or higher annual average wind power. The most extensive area of wind resource includes most of Kansas, Oklahoma, and northwestern Texas, where a large fraction of the land area is well exposed to power-producing winds. Other areas of significant wind resource in the region include the Texas coast and exposed hilltops, ridge crests, and mountain summits in parts of southern Missouri, western Arkansas, eastern Oklahoma, and extreme western Texas.

Since the completion of the regional wind energy atlas (Edwards et al. 1981), many new sites have been instrumented to measure the wind resource throughout much of Kansas, western Oklahoma, and northwestern Texas. Wind measurements at levels up to 46 and 50 m (150 to 164 ft) above ground have been taken at 16 new sites in this area. Four of these were sites instrumented for the DOE candidate site program. These were located near Amarillo, Texas; Meade and Russell, Kansas; and Fort Sill, Oklahoma. Some other organizations involved in wind measurement activities in this area included the Alternative Energy Institute, Kansas State University, and Wichita State University. The composite analysis of the new wind data obtained for this area resulted in some significant revisions in analysis from the previous regional assessment.

For example, the class 5 area previously shown over the southern High Plains from north of Amarillo, Texas, to extreme southwestern Kansas, has been revised to class 4 and 3, based on the wind measurements taken at or near 50 m (164 ft) at five new sites in this area. In eastern Kansas, an area previously assigned class 3 has been up-graded to class 4, reflecting exposed areas in the Flint Hills where several new sites indicate class 4 (and possibly class 5) at 50 m (164 ft) above ground. In the Texas coastal area, the class 4 area was revised to class 3, based on new data at 30 to 60 m (98 to 164 ft) above ground from two sites and a re-analysis of the coastal data previously used in the regional assessment. The seasonal analyses in the Texas coastal area (presented on the national-scale maps) have been revised to show an on-shore maximum in the wind resource in the spring and summer. During these seasons, the wind resource is estimated to be greater along the inner coastal areas than along the offshore islands, such as Padre Island. Additional data are needed, especially at heights to 50 m (164 ft), to provide a more reliable estimate of the extent of this onshore maximum in the wind resource.

Major areas of wind resource in the South Central region are described below. Maps of annual average wind power are presented in Maps 3-41 through 3-47 for Arkansas, Kansas, Louisiana, Missouri, Oklahoma, and Texas. (Texas is displayed in two maps, one for West Texas and one for East Texas.)

The Great Plains

Exposed areas of the Great Plains encompassing a large area of northwestern Texas, Oklahoma, and Kansas have class 3 and 4 annual average wind power. The most extensive area of class 4 power extends from the Texas Panhandle to northwestern Oklahoma and south-central Kansas. In this area, the wind power is estimated to approach class 5 over some of the uplands and hills. However, over much of the Great Plains, local variations in terrain elevations and exposure cause variability in the wind resource, such that the wind resource may vary from class 2 over lowlands and river valleys to class 4 (and possibly class 5) over exposed uplands and hilltops.

Seasonal variations in the wind resource at 50 m (164 ft) over the area from the Texas Panhandle to south-central Kansas are not as large as indicated in the previous regional assessment. Spring is the season of maximum wind power, with class 5; however, an area of class 4 appears in each of the remaining three seasons. At the Amarillo DOE site, 5 years' data indicated that summer was the season of second highest wind power at 50 m or 164 ft (with a strong class 4), although summer was the season of lowest wind power at 10 m or 33 ft (with class 3). Strong nocturnal wind shear, especially prevalent during the summer, results in a higher wind power class at 50 m (164 ft) in the summer than would be indicated by 10-m (33 ft) data. Mean wind speeds at 50 m (164 ft) are greater at night than during the day.

Flint Hills of Eastern Kansas

The Flint Hills extend north to south through eastern Kansas. Wind measurements at heights to 50 m (164 ft) above ground at exposed sites in the Flint Hills indicate class 4 annual average wind power, and possibly class 5 over well-exposed areas of the southern Flint Hills. As it does over exposed uplands in the Great Plains, strong nocturnal shear occurs over elevated areas of the Flint Hills, such that mean wind speeds at 50 m (164 ft) are greater at night than during the day.

The wind resource at 50 m (164 ft) remains high throughout the four seasons; the seasonal average wind power is estimated to be a strong class 5 in the spring and class 4 in the other three seasons. Additional data are needed to verify the seasonal nature of the wind resource, because less than two years' data were available for this area at the time of this analysis.

Over most of the remainder of eastern Kansas, class 3 is estimated for the open plains and exposed uplands and hilltops.

Wichita Mountains of Southwestern Oklahoma

Limited data in the vicinity of the Wichita Mountains in southwestern Oklahoma indicate at least class 4 or higher wind power. Local, strong acceleration of the wind speeds is estimated to occur around the eastern and western ends of the Wichita Mountains, as a result of the prevailing strong northerly and southerly winds over this region. Limited data from a DOE-installed tower on the plains near the eastern end of the Wichita Mountains indicate very good wind energy potential (possibly class 6), although additional data are needed to verify the magnitude and nature of the wind resource in this area.

Texas Coastal Area

The Texas coastal area from Galveston south to the Mexican border is estimated to have class 3 annual average wind power. This wind resource extends up to 30 to 60 km (20 to 40 mi) inland. The wind resource along the inner coastal area (just onshore and to 30 km inland) may be slightly greater than that over the offshore islands, such as Padre Island. New site data from the offshore islands indicate class 2 to class 3 wind power at 50 m (164 ft), rather than the class 4 previously assigned in the regional atlas. Data at 60 m (197 ft) from the inner coastal area indicate class 3 annual average wind power. A reanalysis of the near-surface data from airfields in the inner coastal area also indicates that class 3, rather than class 4, is more appropriate to this area.

Seasonally, the inner coastal area is estimated to have greater wind power in spring and summer than the offshore islands. Existing data indicate a spring maximum of class 4 along the inner coastal area south of Matagorda and a winter maximum along the offshore islands and the coastal fringes northward to Galveston.

Ouachita Mountains and Boston Mountains

Upper-air wind data have been used to estimate class 3 and 4 wind power at exposed areas in the Ouachita and Boston mountains, which extend from Arkansas westward into Oklahoma. Although the wind power map implies that nearly one-fourth of Arkansas has class 3 and 4 wind power, the exposed mountain summits and ridge crests account for only 3% of Arkansas land area. No surface data from mountain summits or ridge crests in these areas were available to verify this wind resource.

Ozark Plateau

The Ozark Plateau is an area of forested hills and low mountains and ridges in southern Missouri and northwestern Arkansas. Exposed hilltops, ridge crests, and mountain summits of the Ozark Plateau are estimated to have class 3 annual average wind power, although no data were available from a well-exposed site to verify this wind resource. However, wind data from the Springfield, Missouri, airport, which is located on an upland near a crest in the Ozark Plateau but at an elevation approximately 60 m (197 ft) lower than the crest, indicates class 2 annual average wind resource. Thus, well-exposed sites at the highest elevations on the Ozark Plateau are expected to have at least class 3 wind power at 50 m (164 ft).

Seasonally, wind power over the Ozark Plateau is estimated to reach a maximum of class 4 in winter and spring, decreasing to a minimum of class 2 in the summer.

Rocky Mountain Extensions

The ridge crests and mountaintops of the Guadalupe and Davis mountains in the basin and range region of the Rocky Mountain extensions in southwestern Texas are estimated to have up to class 6 wind power. Surface data taken at Guadalupe Pass confirms this and suggests that there is some funneling in the passes and valleys.

The Southern Rocky Mountain Region

The Southern Rocky Mountain region consists of Arizona, Colorado, New Mexico and Utah. Over 60% of the region's people reside in the metropolitan areas of Denver, Colorado; Phoenix, Arizona; Salt Lake City, Utah; Tucson, Arizona; Albuquerque, New Mexico; and Colorado Springs, Colorado. The remainder of the region's people live in agricultural, industrial, and resort communities distributed throughout the area. The major cities, rivers, lakes, mountain ranges, and geographical features of the Southern Rocky Mountain region are shown in Map 3-48.

Topography varies dramatically throughout the Southern Rocky Mountain region. The region is dissected by the continental divide, which extends through central Colorado and western New Mexico, and is composed of five basic topographic areas: the high plains, the Rocky Mountains, the Colorado Plateau, the Great Basin, and the southwestern desert. The high plains area occupies roughly the eastern one-third of Colorado and New Mexico. The Rocky Mountains, which extend from north to south through Colorado and New Mexico, are composed of numerous ranges that attain elevations in excess of 4,250 m (13,944 ft). The Colorado Plateau occupies the area surrounding the Four Corners area. The Great Basin of western Utah is composed of desert basins, playas, and small mountain ranges. The southwestern desert includes the desert areas of southern New Mexico and southern Arizona.

Areas of class 3 or higher wind resource can be found throughout the Southern Rocky Mountain region. The most extensive area of wind resource is found over the high plains and uplands of eastern Colorado and eastern New Mexico. Over this area, the annual average wind resource is mostly class 3 and 4, but can be higher on well-exposed hilltops that are found over portions of the high plains region. Mountain summits and ridge crests estimated to have class 3 or higher wind resource exist throughout the Southern Rocky Mountain region. Higher mountain ranges are estimated to have at least class 6 wind power, but many of these may not be suitable because of the ruggedness of the terrain and the potential for extreme wind and icing conditions. Two valley wind corridors have been identified that are estimated to have at least class 3 wind resource. One of these wind corridors is in the vicinity of Milford, Utah, and the other is in the vicinity of Santa Fe, New Mexico.

These major areas of wind resource in the Southern Rocky Mountain region are described below. Maps of annual average wind power are presented in Maps 3-49 through 3-52 for Arizona, Colorado, New Mexico, and Utah.

Eastern Plains of Colorado and New Mexico

Class 3 and 4 annual average wind power is found on the high plains and uplands of eastern Colorado and eastern New Mexico. Strong northerly and southerly winds in this area are usually associated with the intense surface pressure gradients that are prevalent during the winter and spring. Plains areas farther west that are within the sheltering influence of the Rocky Mountains and river drainages generally have less wind power.

Buttes, hilltops, and other types of elevated summits are scattered throughout parts of the high plains, especially in northeastern New Mexico and southeastern Colorado. Well-exposed summits and hilltops, where there is terrain-induced acceleration of the wind, may have class 5 or higher wind resource. For example, a DOE site on a hilltop near Tucumcari in northeastern New Mexico indicated class 5 power at 50 m (164 ft) over a 2-year period. Another DOE site located on open plains near Clayton in northeastern New Mexico had class 3 wind power at 50 m (164 ft), based on 5 years' data. The class 5 power previously estimated for the plains area around Clayton in the regional atlas (Andersen et al. 1981) appears too high. These previous estimates were primarily based on near-surface, airfield data of unknown quality from the 1940s and early 1950s.

New site data throughout northeastern Colorado indicate an extensive area with class 4 annual average wind power. This is an upland region between the South Platte River to the north and the Arkansas River to the south. Wind power is considerably lower in the river plains and valleys than on the uplands.

Seasonal average wind power over the upland plains of eastern Colorado and New Mexico ranges from a maximum of class 4 and 5 in spring to a minimum of class 2 and 3 in summer.

Northern Colorado Plains

North of the South Platte River in northeastern Colorado, the elevation increases northward to the high plains of southeastern Wyoming and western Nebraska. The proximity of the sheltered South Platte River valley to the southern Wyoming wind corridor creates a steep gradient of annual average wind speed, and hence wind power, between these areas. The strong prevailing westerly winds, which blow uninterrupted through the large gap in the Continental Divide in southern Wyoming, appear to extend into northeastern Colorado and western Nebraska.

Class 4 to 6 annual average wind power is found in this part of Colorado south of the Wyoming and Nebraska borders. New site data indicate that class 4 wind power extends eastward to Peetz, Colorado. Class 6 wind power is found on the Laramie Mountains divide, a broad upland which extends southward just into Colorado.

Strongest winds in this area occur during the winter as a result of intense pressure gradients between the low-pressure systems moving east across the northern tier of states, and the semi-permanent high-pressure system that occupies the Great Basin. Prevailing wind directions during strongest winds are generally westerly and northwesterly.

Milford Corridor in Southwestern Utah

Class 3 annual average wind power is found in the valley corridor in the vicinity of Milford, Utah. Strong southwesterly winds frequently occur over this area, especially during the spring when the wind resource averages class 4. Higher wind resource may exist in areas where the terrain causes even stronger channeling of the winds. Data are scarce in this region of southwestern Utah, and the geographical extent of this wind resource area is not well known.

Santa Fe Corridor in Northern New Mexico

Class 3 annual average wind power is estimated for the Rio Grande Valley corridor in the vicinity of Santa Fe, New Mexico. Wind speeds are enhanced as air flowing up or down the Rio Grande Valley is channeled and accelerated through a broad gap between two large mountain ranges. Wind resource reaches a maximum in the spring, when it averages class 4. Higher wind resource may exist in areas where the terrain causes even stronger channeling of the winds.

Exposed Mountain Ridges and Summits

Class 3 or higher annual average wind power is estimated for exposed mountain summits and ridge crests throughout the Southern Rocky Mountain region. Class 6 is estimated for the higher mountain ranges in parts of Colorado, New Mexico, and Utah. However, many of these higher mountain ranges may not be suitable for wind turbine applications because of extreme icing, damaging winds, and inaccessibility, especially during the winter.

Average wind speeds may vary significantly from one ridge crest site to another and are primarily influenced by the height and slope of the ridge, orientation to prevailing winds, and the proximity of other mountains and ridges. High wind resource may exist in mountain passes or saddles where prevailing strong winds are funneled. A DOE site at San Augustin Pass, located about 30 km (20 mi) northeast of Las Cruces in the San Andreas Mountains of southern New Mexico, indicated class 6 annual average wind power at 50 m (164 ft) with a strong class 7 in the winter and spring.

Winter is estimated to be the season of maximum wind power over mountain summits and ridge crests in Utah, Colorado, northern New Mexico, and northern Arizona, because mean upper-air wind speeds are highest over these areas during this season. However, on the exposed mountainous areas of southern Arizona and southern New Mexico, winter and spring power appear about equal and are the seasons of maximum wind power.

The Southwest Region

The Southwest region consists of California and Nevada. (To facilitate the presentation of the wind resource analysis, we have divided California along 37°N into northern and southern California). Nearly three-quarters of the inhabitants of the region live in coastal California, where the region's three large metropolitan areas—the San Francisco Bay area, Los Angeles Basin and San Diego—are located. Major cities, rivers, mountain ranges, and national parks are shown in Map 3-53.

There is a large variety of topography throughout the Southwest. California has many mountain ranges, several of which extend above 3,000 m (10,000 ft) in elevation. It also has some very large flat areas, notably the Central Valley, which is composed of both the Sacramento and San Joaquin valleys and is over 700 km (400 mi) long. The California desert is mostly composed of isolated peaks and ranges dotting an undulating basin. Nevada is composed almost exclusively of basin and range country; there is a series of parallel valleys alternating with steep mountain ranges. Some broad upland plains are found in northern Nevada near the Oregon and Idaho borders.

Considerable wind energy development has occurred in California; more wind turbines have been sited in California than in any other region of the United States. Extensive wind resource assessments have been conducted throughout California by the California Energy Commission (CEC) and various other organizations. The CEC has assimilated a wind resource data base on California that was utilized in verifying or updating this assessment. The DOE has sponsored wind measurement programs at three sites in California - Point Arena, San Gorgonio Pass, and Pacheco Pass - and one site in Nevada - Wells (located on a mountain ridge in northeastern Nevada about 65 km (40 mi) northeast of Elko).

Areas of class 3 and higher wind resource are dispersed throughout the Southwest region. The most notable areas where most of the wind energy development has been occurring are the coastal and inland passes through which cooler marine air is funneled to the warmer, drier valleys in the interior. At least six major passes, or wind corridors, with high wind resource occur throughout central and southern California. These are the Carquinez Straits, Altamont Pass, and Pacheco Pass in north central California and Tehachapi Pass, San Gorgonio Pass, and the Sierra Pelona in southern California. The annual average wind resource can reach class 6 or higher at well-exposed sites in these wind corridors. High wind resource is also found in some of the southeastern California desert corridors, such as the western part of the Antelope Valley and the Barstow-Daggett area.

Other areas of class 3 or greater wind resource in the region are the outer Channel Islands and exposed coastal areas north of Point Conception, and many of the exposed mountain summits and ridge crests that are located throughout the Southwest region.

Major areas of wind resource in the Southwest region are described below in greater detail. Maps of annual average wind power are presented in Maps 3-54 through 3-56 for California and Nevada. (California is displayed in two maps, one for northern California and one for southern California.)

Coastal Areas

The annual average wind power for exposed coastal areas of California north of Point Conception is estimated to be largely class 3, except for class 4 around Cape Mendocino. Because the prevailing wind direction is northwest during spring and summer and between the winter storms, and because much of the California coastline is oriented northwest to southeast, coastal areas that protrude into the flow experience the highest wind power. They also protrude into the southerly or southeasterly flow, which dominates during winter storms. However, because the rest of the shoreline is concave between these areas and thereby out of the strong flow, it experiences a markedly lower wind resource. The abrupt increase in surface roughness inland from the coastline, because of vegetation and topography, further slows the wind.

Almost 5 years of new site data from a DOE-installed tower at Point Arena indicated class 3 wind power at 50 m (164 ft). This site, which is well exposed to prevailing strong winds, is considered largely representative of exposed coastal areas of central California. Previous estimates of class 5 for much of this coastal area, which were based primarily on very limited surface data and offshore marine data (ship observations), appear too high (Simon et al. 1980). However, specific sites that experience local terrain-induced acceleration of the winds may exist that have class 5 or greater wind power. For example, limited data from a site on the exposed ridge crest at an elevation of about 450 m (1,476 ft) on Cape Mendocino indicate class 6 annual average wind power. In such areas of complex terrain, considerable spatial variability in the wind resource can be expected.

The southern California coastline south of Point Conception has very little wind power, because it is sheltered from the northwest winds by the Transverse Ranges. The outer Channel Islands (San Miguel, Santa Rosa, and San Nicolas) of southern California are far enough west to escape the sheltering that affects the rest of the southern California coastal area, and they are estimated to have class 3 to class 4 wind power.

Spring is the season of maximum wind power at exposed coastal areas from Point Arena south to Point Conception and the outer Channel Islands, where exposed areas average class 4 and 5 wind power. Over these areas, class 3 or greater wind resource is experienced in every season except autumn.

From Cape Mendocino northward, wind power is about equal in winter and spring, because strong winds associated with winter storms are more frequent along the northern California coast than the central and southern coast. Exposed areas on Cape Mendocino are estimated to have class 3 or greater wind power in every season.

Coastal Gaps

From spring through summer, the strong surface pressure gradients created by the cold water and warm interior force marine air through the gaps in the coastal mountains into the interior. This sea breeze is funneled in some cases by the topography. Where this happens, very strong and persistent winds are likely to occur. The Carquinez Straits, Altamont Pass, Pacheco Pass, San Gorgonio Pass, and the Sierra Pelona fall into this category. All have high annual average wind power and a spring or summer seasonal maximum. Although not a true gap, the Sierra Pelona region, which is located north of Los Angeles and south of Antelope Valley, is a long stretch of mountains that are lower than the mountain ranges on either side of it, and the marine air flows through this low area on its way to the Mojave Desert. The windiest areas are near the eastern end of each pass and the highest ridges of the Sierra Pelona.

Coastal Mountains

There are four areas of the Coast Range that have wind power of class 5 or better. Two areas, the higher mountains of northwestern California (2,000 to 3,000 m or 6,562 to 9,843 ft) and the San Gabriel Mountains east of Los Angeles (3,000 m or 9,843 ft), are strongly affected by the upper-air winds, and the wind resource therefore shows a strong winter maximum and summer minimum. They are 500 to 1,000 m (1,640 to 3,280 ft) higher than the surrounding mountains, so they are well-exposed to the free-air winds. The Vaca Mountains (about 900 m or 3,000 ft), west of Sacramento, and the Laguna Mountains (about 2,000 m or 6,562 ft), east of San Diego, while higher than surrounding terrain and influenced by the upper-air flow, are also influenced by modified sea-breeze winds of spring and summer. Hence, their season of maximum wind power is winter, but the sea-breeze winds produce almost as much power in the spring, and the summer wind resource is not as low as in the other two areas. This sea-breeze circulation further complicates the wind regime of the Vaca Mountains. The prevailing strong winds of the other areas are generally westerly. This is true for the Vaca Mountains as well, except that they experience a definite wind shift from westerly during the day to northeasterly at night during the spring and summer.

Interior Mountains

The large mountain ranges of the Southwest have a high wind energy resource. The Cascades, Sierra Nevada, Tehachapis, and the ranges of Nevada are well exposed to the upper-air winds and therefore experience a winter maximum wind power. Where the mountain ranges and ridgelines are oriented perpendicular to the free-air flow, these winds may be further enhanced. Additionally, these ranges are large enough to separate adjacent air basins. The unequal heating of these basins during spring and summer produces air flow over some of these barriers. This flow results in wind speeds that are higher than those that would be found if only the upper-air winds produced the wind resource of the mountains.

Desert Wind Corridors of Southern California

East of the Coast Range in southern California, low-elevation wind corridors exist that have class 3 or greater wind resource. One notable wind corridor is Tehachapi Pass, near Mojave, where winds are funneled from the San Joaquin Valley into the Mojave Desert. Areas of class 6 annual average wind resource are indicated by new site data in the Tehachapi Pass vicinity. Spring and summer are the seasons of highest wind resource.

The western part of the Antelope Valley is another area of high resource potential. New site data in the extreme west end of the Antelope Valley indicate class 6 wind resource. Class 3 or higher wind resource is estimated to exist over much of the southern and western parts of the Antelope Valley. Spring and summer are seasons of maximum wind resource.

In the vicinity of Daggett (just east of Barstow), another wind corridor exists where desert winds are channeled between the Calico and Rodman Mountains. Over 20 years of data from the Daggett Airport show class 3 to 4 annual average wind power. New site data by the California Energy Commission also indicate class 3 to 4 wind power in this area. Maximum wind resource occurs in the spring and summer.

Desert Mountains of Southeastern California and Southern Nevada

Desert conditions are found in most of southeastern California and the valleys of southern Nevada. Intense heating will often generate strong afternoon winds that persist into the evening. The lack of vegetation and the preponderance of broad open valleys in California and narrower valleys in Nevada (which may funnel the winds) allow wind storms to sweep the desert with little abatement. In spite of these mechanisms, most desert floors have only class 1 or 2 power, as wind speeds decrease during the night and morning hours. The numerous mountain summits and ridgelines, which are less subject to stable layers that develop in the valley floors, may experience wind power of class 3 and higher. The lower mountains and ridges of southern California and southern Nevada, being more strongly affected by the thermal circulation, experience a spring maximum.

Alaska

Alaska covers an area of 1,518,776 km^2 (586,400 mi^2). Because of the state's large size, in the Alaska wind energy resource assessment (Wise et al. 1981) the state was divided into four subregions: northern,southeastern, south-central, and southwestern. The state population in 1980was 402,000. More than 40% of Alaska's population lives in the metropolitanarea of Anchorage, in the south-central subregion. The major cities, towns, villages, rivers, mountain ranges, and national parks are shown in Map 3-57.

The topography of Alaska varies from subregion to subregion. A large portion of the land is mountainous; the Brooks Range is in the northern subregion, the Alaska Range is in the south-central and southwestern subregions, and the Coast and St. Elias mountains are in the southeastern subregion. Flat coastal plains, such as those along the Arctic coast and Yukon-Kuskokwim Delta (in the northern and southcentral subregions, respectively) are also prominent features. Flat alluvial plains are found in the river valleys, such as the Yukon River valley in the southeast portion of the northern subregion. Up-land plains are found throughout the state.

In Alaska, high wind resource occurs over the Aleutian Islands and the Alaska Peninsula, most coastal areas of northern and western Alaska, offshore islands of the Bering Sea and Gulf of Alaska, and over mountainous areas in northern, southern, and southeastern Alaska. The largest areas of class 7 wind power in the United States are located in Alaska—data from some of the Aleutian Islands indicate an annual average wind power over 1000 W/m^2 at 10 m, which corresponds to about 2000 W/m^2 at 50 m.

Major areas of wind resource in Alaska are described below. Maps of annual average wind power are presented for the four subregions in Maps 3-58 through 3-61.

Beaufort and Chukchi Sea Coast

The annual average wind power for exposed coastal and offshore areas is estimated to be at least class 5. Coastal areas near Barter Island, Point Lay, and Cape Lisburne show class 7. Even though much of the area north of the Brooks Range is of low relief, wind power drops off rapidly with distance from the coast as shown by data from Sagwon and Umiat. On the eastern Beaufort coast, an area with wind power of class 4 or higher appears to extend from the coast southward to the crests of the Brooks Range. Along the Chukchi Sea coast, wind power of class 5 to 7 is probably confined to near the coast, although there are no data available inland to corroborate this assumption.

Bering Sea Islands and Coast

Islands in the Bering Sea, such as the Pribilofs, St. Lawrence, St. Matthew, and Nunivak, all show annual wind powers of class 7 except in the vicinity of Savoonga on St. Lawrence Island, which has class 6. Along the coast from the Alaska Peninsula northward, wind power of class 5 or higher (with class 7 in exposed areas like the west end of the Seward Peninsula and the Cape Romanzof area) is shown. Wind power of class 5 or more extends eastward for 150 km (100 mi) in the Yukon-Kuskokwim Delta area, as shown by Bethel data.

Alaska Peninsula and the Aleutian Islands

The Alaska Peninsula west of 162°W shows annual wind power class 7 at all locations except those shielded somewhat by local terrain. The whole peninsula has class 5 or higher power. This area is along a major storm track from eastern Asia to North America. Storms generally move from west to east. Some storms also move northward through the Bering Sea, especially during the summer months. Amchitka and Asi Tanaga in the western Aleutians show mean annual wind power of over class 7 (1,000 W/m^2). Winter is the season of maximum wind power throughout the area.

Lower Cook Inlet

The area from Iliamna Lake to Kamishak Bay across Cook Inlet to the Barren Islands is a corridor for strong winds. This is reflected at Bruin Bay, which shows an average annual wind power of over 1,300 W/m^2. Subjective comments from mariners indicate that this lower Cook Inlet area can be very windy. Bruin Bay data and an examination of weather records from two drilling rigs operating in the area confirm this impression. There are no other permanent stations besides Bruin Bay that show this wind resource.

Gulf of Alaska Coast

Exposed areas of the entire Gulf of Alaska coast should experience mean annual wind power of class 3 or higher. Offshore data from Middleton Island indicate class 7 wind power. Shore data such as Cape Spencer, Cape Decision, Cape Hinchinbrook, and North Dutch Island reflect class 5 or higher power. Data from more sheltered locations, such as Cordova, Sitka, and Yakutat do not reflect these wind power classes. Most of this coastline is rugged and heavily wooded, so wind power estimates are very site-specific.

Exposed Mountain Ridges and Summits

At least class 3 or higher wind power is estimated for mountain summits and ridge crests in the Alaska Range, the Coast Mountains in southeastern Alaska, and portions of the Brooks Range. The map analyses represent the lower limits of the wind power resource for exposed areas. Wind speeds can vary significantly from one ridge crest to another as a result of the orientation to the prevailing slope of the ridge and its closeness to other ridgelines. Winter is the season for highest wind speed and power at mountain summits and ridge crests.

Hawaii and Pacific Islands Region

The Hawaii and Pacific Islands region differs significantly from the mainland regions. Though millions of square miles of ocean are included, land area is small. The state of Hawaii has 16,710 km^2 (6,450 mi^2), and more than 2,200 Pacific Islands affiliated with the United States have a total land area of 2,621 km^2 (1,012 mi^2). A map of the Hawaiian island chain is given in Map 3-62. The principal Pacific Islands and island groups described in this atlas are Guam, Wake, Johnston, and Midway Islands; and the northern Marianas, Carolines, Marshalls, and American Samoa. A map of the Pacific Islands is given in Map 3-63.

The major Hawaiian Islands (Kauai southeastward to Hawaii) are the peaks of submarine volcanoes. Local relief exceeds 900 m (3000 ft) on most of the major islands. Fifty percent of the land area lies above 600 m (2,000 ft) MSL elevation and nearly 50% lies within 8 km (5 miles) of the coastline.

The state of Hawaii had a population in 1980 of 965,000. The island of Hawaii comprises nearly two-thirds of the state's land area. Over 80% of the residents in the state live on the island of Oahu; this island consumes 90% of Hawaii's electric power.

The Pacific Islands are of two types: mountainous islands and atolls. The former, which are less than 1,000 m (3280 ft) elevation, include the Northern Marianas, Guam, American Samoa, and several of the Carolines. Most of the islands are atolls, which may not rise more than 5 m (17 ft) above the ocean.

The climate in the Pacific Islands is tropical. The Carolines mostly lie within the area of the near-equatorial convergence. Within this region, weather is dominated by light winds and humid, showery conditions. The eastern islands—Johnston, Midway, Wake, and the Marshalls—lie under the influence of brisk trade winds generated by the Pacific anticyclone. The trades weaken slightly in the western Pacific, though migratory anticyclones during winter provide brisk northeasterlies.

Samoa, in the southern hemisphere, experiences brisk trade winds during winter (June-August in the southern hemisphere). In summer, a monsoonal trough develops eastward from Australia, causing weak winds interrupted by tropical cyclones.

Tropical storms are major components of the climate of the Pacific Islands. Guam has been hit by some of the most devastating typhoons on record. Tropical storms are primarily late summer and early fall features, but have occurred in all months.

Local influences on climate vary with island type. Atolls exert little influence on the prevailing air streams. Diurnal variations on atolls match those observed for the open oceans. Mountainous islands, especially in areas of light synoptic winds such as at Ponape, produce significant local effects on cloudiness and precipitation.

Hawaiian Islands

Interactions between prevailing trade winds and island topography determine the distribution of wind power. On all major islands trades accelerate over coastal regions, especially at the corners. The best examples are regions of class 6 or higher wind power on Oahu, Kauai, Molokai, and Hawaii. The rampart-like mountain crests of Oahu enhance prevailing winds to class 6. On other islands, circular mountain shapes and extreme elevations prevent the type of wind acceleration observed on the Oahu ranges (Schroeder et al. 1981).

Annual average wind power in Kauai and Honolulu counties is presented in Map 3-64. The primary wind resources in Kauai County are on the southeastern and northeastern coasts of Kauai where trades accelerate around the island barrier. Broad areas of class 3 or higher wind power occur over the northern, southern, and eastern parts of Kanai, increasing to class 6 over the northeastern (Kilauea) and southeastern (Makahuena) points.

On Oahu (Honolulu County), the long Koolau mountain rampart and shorter Waianae Range enhance trades to class 6, although the rugged topography, watershed value, and turbulent air flows over these ranges may preclude practical application of wind power generation. The northeastern (Kahuku) and southeastern (Koko-head) tips of Oahu have areas of class 7 and broad areas of class 3 or higher. A class 3 and 4 area exists at Kaena Point on the island's northwestern tip, and class 3 areas exist along the southern coast west of Honolulu and southeastern coast north of Makapuu Point.

Maui County is made up of three principal islands: Molokai, Maui, and Lanai. A map of annual average wind power for Maui and Hawaii counties is given in Map 3-65.

Molokai is unique among the major Hawaiian Islands in that it lies almost parallel to the prevailing trades. Exposed areas on most of the island are estimated to have class 3 or above, and much of the northwestern quadrant is class 4 or above, becoming class 7 at Ilio Point. Eolian features are found in northwestern Molokai. A narrow belt of class 4 lies on the southeastern coast.

The primary wind resource on Maui lies in the central valley where trades accelerate between Haleakala and west Maui Volcano existing as class 5 and 6 near Maalaea Bay. Secondary power resources exist at the northern (class 3 and 4) and southeastern (class 3) tips.

Lanai lies partly in the wind shadow of western Maui. Nevertheless, deformed trees indicate that winds are slightly accelerated (class 4) over the northwestern third of Lanai. This area is exposed to winds funneling through the Pailolo Channel between Maui and Molokai. Exposed areas over the remainder of Lanai are estimated to have class 3 power.

Hawaii consists of five major mountains and the saddles between them. The tall volcanoes, Mauna Loa and Mauna Kea, provide a barrier to the trade winds, producing a stagnation which extends well upwind of Hilo. Trades diverted to the north of Mauna Kea accelerate through the Waimea saddle and over the Kohala Mountains, producing a significant area of class 7 wind power and a broad area of class 3 or higher wind power. A smaller area of high wind resource, up to class 7, exists at the south cape.

Pacific Islands

Wind power maps for the Pacific Islands are presented by island group - for Guam and the Marshalls (Map 3-66), the northern Marianas (Map 3-67), the Carolines and American Samoa (Map 3-68), and the isolated islands of Midway, Wake, and Johnston (Map 3-69). Except for Guam (the largest Pacific Island), wind power values are presented for the surrounding ocean areas; these estimates are based on ship wind data (Wyrtki and Meyers 1975) obtained over 6 years (1965 through 1970). The wind power estimates were calculated from mean wind speeds (averaged over 6 years) assuming a Rayleigh distribution of wind speeds.

Wind data from the Pacific Islands are sparse. Approximately half of the documented stations have questionable anemometer heights and exposures as a result of inadequate documentation. Wind power densities were available for some of the islands. Except for some of the small atolls, open-ocean wind power considerably exceeds island values. Apparently, well-exposed sites are rare in the Pacific Islands. Available site descriptions consistently mention adjacent stands of coconut palms.

Guam is the only Pacific island outside of the Hawaiian chain with more than one wind station. The island data indicate class 2 power, although ship wind data indicate class 5 to class 6 power in surrounding waters. Data from Andersen Air Force Base, on the plateau on what should be a windy island corner, indicate only class 2 power.

The Marshall Islands lie in a belt of strong ocean winds and possess the best wind power potential of the major Pacific Islands groups. Ship wind power densities reach class 7 in the northern Marshalls and class 4 in the south. With the exception of Enewetak and Kwajalein, island wind power densities differ drastically from the ship values.

The northern Marianas, which extend 700 km (435 mi) in a nearly north-south line, are volcanic peaks, some with considerable relief. Ship winds indicate power densities of class 5 to class 6 in surrounding waters, although available island data indicate class 2 and 3 power.

The Caroline group lies in a region of weaker ocean winds. The near-equatorial convergence migrating back and forth during the year accounts for weak winds, especially in the south. The islands lie well away from the major winter or summer trade wind belts. However, class 3 wind power potential appears to exist in the northern atolls such as Ulithi.

American Samoa consists of six mountainous islands. The main island, Tutuila, contains the only NCDC station, Pago Pago. Island data indicate little wind power potential, but ship winds indicate power densities of class 3 to class 4 in surrounding waters.

Midway, Wake, and Johnston Islands were grouped for convenience even though they are widely separated. Each is a low coral island with negligible relief and little vegetation. The data on Midway indicate only class 2 power. However, ship data show class 6 power for the ocean area. Thus, exposed sites on Midway may have higher power than that estimated from the island data. At Johnston Island, an atoll located 1,500 km (900 mi) south-southeast of Midway, brisk trade winds prevail throughout the year. Data from an apparently well-exposed station on Johnston Island indicate class 5 power, which is not significantly different from the class 6 power estimated for the ocean area. Wake Island is also an atoll, located north of the Marshall Islands. Like Johnston, data from an apparently well-exposed station on Wake Island indicate class 5 power, which is not significantly different from the class 6 power estimated for the ocean area.

Puerto Rico and Virgin Islands

The Puerto Rico/ Virgin Island region consists of the main island of Puerto Rico, its surrounding islands, the three main Virgin Islands (St. Thomas, St. Croix, and St. John), and several small islands in their immediate vicinity (see Map 3-70). This group of islands lies at the dividing point between the Greater and Lesser Antilles (which separate the Atlantic Ocean from the Caribbean Sea). The region totals slightly more than 9,100 km^2 (3,570 mi^2), which makes it a little smaller than the state of Connecticut, and has a population of approximately 3,000,000. Nearly 98% of the people in the region reside in Puerto Rico; about one-third of Puerto Rico's population lives in the metropolitan area of San Juan.

The topography throughout the region is generally hilly to mountainous. The main island of Puerto Rico is bounded on the north by a coastal plain averaging about 8 km (5 mi) in width. On the south coast the plain varies in width as mountains and hills intersect the coastline at several points. On the eastern end of the island a hilly valley extends inland to near Caguas. The coastal plain and valleys comprise 27% of Puerto Rico's total area. Hilly land surrounding the central mountain range occupies about 37% of the island's area. The interior of Puerto Rico consists of mountainous terrain of high local relief. This range of mountains, comprising 36% of the land area, runs east and west and is called the Cordillera Central. To the east of the main island are the hilly islands of Culebra and Vieques and to the west lies the island of Mona.

The three main Virgin Islands—St. Thomas, St. Croix, and St. John—are essentially mountains protruding from the sea. St. Croix, which has a valley sloping down from the center of the island to a broad coastal plain on the southern coast, is the only U.S. Virgin Island with a significant portion of flat land.

Puerto Rico - Windward Coastlines and Interior Mountains

Exposed points and capes along the entire northern coast, and most of the eastern coast, of Puerto Rico appear to have class 3 annual wind power as do the windward (northeastern) coasts of Culebra, Vieques, and Mona (Map 3-71). Perhaps the best wind resource in Puerto Rico can be found on Cape San Juan, which extends approximately 5 km (3 mi) seaward from the mainland on the extreme northeastern corner of Puerto Rico (Wegley et al. 1981). The mean wind speed at Cape San Juan slightly exceeds that of the mean trade wind flow because of acceleration of the trades as they round the windward corner of the island. The wind at this location appears to have a slight winter maximum, but remains strong during all seasons of the year.

The highest peaks and ridge crests of the Cordillera Central, Sierra de Cayey, and Sierra de Luquillo are estimated to have class 3 annual wind power. Considering the complexity of the terrain here, there may be individual ridges, gaps, or other wind-enhancing terrain features that have class 4 wind power.

St. Thomas - Windward Coast and Central Ridge

Several islands lie offshore near the northern coast of St. Thomas. The windward sides of these islands are estimated to have class 3 annual wind power. Exposed coastal sites on the northern coast as well as the exposed points at the southeast corner of St. Thomas also appear to have class 3 wind power (Map 3-72).

In central St. Thomas, the higher ridge and summits should have class 4 power. Some of the slightly lower peaks, particularly on the northeastern side of the island, are estimated to have class 3 annual wind power.

St. Croix - Central Ridge and Exposed Coastal Locations

The central St. Croix ridge runs east-west the entire length of the island. The orientation of the island and its ridgeline suggests that the areas of highest wind power include the higher peaks as well as their northern and southern shoulders, where acceleration of the prevailing easterlies occurs as they flow around these topographical barriers.

The eastern tip of St. Croix points into the trade winds. This tip, the exposed points on the northern and southern coast, and Buck Island (near the northeastern coast) are all estimated to have class 3 annual average wind power.

St. John - Ridge, East End Hills, and Windward Coast

A ridge of approximately 300 m (1,000 ft) MSL, paralleling the western shore of Coral Bay, appears to be the region of strongest winds (class 4 wind power) on St. John Island. The irregular coastline leaves many jutting points along the northeastern, eastern, and southeastern coasts. These points should have annual wind energy densities near class 3.

Chapter 4 References

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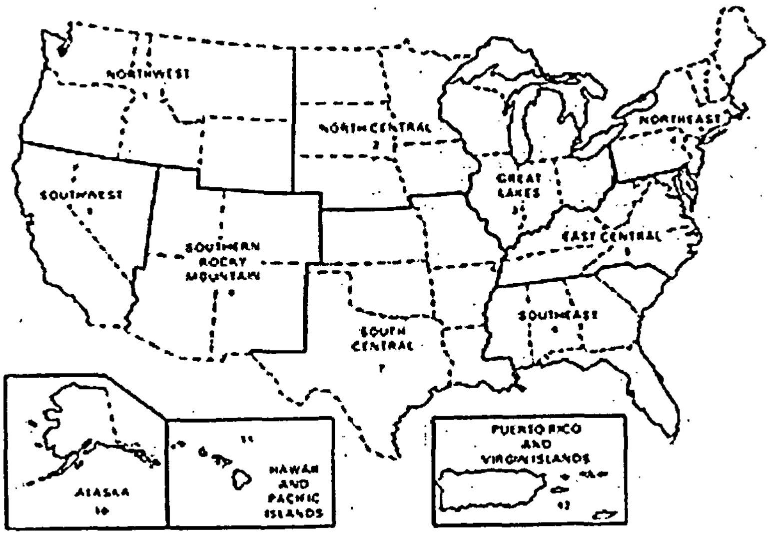

3-1 Geographic divisions of the 12 regional wind energy assessments

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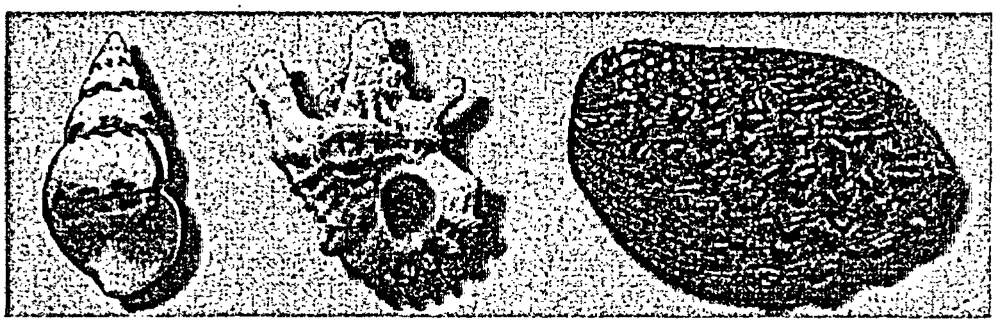

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Mission

The mission of the Mollusc Division is teaching, research and service through the use of collections of specimens, literature and related data. As needs arise and opportunities become available the emphasis on teaching or research or service changes so as to achieve maximal productivity of the staff and faculty. The scope of interest is both fossil and recent, local and world-wide; but the collections are richest in North American, European or Asiatic faunas.

The collections

The Division of Molluscs is divided into two major collections, housed in separate ranges. The bivalve collection consists of ~80,000 catalogued lots, mainly composed of North American freshwater mussels. The gastropod collection (and a small amount of material of other molluscan orders) consists of ~63,000 catalogued lots, primarily North American freshwater snails. The collections are among the largest in the world for freshwater Mollusca. Computers in each range link to central bivalve and gastropod databases.

Visit us

The Museum of Biological Diversity, including the Mollusc Division, houses research collections. As such they do not have the extensive displays and dioramas found in most public museums. Nevertheless, we are happy to show the collection and answer any questions. Contact us to arrange for a tour.

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- Visit The Department of Evolution, Ecology and Organismal Biology web site
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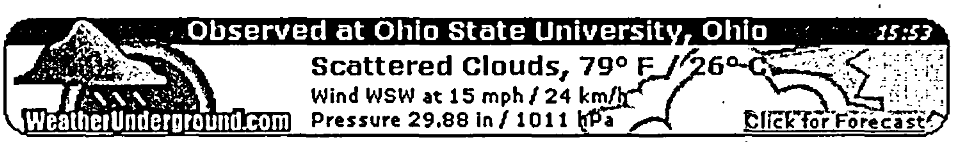

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Wisconsin Natural Resources magazine

From the June 1998 issue:

Into Lake Michigan's waters

Exotic fish took hold by many routes

Paul Peeters

special Sesquicentennial issue

From the surface, Lake Michigan seems timeless and unchanging, but the waterscape, like the landscape, has been altered dramatically since statehood. Events in the watery world set the stage for changes that would allow exotic species into the Great Lakes and spell the demise of many native species.

In 1848, Lake Michigan was an important trade route, and a source of food and income. Lake trout, lake whitefish, lake herring, and seven species of lake chub dominated the native fish community. Yellow perch, lake sturgeon, emerald shiner, spottail shiner, white sucker, longnose sucker, burbot, round whitefish, and four species of sculpin were also part of the mix. . These fish had evolved together since the retreat of the Ice Age glaciers in a diverse, yet balanced fish community, isolated from the rest of the aquatic world. The 200-foot vertical drop of the Niagara River plunging over Niagara Falls was an insurmountable barrier to fish from the outside world.

But Niagara Falls wasn't a barrier from people, and people brought dramatic changes to the native fish community. In the late 1800s, sawdust and wood scrap from sawmills were dumped in rivers destroying fish spawning areas in many streams. Lake sturgeon were considered a nuisance by commercial gill netters and were caught and stacked like cordwood on the Great Lakes beaches. Dam construction on tributary streams also prevented sturgeon from reaching their spawning grounds, which all but eliminated these relics from Lake Michigan. Unregulated commercial fishing further depleted various stocks of fish. However, none of these factors caused a bigger or more permanent change in Great Lakes fish populations than the unintended introduction of exotic species.

These new species upset the delicate balance of fish communities that had developed in Lake Michigan.

Exotic species entered the upper Great Lakes by many routes. The Welland Canal (click for a map), completed in 1829, bypassed Niagara Falls and connected Lake Erie to Lake Ontario and the St. Lawrence Seaway. The canal system was designed to give ships a navigable route from the Atlantic all the way to the Great Lakes ports in the Midwest. Naturally, fish used the new passages as well. Sea lamprey, alewife, and white perch migrated through the canal system and invaded the upper Great Lakes. Other species like river ruffe, zebra mussels, and spiny water flea "booked passage" as stowaways in the ballast water of large vessels. Many fish like rainbow and brown trout, chinook and coho salmon, and carp were intentionally introduced by people.

More than 140 exotic species of animals and plants have taken hold in the Great Lakes since the early 1800s. A partial list includes Atlantic and pink salmon, goldfish, smelt and round-nose goby. As in any ecological system, these exotic species settled in at the expense of something that was there before.

The sea lamprey was first observed in Lake Michigan in 1936. This eel-like predator with rasp-like teeth victimized lake trout, lake sturgeon, lake whitefish, and burbot. These fish had no natural defenses against the sea lamprey. By the mid 1950s, lamprey had all but eliminated the native population of lake trout in Lake Michigan, and significantly reduced populations of other species.

Like the sea lamprey, the alewife also entered the upper Great Lakes through the Welland Canal and was first documented in Lake Michigan in 1949. When the lake trout population collapsed in the 1950s, there were no predators to control alewife and their population grew rapidly. By 1967, alewife comprised an estimated 85 percent of the mass of the Lake Michigan fishery.

The alewife population explosion affected many other fish species in Lake Michigan. Six of seven chub species were eliminated and the commercial chub season was closed. Lake herring, yellow perch, and emerald shiner populations crashed. From the mid 1950s through the mid 1960s, neither commercial netters nor sport anglers found the Lake Michigan fishery desirable.

During the mid 1960s the U. S. Fish and Wildlife Service and its Canadian counterpart developed techniques to limit sea lamprey reproduction. Selective chemicals and physical barriers were used throughout the Great Lakes and lamprey populations were reduced, but not eliminated. Unfortunately, lamprey control came too late to save Lake Michigan lake trout.

Predatory fish were desperately needed to control the burgeoning alewife population. Fish managers selected strains of Pacific salmon to do the job. In 1966 coho salmon were stocked in Lake Michigan followed by chinook salmon in 1967. Salmon did well and grew quickly. Twenty-pound coho and 30-pound chinook were not uncommon. Rainbow, brown, brook, and lake trout were also stocked in Lake Michigan.

Sport anglers quickly learned how to catch the trout and salmon, and an exciting new sport fishery was born. Alewife are now considered an important part of the Lake Michigan food base that supports trout and salmon. As alewife numbers dropped, other Lake Michigan fish species have recovered. The one species of chub that survived the exotic invasion has come back strong and is currently fished commercially. Also, Wisconsin commercial fishers currently harvest more lake whitefish than at any time in history.

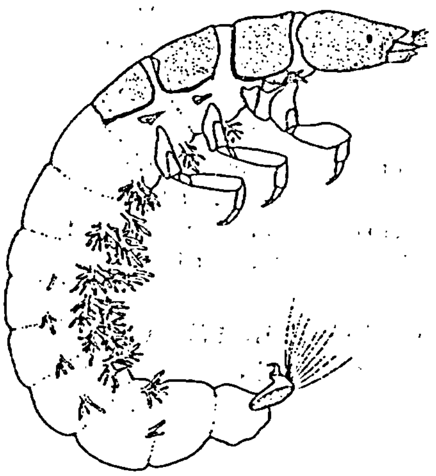
The Wisconsin Department of Natural Resources , other state and federal agencies and sporting groups are attempting to restore some of the native Lake Michigan fish species. The effort has had little success, and lake trout and lake herring still don't reproduce naturally in the lake.

Some people favor managing Lake Michigan exclusively for native species, but many species that were part of the original fish community are now extinct or have been extirpated from Lake Michigan. Also, many of the exotic species are so firmly established, that complete elimination is not feasible. Like it or not, many of these are now a naturalized part of the Lake Michigan fishery community.

If properly managed, Lake Michigan can provide both a world-class sport fishery and a healthy, viable commercial fishery. Effective management includes ongoing surveys to understand the changing nature of the fishery, a sustained commitment to limit pollution sources, controls on development and attention to other changes people can bring to resources as vast as Lake Michigan.

About the author

Paul Peeters is a Lake Michigan fisheries biologist.



IDENTIFICATION MANUAL

FOR THE

CADDISFLY (TRICHOPTERA) LARVAE

OF

FLORIDA

by

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INTRODUCTION

Caddisflies (Trichoptera) are a diverse and vital biotic component of freshwater ecosystems, having been able to adapt and succeed in nearly every type of aquatic habitat. Although the greatest species diversity occurs in cool running waters, many species inhabit lakes and ponds including specialized habitats such as marshes, swamps, springs, seeps, and intermittent streams. A few species live on marine shores and some in moist soil as well. The biological roles of caddisflies in freshwater ecosystems have been well documented (Scott and Crossman, 1973; Wallace et al., 1982; Merritt et al., 1984; Irons et al., 1988), and their potential use as biological indicators of water quality is well known (Plafkin et al., 1989; Resh and Jackson, 1993; Johnson et al., 1993).

Caddisflies are one of the dominant aquatic insect groups in Florida. However, knowledge of the systematics of the caddisfly fauna in the state is still limited, most particularly for the larvae, the life stage that benthologists most often encounter in the field. Caddisflies are excellent indicators of water quality, and to appreciate fully the utility of the group as a bioassessment tool requires a good taxonomic knowledge of the fauna, particularly at the species level (Resh and Unzicker, 1975; Lenat, 1988). The ability to distinguish the larvae provides a better understanding of the patterns of population and production dynamics in freshwater ecosystems (Resh, 1976).

The literature dealing with the taxonomy of the caddisflies of Florida are very scattered in various publications, and it is a time-consuming exercise to search these references. The present study represents the first attempt to consolidate the available taxonomic information on the larval taxonomy of the caddisfly fauna in the state. This manual is far from being a panacea to the problem of limited taxonomic knowledge of the group but rather serves as a reminder of how much work still needs to be done. Larval-adult associations are available for only approximately 50% of the approximately 170 species represented in the state. The manual leaves plenty of room for improvement in this regard. A group as large as caddisflies requires years to conduct a more thorough and comprehensive taxonomic study.

HOW TO USE THE MANUAL

Area covered: This manual was prepared to aid aquatic biologists in the identification of the caddisfly larvae of Florida. The manual provides keys to the families, genera, and species (where possible) for the mature larvae of the caddisflies presently thought to occur in the state. In cases where the family is represented by a single genus, the generic names are included in the key to the families (e.g., Dipseudopsidae, Lepidostomatidae, Molannidae, Odontoceridae, Rhyacophilidae, Sericostomatidae). Furthermore, in cases where the family is represented by a single species, the specific names are indicated (e.g., Beraeidae, Helicopsychidae, Uenoidae). Similarly, in the key to genera of a particular family, a genus may be represented by one species; the specific name is then indicated in the key [e.g., *Ironoquia* (Limnephilidae), *Cyrnellus* (Polycentropodidae)]. The sources of information from which the keys are adapted are indicated at the end of each key.

During the course of preparing the manual, we found many species and a few genera that represent new state records. As a matter of fact, we have seen some specimens that presumably may represent new species (e.g., *Setodes* n. sp., *Agarodes* n. sp.). Certainly more new state records will be added in the future and more larval-adult associations of species will be accomplished. Therefore, we strongly recommend that other sources must be consulted in addition to this manual when identifying the larvae of the caddisfly fauna of the state. For larval keys of families and genera, the papers by Ross (1944), Wiggins (1977, 1984), Unzicker et al. (1982), and Morse and Holzenthal (1984) are very useful. Significant references for the larval taxonomy of a given genus are included in the text as ADDITIONAL REFERENCES following the NOTES section. Complete information on these references is indicated in the LITERATURE CITED section of the manual.

Illustrations: The figures in this manual are a combination of original illustrations based on Florida specimens and illustrations adapted from other sources. If the illustrations were adapted or modified from other publications, the source of each figure is cited at least once within the manual. Diagnostic characters in the keys that a novice may have difficulty locating are indicated by arrows in the illustrations. The figures of diagnostic characters in the family key are numbered accordingly. In the keys to genera and species, if two or more figures are involved in a couplet, the left figure corresponds to the first diagnostic character that is referenced in the couplet.

Taxonomy: Appendix A shows that the arrangement of taxa follows the scheme of classification proposed by Weaver and Morse (1986). The subfamily level is excluded in the list of taxa. Taxonomic accounts (i.e., synonymies) of the genera and species are excluded in the text. Species that are presumably new to science are simply referred to as sp. A, B, etc... and their descriptions will be published elsewhere. Additionally, the appendix includes species (with question marks) that have not been recorded in the state but may occur here, based on their present geographic range. These yet-unreported species are briefly discussed in the text.

Text: The text for each family summarizes genera represented in the state and provides a short diagnosis of the larva and larval case and general habitat information. This is followed by a key to larvae of the Florida genera. The text for each genus gives a brief morphological DIAGNOSIS (in telegraphic form); NOTES of general information on the morphology, life history and ecology of the various species represented in the state; and ADDITIONAL REFERENCES for significant literature regarding the larval taxonomy of that particular genus. The authors of species names, noted in the CHECKLIST OF FLORIDA CADDISFLIES (Appendix A), are not shown in the text.

ACKNOWLEDGEMENTS

This manual is a product of the collective efforts of friends and colleagues. Our sincere thanks to R. W. Flowers, M. D. Hubbard, J. Jones, M. Lara, and J. G. and W. L. Peters for their encouragement and tremendous contributions to the caddisfly collections at Florida A&M University (FAMU). E. A. Gordon curated many of FAMU caddisfly collections, and her list of the caddisfly species of Florida (Gordon, 1984) provided us the impetus to conduct a more in-depth study of the group; to her we express our special thanks.

In addition to the FAMU caddisfly collection, this study was immensely enhanced by the generous loans of specimens from the following biologists: W. R. Karsteter [Center for Aquatic Research and Resource Management (FSU)], L. Banks (FDEP, Jacksonville), L. Burton, J. Daigle, and R. Frydenborg (FDEP, Tallahassee), J. H. Epler (Crawfordville, FL), R. Mattson (Suwannee River Water Management District), P. Morgan (FDEP, Tampa), R. Payne and D. Ray (FDEP, Pensacola), R. Rutter and A. Walton (FDEP-Punta Gorda), and D. Strom (FDEP, Port

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Last but not least, we sincerely thank James L. Hulbert, Director, Surface Water Ambient Monitoring Program (FDEP), for his assistance in getting this research funded.

PREPARATION OF SPECIMENS

Preservation and Storage: Generally, the morphological structures that are used to identify the mature larvae of caddisflies preserve well as long as proper preserving procedures are followed. From experience, the following procedures work well. Newly collected benthic samples must be preserved in 85-95% ethyl alcohol. The preservative must be replaced with the same concentration within 24 hours if the samples are not processed or sorted immediately, or else the integrity of the insect tissues is destroyed. Once the specimens are sorted, they should be preserved in 75-80% ethyl alcohol. Wiggins (1977) recommended an initial preservation in Kahle's fluid for its superior fixing quality. We have experienced difficulty identifying specimens that were treated with Rose Bengal stain. The stain diffuses the cuticular coloration, thus making it difficult to discern the patterns of muscle scars. Small-sized species (e.g., *Oecetis* spp., *Hydroptila* spp.) are better stored in microvials inside 2 or 4-dram vials filled with alcohol. This procedure prevents or minimizes the mutilation of the larvae and breakage of the larval cases. Vials or any storage container with specimens must have complete locality labels. One of the pet peeves of systematists is identifying specimens that are not properly labeled or with field codes only. Locality, to some extent, may provide invaluable information for the identification of specimens.

Dissection: When dissection is needed, the larvae may be heated in 10% potassium hydroxide (KOH) for 3-5 minutes. Jewelers forceps and dissecting needles work very well in dissecting the structures for examination. Dissected structures placed in a concavity slide filled with 75% alcohol or glycerin generally offers a good view of the specimen under a good dissecting microscope (see equipment below); otherwise, mounting the specimen on a microscope slide would be the next step toward resolution of fine structures.

Equipment.

A. Dissecting Items: The examination of larvae under a dissecting microscope requires a minimum number of dissecting items: jewelers forceps, a set of dissecting needles, microdissecting scissors, dissecting containers (e.g., Petri-dishes, Syracuse watch glasses) and polyethylene wash bottles.

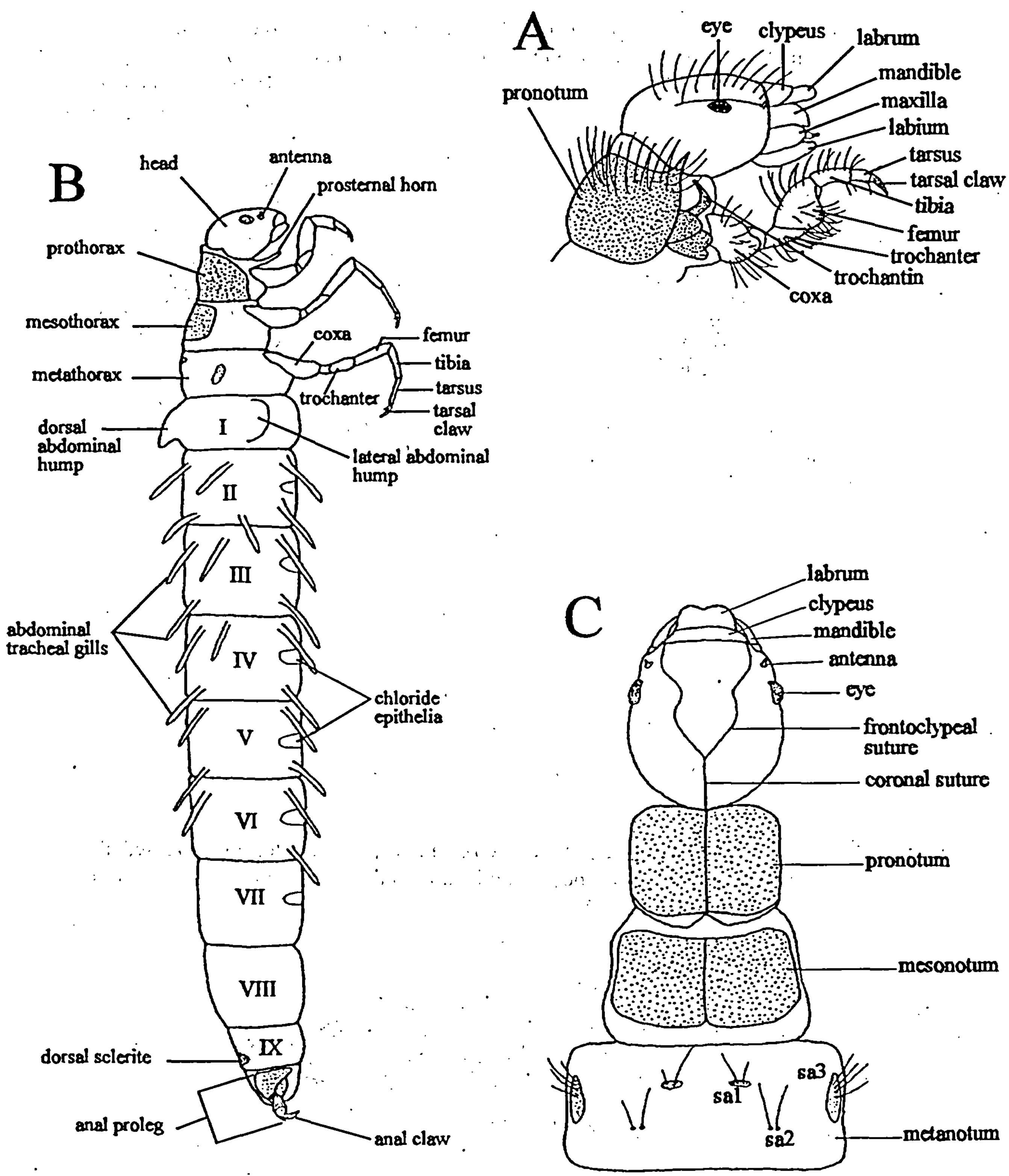
B. Microscopes: Most of the external morphological characters that are involved in identifying the larvae can be seen under a dissecting microscope that is equipped with 50X magnification. For illustrations or better viewing of minute parts, slide mounts may be required, together with a compound microscope with at least 100X magnification.

C. Mounting Media, and Microscope Slides: The CMC-10 medium is frequently used for mounting. One advantage of using the medium is that the specimen can be viewed immediately after mounting. This medium, however, has the tendency to form bubbles unless the glass slide cover slip is ringed with CMC-10 or Canada Balsam after the slide mount is dry. Canada Balsam is also a popular mounting medium. The resulting slide mount is more permanent than CMC-10. The Balsam reacts with alcohol or most preservatives and becomes cloudy for some time. The slide mount must be dry before the mounted specimen can be viewed under the microscope. Usually a Canada Balsam slide mount takes 24 hours to clear and dry when exposed to 62° C temperature. All slide mounts must be labeled properly with complete locality information.

MORPHOLOGY (Refer to Figures A, B, and C on next page)

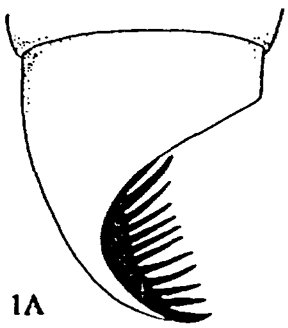
A general knowledge of the morphological terms associated with caddisfly larvae is necessary for ease of identification. The head is dorsally divided by a Y-shaped ecdysial line also referred to as the frontoclypeal and coronal sutures; the frontoclypeus is bordered laterally by the frontoclypeal sutures; and the parietals extend posteromesally along the coronal suture. Ventrally, the parietals mostly occupy the venter of the head and are separated by the ecdysial line, and the anterior and posterior apotomes. On the anterolateral portion of the head is located the eyes and antennae, which vary in location from family to family. Mouthparts include the labrum and labium, between which are mandibles and maxillae. Closely associated with the labium is the opening of the silk gland. The posterior portion of the head often has a number of muscle scars which appear as dark or light spots.

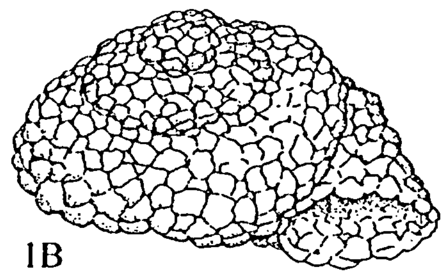
The thorax is composed of three segments: the prothorax, mesothorax and metathorax, each of which bears a pair of legs and often a sclerotized notum. The prothorax often has a finger-like prosternal horn and a lateral pair of trochantins, which can be distinctive for several families. The prothorax is always covered by dorsal sclerotized plates, while the meso- and metathorax are variable both in presence or absence of notal plates, and in extent of notal subdivisions. Setae, if arising on the meso- or metanota, are located in distinct areas termed setal area 1 (sa1), setal area 2 (sa2) and setal area 3 (sa3). Arrangement of both setal areas and sclerites can be of taxonomic significance. Thoracic legs are subdivided into the basal coxa, followed by the trochanter, femur, tibia and tarsus, which bears a tarsal claw apically. Tarsal claws usually each have a basal seta, the size of which can be of taxonomic value. The abdomen has nine segments that are usually membranous except for segment IX which has dorsal sclerites in some families. The first abdominal segment often bears a dorsal hump and a pair of lateral humps which function in allowing circulation of water through the case, as well as in securing the larva in the case. Some families have abdominal segments with numerous tracheal gills which function in gaseous exchange. Chloride epithelia, seen as oval rings especially on the venter of the abdomen, are found in the Limnephilidae, Hydroptilidae and Molannidae, and function in osmoregulation. The anal prolegs vary from family to family in degree of separation from the body, in associated sclerites, and in extent and nature of setation. Anal prolegs each have an anal claw which may be simple or complex, and which may bear accessory spines.


A
eye
clypeus
labrum
mandible
maxilla
labium
pronotum
tarsus
tarsal claw
tibia
femur
trochanter
trochantin
coxa
B
head
antenna
prosternal horn
prothorax
mesothorax
metathorax
coxa
femur
tibia
tarsus
trochanter
tarsal claw
dorsal abdominal hump
lateral abdominal hump
I
II
III
IV
V
VI
VII
VIII
IX
abdominal tracheal gills
chloride epithelia
dorsal sclerite
anal proleg
anal claw
C
labrum
clypeus
mandible
antenna
eye
frontoclypeal suture
coronal suture
pronotum
mesonotum
sa1
sa2
sa3
metanotum

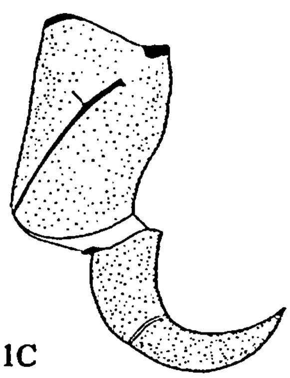
KEY TO FAMILIES FOR MATURE LARVAE OF THE CADDISFLIES (TRICHOPTERA) OF FLORIDA*

1. Anal claw comb-shaped (fig. 1A), larva constructing portable case of sand grains or small rock fragments, coiled to resemble a snail shell (fig. 1B) . . . . Helicopsychidae (p. 29), *Helicopsyche borealis*

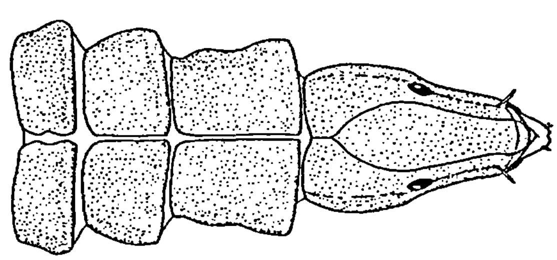

1A


1B

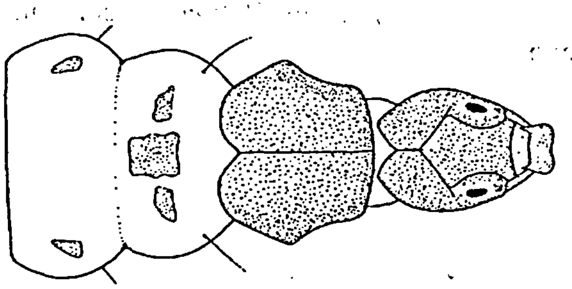
Anal claw hook-shaped (fig. 1C); larval case straight or nearly so, not resembling a snail shell, or larva not constructing a portable case 2


1C

2(1) Top of each thoracic segment covered by plates, usually closely appressed along the middorsal line, sometimes subdivided with thin transverse sutures, or some sclerites undivided (fig. 2A) 3


2A

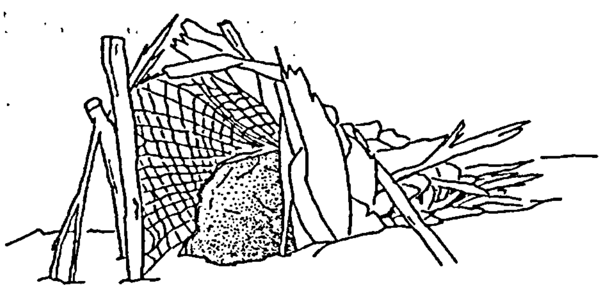
Metanotum and sometimes mesonotum entirely membranous, or largely so and bearing several pairs of smaller sclerites (fig. 2B)
. . . . 4



2B

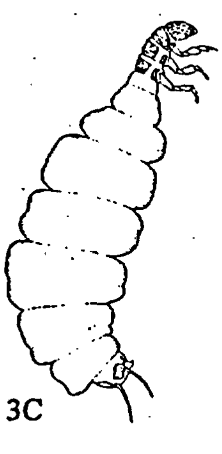
3(2) Abdomen with ventrolateral rows of branched gills, and with prominent brush of long hairs at base of anal claw (fig. 3A); larvae construct fixed retreats (fig. 3B)
. . . . Hydropsychidae (p. 30)

3A

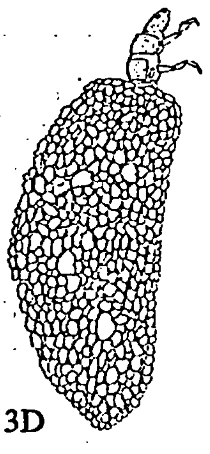


3B

Abdomen without ventrolateral gills, and with only 2 or 3 hairs at base of anal claw (fig. 3C); larvae small, usually less than 6 mm long; construct portable cases of sand, algae, or fixed cases of silk (fig. 3D)
. . . . Hydroptilidae (p. 42)

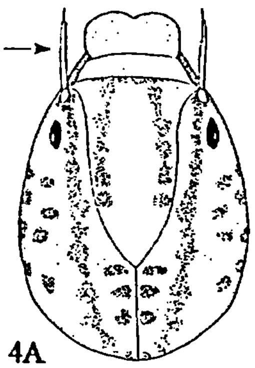


3C

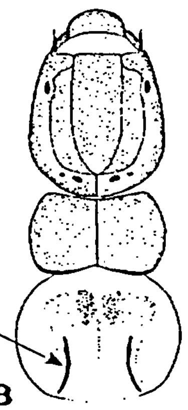


3D

4(2) Antennae very long and prominent, at least six times as long as wide (fig. 4A) and/or sclerites on mesonotum lightly pigmented except for a pair of dark curved lines on posterior half (fig. 4B); larvae construct portable cases of various materials .... Leptoceridae (p. 50)

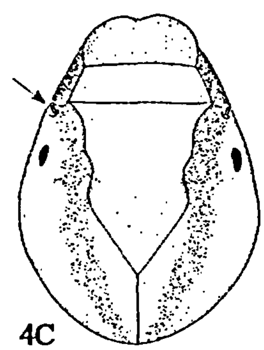


4A



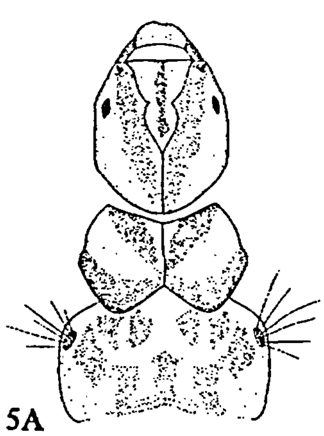
4B

Antennae of normal length, no more than three times as long as wide (fig. 4C), or not apparent; mesonotum without a pair of dark curved lines
.... 5

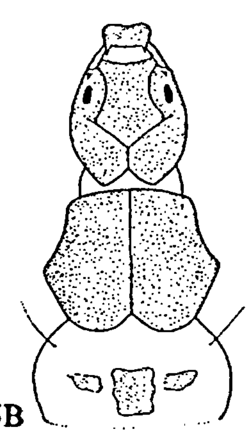


4C

5(4) Mesonotum largely or entirely membranous (fig. 5A), or with small sclerites covering not more than half of notum (fig. 5B); pronotum without anterolateral projections 6

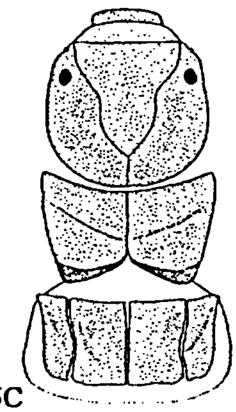


5A

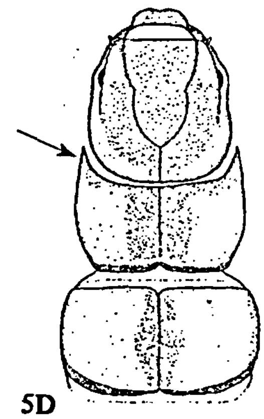


5B

Mesonotum largely covered by variously subdivided sclerotized plates (figs. 5C & 5D); pronotum sometimes with prominent anterolateral projections or processes (fig. 5D) 12

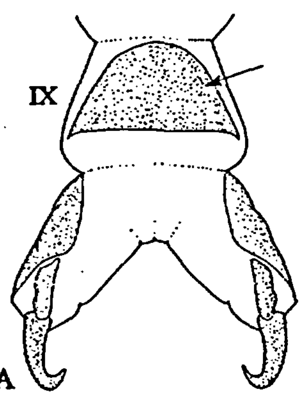


5C



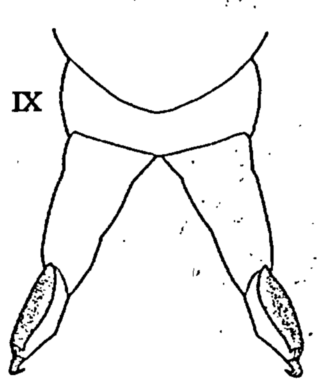
5D

6(5) Abdominal segment IX with sclerite on dorsum (fig. 6A), sometimes difficult to see and detectable only by its shiny surface
.... 7



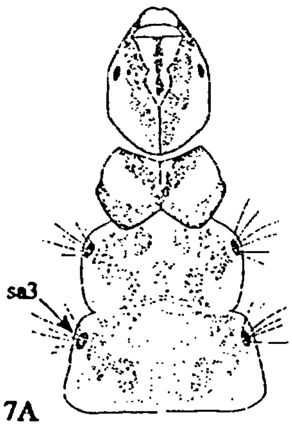
6A

Abdominal segment IX with dorsum entirely membranous (fig. 6B)
.... 9

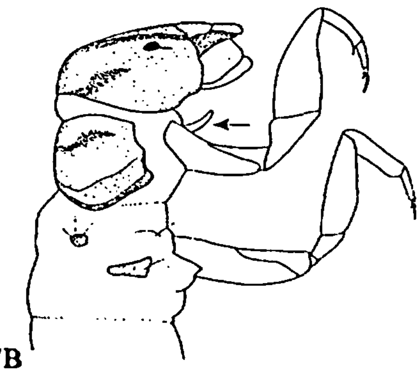


6B

7(6) Metanotal sa3 usually consisting of a cluster of setae arising from a small rounded sclerite (fig. 7A); prosternal horn present (fig. 7B); larvae construct tubular portable cases, mainly of plant materials
. . . . Phryganeidae (p. 98)

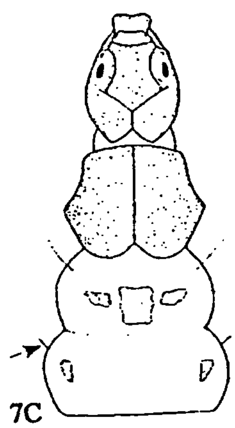


7A



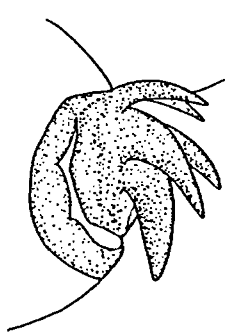
7B

Metanotal sa3 consisting of a single seta not arising from a sclerite (fig. 7C); prosternal horn absent; larvae either constructing a tortoise-like case of stones or free living 8

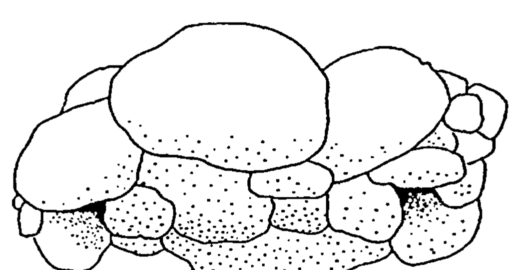


7C

8(7) Anal claw with at least one dorsal accessory hook (fig. 8A); basal half of anal proleg broadly joined with segment IX; larvae construct tortoise-like portable cases of small stones (fig. 8B)
. . . . Glossosomatidae (p. 28), *Protoptila*

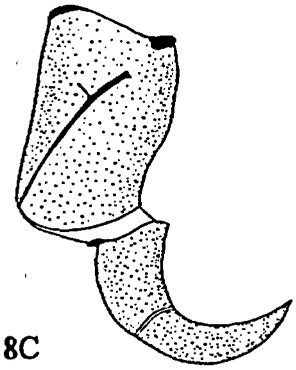


8A

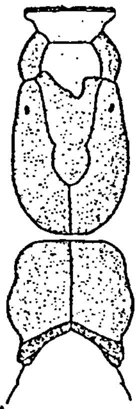


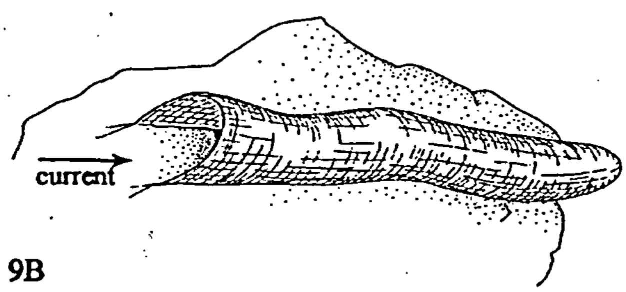
8B

Anal claw without dorsal accessory hooks (fig. 8C); most of anal proleg free from segment IX; larvae free living without cases
. . . . Rhyacophilidae (p. 112),
Rhyacophila (key to species, p. 113)


8C

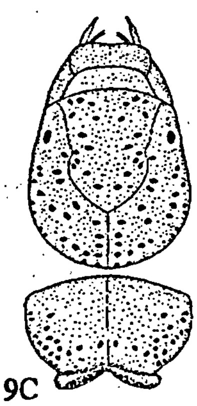
9(6) Labrum membranous and T-shaped (fig. 9A), often withdrawn from view in preserved specimens; larvae construct fixed sac-shaped nets of silk (fig. 9B)
. . . . Philopotamidae (p. 96)


9A

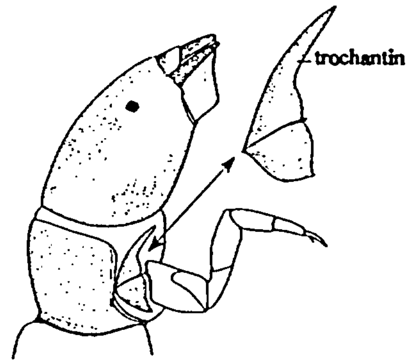


9B

Labrum sclerotized, rounded and articulated in normal way (fig. 9C), always exposed 10

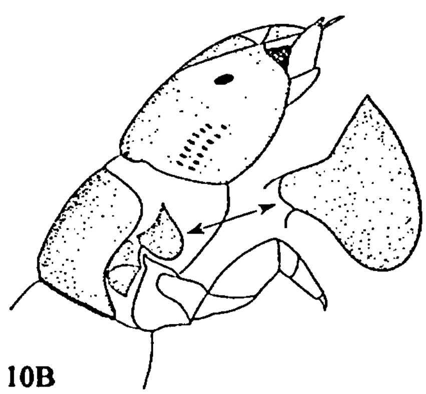

9C

10(9) Trochantin of prothoracic leg with apex acute, (fig. 10A); larvae construct exposed funnel-shaped capture nets, flattened retreats, or tubes buried in loose sediments
. . . . 11



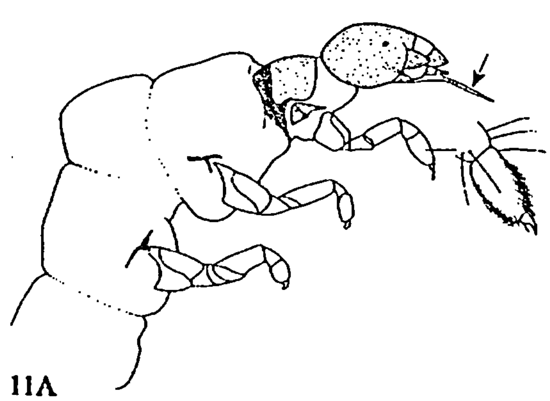
10A

Trochantin of prothoracic leg broad and hatchet-shaped, (fig. 10B); larvae construct tubular retreats on rocks and logs
. . . . Psychomyiidae (p. 109)



10B

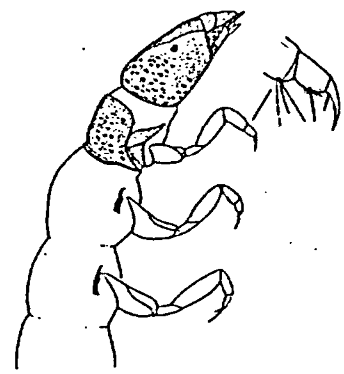
11(10) Tarsi of all legs broad and flat, tarsal claws reduced (fig. 11A); tip of labium extremely elongate (fig. 11A)
. . . . Dipseudopsidae (p. 27), *Phylocentropus*



11A

Tarsi of all legs elongate, not broad and flat, tarsal claws not reduced (fig. 11B); tip of labium not as elongate

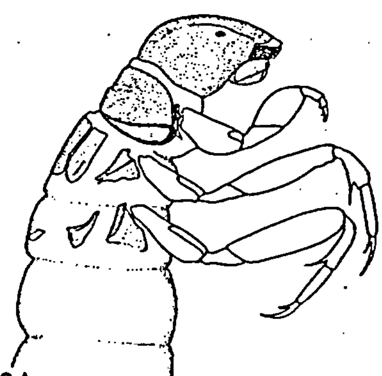
. . . . Polycentropodidae (p. 101)



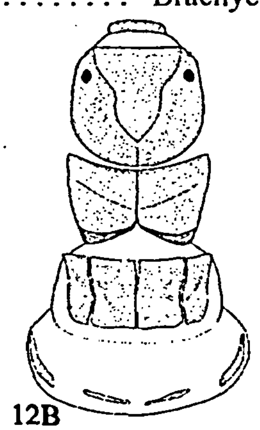
11B

12(5) Abdominal segment I lacking both dorsal and lateral humps (fig. 12A); metanotal sa1 usually lacking entirely, or, represented only by a single seta without a sclerite (fig. 12B); mesonotal sclerites subdivided (fig. 12B)

. . . . Brachycentridae (p. 20)



12A

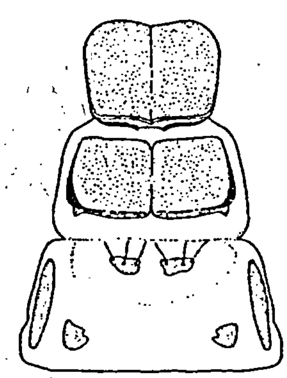


12B

Abdominal segment I always with a lateral hump on each side although not always prominent, and with or without a median dorsal hump (fig. 12C); metanotal sa1 always present, usually represented by a sclerite bearing several setae, but with at least a single seta (fig. 12D); mesonotal sclerites not as above (fig. 12D)

. . . . 13

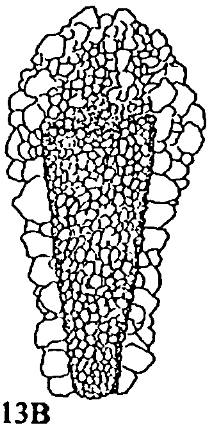
12C



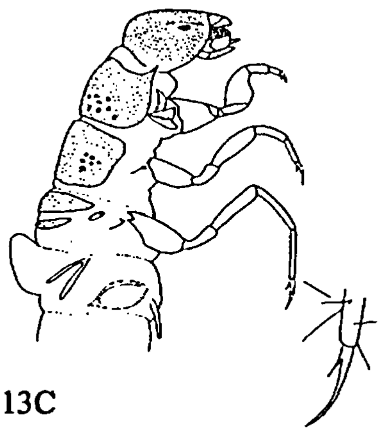
12D

13(12) Tarsal claw of hind leg modified to form a short setose stub (fig. 13A), larval case of sand grains with a dorsal cowl and lateral flanges (fig. 13B)
. . . . Molannidae (p. 92),
Molanna (key to species, p. 93)

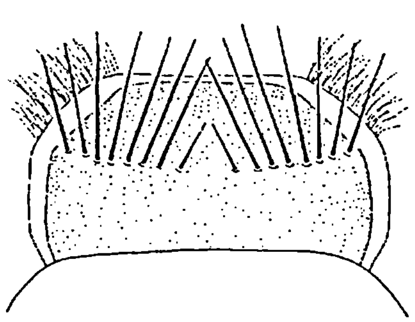

13A

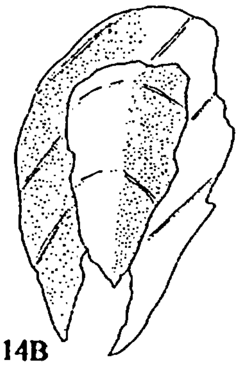

13B

Tarsal claw of hind legs no different in structure from those of other legs (fig. 13C); larval case not as above
. . . . 14

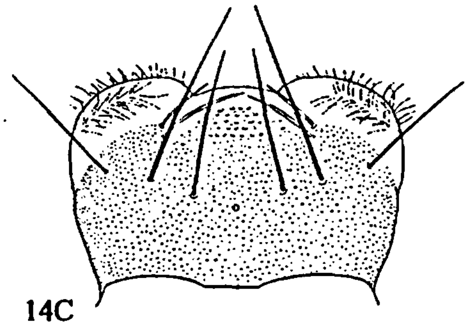

13C

14(13) Labrum with transverse row of approximately 16 long setae across central part (fig. 14A); larval case a hollowed twig or 2 leaf pieces (fig. 14B)
. . . . Calamoceratidae (p. 25)

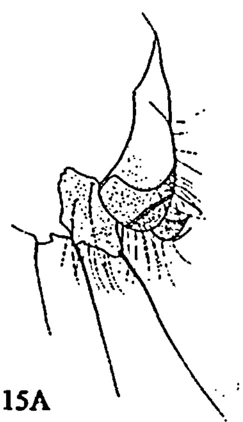

14A

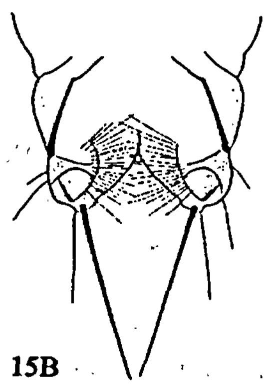

14B

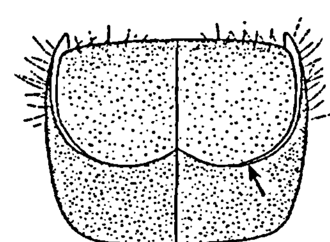
Labrum with no more than 6 long setae across central part (fig. 14C) 15


14C

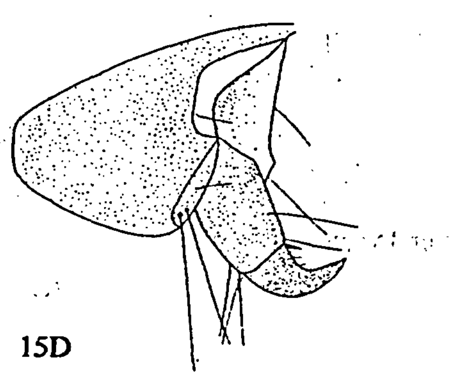
15(14) Anal proleg with lateral sclerite much reduced in size and produced posteriorly as a lobe from which a stout apical seta arises (fig. 15A); base of anal claw with ventromesal membranous surface bearing a prominent brush of 25-30 fine setae (fig. 15B); transverse carina on pronotum (fig. 15C); larval case of sand grains .... Beraeidae (p. 19), *Beraea gorteba*

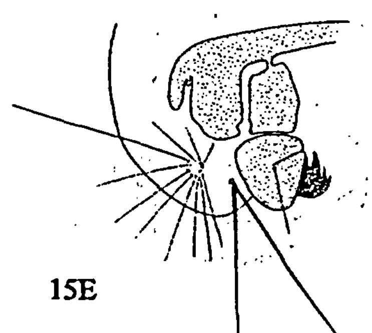

15A


15B

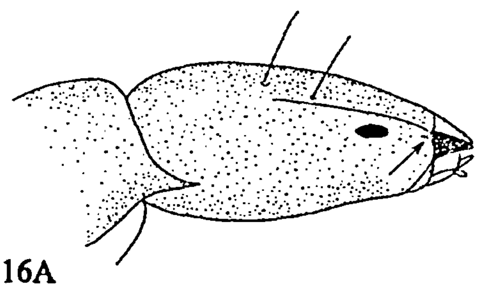

15C

Anal proleg with lateral sclerite not produced posteriorly as a lobe around base of apical setae (figs. 15D & 15E); base of anal claw with ventromesal surface lacking prominent brush of fine setae although setae may be present dorsally 16

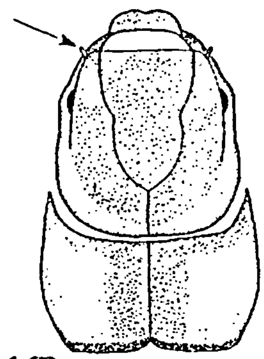

15D


15E

16(15) Antennae situated at or very close to the anterior margin of the head capsule (figs. 16A & 16B); prosternal horn lacking; larval cases mainly of rock fragments
. . . . 17

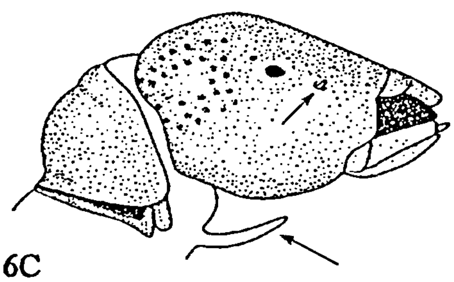


16A



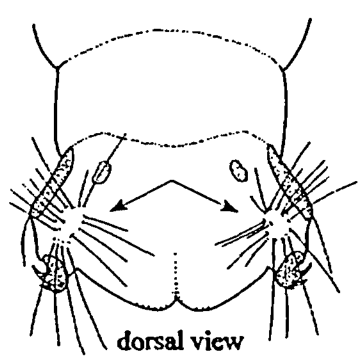
16B

Antennae removed from the anterior margin of the head capsule and approaching the eye (fig. 16C); prosternal horn present although sometimes short (fig. 16C); larval cases of rock fragments or plant materials
. . . . 18

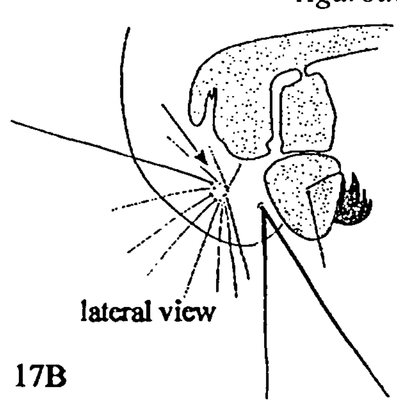


16C

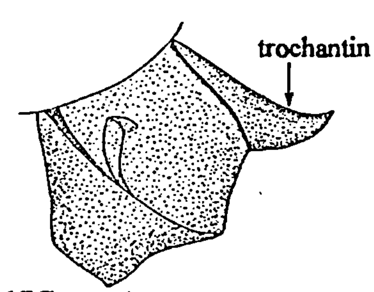
17(16) Anal proleg with dorsal cluster of setae posteromesad of lateral sclerite (figs. 17A & 17B); foretrochantin relatively large, the apex hook-shaped (fig. 17C); dorsal sclerites of metathorax divided at midline; larval case mainly of sand
. . . . Sericostomatidae (p. 114), *Agarodes* (key to subgenera, p. 115)



17A

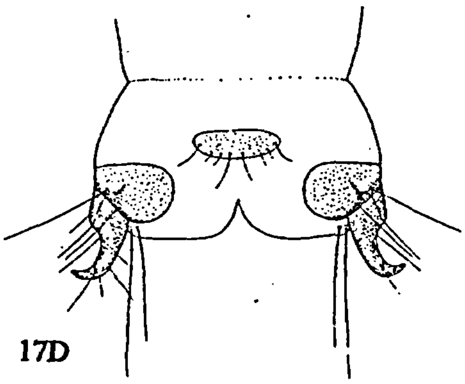


17B

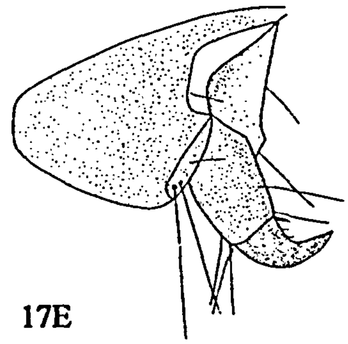


17C

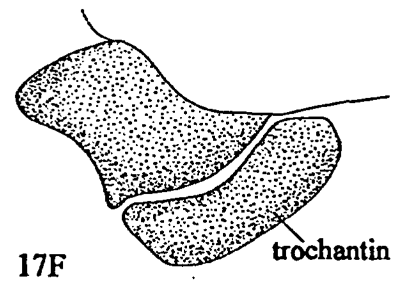
Anal proleg without cluster of dorsal setae posteromesad of lateral sclerite (figs. 17D & 17E); foretrochantin small, the apex not hook-shaped (fig. 17F); dorsal sclerites of metathorax entire; larval case mainly of small rock fragments
.... Odontoceridae (p. 94),
Psilotreta (key to species p. 95)



17D

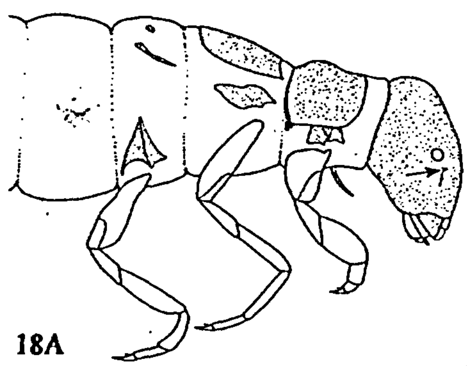


17E



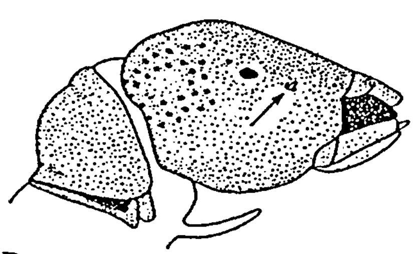
17F

18(16) Antennae close to the anterior margin of the eye (fig. 18A), median dorsal hump of segment I lacking (fig. 18A); larval cases of various materials and arrangements, frequently 4-sided
.... Lepidostomatidae (p. 49),
Lepidostoma

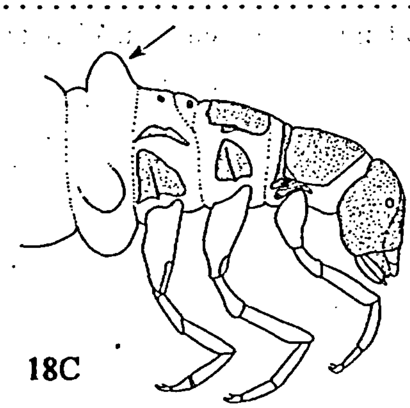


18A

Antennae approximately halfway between the anterior margin of the head capsule and the eye (fig. 18B); median dorsal hump of segment I almost always present (fig. 18C)
.... 19

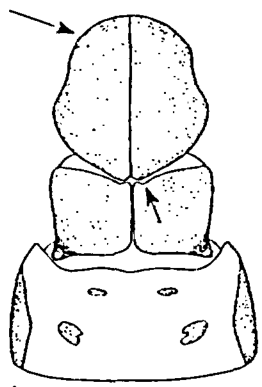


18B

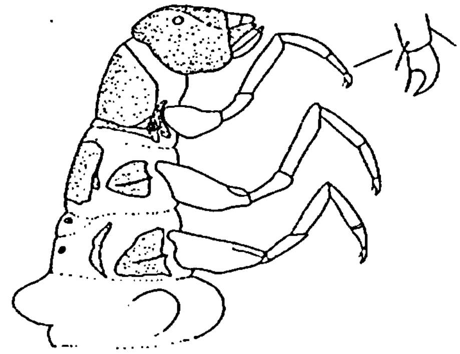


18C

19(18) Anterior margin of pronotum rounded and anterior margin of mesonotum notched on either side of meson (fig. 19A); prosternal horn reduced; basal seta of tarsal claw elongate, extending to near tip of claw (fig. 19B)
.... Uenoidae (p. 116), *Neophylax concinnus*

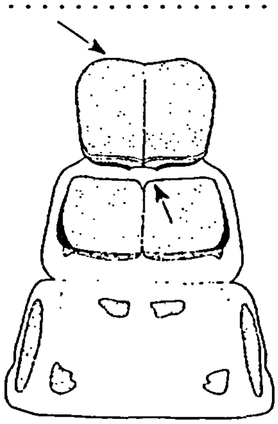


19A

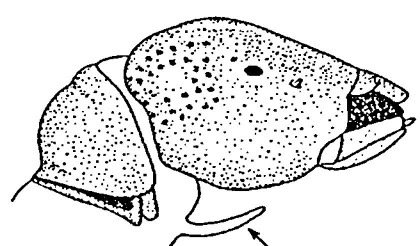


19B

Anterior margin of pronotum and mesonotum more or less straight (fig. 19C); prosternal horn not reduced (fig. 19D); basal seta of tarsal claw short, not extending to tip of claw
.... Limnephilidae (p. 89)



19C



19D

* key to families adapted from Wiggins (1984).

FAMILY BERAEIDAE

The beraeids are rare caddisflies, and are represented in North America by the genus, *Beraea.* The larvae are morphologically recognized by the greatly reduced lateral sclerite of each anal proleg, each with a posteriorly produced lobe supporting a stout seta, and the setaceous ventromesal membranous surface of the anal claw (figs. 15A, 15B in family key). The larval case is constructed mainly of sand grains.

Genus *Beraea* Stephens

DIAGNOSIS: The above morphological characteristics of the larva identify the genus as well.

NOTES: Of the three North America species of *Beraea, B. gorteba, B. fontana, B. nigritta,* only *B. gorteba* occurs in the Southeast. The species has never been recorded in Florida, but the geographic proximity of the type locality (Roberta, Georgia) to Florida suggests that the species may occur in the state. The type locality is within the Flint River watershed, and the Flint and Chattahoochee Rivers are the two main branches of the Apalachicola River.

The larva of *B. gorteba* has 3-4 large spines on each anterolateral process of the pronotum (fig. A below) compared to 5-7 smaller spines in *B. fontana* and *B. nigritta* (Hamilton, 1985).

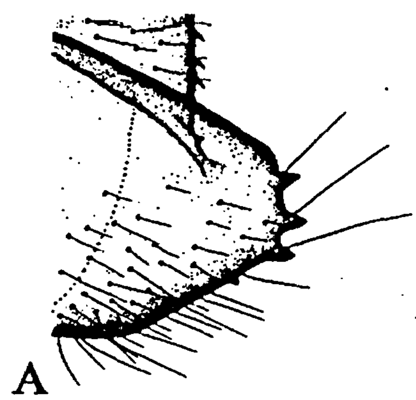


FIGURE: (Hamilton, 1985) - A. *Beraea gorteba,* anterolateral process of pronotum, right lateral.

Knowledge of the ecology and life history of *B. gorteba* is limited. According to Hamilton (1985) the larvae and pupae were collected in a side channel of Spring Creek, a small, second order, blackwater stream near Roberta, Georgia. The side channel where the larvae were mostly collected receives ground water and seepage from hillside springs as the main sources of water. Gut content analysis suggested that the larvae are primarily detritivores (Hamilton, 1985).

The adult emergence of *B. gorteba* has been observed in May and early June, in central Georgia (Hamilton, 1985).

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1954, 1977, 1984); Unzicker, Resh, and Morse (1982); Hamilton (1985).

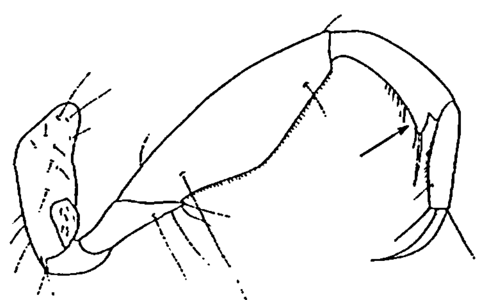
FAMILY BRACHYCENTRIDAE

The brachycentrid caddisflies are represented in Florida by the genera *Brachycentrus* and *Micrasema*. Both genera occur throughout much of North America.

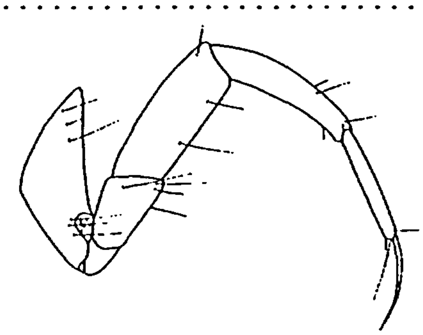
The brachycentrid larvae are morphologically distinguished from the other caddisfly families by the following combination of characters: absence of dorsal and lateral humps on abdominal segment I, metanotal sa1 either is entirely lacking or is represented by a single seta without a sclerite, and subdivided mesonotal sclerites (figs. 12A, 12B in family key). The portable larval cases are constructed of various materials and arrangements. The larvae are most abundant in cool lotic habitats such as springbrooks, creeks and streams, and some species also inhabit the wave-washed shores of lakes.

KEY TO GENERA FOR MATURE LARVAE OF FLORIDA BRACHYCENTRIDAE*

1. Meso- and metathoracic legs long, femora about as long as head capsule, tibiae each produced distally into prominent process from which stout spur arises . . . . *Brachycentrus* (p. 21)



Meso- and metathoracic legs shorter, femora much shorter than head capsule, each tibia not produced distally into prominent process, although spur arises from about the same point on unmodified tibia
. . . . *Micrasema* (p. 23)



* key to brachycentrid genera adapted from Morse and Holzenthal (1984).

Genus *Brachycentrus* Curtis

DIAGNOSIS: Ventral margin of femora, tibiae, and tarsi of meso- and metathoracic legs each with row of modified, short spinous setae; and tibiae each produced distally into prominent process with stout spur (see figure in key to genera).

NOTES: There are two species of *Brachycentrus* in Florida, *B. chelatus* and *B. numerosus*, the latter species is herein reported in the state for the first time. The species, *B. americanus*, was erroneously reported to occur in Florida by Denning (1971) (Flint, 1984). Both *B. chelatus* and *B. numerosus* belong to the subgenus *Sphinctogaster*, a group that uniquely has 2 pairs of long submesal setae on the abdominal sternum.The larval cases are typically 4-sided, tapered, and constructed of small rectangular pieces of plant material. The larvae attach the anterior end of the case to the substrate and extend the head and legs in a filtering posture to obtain food (Flint, 1984). The larvae of *B. chelatus* have a uniformly dark brown or fuscous head and brownish-fuscous meso- and metathoracic tarsi compared to the banded or spotted head and generally pale yellow meso- and metathoracic tarsi (except ventral margins dark brown) of *B. numerosus*.

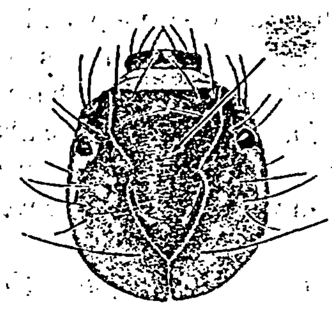
The life histories of *B. chelatus* and *B. numerosus* have never been observed in Florida. Collection records, however, indicate that the larvae of both species apparently occur throughout the year.

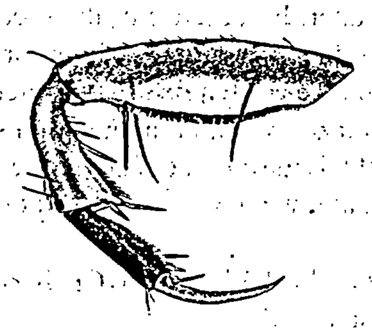
The larvae of both *B. chelatus* and *B. numerosus* have been collected in cool lotic habitats in the panhandle region of the state. We have examined larvae of *B. chelatus* that were collected from the Blackwater River, Okaloosa Co.; Crooked Creek, Gadsden Co.; Juniper Creek, Santa Rosa Co.; and Perdido River, Escambia Co. Likewise, we have seen larvae of *B. numerosus* from the Escambia River, Escambia Co.; Holmes Creek, Holmes Co.; and Yellow River, Okaloosa Co.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982); Flint (1984).

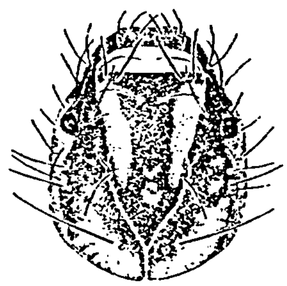
KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *BRACHYCENTRUS**

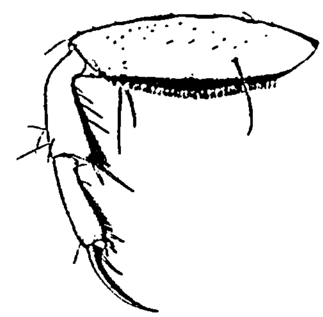
1. Head uniformly dark brown or fuscous, rarely paler over muscle scars; coloration of meso- and metathoracic tarsi dark brown .... *Brachycentrus chelatus*





Head distictly banded or spotted with fuscous and yellow marks; meso- and metathoracic tarsi pale except ventral margins dark brown
. . . . *Brachycentrus numerosus*





* key and figures to *Brachycentrus* species adapted from Flint (1984).

Genus *Micrasema* MacLachlan

DIAGNOSIS: Ventral margins of meso- and metathoracic legs lacking specialized setal fringe, apex of each tibia unmodified but with one large seta (see figure in key to genera).

NOTES: Three species of *Micrasema*, *M. rusticum*, *M. wataga*, and *Micrasema* n. sp., occur in Florida. All three species belong to the *M. rusticum* group whose larvae have the mesonotal sclerite partially or completely divided into four plates. The larvae are easily separated by the pattern of muscle scars on the head, and the material and construction of their larval cases. *Micrasema rusticum* has a curved larval case constructed of sand, and a distinctly bold, regular pattern of muscle scars on the head. *Micrasema wataga* and *Micrasema* n. sp. both have straight larval cases constructed of plant material, the latter, however, has more well-defined muscle scars on the head than the former (see figures in key).

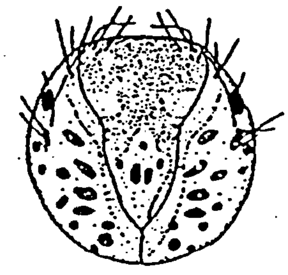
Knowledge of the biology of *Micrasema* is limited. A summary of available information on emergence of *Brachycentrus* and *Micrasema* in North and South Carolina, by Unzicker et al. (1982), indicated that *M. rusticum* emerges in mid-April through May, and *M. wataga* in May to early October. Emergence of the species in Florida has never been reported.

Micrasema spp. mainly occur in cool spring-fed streams and rivers in panhandle Florida where the larvae are mostly associated with submerged vegetation. We have examined larvae of *Micrasema rusticum*, an uncommon species in Florida, collected from the Shoal River, Okaloosa Co. and the Econfina Creek, Bay Co. Larvae of *Micrasema* n. sp. and *M. wataga* are more common, and we have examined larvae collected from various sites in the western panhandle.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Chapin (1978); Unzicker, Resh, and Morse (1982).

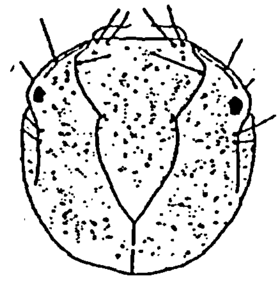
KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *MICRASEMA**

1. Case curved, constructed of sand; head pale yellow to light brown, with bold, regular muscle scar pattern of dark spots
. . . . *Micrasema rusticum*

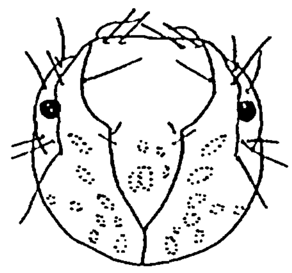


Case straight, constructed of strips of plant materials wound around the circumference; head lacking pattern of bold, regular muscle scars, if evident, these appearing as indistinct blotches or rings or light brown spots
. . . . 2

2(1) Head pattern with very irregular or mottled appearance
. . . . *Micrasema wataga*



Head pale yellow with posterior light brown muscle scars
. . . . *Micrasema* n. sp.



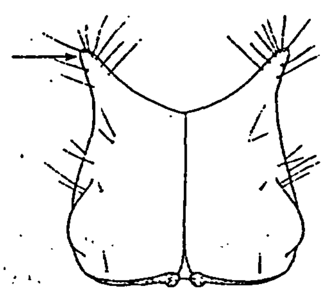
* key and figures to *Micrasema* species adapted from Chapin (1978).

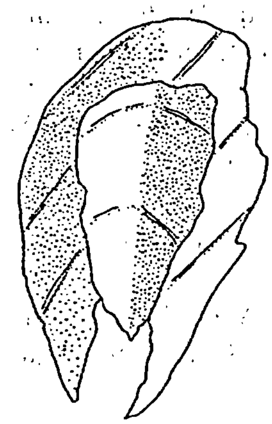
FAMILY CALAMOCERATIDAE

The Calamoceratidae include three North America genera of which *Anisocentropus* and *Heteroplectron* are found in Florida. Calamoceratid larvae are morphologically recognized by a prominent midtransverse row of approximately 16 long setae on the labrum (fig. 14A in family key). Larvae of both Florida genera are shredders, feeding upon decomposing vascular plant tissue (Unzicker et al., 1982). *Anisocentropus* larvae construct relatively flat cases of two fastened and overlapping leaf pieces. *Heteroplectron* use twigs which are hollowed out and lined with silk for their cases.

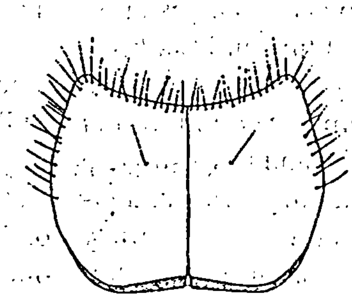
KEY TO THE GENERA AND SPECIES FOR THE MATURE LARVAE OF FLORIDA CALAMOCERATIDAE*

1. Anterolateral corners of pronotum each extended into prominent projection; gills branched; larval case consists of two leaf pieces, larger dorsal piece overlapping smaller ventral one
 .... *Anisocentropus, A. pyraloides*





Anterolateral corners of pronotum somewhat extended, but much less than above; gill filaments single; larval case a hollowed twig
 .... *Heteroplectron, H. americanum*



* key to calamoceratid genera adapted from Morse and Holzenthal (1984).

Genus *Anisocentropus* (MacLachlan)

DIAGNOSIS: Larvae with anterolateral corners of pronotum each produced into prominent projection, and abdominal gill filaments branched. Larval case constructed from 2 ovately cut leaf pieces with larger dorsal piece fastened to smaller ventral piece, space between two pieces providing larval chamber.

NOTES: The larvae of *Anisocentropus pyraloides* are strongly depressed dorsoventrally, the spindly hind legs are twice as long as the mesothoracic legs, and the abdomen is laterally fringed with dense setae. The head and thorax are yellowish brown.

Except for the collection records, life history information of *A. pyraloides* in Florida is non-existent. We collected larvae of various sizes almost all year and the adults came to light March through October. Wallace and Sherberger (1970) observed the species to have multi-cohort populations, with early- and last-instar larvae occurring in both late winter and early spring in south and southeastern Georgia. Pupation takes place in mid- to late April, and adult emergence occurs in May.

Anisocentropus pyraloides is fairly common in sand-bottomed streams in North and Northwest Florida. We have found that the larvae are commonly associated with trapped debris, snags and exposed roots where the stream undercuts the bank.

ADDITIONAL REFERENCES: Wallace and Sherberger (1970); Wiggins (1977); Unzicker, Resh, and Morse (1982).

Genus *Heteroplectron* (MacLachlan)

DIAGNOSIS: Anterolateral corners of pronotum not extended into prominent projections as in *Anisocentropus* and abdominal gills single. Larval case consisting of hollowed-out twig lined with silk.

NOTES: Larvae of *Heteroplectron* differ greatly in general appearance from *Anisocentropus*. The abdomen of *Heteroplectron* is cylindrical and lacks the lateral fringe of dense setae of *Anisocentropus*. The head and thoracic sclerites are dark brown, and the hind and middle legs are subequal in length.

Heteroplectron contains only two species (*H. americanum* and *H. californicum*). *Heteroplectron americanum*, previously thought to occur only as far south as the Appalachians of Georgia and Alabama, is herein reported for the first time in Florida.

The life history of *H. americanum* in the southeast has not been studied. However, a life history study of *H. americanum* from a coastal plain stream in Delaware by Patterson and Vannote (1979), established that *H. americanum* is univoltine and has a single population cohort. In Florida we collected the mature larvae of *H. americanum* during spring and fall months from small ravine streams within the Apalachicola Bluffs and Ravines Preserve in Liberty Co. We are unaware of its occurrence anywhere else in Florida, although its occurrence in similar ravine habitats is certainly possible. Larvae of *H. americanum* are difficult to detect in the field because their hollow twig case provides excellent camouflage.

ADDITIONAL REFERENCES: Wiggins (1977); Unzicker, Resh, and Morse (1982).

FAMILY DIPSEUDOPSIDAE

Wells and Cartwright (1993) recently broadened the definition of the family Dipseudopsidae based primarily on the morphological features of the female abdomen and the larvae. These authors also discussed briefly the taxonomic history of the group. Earlier papers by Ross (1965) and Ross and Gibbs (1973) discussed the evolutionary history of the group as well. Of the four dipseudopsid genera presently recognized worldwide, only the genus *Phylocentropus* is represented in the Nearctic Region and the species are mostly found in eastern North America.

The dipseudopsid larvae are morphologically recognized by the flat tarsi which are broader than the tibiae, the long tip of the labium (fig. 11A in family key), and the short and basally broad mandibles, each with a thick mesal brush. These modifications of the legs and mandibles are adaptations to life in sand tubes which are buried deeply into the substrate and project a short distance up into the current of the stream (Ross and Gibbs, 1973; Wallace et al., 1976).

Genus *Phylocentropus* Banks

DIAGNOSIS: Larvae with broad and densely pilose tarsi, and mandibles short and triangular with thick mesal brush (fig. 11A in family key). Larvae construct bi- and multibranched tubes of fine sand glued together with silk and buried into substrate.

NOTES: Of the five presently recognized Nearctic species of *Phylocentropus*, three are represented in Florida, *P. carolinus*, *P. lucidus*, and *P. placidus*. One other species, *P. harrisi*, may also be found in the state as its present geographic distribution extends to the Alabama-Florida line (Schuster and Hamilton, 1984; Harris et al., 1991).

Although the larvae of *P. carolinus*, *P. lucidus*, and *P. placidus* have been described, we have not found reliable morphological characters to separate the larvae of these species with confidence. Mature larvae of *P. lucidus* have head capsules of less than 0.6mm width, those of mature *P. carolinus* and *P. placidus* are larger (Menking, 1978), but other characters are needed to distinguish *P. lucidus* larvae from young *P. carolinus* and *P. placidus* larvae.

The *Phylocentropus* spp. of Florida appear to be geographically confined to the northern half of the state, from Gainesville northward. We have collected the larvae in small streams (e.g., Attapulgus Creek, Gadsden Co.; Burnt Mill Creek, Jefferson Co.; FAMU farm streams, Gadsden Co.; and streams in the Apalachicola Bluffs and Ravines Preserve) to medium-sized rivers (e.g., Aucilla River, Jeff./Madison Co.; St. Marks River, Wakulla Co.). The larvae were collected by dipnets near the stream or river shorelines where snags and decaying leaves were trapped in the sandy substrates. So far, we have collected the adults of *P. lucidus* by light traps only along small spring-fed and sand-bottomed streams like the ones in the FAMU farm and in the Apalachicola ravines. The adults of *P. carolinus* and *P. placidus* have been collected along small streams as well as medium-sized rivers (e.g., Aucilla River).

Like most of the caddisflies in Florida, the life history of *Phylocentropus* is unknown. We have collected adults in both spring and fall and larvae of various sizes throughout the year. Whether the multi-cohort pattern is reflective of a multivoltine life cycle remains to be investigated.

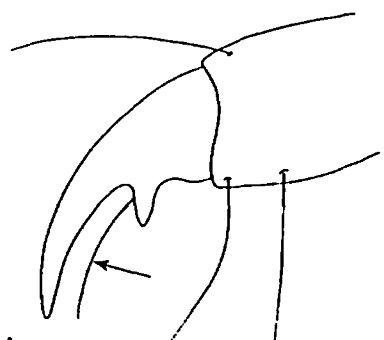
ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982), Wells and Cartwright (1993).

FAMILY GLOSSOSOMATIDAE

The genus *Protoptila* is the only glossosomatid caddisfly represented in Florida. The glossosomatid larvae are easily distinguished by the presence of anal claws with at least one dorsal accessory hook (fig. 8A in family key) and the unique tortoise-like case constructed of small stones (fig. 8B in family key).

Genus *Protoptila* Banks

DIAGNOSIS: Larvae with long, thin seta on each tarsal claw (fig. A below), and larval case made of relatively large stones (fig. 8B in family key).



A

FIGURE: A. *Protoptila* sp., mesothoracic tarsus, lateral.

NOTES: *Protoptila* is herein reported for the first time in the state and has been collected from the Chipola River, Calhoun Co. and Holmes Creek, Washington Co. The identification of these larvae to species remains unresolved until the adults are associated. *Protoptila palina* has been recorded near the Alabama-Florida line (Harris et. al., 1991), and there is a good possibility that the *Protoptila* larvae collected in Florida are *P. palina*.

The life history of *Protoptila* in Florida is unknown. The specimens collected from the Chipola River were associated with limestone outcroppings and were collected from the same locality as the larvae of *Setodes*.

ADDITIONAL REFERENCES: Wiggins (1977); Unzicker, Resh, and Morse (1982).

FAMILY HELICOPSYCHIDAE

The family Helicopsychidae is represented in North America by the geographically widespread genus *Helicopsyche*. The larvae are morphologically recognized by the broad joint of the basal-half of the anal proleg and abdominal segment IX, and the comb-shaped anal claw (fig. 1A in family key). Unique to the group is the helical, shell-like, larval case which is constructed of sand grains (fig. 1B in family key).

Genus *Helicopsyche* von Siebold

DIAGNOSIS: The characters above define the larva of the genus as well.

NOTES: Of the seven species of *Helicopsyche* represented in North America, *H. borealis* and *H. paralimnella* are the only species known to occur east of the Mississippi River. *Helicopsyche borealis* extends its southern geographic range to Florida. The larvae have been collected from the Chipola River, near the boat ramp north of State Rd. 274, Calhoun Co. in July and September and from the Alapaha River, Hamilton Co. in August (J. Epler, pers. comm.). The species was previously reported from Gilchrist Co. (Gordon, 1984) and the Suwannee River (Mattson, 1992).

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982).

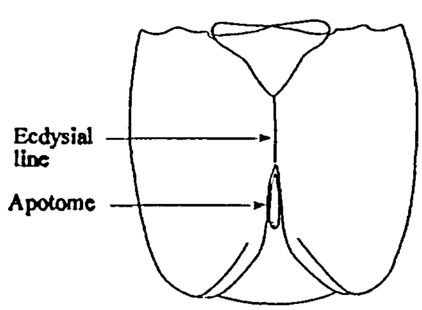
FAMILY HYDROPSYCHIDAE

The highly diverse hydrosychid caddisflies are represented in Florida by the genera *Cheumatopsyche*, *Diplectrona*, *Hydropsyche*, *Macrostemum*, and *Potamyia.* The heavily sclerotized plate of each thoracic notum and conspicuously branched ventral abdominal gills of the larvae (fig. 3A in family key) easily separate the Hydropsychidae from the other caddisfly families. The larvae typically construct a fixed retreat where they live and spin a net for capturing food (fig. 3B in family key).

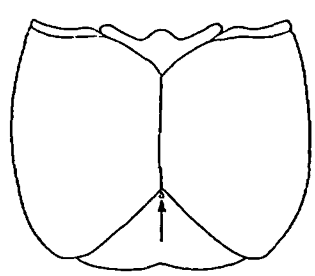
The larvae are mostly lotic dwellers and are quite common in streams and rivers of various sizes. Some larvae also live in lentic habitats, particularly along the wave-swept shores of lakes and impoundments, and lotic-depositional habitats as well.

KEY TO GENERA FOR MATURE LARVAE OF FLORIDA HYDROPSYCHIDAE*

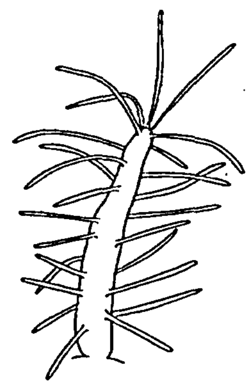
1. Posterior ventral apotome at least one-half as long as median ecdysial line .... (Subfamily Diplectroninae), *Diplectrona*, *D. modesta*



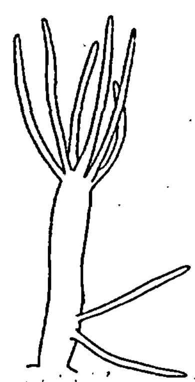
Posterior ventral apotome much less than one-half as long as median ecdysial line or inconspicuous
.... 2



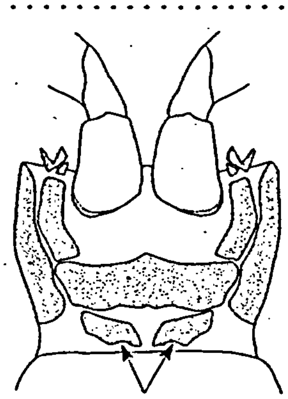
2(1) Abdominal gills with up to 40 filaments arising fairly uniformly along central stalk; foretrochantin never forked
.... (Subfamily Macronematinae), *Macrostemum, M. carolina*

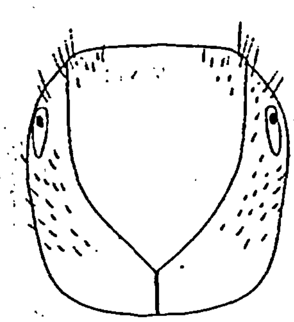


Abdominal gills with up to 10 filaments arising mostly near apex of central stalk; foretrochantin usually forked
.... (Subfamily Hydropsychinae)...3

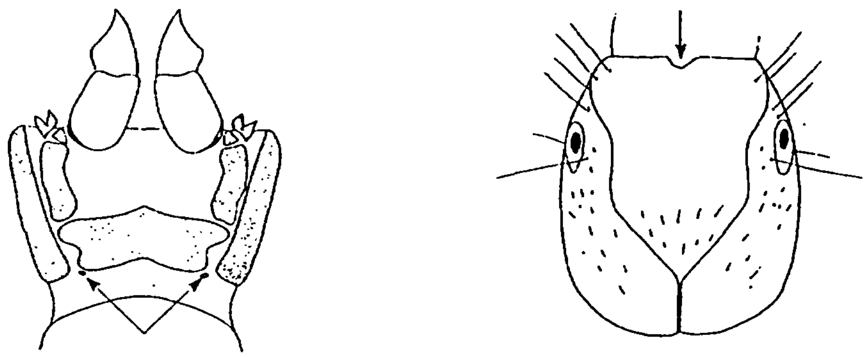


3(2) Prosternum with a pair of large sclerites in intersegmental fold posterior to prosternal plate; anterior margin of frontoclypeus entire
.... *Hydropsyche* (p. 35)

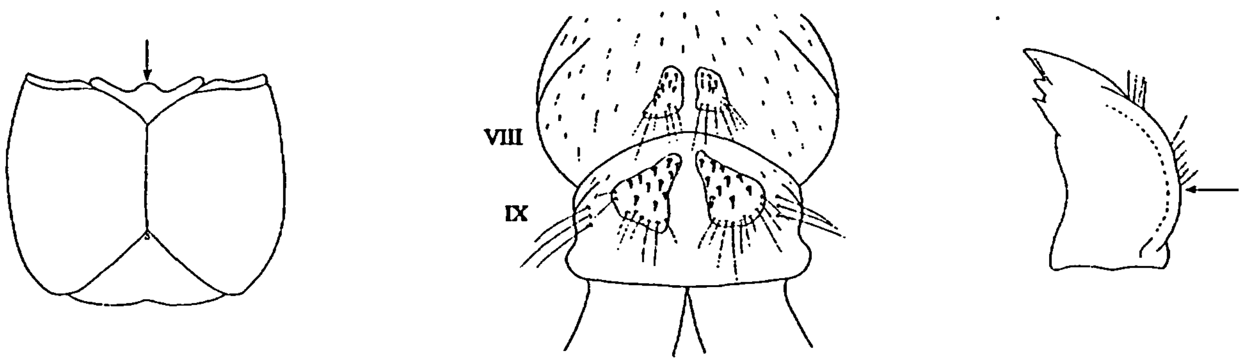




Prosternum with 2 very small sclerites posterior to prosternal plate; anterior margin of frontoclypeus usually with median notch
. . . . 4



4(3) Anterior ventral apotome of head with prominent anteromedian projection; posterior margin of each sclerite on abdominal sternum IX entire; lateral border of each mandible flanged; foretrochantin forked or not
. . . . *Potamyia, P. flava*



Anterior ventral apotome without anteromedian projection; posterior margin of each sclerite on abdominal sternum IX notched; mandible not flanged; fore trochantin forked
. . . . *Cheumatopsyche*

* key to hydropsychid genera adapted from Morse and Holzenthal (1984).

Genus *Cheumatopsyche* Wallengren

DIAGNOSIS: Larvae of *Cheumatopsyche* distinguished from other hydropsychid genera by the following combination of characters: absence of anteromedian projection on anterior ventral apotome of head; notched posterior margin of each sclerite on abdominal sternum IX; inconspicuous posterior ventral apotome; tiny posterior sclerites on prosternum; and forked trochantins (see figures in key to genera).

NOTES: The eight *Cheumatopsyche* species (see Appendix A) reported in Florida are known only from the adults. Four other species, *C. campyla*, *C. geora*, *C. miniscula*, and *C. sordida*, very likely occur in the state based on their geographic distribution. Harris et al. (1991) have collected all four species from streams and rivers near the Alabama-Florida state line.

Cheumatopsyche is a common and often one of the most dominant hydropsychid genera in many river systems in the Southeast. We also found this to be the case in Florida; the genus is not only geographically widespread in the state but the larvae were collected from a wide variety of habitats ranging from small streams to large rivers, and pristine to seriously damaged systems. The presence of *Cheumatopsyche* larvae in the Fenholloway River, a damaged system that has received about 190 million liters per day of cellulose mill wastes the past 40 years, strongly suggests a broad spectrum of tolerance to organic pollution. Although *Cheumatopsyche* is generally considered a pollution-tolerant group, the various species certainly have different levels of tolerances to contamination. Unfortunately, the larvae of *Cheumatopsyche* are taxonomically one of the least known and presently are not identifiable to species.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982).

Genus *Diplectrona* Westwood

DIAGNOSIS: Larvae of *Diplectrona* distinguished from other Florida hydropsychid genera by presence of posterior ventral apotome with length of at least one-half of median ecdysial line (see figure in key to genera).

NOTES: The genus *Diplectrona* is represented in Florida by the species, *D. modesta*. The broad lateral angles near the midlength of the frontoclypeus (fig. A below) are characteristic of *D. modesta* as well as other species in this subfamily not present in Florida.

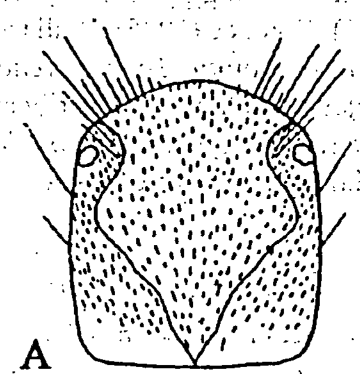


FIGURE: (Ross, 1944) - A. *Diplectrona modesta*.

Life history information on *D. modesta* in Florida is unknown. The species has been observed to have a univoltine life cycle in a 4th order southern Appalachian stream (Benke and Wallace, 1980). We found the species to be very common in small clear streams in North Florida, and particularly abundant and often the most dominant hydropsychid in small ravine and steephead streams. The filter feeding larvae are commonly associated with areas of leaf accumulation.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982); Morse and Barr (1990).

Genus *Hydropsyche* Pictet

DIAGNOSIS: Larvae of *Hydropsyche* distinguished from other hydropsychid genera by pair of large sclerites in intersegmental fold posterior to prosternal plate of prosternum (see figure in generic key).

NOTES: A key to the larvae of the caddisfly genera *Hydropsyche* Pictet and *Symphitopsyche* Ulmer (now *Ceratopsyche* Ross and Unzicker for Nearctic species, debatably genus or subgenus) in eastern and central North America (Trichoptera:Hydropsychidae) by Schuster and Etnier (1978) includes most of the species occurring in Florida. The key, however, relies heavily on color pattern and it must be used with caution. We found that the *Hydropsyche* larvae in Florida are generally paler than the northern conspecific populations, and the color patterns are often not as distinctive as the figures in the key show. We have seen larvae showing a wide range of head color patterns that would not fit the key to species. A good example is the larvae that we have collected from the Fenholloway River, a damaged system as previously mentioned.

There are eight species of *Hydropsyche* that have been reported in Florida (see Appendix A), and perhaps five more, *H.* (*H.*) *alabama*, *H.* (*H.*) *betenni*, *H.* (*H.*) *scalaris*, *H.* (*Ceratopsyche*) *sparna*, and *H.* (*H.*) *venularis*, may be found in the state based on their present geographic distribution.

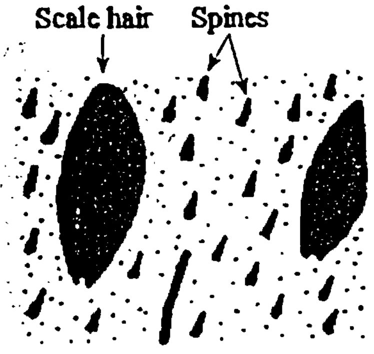
Except for *H.* (*H.*) *alvata* and *H.* (*H.*) *orris* the rest of the *Hydropsyche* represented in Florida are known from the larval stage. Based on the specimens that we have examined, it appears that *H.* (*H.*) *decalda* and *H.* (*H.*) *rossi* are the most common species of *Hydropsyche* in the state. Like the genus *Cheumatopsyche*, *Hydropsyche* spp. are geographically widespread in Florida, and occur in a wide variety of lotic habitats and from relatively clean to heavily contaminated systems.

Studies on the ecology and general biology of *Hydropsyche* have been conducted elsewhere [Gordon and Wallace (1975), Wallace (1975), Wallace et al. (1977), and Merritt and Wallace (1981)], but none have been from Florida. *Hydropsyche* larvae [e.g., *H.* (*H.*) *betteni*] feed primarily on fine particles collected in their nets, primarily animal remains and diatoms (Fuller and Mackay, 1981). A more recent study on *Hydropsyche* spp. [i.e., *H.* (*H.*) *betteni*, *H.* (*Ceratopsyche*) *sparna*] has indicated the importance of microhabitat flow on larval distribution (Osborne and Herricks, 1987).

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Schuster and Etnier (1978); Flint, Voshell, and Parker (1979); Unzicker, Resh, and Morse (1982); Sheftner and Wiggins (1986).

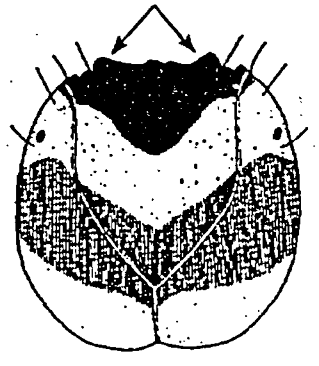
KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *HYDROPSYCHE** **

1 Dorsum of abdominal segments with minute spines on at least segments I-III ; scale hairs present on at least the last 3 abdominal segments
. . . . (Subgenus *Hydropsyche*). . . 2



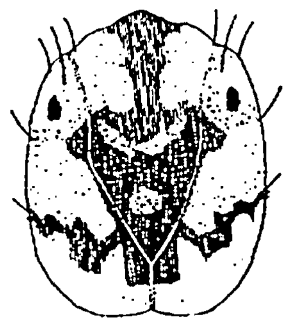
Dorsum of abdomen lacking minute spines; club hairs present on dorsum of abdomen; scale hairs lacking
. . . . (Subgenus *Ceratopsyche*), *H. sparna*

2(1) Anterior margin of frontoclypeus with 2 upturned teeth or denticles
. . . . *H. incommoda*



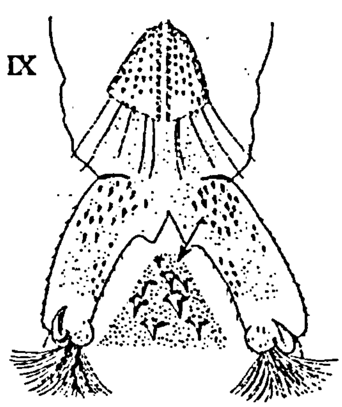
Anterior margin of frontoclypeus without teeth, margin straight or convex; color pattern of head not as above
. . . . 3

3(2) Frontoclypeus produced into a low, wide angle forming a triangular point
. . . . *H. phalerata*



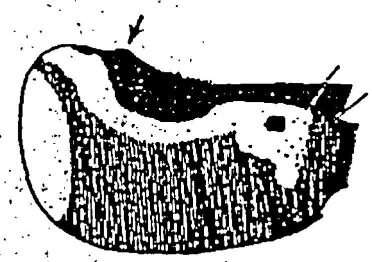
Anterior margin of frontoclypeus straight or, at most, broadly rounded
. . . . 4

4(3) Venter of anal leg with large, stout, heavily sclerotized setae
. . . . *H. scalaris*

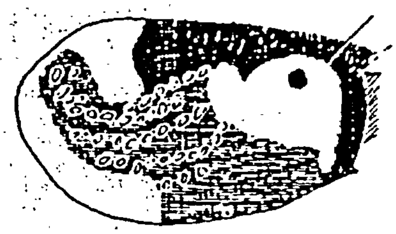


Venter of anal leg without such setae
. . . . 5

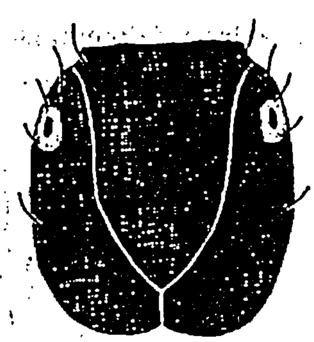
5(4) Posterior angle of frontoclypeus with elevated mound or tubercle (best seen in lateral or posterior aspect of head) 6



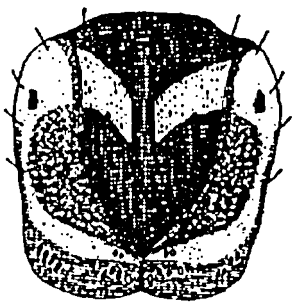
Posterior angle of frontoclypeus level with remaining posterior part of sclerite, mound or tubercle absent 7



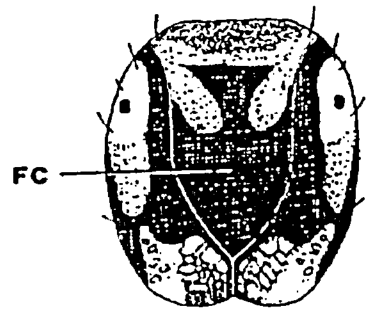
6(5) Sides of head evenly curved; head typically unicolored dark brown to black except for light area around eye and occasionally behind eye .... *H. betteni*



Sides of head constricted centrally and widened anteriorly (in dorsal aspect), posterior area of head not as wide as anterior; head mostly dark brown with pair of large, diagonal, tear-shaped spots; sides and top of head near epicranial stem with several dark brown, oval muscle scars
. . . . *H. elisoma*

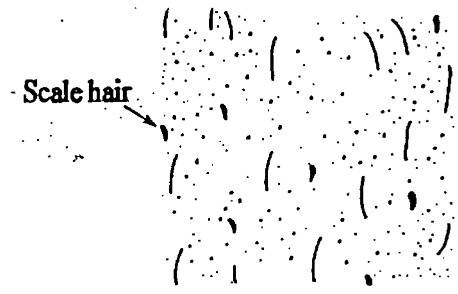


7(5) Frontoclypeus (FC) with many stout, bristle-like setae conspicuous on body of sclerite, most abundant on posterior half of sclerite
. . . . *H. mississippiensis*

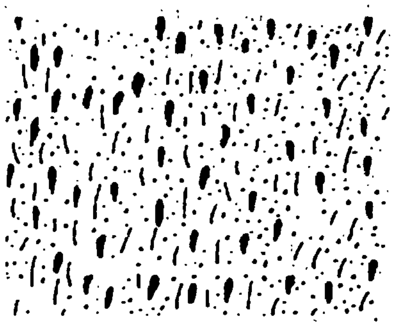


Bristle-like setae if present, restricted to anterolateral corners of frontoclypeus; posterior half of sclerite may have minute, clear, spine-like setae, but lacks larger bristle-like setae; color pattern of head not as above
. . . . 8

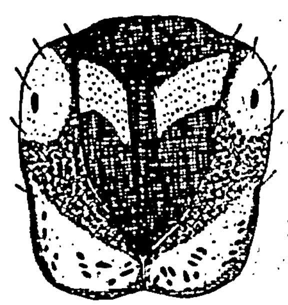
8(7) Scale hairs sparse on at least abdominal segments I-IV
. . . . 9



Scale hairs abundant on abdominal segments I and II
. . . . 10

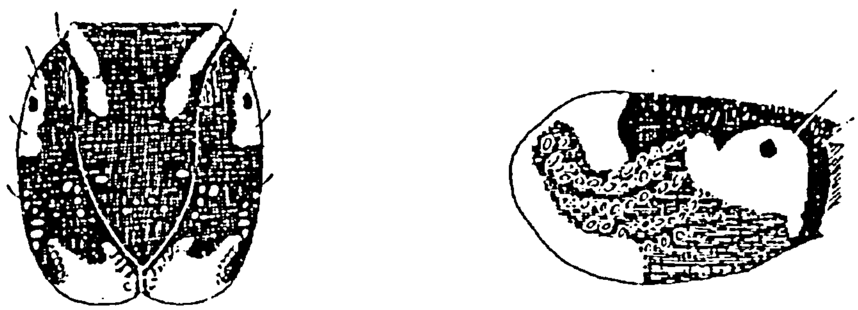


9(8) Frontoclypeus brown with large anterolateral, tear-shaped yellow spots; genae with numerous dorsolateral brown muscle scars
. . . . *H. decalda*

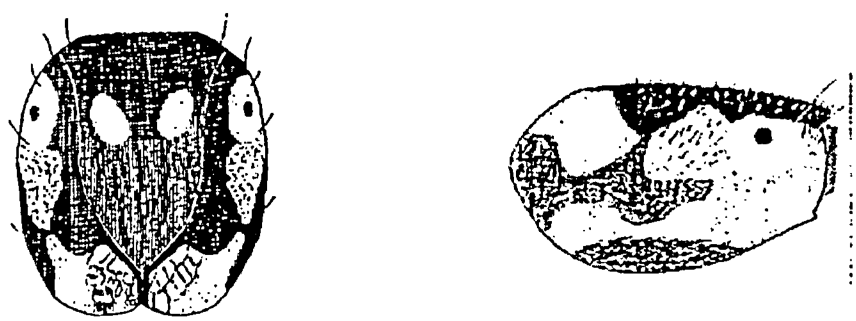


Frontoclypeus brown with tranverse yellow band anterior to anterolateral pale yellow spots; genae with dorsolateral pale yellow muscle scars
. . . . *Hydropsyche* sp.

10(8) Frontoclypeus with 2 pairs of yellow spots, 1 pair located centrally, and 2nd pair anterolateral to lst pair, often fused to form large, diagonal streaks on anterior portion of sclerite, posterior half of sclerite mottled; in lateral aspect, dark area behind eye with 3 to 4 horizontal rows of yellow muscle scars curved dorsad posteriorly, dark pigment behind eye contiguous with dark pigment on venter of head . . . . *H. venularis*



Frontoclypeus with single pair of centrally located spots, posterior half of sclerite solid brown, not mottled; in lateral aspect, area behind eye as in figure below . . . . *H. rossi*

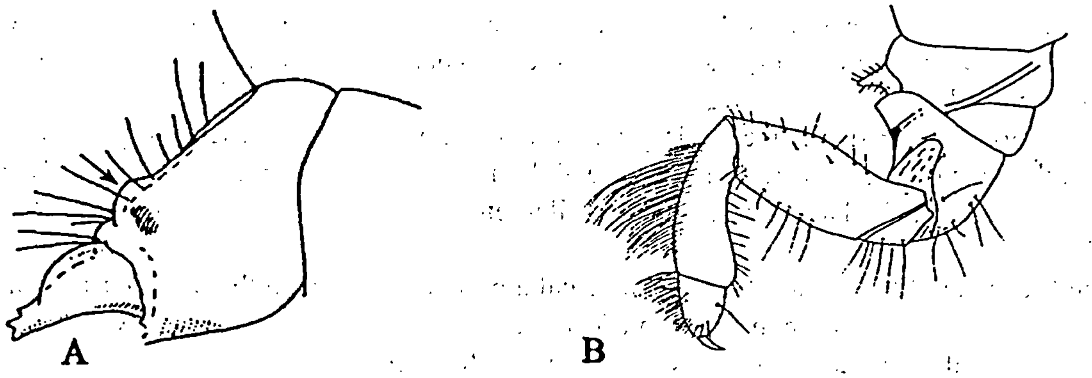


* key and figures to *Hydropsyche* species modified from Schuster and Etnier (1978).
** key does not include *H. alabama*, *H. alvata*, or *H. orris*.

Genus *Macrostemum* (Pictet)

DIAGNOSIS: Larvae of *Macrostemum* with distinctively flat head with U-shaped carina; pair of sclerites at base of labrum; and gills with up to 40 filaments attached to common stalk (see figure in key to genera). Larval case consisting of feeding chamber and retreat compartment.

NOTES: *Macrostemum* includes three species in North America, but only *M. carolina* is represented in Florida. *Macrostemum carolina* is morphologically distinguished from the other North American *Macrostemum* species by having a large tubercle near each eye (fig. A below). Larvae of the genus have dense brushes of setae on the prothoracic tibia and tarsus (fig. B below), which are used to clean food from their capture net. Wallace and Sherberger (1974) aptly described the larval case of *M. carolina* and discussed the functions of the food and retreat chambers.



FIGURES: A. (Ross, 1944) - *Macrostemum carolina*, lateral view of head; B. *Macrostemum carolina*, prothoracic leg.

Like the other hydropsychid genera found in Florida, *Macrostemum* spp. live in a wide variety of lotic habitats, but are mostly found in large rivers. We found the larvae of *M. carolina* to be most abundant in areas where snags and submerged tree limbs abound, and such habitat preferences may have something to do with their retreat construction behavior.

ADDITIONAL REFERENCES: Ross (1944); Wallace and Sherberger (1974); Unzicker, Resh, and Morse (1982).

Genus *Potamyia* Banks

DIAGNOSIS: Larvae of *Potamyia* morphologically distinguished from other hydropsychid genera by prominent anteromedian projection on ventral apotome of head; entire posterior margin of each sclerite on abdominal sternum IX; and prominently flanged lateral border of each mandible (see figures in key to genera).

NOTES: *Potamyia flava* is the only known species of *Potamyia* in North America. The species is rare in Florida, and has been collected only from small sand-bottomed streams in the steep ravines that dissect the eastern banks of the Apalachicola River near Bristol. The species, normally associated with large rivers, has probably invaded the ravine streams from the Apalachicola River. The life history of the species in Florida is unknown. We have collected the adults in the months of April and August. *Potamyia flava* has been observed to have either a univoltine (Hilsenhoff, 1975) or bivoltine life cycle (Fremling, 1960).

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982).

FAMILY HYDROPTILIDAE

The Hydroptilidae, or microcaddisflies, include the smallest of the caddisflies, most members being 2-3 mm in length. In North America there are 14 genera with nearly 250 species (Morse, 1993). In Florida, the family is represented by as many as seven genera and at least 48 species (See Appendix A).

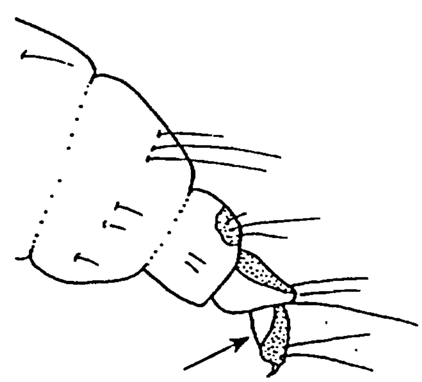
In addition to their small size, hydroptilids are recognized by the presence of sclerotized plates on all thoracic nota and lack of gills on the abdominal segments (fig. 2A, 3C in family key). [Note: larvae of *Hydroptila* have three, very thin filamentous gills on the posterior end of the abdomen].

The life cycle of the Hydroptilidae is unusual among caddisflies in that the first four larval instars are free-living, with case construction taking place in the final instars. Case type and construction material are variable and may be diagnostic for a genus.

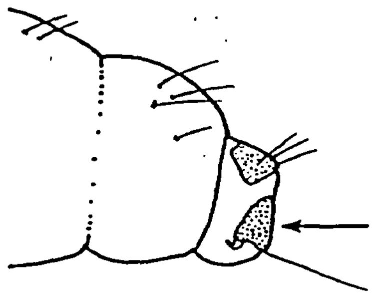
Hydroptilids occur in a wide array of lotic environments from small springs and seeps to large streams and rivers. Many species are also found in standing waters, including ponds, marshes, lakes and reservoirs, with some genera being more predominant in such environments. Larvae occur on variety of substrates, including submerged vegetation and algae, root masses, as well as rocks, sand and gravel, but are easily overlooked because of their size. Most microcaddisfly larvae feed on algae, either by grazing on diatoms and periphyton or by piercing filamentous forms.

KEY TO GENERA FOR FINAL INSTAR LARVAE OF FLORIDA HYDROPTILIDAE

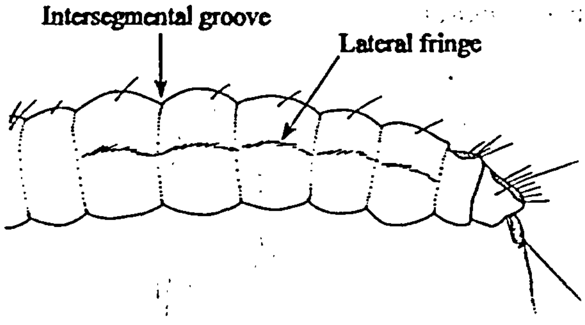
1. Anal prolegs elongate and cylindrical, projecting well beyond abdomen; head narrowing anteriorly in dorsal aspect (figure 2A in family key) 2

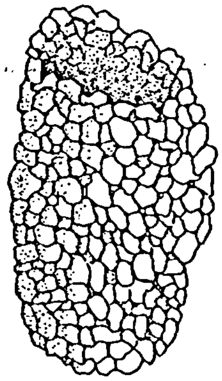


Anal prolegs short, not projecting conspicuously beyond abdomen; head not noticeably narrowing anteriorly in dorsal aspect
. . . . 3

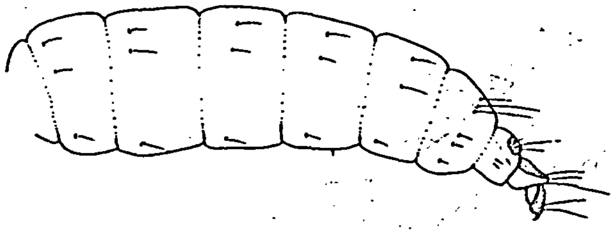


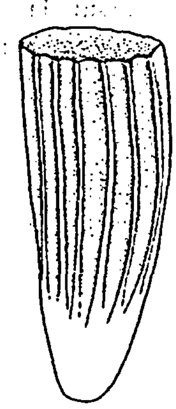
2(1) Abdomen with lateral fringe of hair; intersegmental grooves of abdomen prominent; cylindrical case of sand or sometimes plant pieces
. . . . *Neotrichia*



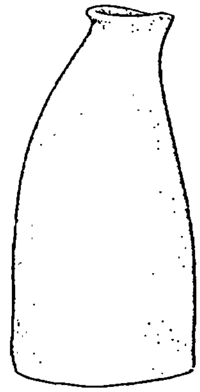


Abdomen without lateral fringe of hair; intersegmental grooves of abdomen not prominent; case of silk, often with longitudinal ridges
. . . . *Mayatrichia*, *M. ayama*





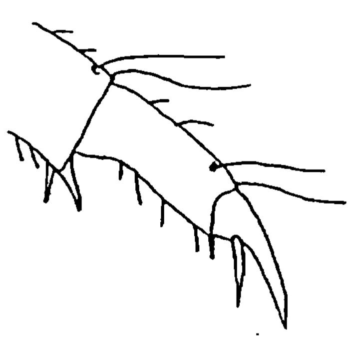
3(1) Middle and hind legs over twice as long as foreleg; bottle-like case constructed of silk . . . . *Oxyethira*



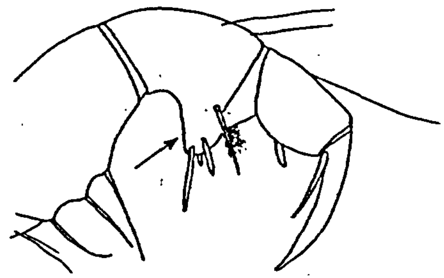
Middle and hind legs similar in length to forelegs; purse-like cases of sand or silk, sometimes mixed with plant material
. . . . 4

4(3) Tarsal claws stout with thick, blunt spur at base; case almost entirely of silk
. . . . *Stactobiella*

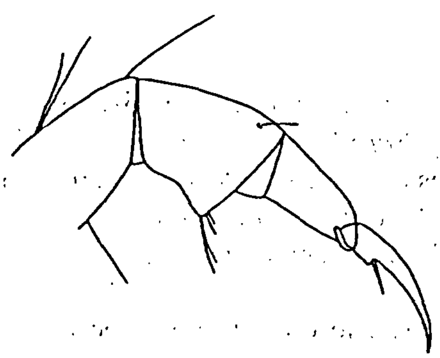
Tarsal claws slender with thin, pointed spur at base; case of sand or silk, sometimes mixed with plant material
. . . . 5

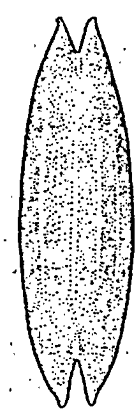


5(4) Tibia of foreleg with prominent, posteroventral lobe; middle and hind legs thickened; case of sand, sometimes mixed with plant material
. . . . 6

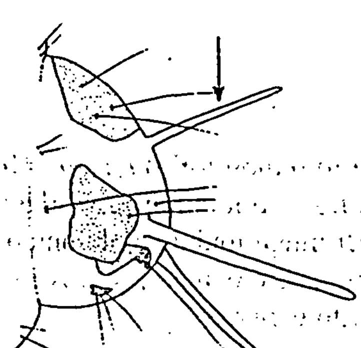


Tibia of foreleg without prominent, posteroventral lobe; middle and hind legs slender; case entirely of silk, with prominent longitudinal ridges
. . . . *Orthotrichia*

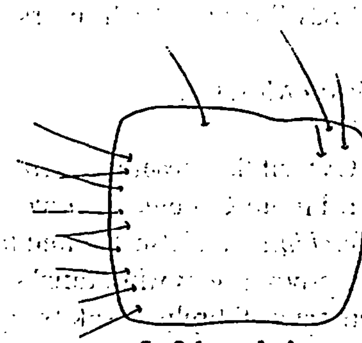




6(5) Three filamentous gills arising from posterior end of abdomen; anterior edge of meso- and metathoracic plates square at lateral edges
. . . . *Hydroptila*

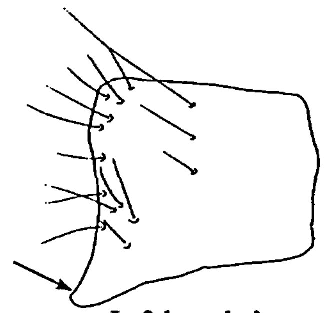


Lateral view



Left lateral view of metanotum

Posterior end of abdomen without filamentous gills; anterior edge of meso- and metathoracic plates lobate at lateral edges
. . . . *Ochrotrichia*



Left lateral view of metanotum

Genus *Hydroptila* Dalman

DIAGNOSIS: Larvae of *Hydroptila* characterized by three long, thin gills arising from posterior end of abdomen (see figure in key to genera). *Hydroptila* and *Ochrotrichia* similar in overall appearance and in construction of purse-like cases of sand, sometimes with plant materal mixed in. In addition to apical abdominal gills, *Hydroptila* distinguished from *Ochrotrichia* by lack of anterolateral lobes on meso- and metanota (see figure in key to genera).

NOTES: The genus *Hydroptila* is likely the most speciose genus of microcaddisflies in Florida, as is the case in North America. The genus inhabits a wide variety of habitats from small streams to large rivers and most lentic environments. All instars feed on filamentous algae (Nielsen, 1948), as well as diatoms and other algae (Wiggins, 1977). Most microcaddisflies complete development in a year or less.

ADDITONAL REFERENCES: Ross (1944); Nielson (1948); Wiggins (1977); Unzicker, Resh, and Morse (1982); Morse (1982, In Press).

Genus *Mayatrichia* Mosely

DIAGNOSIS: Overall, larvae of *Mayatrichia* similar to those of *Neotrichia*. However, anterior narrowing of head more acute in *Mayatrichia* (see fig. 2A in family key) and legs shorter and less slender. *Mayatrichia* larvae also without lateral hair fringe found on abdomen of *Neotrichia* and intersegmental grooves less well-defined (see figure in key to genera). Cases of *Mayatrichia* cylindrical and made entirely of silk (see figure in key to genera).

NOTES: Larvae of *Mayatrichia* occur in a variety of streams and large rivers, often on rocks and gravel. Only a single species, *Mayatrichia ayama*, is reported from Florida. In Alabama, this species occurred in small sandy streams and large rivers on the Coastal Plain and emerged from May through October (Harris et al., 1991). Larvae are characterized as algal scrapers by Wiggins (1984), although gut contents examined by Wiggins (1977) consisted of fine organic particles.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982).

Genus *Neotrichia* Morton

DIAGNOSIS: *Neotrichia* larvae, as with *Mayatrichia*, recognized by distal narrowing of head. Legs narrow and anal prolegs projecting free of body. Among smallest of hydroptilids, *Neotrichia* larvae separated from similar *Mayatrichia* by lateral fringe of hair on abdomen and well-defined intersegmental grooves of abdomen (see figure in key to genera). Cases of *Neotrichia* cylindrical and composed of sand grains or sometimes plant material (see figure in key to genera).

NOTES: Larvae occur in a variety of lotic habitats, including swift, rocky streams and slow-moving rivers. *Neotrichia* immatures are classified as algal scrapers on rocks and fixed substrates (Wiggins, 1984). Many of the *Neotrichia* species occurring in Alabama appeared to be multivotine (Harris et al., 1991).

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982).

Genus *Ochrotrichia* Mosely

DIAGNOSIS: Larvae of *Ochrotrichia*, in overall appearance, similar to those of *Hydroptila*. Both with short, rather thick legs, with foretibiae each bearing posteroventral lobe. *Ochrotrichia* larvae distinguished from those of *Hydroptila* by lack of apical, abdominal gills and presence of anterolateral lobes on meso- and metanota (see figure in key to genera). Cases of *Ochrotrichia* similar to those of *Hydroptila*, being purse-shaped and constructed of sand, sometimes with plant material mixed in.

NOTES: Only three species of *Ochrotrichia* have been reported from Florida. *Ochrotrichia tarsalis* is widespread, occurring in a wide variety of streams and rivers, but both *O. okaloosa* and *O. provosti* are restricted to cold, spring-fed streams of northern and central Florida. Larvae are characterized by Wiggins (1984) as detritivores and piercing herbivores, but Vaillant (1965) suggested some species are diatom scrapers on rock surfaces.

ADDITIONAL REFERENCES: Ross (1944); Vaillant (1965); Wiggins (1977); Unzicker, Resh, and Morse (1982); Morse (In Press).

Genus *Orthotrichia* Eaton

DIAGNOSIS: Larvae of *Orthotrichia* distinguished by combination of characters, including slender meso- and metathoracic legs, patch of spines on each fore coxa, and asymmetrical labrum. Silken larval case with longitudinal ridges distinctive for genus (see figure in key to genera).

NOTES: Only six species of *Orthotrichia* are known from North America and all are reported from Florida. Larvae are abundant on submerged vegetation along the littoral zones of lakes and other standing waters. The larvae also occur on vegetation along the margins of slow-moving rivers and streams. Nielson (1948) observed *Orthotrichia* larvae feeding on the contents of large algal filaments. In Alabama, *Orthotrichia* species had long emergence patterns suggesting multiple generations each year (Harris et al., 1991).

ADDITIONAL REFERENCES: Ross (1944); Kingsolver and Ross (1961); Morse (1975); Wiggins (1977); Unzicker, Resh, and Morse (1982).

Genus *Oxyethira* Eaton

DIAGNOSIS: *Oxyethira* larvae easily identified by long, thin meso- and metathoracic legs. Fore tibiae each also possesses elongate posteroventral process similar to that found in *Hydroptila* and *Ochrotrichia*. *Oxyethira* spp. also readily recognized by bottle-shaped, silken cases (see figure in key to genera).

NOTES: Larvae of *Oxyethira* are often abundant in lakes and other lentic environments, but they also occur in slower stretches of streams and rivers, particularly in beds of submerged vegetation. In number of species likely to be found in Florida, *Oxyethira* is second only to *Hydroptila*.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Kelley (1982); Unzicker, Resh, and Morse (1982); Morse (1982, In Press).

Genus *Stactobiella* Martynov

DIAGNOSIS: Thick tarsal claws of *Stactobiella* with large, blunt basal spurs (see figure in key to genera) unique among hydroptilids occurring in Florida. Blunt spurs easily discerned, being nearly as long as claws. Case purse-like and composed nearly entirely of silk (see figure in key to genera).

NOTES: The genus *Stactobiella* has not been reported from Florida, but both *S. palmata* and *S. martynovi* have been documented from adjacent Alabama counties (Harris et al., 1991). The genus would be expected to occur in the cool, spring-fed streams of northern Florida. Harris et al. (1991) reported *Stactobiella* spp. emerging early in spring through late summer.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982).

FAMILY LEPIDOSTOMATIDAE

The family Lepidostomatidae has two North American genera, *Lepidostoma* and *Theliopsyche*, but only the former is represented in Florida. The lepidostomatid larvae are morphologically distinguished from the the other caddisfly families by the placement of the antenna close to the anterior margin of the eye, and the lack of a median dorsal hump on abdominal segment I (fig. 18A in family key). The larval cases which are constructed from various materials are often four sided.

Genus *Lepidostoma* Banks

DIAGNOSIS: Larvae of *Lepidostoma* morphologically distinguished from other North American lepidostomatid genus, *Theliopsyche*, by having longer body length (approximately 10 mm), rounded dorsal profile of head, and ventral apotome of head as long as, or longer than, median-ecdysial line.

NOTES: The four species of *Lepidostoma* presently known to occur in Florida (See Appendix A) can be determined only from the adult stage. Adults of *Lepidostoma griseum* and *L. latipenne*, previously unknown from Florida, were collected along spring-fed streams within the Apalachicola ravines. We also collected *Lepidostoma* adults and larvae which may represent a new species, close to *L. serratum*, from seepage spring heads in Gadsden County. *Lepidostoma morsei* was described by Weaver (1988) in which the adult paratypes were collected in Walton Co., (Portland, Little Alaqua Ck). This species has not been collected from other areas of Florida and is considered a threatened species in Florida (Morse, In Press).

In North America the larvae of *Lepidostoma* have been collected from a wide variety of habitats ranging from small cool springs and streams, intermittent streams, backwater areas of rivers to wave-washed shores of lakes (Clifford, 1966; Anderson, 1976; Barton and Hynes, 1978; Unzicker et al., 1982). In Florida we have collected larvae of the genus only from small spring-fed ravine streams.

The life histories of the *Lepidostoma* spp. from Florida are unknown. According to Morse (In Press), species of the subgenus *Mormomyia*, in which *L. griseum*, *L. morsei*, and *L. serratum* are members, have the pupal, adult, and egg stages relatively short, the larval stage much longer, generally with a univoltine life cycle.

SELECTED REFERENCES: Ross (1944); Wiggins (1977); Unzicker, Resh, and Morse (1982); Weaver (1988); Morse (In Press).

FAMILY LEPTOCERIDAE

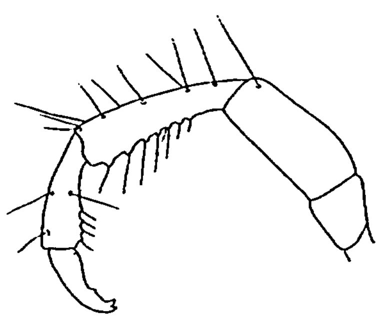
The Leptoceridae, a highly diverse family, are represented in Florida by six genera: *Ceraclea*, *Leptocerus*, *Nectopsyche*, *Oecetis*, *Setodes*, and *Triaenodes*. The larval taxonomy of the leptocerids is the most well known among the large caddis families in the state. Recent work on the larvae makes it possible to identify most of the approximately 50 Florida leptocerids to species level.

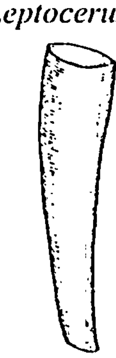
The larvae of Leptoceridae, commonly known as "long-horned caddisflies", can be distinguished from the other caddis families by the relatively long antennae which are at least six times as long as wide (fig. 4A in family key). The exception is *Ceraclea*, which have short antennae in some species, but may be identified by the dark curved lines on the posterior half of the mesonotum (fig. 4B in family key).

This family, along with Hydroptilidae, is the most geographically widespread and speciose in Florida due to the wide range of environmental tolerances its species exhibit in both lotic and lentic habitats. Many species are well adapted to inhabiting the warm waters so prevalent in the state. Leptocerids occupy a number of trophic groups depending on the genus, including carnivore, herbivore, detritivore and grazer. Larvae construct portable cases which are generally cylindrical and tapered. Case materials and structures vary among genera and species and are often used as diagnostic characters.

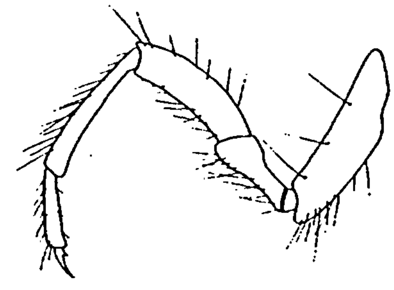
KEY TO GENERA FOR MATURE LARVAE OF FLORIDA LEPTOCERIDAE*

1. Tarsal claws of each mesothoracic leg hooked and stout; tarsus curved; slender case of transparent silk
. . . . *Leptocerus*, *L. americanus*

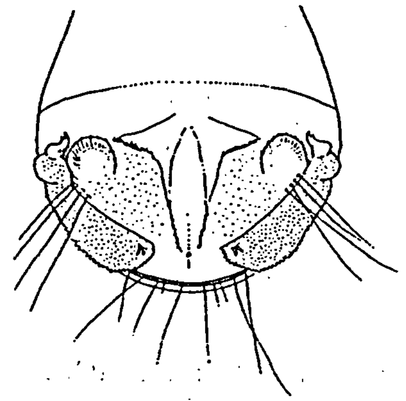




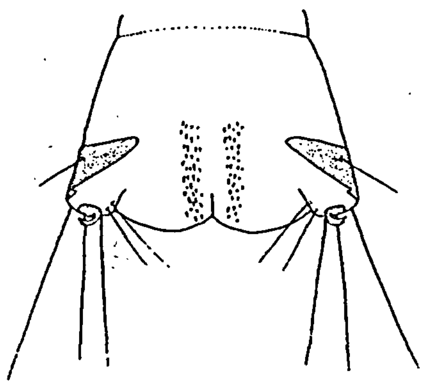
Tarsal claws of each mesothoracic leg slightly curved and slender; tarsus straight
. . . . 2



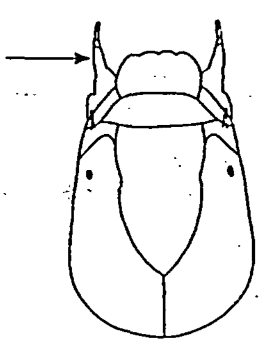
2(1) Sclerotized, concave plate with marginal spines on each side of anal opening and exiting onto ventral lobe; cylindrical case of stones
. . . . *Setodes* (p.75)



Sclerotized, spiny plates absent, although patches of spines or setae may be present
. . . . 3

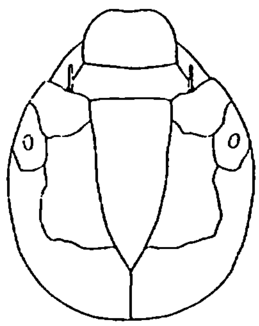


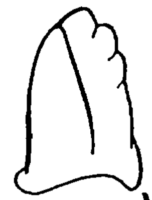
3(2) Maxillary palpi extending far beyond labrum; mandibles long and bladelike, with sharp apical tooth separated from remainder of teeth; cases of various types and materials . . . . *Oecetis* (p. 68)



Maxillary palpi extending little, if any, beyond labrum; mandibles short, wide, with teeth grouped close to apex around central concavity

. . . . 4

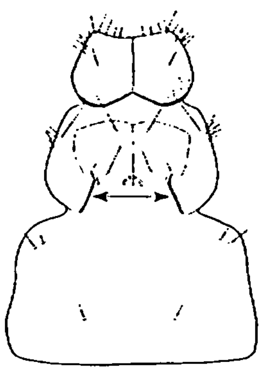


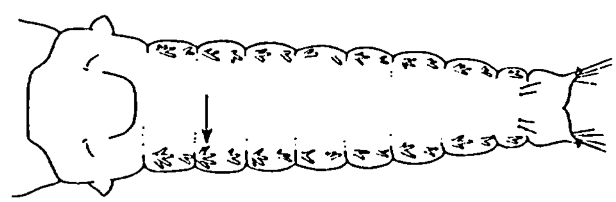


Mandible

4(3) Mesonotum with pair of dark, curved bars on weakly sclerotized plates; abdomen broad basally, tapering posteriorly, with gills usually in clusters of 2 or more; cases of various shapes and materials, sometimes including spicules and pieces of freshwater sponges

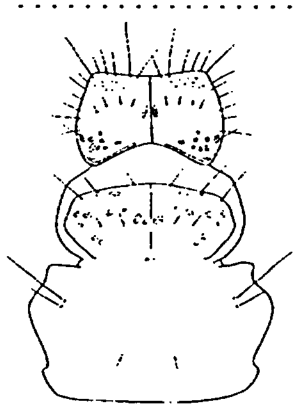
. . . . *Ceraclea* (p. 54)

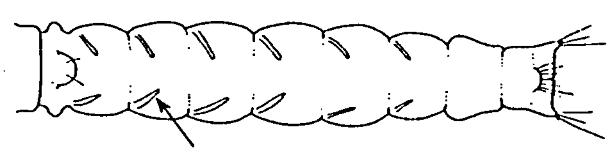




Mesonotum without pair of dark bars; abdominal segments I-VII more slender anteriorly, nearly parallel-sided, with gills single or absent

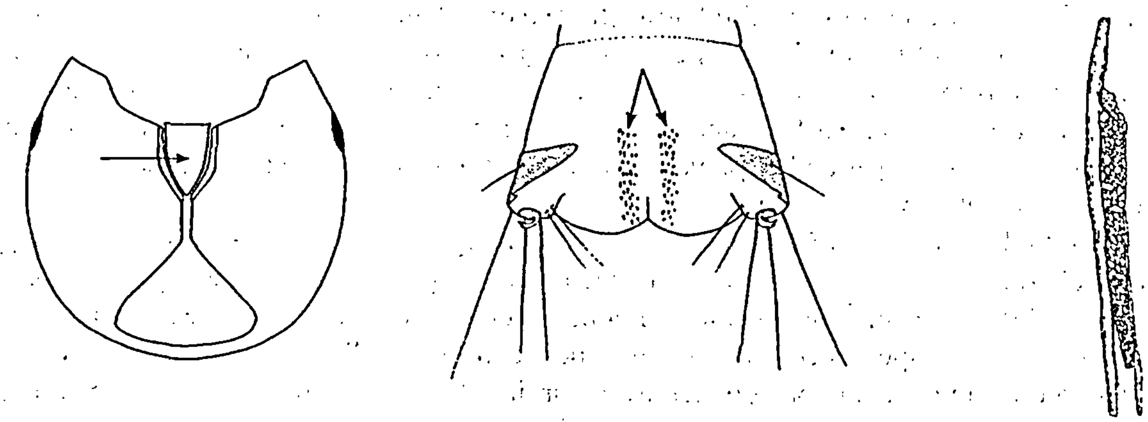
. . . . 5





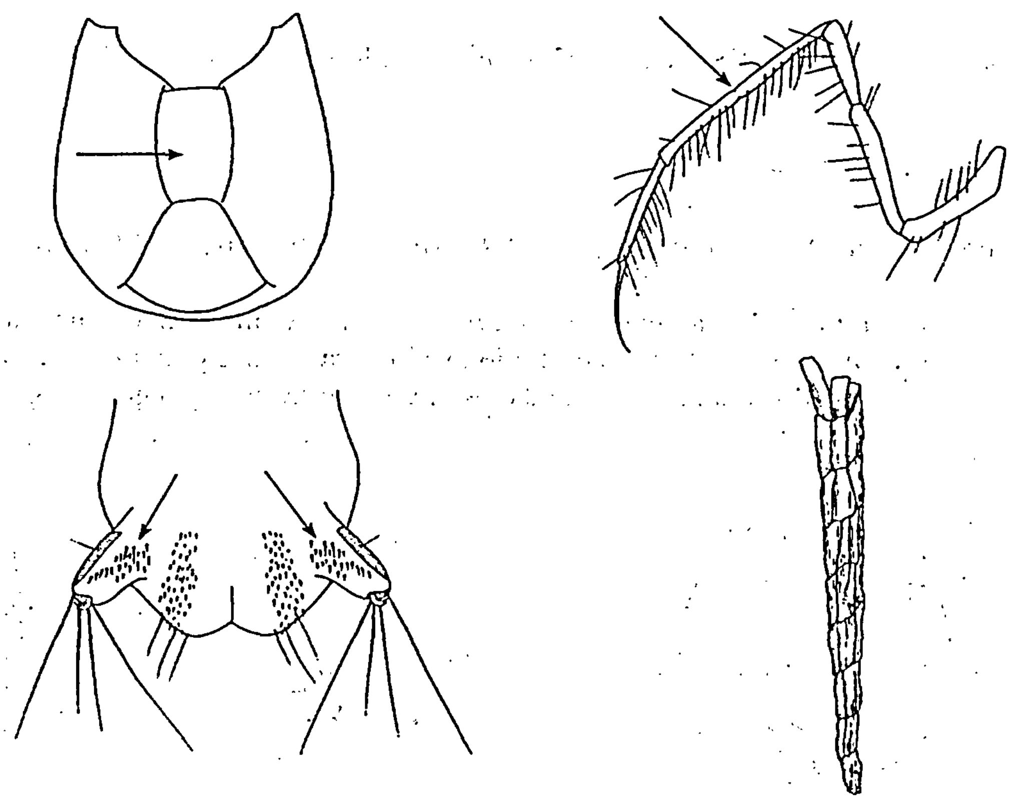
5(4) Ventral apotome of head triangular; tibia of each hind leg usually without apparent constriction; pair of ventral bands of uniformly small spines beside anal opening or spines absent in this position, but no lateral patches of longer spines; slender case of plant fragments, fine sand, and/or diatoms with usually 1 twig or conifer needle extending length of case and beyond at 1or both ends

.... *Nectopsyche* (p. 62)



Ventral apotome of head rectangular, if triangular, case a spiral of plant pieces; tibia of each hind leg with translucent constriction, apparently dividing it into 2 subequal parts; patch of longer spines laterad of each band of short anal spines

.... *Triaenodes* (p. 79)



* key to leptocerid genera adapted from Morse and Holzenthal (1984).

Genus *Ceraclea* Stephens

DIAGNOSIS: Larvae of *Ceraclea* distinguished from other leptocerid genera by presence of pair of dark curved bars on mesonotum (see fig. in generic key). Larvae stout bodied, widest at first abdominal segment and tapering posteriorly. Abdominal gills usually in clusters of two or more.

NOTES: Of the 35 species of *Ceraclea* known from North America, 13 have been recorded in Florida. Larvae of 10 of the 13 Florida species are known and can be identified to species using the key presented below. One species, *C. floridana*, is known only from the holotype specimen collected along Biscayne Bay in 1903 and has not been reported since. This species may now be extinct. *Ceraclea ophioderus* and *C. protonepha*, both of which occur in northern Florida, are the other species still unknown as larvae.

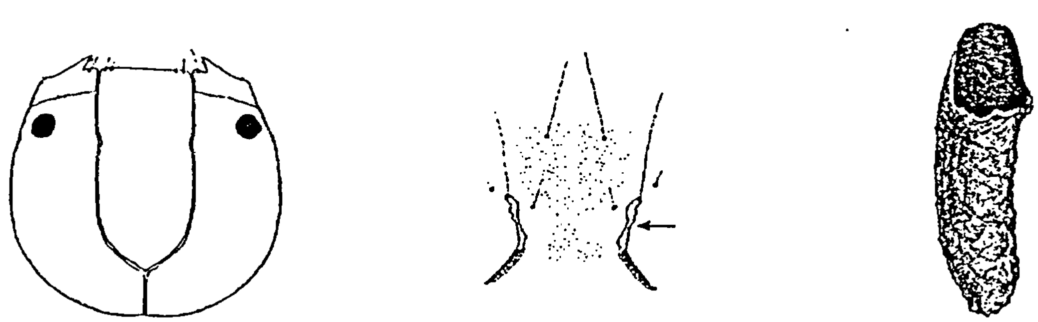
Feeding habits range from detritus and algal grazing to several species of *Ceraclea* (*C. resurgens*, *C. transversa*, *C. spongillovorax*) which feed on freshwater sponges (Resh, 1976; Resh et al., 1976). Case construction varies among species as to materials and architecture. Certain sponge-feeding species construct cases almost entirely of silk secretions, while other species incorporate mineral and plant materials to varying degrees into the silk matrix. Some species construct cornucopia-shaped cases while others construct cases which are stout and cylindrical. *Ceraclea flava* constructs a case with lateral expansions which form a dorsal awning.

Ceraclea spp. are geographically widespread throughout the state and occur in a wide array of lotic and lentic habitats, although some species may be restricted to a narrow range of habitat types based on unique ecological requirements.

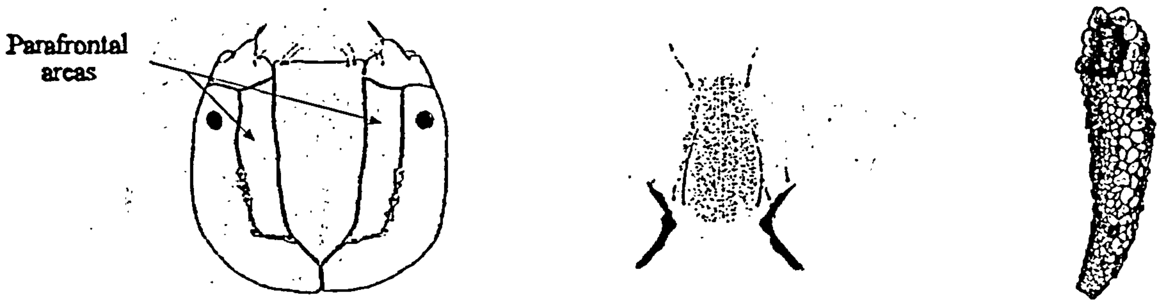
ADDITIONAL REFERENCES: Resh (1976); Unzicker, Resh, and Morse (1982).

KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *CERACLEA* * **

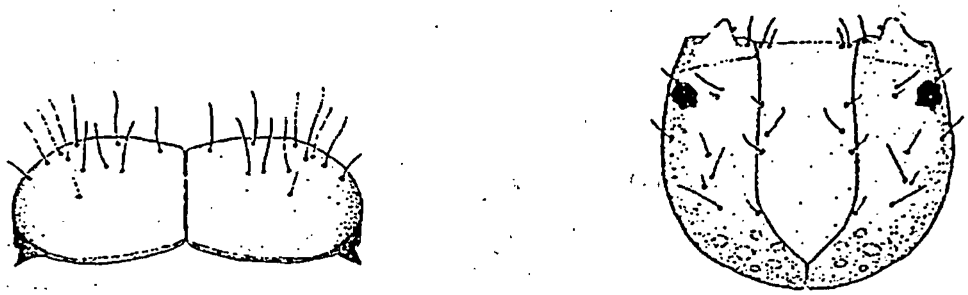
1 Parafrontal areas absent; antennae no more than 2 times longer than wide; mesonotal bars with anterior portion yellow; case made primarily of silk secretion, occasionally adorned with sand or pieces of freshwater sponge; sponge feeders 2



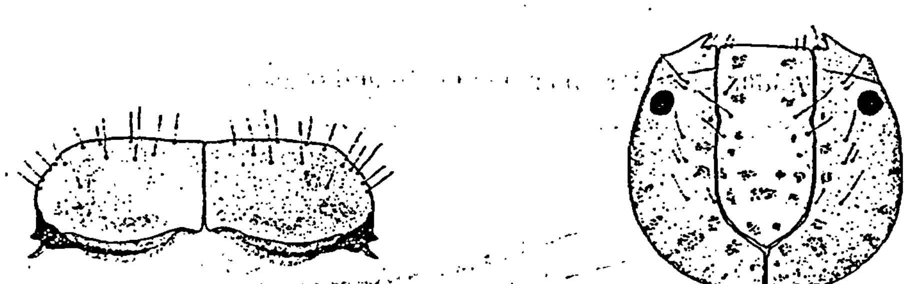
Parafrontal areas present; antennae ranging 2-8 times longer than wide; mesonotal bars unicolored; case made primarily of sand, pebbles, or plant material; usually detritus or algae feeders
. . . . 3



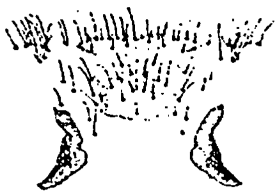
2(1) Pronotum lacking contrasting spots; head with spots pale yellow on a yellow background; length of last instar larva, 5-7 mm
. . . . *C. transversa*

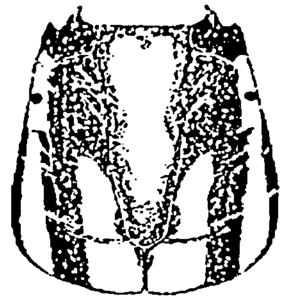


Pronotum with some contrasting spots; head with brown spots on yellow background; length of last instar larva, 11-12 mm
. . . . *C. resurgens*

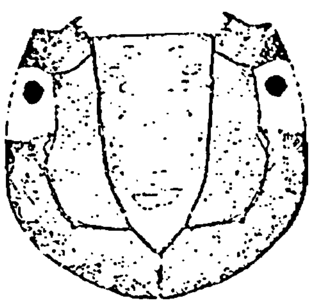


3(1) Mesonotum with at least 20 setae along middorsal groove; head with longitudinal stripes; trochantin with 2 or more dorsal setae
. . . . *C. slossonae*





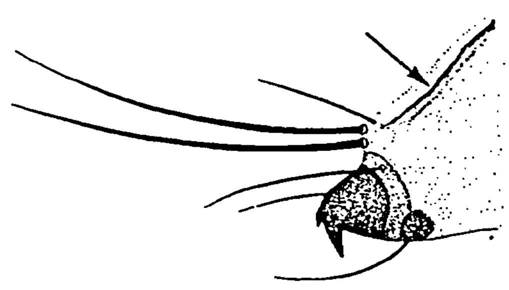
Mesonotum with only a few setae along middorsal groove; head lacking longitudinal stripes; trochantin with 1 dorsal seta
. . . . 4



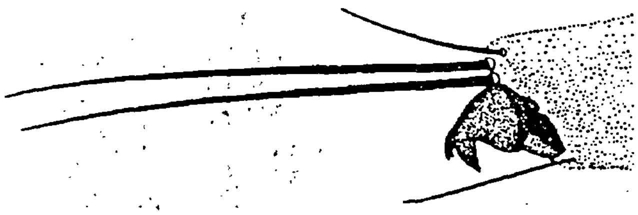
4(3) Two pairs of long setae on 9th abdominal tergite
. . . . 5

One pair of long setae or setae lacking entirely on 9th abdominal tergite
. . . . 9

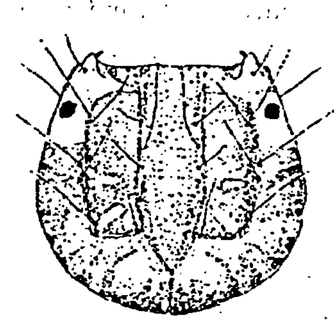
5(4) Dorsolateral sclerite on anal leg long and rodlike
. . . . 6



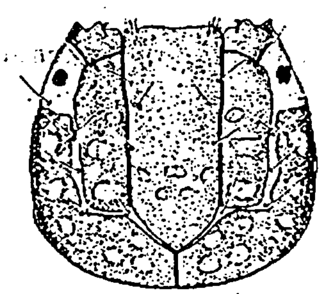
Dorsolateral sclerite not rodlike, or absent entirely
. . . . 8



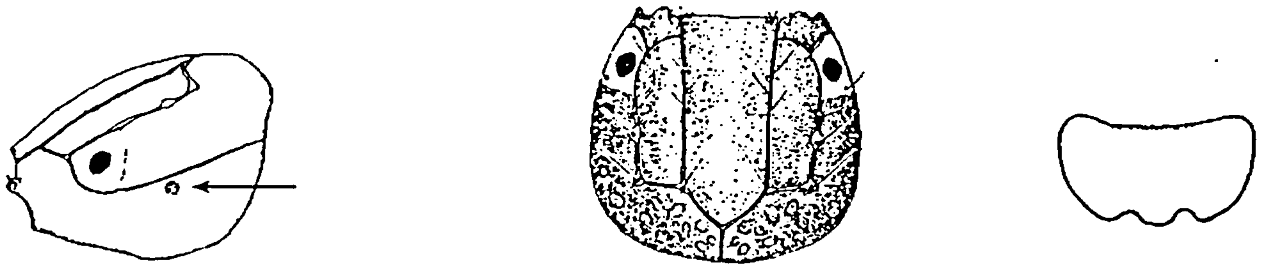
6(5) Mesonotal bars gently curved; head lacking contrasting spots posteriorly
. . . . *C. càncellata*



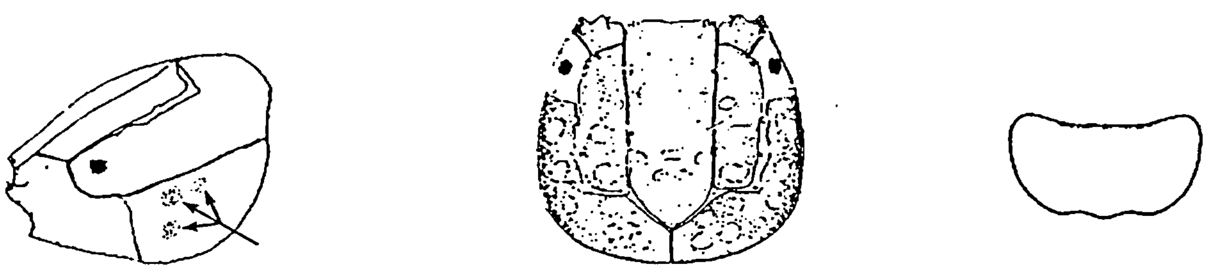
Mesonotal bars sharply angled; head with contrasting spots posteriorly
. . . . 7



7(6) Head with only 1 lateral spot; frontoclypeus usually lacking spots; ventral apotome deeply indented; larvae found in association with freshwater sponge
. . . . *C. spongillovorax*

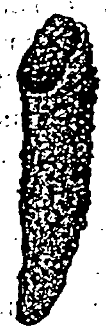


Head with 3 lateral spots; frontoclypeus with contrasting spots; ventral apotome only slightly indented; larvae not found in freshwater sponge
. . . . *C. maculata*

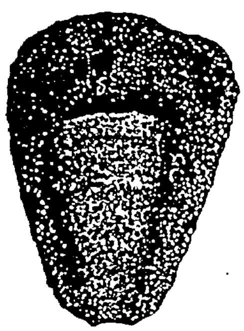


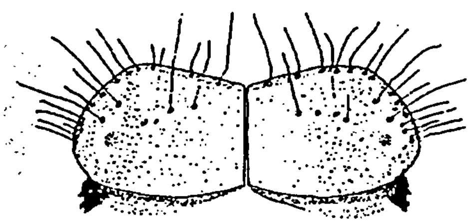
8(5) Case made of plant material
. . . . *C. tarsipunctata*

Case made entirely of sand grains
. . . . *C. nepha, C. protonepha*?***

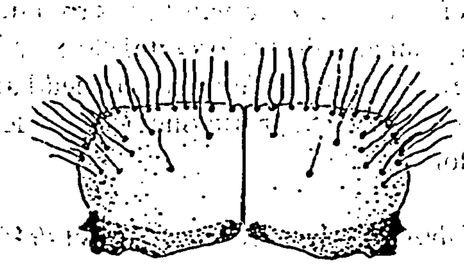


9(4) Case with lateral expansions; pronotum with single spot surrounded by a light corona laterally
. . . . *C. flava*





Case cornucopia-shaped, without lateral expansions; pronotum usually lacking a lateral spot
. . . . *C. diluta*

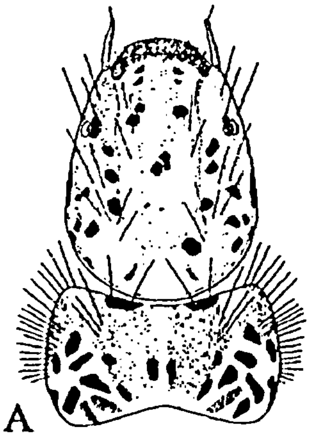


* key and figures to *Ceraclea* species adapted from Resh (1976).
** key does not include *C. floridana* or *C. ophioderus*.
*** larva of *C. protonepha* is unknown but will likely key out to *C. nepha*.

Genus *Leptocerus* Leach

DIAGNOSIS: Larvae of genus *Leptocerus* distinguishable from other leptocerid genera by hooked tarsal claws with two apical points of mesothoracic leg and curved mesotarsi. Mesothoracic tibiae and tarsi each thickened, bearing ventral row of teeth with stout setae (see figure in key to genera). Larval cases long and slender, constructed of translucent silk (see figure in key to genera).

NOTES: Only a single species, *Leptocerus americanus*, occurs in North America. Ross (1944) provided a larval description for this species. The head and pronotum have many black spots (Fig. A below). The hind legs have dense swimming hairs; abdominal gills are absent.



A

FIGURE: (Ross, 1944) - A. *Leptocerus americanus*, head and pronotum.

Leptocerus americanus is widespread across eastern North America. This species is known to occur in lakes and marshes as well as in slow stretches of river among aquatic macrophytes (Unzicker et al., 1982). Larvae are able to swim among aquatic plants, and the modified mesothoracic tibiae and tarsi are believed to enable the larva to hold firmly in a resting position on plants (Wiggins, 1977).

Leptocerus americanus has been reported from Osceola and Baker counties within the Osceola National Forest (Gordon, 1984). We have collected adults along sand-bottomed creeks in Gadsden County and have examined larvae from Lake Rowell, Bradford Co. Additional collecting in lentic habitats should provide a better understanding of its geographic distribution here in Florida.

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977).

Genus *Nectopsyche* Müller

DIAGNOSIS: Hind tibiae not secondarily subdivided as in *Triaenodes.* Sclerotized bar and circular roughened area on each lateral hump and unpigmented lines delimiting anterolateral corners of pronotum. Ventral apotome triangular.

NOTES: *Nectopsyche* larvae occur in lentic and lotic habitats throughout the state and, like most leptocerids, have a very broad range of environmental tolerances. In lentic habitats they are often associated with aquatic macrophytes. In lotic habitats they can be collected along the margins of slowly moving sections of streams and rivers. With the exception of *N. pavida*, larval cases are usually long and slender, made with sand grains and/or plant materials incorporated into the matrix. Stems or pine needles may be attached to the case extending beyond either end. *Nectopsyche pavida* builds a non-tapering case which is dorsoventrally compressed with uneven sides.

Nectopsyche candida, N. exquisita, and *N. pavida* are widely distributed and fairly common in small to medium size streams and rivers throughout much of Florida. *Nectopsyche pavida* also occurs in lakes of central Florida. *Nectopsyche spiloma,* widely distributed in the Mississippi River drainage, has not been recorded in Florida but very likely occurs in the state, based on adults collected near the Florida-Alabama state line (Harris et al., 1991).

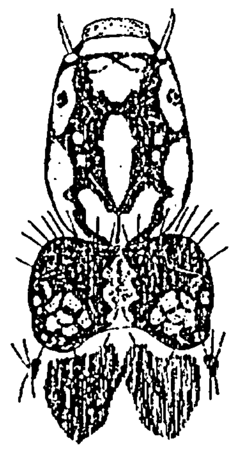
Nectopsyche tavara is endemic to lakes of peninsular Florida and has been recorded from Highlands, Lake, Levy, Orange, and Seminole counties. We have examined larvae collected from several lakes in Highlands Co., Lake Samson, Bradford Co., as well as larvae associated with *Najas* sp., collected from Lake Okeechobee, Glades Co. Adults of *N. tavara* have been reported to emerge from March to October, with peak emergence occurring in early July (Daigle and Haddock, 1981).

The larva of *N. paludicola* is unknown. Harris et al. (1991) reported that it is endemic to small coastal streams of Alabama and from the western portion of the Florida panhandle.

ADDITIONAL REFERENCES: Ross (1944); Haddock (1977); Daigle and Haddock (1981); Unzicker, Resh, and Morse (1982).

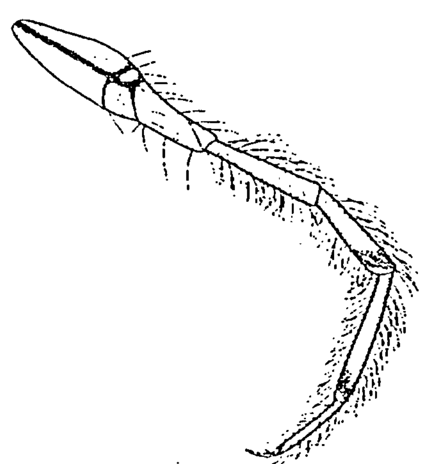
KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *NECTOPSYCHE* * **

1. Conspicuous, oval, light brown marking present in median area of frontoclypeus; case dorsoventrally compressed, with uneven sides, made entirely of plant materials, such as leaf fragments
. . . . *N. pavida*

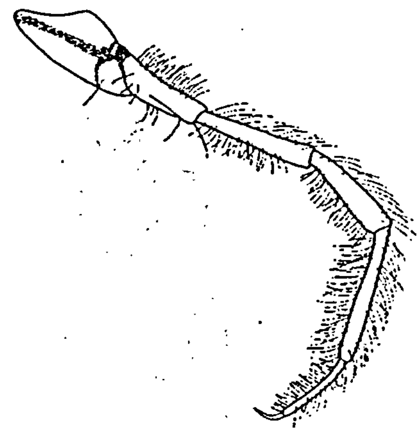


Conspicuous, oval, light brown marking absent from median area of frontoclypeus; case circular in cross section, gradually tapering posteriorly, with even sides, made of mineral materials (sand grains) and/or plant materials (fragments of stems)
. . . . 2

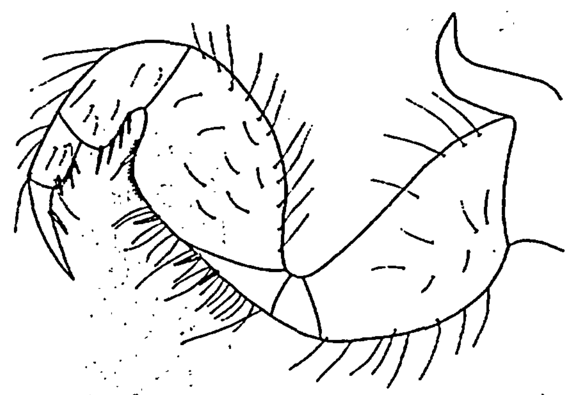
2(1) Meso- and metathoracic legs either entirely dark brown or black, or with conspicuous bands at junctions of segments
. . . . *N. exquisita*



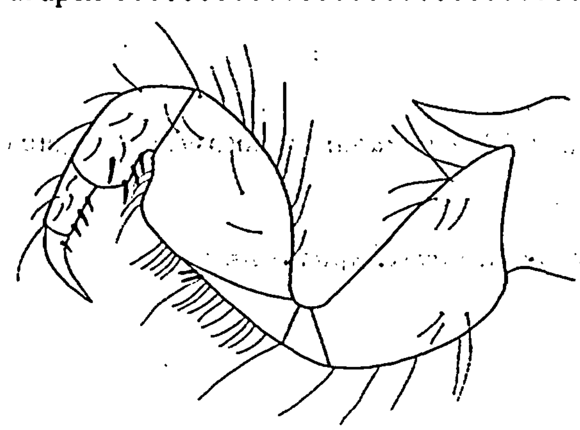
Meso- and metathoracic legs pale brown to light yellow 3



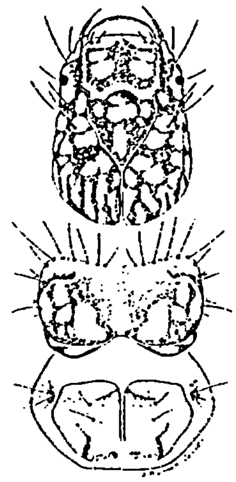
3(2) Prothoracic legs each with tibia having series of four spines on ventral margin, single spine on ventral margin of femur, and series of small crenulated spines apically on ventral margin of tarsus and femur; trochantin strongly upturned at right angle apically 4



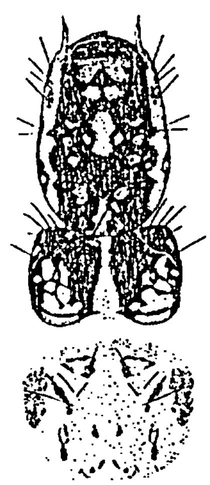
Prothoracic legs each with tibia having series of three spines on ventral margin, 4th spine apically on inner margin, spines absent on ventral margin of femur, small crenulated spines absent on ventral margin of femur and tarsus; trochantin not strongly upturned at apex .... *N. spiloma*



4(3) Frontoclypeus with medial transverse light stripe, anterior portion of frontoclypeus with lateral spots each connected as "figure 8"; dorsum of head with extensive light spots . . . . *N. tavara*



Frontoclypeus without medial transverse light stripe, anterior portion of frontoclypeus with lateral spots each clearly separated; dorsum of head mostly brown with few light spots
. . . . *N. candida*



* figures of *N. pavida* and *N. candida* from Ross (1944); figure of *N. tavara* from Daigle and Haddock (1981).

** key does not include *Nectopsyche paludicola.*

Genus *Oecetis* MacLachlan

DIAGNOSIS: *Oecetis* larvae easily distinguished from other leptocerid genera by long maxillary palpi which extend beyond labrum and long knife-like mandibles with sharp apical tooth separated from remainder of teeth (see figures in key to genera).

NOTES: Approximately thirty species of *Oecetis* occur in North America, north of Mexico, 18 of which are known or are likely to occur in Florida. Recent work done by Floyd (1994) provided descriptions and a larval key for 22 North American species along with notes on biology and distribution. Floyd's key covered 13 of the 18 Florida species, including three species believed to belong to the *Oecetis inconspicua* complex.

Larvae of *Oecetis* are strictly predaceous, as evidenced by their elongate bladelike mandibles, making them unique among Leptoceridae. They are highly diverse in terms of habitat preferences and have succeeded in exploiting nearly every type of aquatic habitat. Adults have been frequently collected in coastal areas, indicating that some species may be tolerant of brackish water (Floyd, 1994). Case construction is highly variable between species in terms of materials and architecture.

SPECIES NOTES:
Oecetis avara - This species is widespread across eastern North America, although previously unreported in Florida. Larvae we have examined were collected from a riffle area in the Chipola River, Jackson Co. *Oecetis avara* is easily distinguished by the two groups of micro-hooks present on abdominal segment I.

Oecetis cinerascens - One of the most commonly collected *Oecetis* species in Florida. It is widepread throughout the state and can be found in lentic and lotic environments including canals. Larvae are often associated with aquatic macrophytes. The brown head with pale muscle scars is distinctive and makes identification easy.

Oecetis daytona - Larvae are unknown. This species is endemic to the southeastern Coastal Plains and is listed as Rare in Florida (Morse, In Press). In Florida, adults have been reported from Baker, Duval, and Volusia counties (Gordon, 1984). It is likely this species also occurs in the western panhandle as adults have been reported in adjacent counties of Baldwin and Escambia counties, Alabama (Harris et. al., 1991).

Oecetis ditissa - Larvae are unknown. Adults have been reported from Alachua Co. (Gordon, 1984), and we have collected adults from Little Sweetwater Ck., Liberty Co.; Attapulgus Ck., Gadsden Co.; and Florida A&M farm stream, Gadsden Co.

Oecetis floridanus - Larvae are unknown. Morse (In Press) indicated this species is known from a unique type specimen collected along Biscayne Bay. The species should be renamed since it is preoccupied in *Oecetis* by *Oecetina floridana*, which was synonymised to *Oecetis cinerascens* (Holzenthal, 1982; Chen, 1993).

Oecetis georgia - Endemic to the southeastern United States. According to Floyd (1994), this species is strictly lotic, usually found on root mats and snags. Larvae are common in blackwater streams in northern Florida. Larvae most resemble *Oecetis persimilis* but, unlike those of *O. persimilis*, *O. georgia* larvae lack dark muscle scars on the head.

Oecetis inconspicua complex - Floyd (1994) presented sufficient evidence to support the notion that *Oecetis inconspicua* is actually a complex of species, which as adults are very difficult to distinguish but as larvae are morphologically distinct. Floyd (1994) associated seven different species with distinctive larvae which as adults fit the description of *Oecetis inconspicua*. The species complex theory is further supported by the fact that *Oecetis* spp. are widespread throughout North America and show a great deal of variation in terms of genitalic structure and overall size of the adults. It is likely that the number of species in the complex will grow. We have examined specimens which key only to *Oecetis inconspicua* complex but no further. It is very likely they represent another new species in the complex, but we cannot be sure until larva-adult associations are made. It is possible they are the larvae of one of the unassociated species.

> *Oecetis inconspicua* - The actual larval identity of *O. inconspicua* is unknown until further investigations and taxonomic revisions of member species is completed.
>
> *Oecetis* sp A - Floyd (1994) reported this species from only Alabama and South Carolina; however the species appears to be widespread throughout Florida. We have examined specimens from Escambia and Walton counties in North Florida as well as Desoto, Glades, and Hendry counties in South Florida. Larvae were collected from small to medium size rivers.
>
> *Oecetis* sp C - Floyd's (1994) larval associations were made from specimens collected from two small ponds in Clay Co. We have examined specimens collected from Lake Placid and Lake Grassy, Highlands Co. and Santa Fe Lake, Alachua Co. The species has not been reported from any states other than Florida. Larvae are easily distinguished by the dense patch of setae on the meso- and metasterna.
>
> *Oecetis* sp F - The larval association made by Floyd (1994) is based on specimens collected from Lake Tohopekaliga, Osceola Co. We have examined larvae collected from widespread localities that appear to be this species. However, there does seem to be a lot of variation in the number of setae on the metasternum (8-15), so it is possible this represents more than one species.

Oecetis morsei - Larvae cannot be distinguished from *O. sphyra* based on the associations done by Floyd (1994). This species is considered Rare in Florida (Morse, In Press) and has only been reported in Florida (as *Oecetis* n. sp.) from Ramer Branch in Eglin Air Force Base, Okaloosa Co., (Harris, et al., 1982).

Oecetis nocturna - This species is widespread throughout Florida and occurs in both lentic and lotic habitats. The larval case is easily recognized by the laterally attached ballast stones.

Oecetis osteni - Widespread throughout Florida, inhabiting both lentic and lotic habitats, often in association with aquatic vegetation. Larvae are easily recognized by the irregular darkened areas on the mesonotum.

Oecetis parva - Endemic to the southeastern United States, this species has only been recorded from Florida and Alabama. Floyd's (1994) larval-adult association is based on larvae collected from Lucas Lake, Washington Co., and were found attached to *Myriophylum laxum*. *Oecetis parva* is uncommon, and we were unable to collect nor borrow specimens for examination. Floyd (1994) indicated the larvae can be recognized by their small size, long antennae, and case structure.

Oecetis persimilis - Widespread and common throughout Florida as well as the eastern United States. Larvae occur in a wide array of lotic habitats. This species is morphologically similar to *O. georgia* but can be distinguished by the presence of dark muscle scars on the head.

Oecetis porteri - Endemic to the southeastern United States, this species has been reported from Florida, Alabama, and North Carolina. Floyd (1994) reported this species from numerous natural sand-bottomed lakes throughout much of Florida. We have examined specimens collected from Lake Josephine and Lake Clay, Highlands Co.; Santa Fe Lake, Alachua Co.; as well as specimens associated with *Eleocharis* sp. and *Utricularia* sp. collected from Lake Okeechoobee. Larvae are immediately recognizable by the reddish brown reticulations on the head and pronotum.

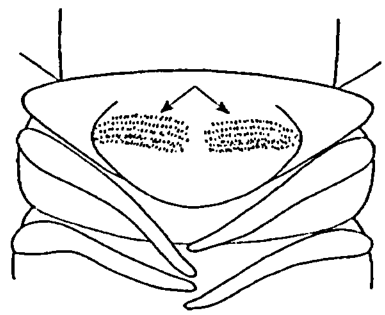
Oecetis pratelia - Larvae are unknown. This species is known only from the holotype specimen collected from Hendry Co., and described by Denning (1948a). Floyd (1994) believed this species may be extinct and was unable to collect the species from the type locality.

Oecetis sphyra - Widespread across North Florida, occurring in small to medium size rivers. The larval and case morphology are identical to *O. morsei* and separation of the two species is presently not possible.

ADDITIONAL REFERENCES: Ross (1944); Floyd (1994).

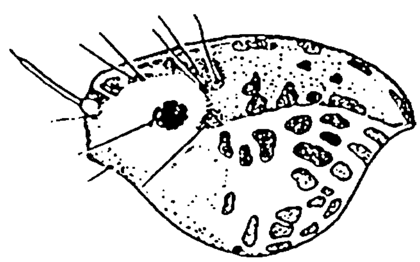
KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *OECETIS* * **

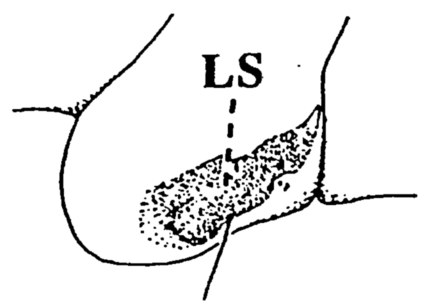
1. Dorsal hump of abdominal segment I with 4-6 rows of micro-hooks on each side
. . . . *O. avara*



Dorsal hump of abdominal segment I without micro-hooks
. . . . 2

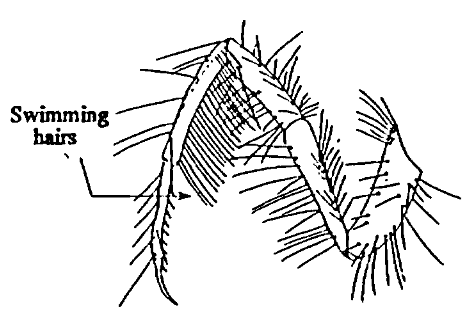
2(1) Postgenal sclerites separated by distinctive brown and pale areas; lateral hump of abdominal segment I with dark, elongate sclerite (LS)
. . . . *O. morsei/sphyra*



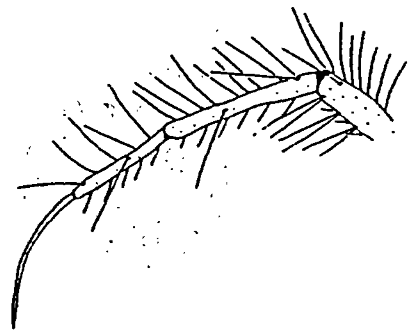


Postgenal sclerites not separated by dark and pale areas, shape of lateral sclerite of abdominal segment I variable 3

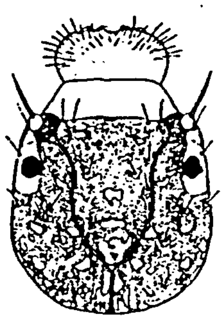
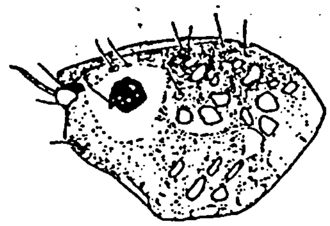
3(2) Metasternum with 2 setae; swimming hairs present on hind tibiae; hind tarsi longer than tarsal claws; case constructed of root or plant fragments placed transversely
. . . . 4



Metasternum with more than 2 setae (except *O. osteni* which may have only 2), often with row of 10 or more; swimming hairs absent on hind tibiae; hind tarsi each as short as or shorter than its tarsal claw; case constructed of sand grains or irregularly placed plant or detrital pieces
. . . . 6

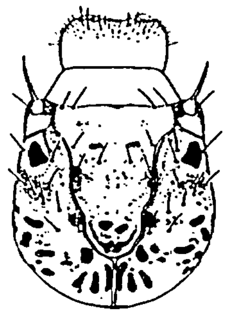


4(3) Head brown with light muscle scars; case constructed either of short twigs or roots (angled "log cabin" appearance) or thin, flat, quadrate, plant fragments; on vegetation in lakes, some slow-moving streams
. . . . *O. cinerascens*

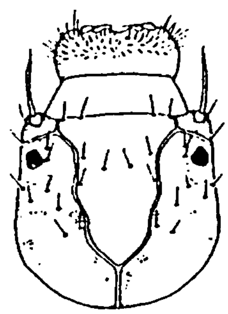



Head yellow with dark muscle scars or pale; case exterior more rounded and often curved, especially in early instars; on roots, woody debris, and vegetation in streams 5

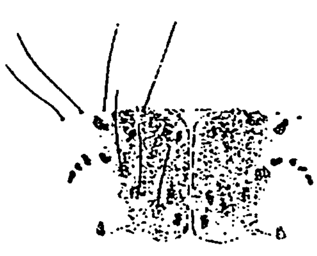
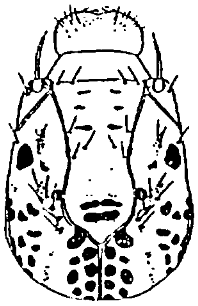
5(4) Head with scattered, well-defined muscle scars; antennae short, reaching posterior edge of labrum
. . . . *O. persimilis*



Head without dark, well-defined muscle scars; antennae longer, reaching to middle of labrum
. . . . *O. georgia*

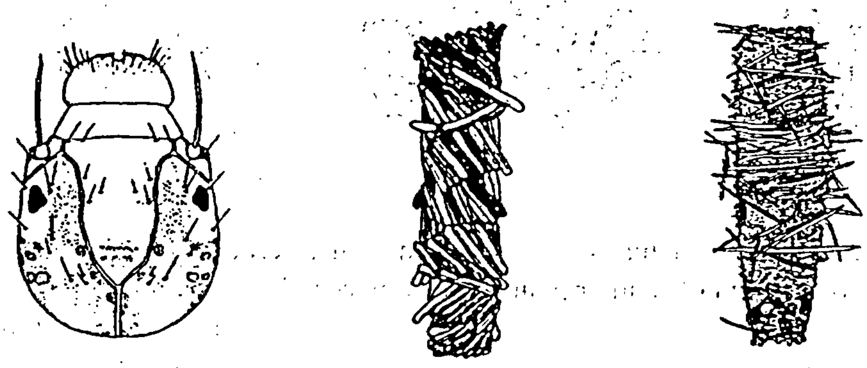


6(3) Mesonotum with pair of irregular dark areas on each side of meson; coronal suture bordered by row of 3-4 dark muscle scars on each side; left mandible with deep crease running from apical tooth; case constructed of sand grains
. . . . *O. osteni*

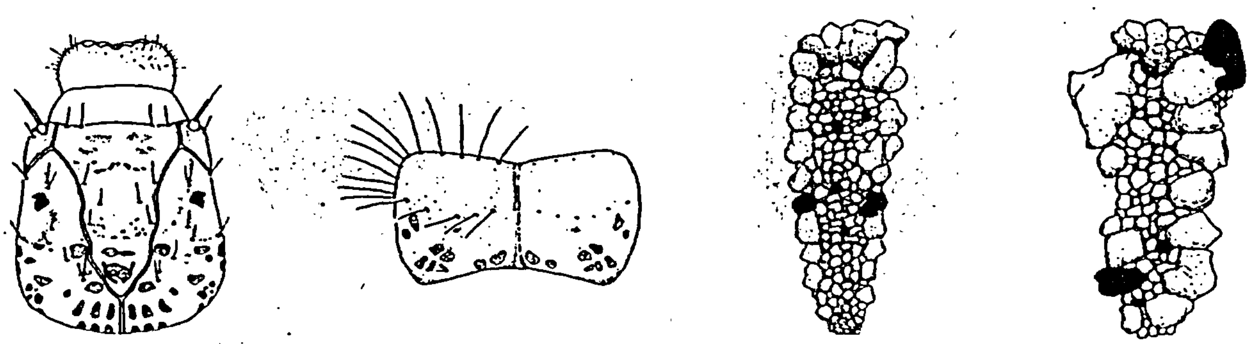

Mesonotum without distinct pair of irregular dark areas; coronal suture bordered by 0-2 muscle scars; left mandible without crease; case constructed of plant or sand grains
.... 7

7(6) Antennae long, reaching at least to anterior edge of labrum; case as shown in figures; on vegetation in natural lakes
.... *O. parva*



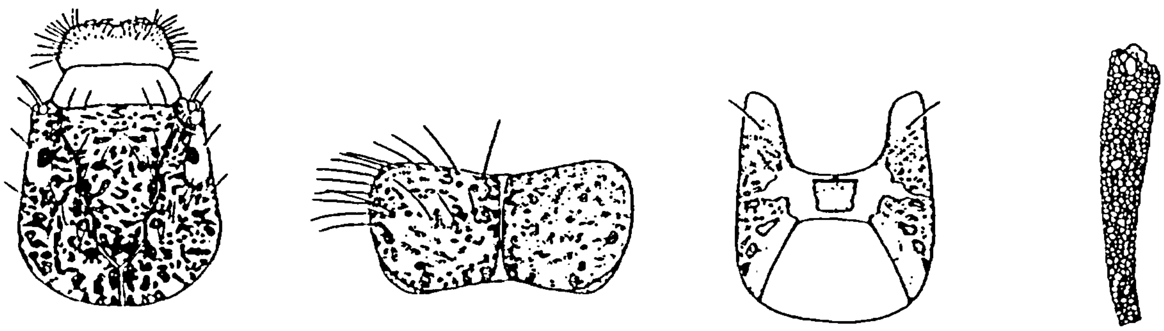
Antennae short, reaching only to posterior edge of labrum 8

8(7) Head and pronotum usually with several light brown muscle scars; case constucted of sand or rock pieces with larger ballast stones attached to the sides
.... *O. nocturna*



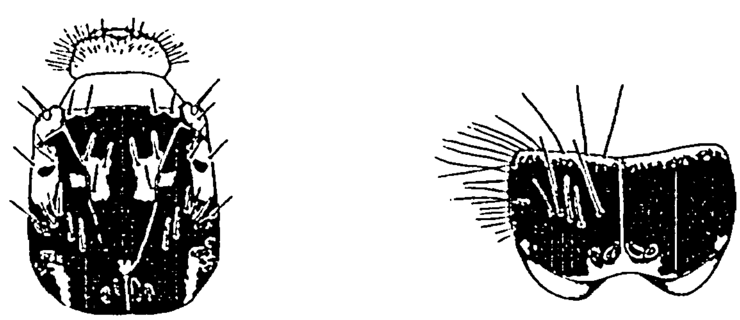
Head and pronotum pale or with various combinations of dark muscle scars, spots, or stripes; case constructed of variety of materials
.... 9

9(8) Head and pronotum covered with dense, brown markings in addition to well-defined muscle scars; ventral apotome reddish-brown, subrectangular; case constructed of sand, curved, and with a very smooth exterior; sand-bottomed lakes
. . . . *O. porteri*



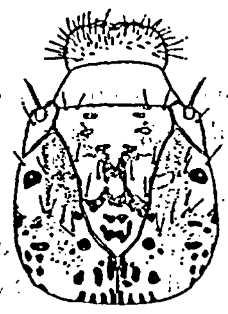
Head and pronotum with variable markings; ventral apotome variable; case constructed of sand or plant/detrital pieces; diverse habitats
. . . . *O. inconspicua* complex*** 10

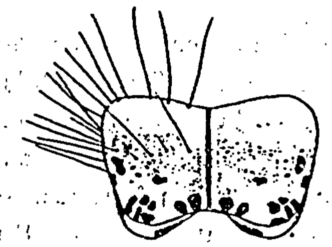
10(9) Mesosternum with irregular patch of 80 to 100 setae; case somewhat flattened dorsoventrally, composed of sand; dorsum of hind legs dark brown; head and pronotum dark brown with pattern as shown in figure
. . . . *Oecetis* species C



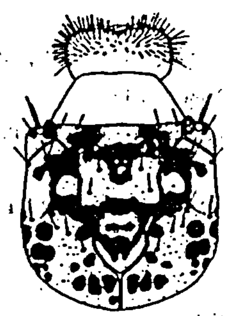
Mesosternum with no more than 6 setae; case tubular, composed of sand or woody debris; dorsum of hind legs same color as rest of leg; head and pronotum pattern not as above
. . . . 11

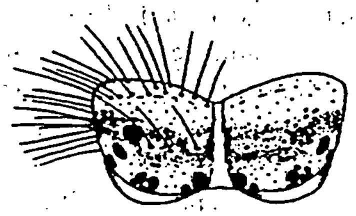
11(10) Metanotum with no more than 4 sa3 setae; metasternum with row of 8-15 setae; head and pronotum as shown in figure; case constructed of sand .... *Oecetis* species F





Metanotum with 8-9 sa3 setae; metasternum with 30-36 setae; head and pronotum as shown in figure; case constructed of wood and bits of detritus .... *Oecetis* species A





* Key and figures to *Oecetis* species adapted from Floyd (1994).

** Key does not include *O. daytona*, *O. ditissa*, *O. inconspicua*, *O. pratelia*. Larvae of these species are unknown.

*** The actual number of species belonging to the *O. inconspicua* complex is unknown. It contains at least 7 North American species of which *Oecetis* species A, C, and F occur in Florida.

Genus *Setodes* Rambur

DIAGNOSIS: Larvae of North American species of genus *Setodes* distinguished from those of other leptocerid genera by presence of sclerotized concave plates with marginal spines on each side of anal opening (see figure in key to genera).

NOTES: Eight recognized species of *Setodes* are known to occur in North America. Previously, the genus has not been reported from Florida and was thought to extend its southerly geographic range only to Alabama and Georgia. We found that the genus is represented in the state by possibly three species: *S. guttatus*, *S. dixiensis*?, and *Setodes* n. sp.

Larvae of the eight North American species of *Setodes* have recently been described and a taxonomic key provided (Nations, 1994). Prior to that, only the larvae of *S. incerta* (=*incertus*) were known (Merrill and Wiggins, 1971). Nations (1994) found that there is little morphological variation among the larvae; however differences in head coloration and gill structure were deemed suitable characters for differentiating the species. The larval cases of the genus are cylindrical, generally straight, with little or no taper, and constructed of flat sand grains fitted tightly together. The posterior end of the larval case is open and without a sieve plate or other obstruction. Larvae are known to burrow into sand and are able to reverse their position within the case, hence the advantage of a non-tapering case which is open and essentially the same at both ends (Merrill and Wiggins, 1971).

Setodes spp. are primarily rheophilics and can be collected in pockets of sand on limestone shoals or from sand deposited on the leeward side of rocks in riffle areas. Larvae may also be found with their cases attached to stones by thick cords of silk (Nations, 1994). Nations (1994) surmised that this adaptation allows the larva to graze the surface of the stone effectively in the 360° area around the point of attachment, while maintaining its position in rapid current via the anchor line.

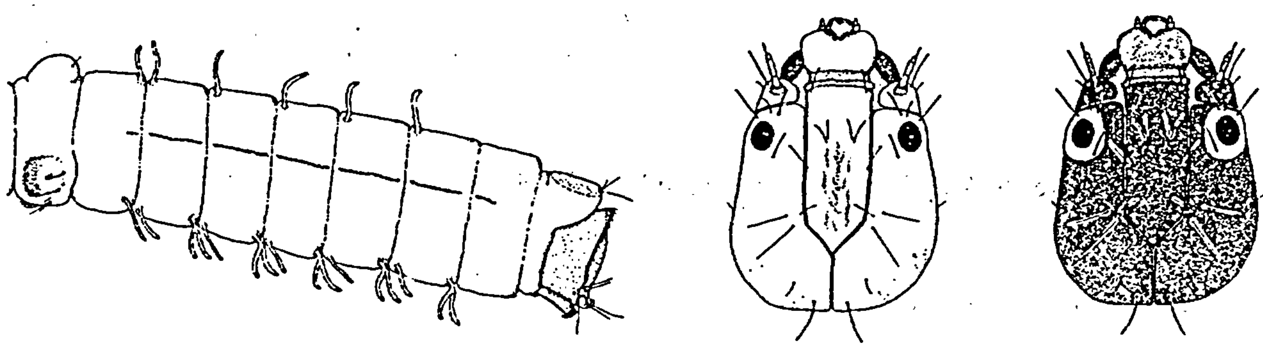
Setodes is herein reported for the first time in Florida and appears to be restricted to the Chipola River basin. All specimens that we have examined were either collected in the main river stem or from tributaries (Dry Creek and Rocky Creek, Jackson County). Adults of *Setodes* n. sp. were collected in large numbers along Rocky Creek and the Chipola River in the middle part of May.

A tentative key to Florida *Setodes* is presented below. The key is considered tentative since it is based on only 25 larvae; hopefully improvements can be made as more specimens are collected and examined. *Setodes* larvae with many dorsal gills can be confidently determined as *S. guttatus*. Larvae examined by Nations that key to *S. dixiensis*? were found to fit the description of *S. dixiensis* in Alabama, but some of the Florida specimens included a pair of dorsal gills on abdominal segment III, thus the uncertainty. Both *S. guttatus* and *Setodes* n. sp. have variable head coloration which includes a light and dark morph. *Setodes* n. sp. can be distinguished from *S. dixiensis* by the single pair of forked gills on the ventral surface of abdominal segment II.

ADDITIONAL REFERENCES: Merrill and Wiggins (1971); Wiggins (1977); Nations (1994).

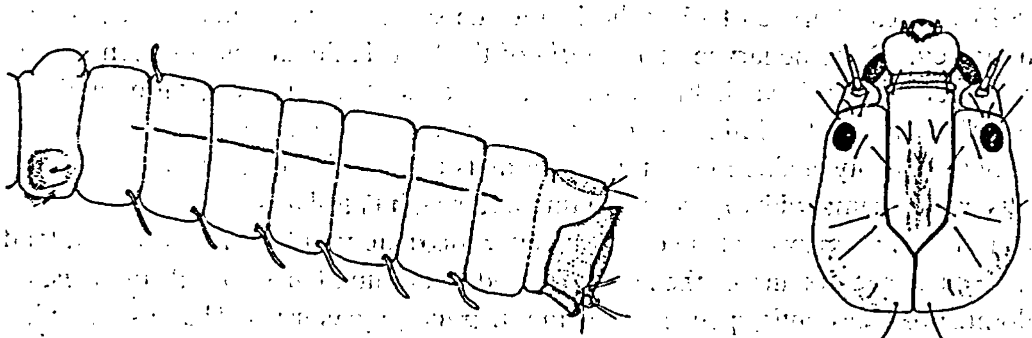
TENTATIVE KEY TO SPECIES FOR THE MATURE LARVAE OF FLORIDA *SETODES* *

1. One pair of forked or single gills on dorsal surface of abdominal segments 5-7 (and usually segments 2-4), and forked and single gills on ventral surface of abdominal segments 2-7; head tan or completely dark brown, with ring of lighter color around each eye spot
.... *S. guttatus*

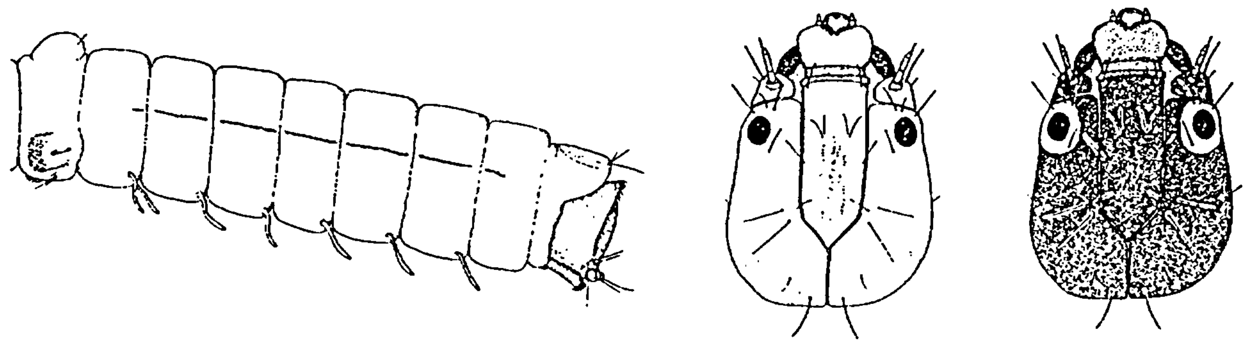


No more than one pair of gills on dorsal surface of abdomen
.... 2

2(1) Single gills on ventral surface of abdominal segments 2-7, and sometimes one pair of single gills on dorsal surface of abdominal segment 3; head tan, perhaps with darker mottling or streaks
.... *S. dixiensis?*



Forked gills on ventral surface of abdominal segment 2, and single gills on ventral surface of abdominal segments 3-7; head tan or completely dark brown with ring of lighter color around each eye spot
. . . . *Setodes* n. sp.



* key and figures to *Setodes* species prepared by Victoria C. Nations.

Genus ***Triaenodes*** MacLachlan

DIAGNOSIS: Larvae of *Triaenodes* distinguished by following characters: ventral apotome of head rectangular, except in early instars where it may appear triangular; tibia of each hind leg with constriction near center; hind legs usually with dense fringes of long setae (swimming hairs) (see figures in key to genera), except in *T. perna* and *T. helo* in which setae not nearly as dense.

Larval cases of *Triaenodes* unusual among North American trichopteran genera, constructed of spirally arranged plant pieces; cases usually long and tapered with exception of *T. perna* and *T. helo* with cases only slightly longer than larvae and tapered only slightly.

NOTES: Twenty-three species of *Triaenodes* occur in North American with 16 of these known or likely to occur in Florida. The recent dissertation by James B. Glover (1993) at the University of Louisville on larval taxonomy and biology of *Triaenodes* has provided an excellent key to species for 19 of the 23 species. Larvae of 15 of the 16 Florida species have been associated and are presented in the key. Only the larvae of *T. smithi* of the Florida fauna has not been described.

Larvae occur in two basic habitats: submerged roots of riparian vegetation and aquatic macrophytes. They inhabit the full range of lotic and lentic environments. Successful collecting can be done by vigorously shaking or kicking root mats into a collecting net or hand screen. Aquatic plants can be sampled by sweeping a dipnet through the plants.

Glover (1993) reported that species found predominately in lotic roots show a tendency for parallel stripes on the dorsum of the head, reduced swimming hairs on the hind legs, and reduced abdominal gills. Lentic species occurring in macrophytes usually have spotted heads or heads with light brown lines, well developed swimming hairs, and well developed abdominal gills. Patterns of muscle scars and other pigmentation of the head and pro- and mesothorax, and chaetotaxy of the metathoracic legs are the most useful characters for species identification (Glover 1993). Case structure, while distinctive to the genus, varies little among different species. The case is constructed of spirally arranged pieces of aquatic macrophytes or the tips of roots from riparian vegetation.

When larval cases are not available, *Triaenodes perna* and *T. helo* will run to *Mystacides* spp. using Wiggins's (1977) key to leptocerid genera. Both *Mystacides* and *T. perna/helo* have only scattered setae on the metathoracic legs and dark head coloration, thus the confusion. The two genera can be distinquished by examining the mandibles. *Triaenodes* spp. have asymmetrical mandibles, with the left mandible evenly convex along the entire outer edge and the right mandible concave on the outer basal portion and angled sharply inward. Mandibles of *Mystacides* spp. are symmetrical. All Florida material we have examined, that was identified as *Mystacides* spp., has been *T. perna/helo*. *Mystacides* spp. are unlikely to occur in Florida, since the geographic range of this genus extends south only to the lower Appalachians of Georgia and Alabama (Glover, 1993).

SPECIES NOTES:

Triaenodes abus - The sole Florida record is from Columbia Co. (Gordon, 1984).

Triaenodes flavescens - Considered a macrophyte species, found in both lentic and lotic habitats. We have collected larvae in aquatic macrophytes from the St. Marks River, Wakulla Co.

Triaenodes florida - Widespread in lakes throughout Florida, occurring among macrophytes. Glover (1993) reported collecting large numbers in emergent sedges and coontail (*Myriopyllum*) from Lucas Lake,Washington Co. Identification of this species is quite easy, as the black bands surrounding leg segments are distinctive. The case is light, long and tapered making this species an especially proficient swimmer (Glover, 1993).

Triaenodes furcellus - Endemic to peninsular Florida. We have examined larvae of this species collected from North Prong Alligator Ck., Charlotte Co.; Fisheating Ck., Glades Co.; and Lake Placid and Arbuckle Ck., Highlands County. Morse (In Press) listed this species as Threatened.

Triaenodes helo - Widely distributed across the state but uncommon. It has been reported from streams of Eglin Air Force Base (Harris et al., 1982); and Highlands Hammock State Park and an unnamed tributary of Six Mile Creek, Duvall County (Glover, 1993). *Triaenodes helo* is closely related to *T. perna* and positive identification of the larvae is still considered unresolved (Glover, 1993). However, Glover (1993) indicated that the head of *T. helo* usually has a strong mesal indentation along the posterior edge of dark pigmentation near the occipital foramen, while in *T. perna* the line of dark pigmentation is nearly straight.

Triaenodes ignitus - Probably the most widespread and common species in Florida, as well as North America. It is mainly a lotic root species which can occur in large numbers. Tolerant of a wide range of water quality conditions, this species has been collected in a wide array of lotic habitats, from small spring-fed streams to larger rivers such as the Suwannee and Apalachicola.

Triaenodes injustus - Widely distributed in the eastern U.S., although not commonly found in coastal areas (Glover, 1993). This species has not been reported within the state; however it is likely to occur, having been recorded from the Blackwater River basin, Covington Co., Alabama (Harris et al., 1991).

Triaenodes marginatus - Another species that probably occurs in North Florida, although we have not collected nor seen any record of it. It has been collected to a limited extent in southern Alabama, Apalachicola River Basin (Harris et al., 1991).

Triaenodes melacus - This species probably occurs in Florida, although there is no record of it. The species has been collected in southern Alabama where it occurs in cool, gravel-bottom streams and rivers (Harris et al., 1991).

Triaenodes new sp. A - Endemic to the southeastern United States, found primarily in small coastal blackwater streams and swamps of Alabama and the western portions of the Florida panhandle. According to Glover (1993), larval identification should be considered tentative until further associations have been done.

Triaenodes new sp. C - This species is known to occur only in North Carolina, South Carolina, and Florida (Glover, 1993). Although adults have been collected in Florida, larvae have not yet been reported.

Triaenodes nox - Probably widely distributed in North Florida but uncommon. It has been collected in aquatic macrophytes from Lake Miccosukee, Jefferson Co.; and the Escambia River Basin, Escambia Co., Alabama (Harris et al., 1991).

Triaenodes ochraceus - This species is not commonly found in Florida. We have collected larvae from the upper Aucilla River, Jefferson/Madison Co. and Attapulgus Creek, in Gadsden County. It has also been reported from an unnamed tributary of Six Mile Creek, Duval Co. (Glover, 1993).

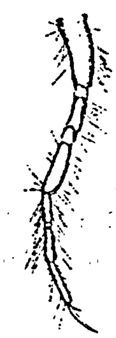
Triaenodes perna - Widespread in North Florida. It may be collected in roots of riparian vegetation from small streams to large rivers or swamps (Glover, 1993). This species lacks the dense fringe of swimming hairs, and the dorsum of the head is very black, like that of *T. helo*. Possible distinguishing characters are described under *T. helo*.

Triaenodes smithi - Present in the Blackwater and Chipola river basins in southern Alabama (Harris et al., 1991) and likely to occur in Florida. This is the only *Triaenodes* species thought to occur in Florida in which the larvae have not yet been associated with the adults.

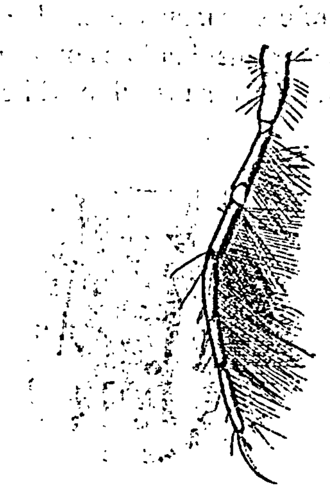
Triaenodes tardus - This species is more northern in its distribution and is uncommon in Florida. The extent of its presence in lakes of North Florida is unknown; sampling of macrophytes should provide more information on Florida distribution. The larval association, made by Glover (1993), is based on larvae collected along with a pharate male pupa from Lake Jackson, Leon Co.

KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *TRIAENODES* * **

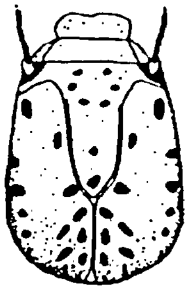
1. Dorsum of head almost completely black; swimming hairs on rear legs reduced; antennae unpigmented; case usually only slightly longer than larva and composed of tips of rootlets of riparian vegetation
. . . . *T. perna/helo*



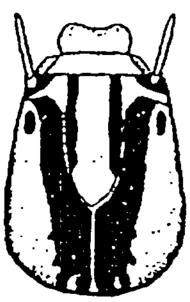
Dorsum of head not as above, marked with dark parallel stripes, muscle scars, or combination of both; swimming hairs usually well developed; antennae pigmented or unpigmented; case usually long and tapered, composed of rootlets or aquatic macrophytes [1]
. . . . 2

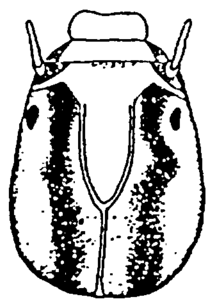


2(1) Conspicuous pattern of four inner muscle scars from occipital foramen to base of frontoclypeal suture on either side of coronal suture; other dorsal muscle scars often present
. . . . 3

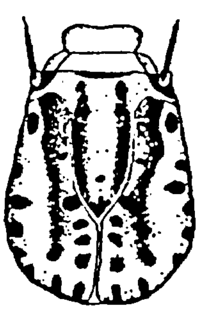


Dorsum of head capsule with inner muscle scars connected by dark pigment forming brown or black lines parallel with frontoclypeal and coronal sutures from subocular lines to occipital foramen; at most two inner muscle scars parallel to coronal suture but usually appearing light brown or lighter than background color
. . . . 11

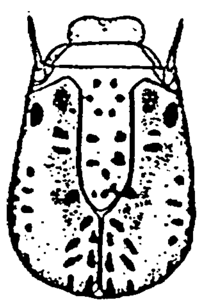


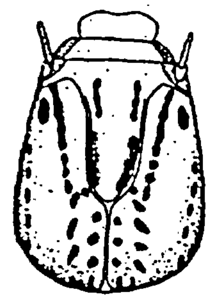


3(2) Dorsum of head with parallel black lines extending from subocular line posteriorly and parallelling at least part of coronal suture, gradually broken into muscle scars near occipital foramen; longitudinal black lines on frontoclypeal apotome well developed; antennae black, sometimes tipped in white
. . . . 4

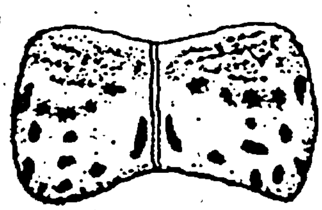


Dorsum of head without such black lines, although sometimes diffuse dark lines along outside of frontoclypeal sutures present but not encompassing coronal suture scars; head with pattern of muscle scars; without thick black longitudinal lines on frontoclypeus, although thin broken lines sometimes present; antennae pale, brown or black
. . . . 5

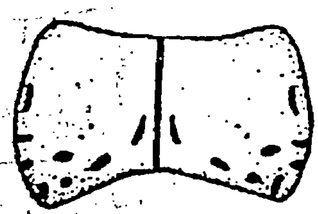




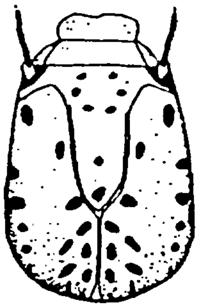
4(3) Ventral apotome appearing brown in places; anterior portion of pronotum also slightly pigmented
. . . . *T. furcellus*



Ventral apotome pale, without pigmentation; anterior portion of pronotum pale
. . . . *T. injustus*

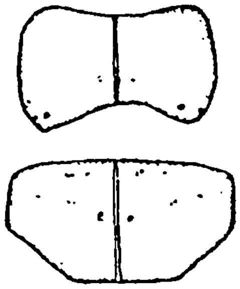


5(3) Legs with conspicuous black bands at joints; antennae dark black; case long and tapering, constructed of aquatic macrophytes
. . . . *T. florida*

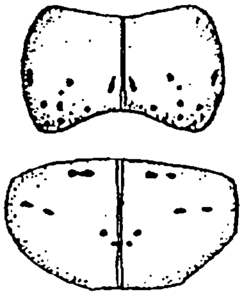


Legs without conspicuous black bands at joints; antennae black or pale
. . . . 6

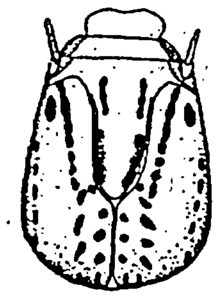
6(5) Muscle scars reduced on pronotum and mesonotum; antennae usually pale
. . . . *T. tardus*

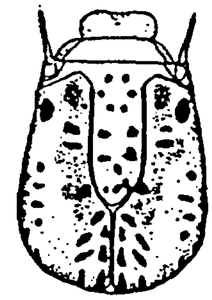


Muscle scars well developed on pronotum and mesonotum; antennae pale or dark
. . . . 7

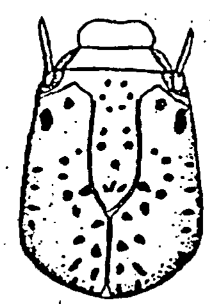


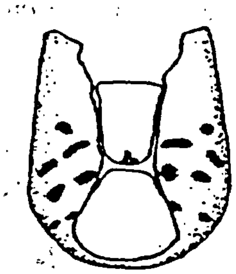
7(6) Head in dorsal view with parallel dark stripes along outer portion of frontoclypeal suture; scars never present at base of ventral apotome; antennae brown or sometimes black; base usually lighter than tip 8



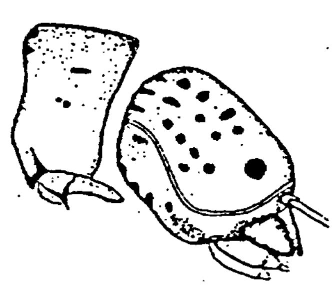


Head in dorsal view not as above; scars sometimes present at base of ventral apotome pigmentation of antennae variable 9

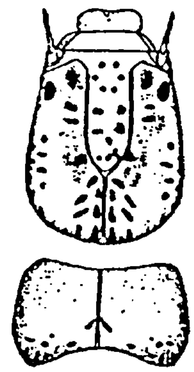




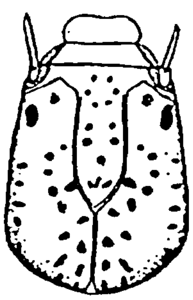
8(7) Parallel lines outside frontoclypeal sutures thin; frontoclypeal muscle scars usually coalesced to form thin parallel lines; pronotum background color uniform .... *T. flavescens*, in part

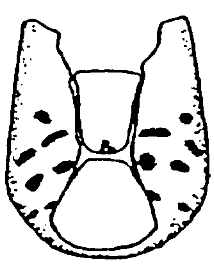


Parallel lines outside frontoclypeal sutures usually wide and diffuse; frontoclypeal muscle scars not coalesced; anterior portion of pronotum loosely pigmented
. . . . *T. ochraceus*

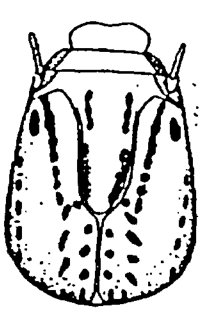


9(7) Head in dorsal view with series of five or six muscle scars in semicircle on each side of ecdysial line, first at midpoint of frontoclypeal suture and last where frontoclypeal suture joins coronal suture; antennae without pigmentation; muscle scars usually present at base of ventral apotome
. . . . 10

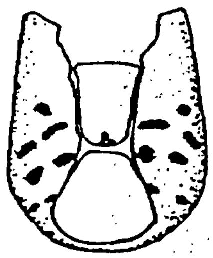


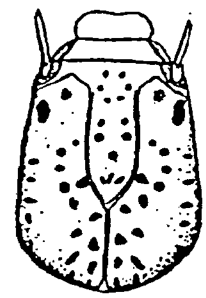


Head without semicircle of muscle scars; antennae usually lightly pigmented to black; muscle scars absent from base of ventral apotome
. . . . *T. flavescens*, in part

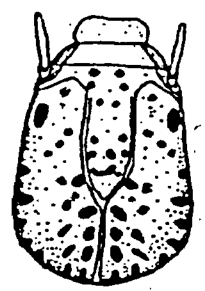


10(9) Muscle scars present on ventral apotome; head pattern as in figure below; anterior fringe of tarsal swimming hairs absent from metathoracic legs
.... *T. ignitus*

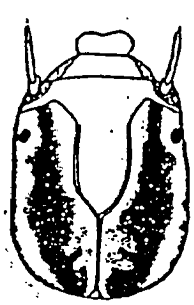


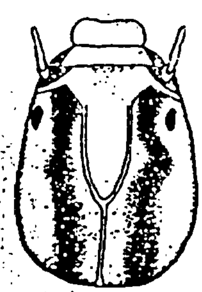


Muscle scars absent from ventral apotome; head pattern as in figure below; anterior fringe of tarsal swimming hairs present on each metathoracic leg
.... *Triaenodes* new sp. A ?

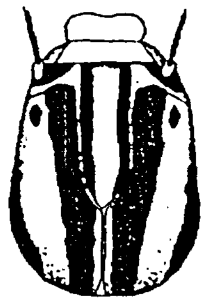


11(2) Dorsal head stripes diffuse, not appearing to be sharply delineated, often appearing brown and having muscle scars parallel to coronal suture lighter than background color; pronotum often with pair of complete or incomplete longitudinal stripes; antennae usually pale
.... 12

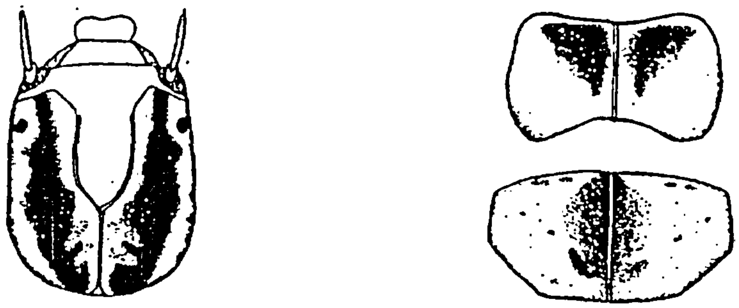




Dorsal head stripes black, dark, and well defined, without light muscle scars parallel to coronal suture; pronotum without longitudinal stripes; antennae usually black
. . . . 13



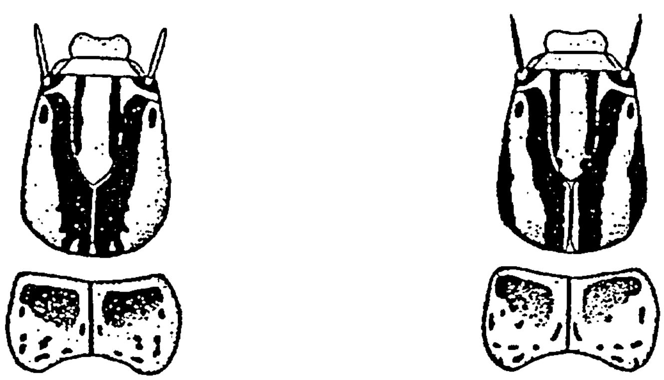
12(11) Dark stripes often covering most of dorsum of head; pronotum with pair of triangular patches of pigmentation anteriorly; mesonotum with large mesal region darkened
. . . . *Triaenodes* new sp. C



Dark stripes of dorsum of head narrower than above; pronotum usually with pair of complete longitudinal stripes; mesonotum without large region of pigmentation
. . . . *T. nox*

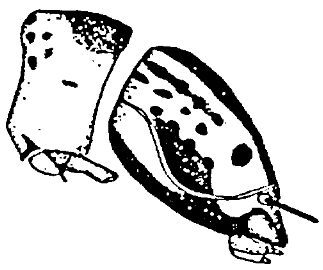
13(11) Pronotum nearly completely black, sometimes with small unpigmented area posteromesally
. . . . *T. melacus*

Pronotum light with muscle scars and sometimes small patches of pigmentation near anterior margin
. . . . 14



14(13) Postgenae with distinct muscle scars present; antennae pale or black
. . . . *T. abus*

Postgenal muscle scars coalesced to form stripes; antennae black
. . . . *T. marginatus*



* key and figures to *Triaenodes* species adapted from Glover (1993).

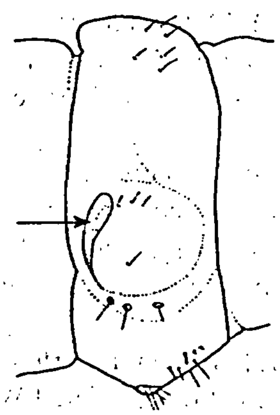
** key does not include *Triaenodes smithi.*

FAMILY LIMNEPHILIDAE

Considered the largest caddisfly family in North America, with approximately 52 genera and over 250 species, the Limnephilidae is represented in Florida by only two genera, *Ironoquia* and *Pycnopsyche*. The limnephilid larvae are distinguished morphologically by the following combination of characters: antennae located halfway between anterior margin of head capsule and eye (fig. 19D in family key); anterior margin of pronotum straight (fig. 19C in family key); prosternal horn not reduced (fig. 19D in family key); and basal seta of tarsal claw short, not extending to tip of claw. The larval cases are constructed of plant materials or rock fragments with rough or irregular texture. Limnephilid larvae live in a wide variety of lotic habitats ranging from temporary or permanent streams, springs, spring seeps, rivers, and lentic environments which include pools, ponds, marshes, swamps, and lakes (Unzicker et al., 1982).

KEY TO GENERA FOR MATURE LARVAE OF FLORIDA LIMNEPHILIDAE

1. Abdominal gills single or unbranched; lateral hump of abdominal segment I with one long sclerite adjacent to base, the sclerite sometimes only lightly pigmented, but distinguishable by the smooth and relatively shinier surface
. . . . *Pycnopsyche*



Most abdominal gills with multiple branching of up to 10-15 filaments; sclerite absent from area adjacent to base of lateral hump.
. . . . *Ironoquia, I. punctatissima*

Genus *Ironoquia* Banks

DIAGNOSIS: Larvae morphologically recognized by multibranched abdominal gills, lack of sclerite adjacent to base of lateral hump, and meso- and metathoracic femora each with 5-7 major setae along ventral edge. The cylindrical larval cases are slightly tapered and curved, and constructed of either sand grains or pieces of plant materials.

NOTES: The larva of *Ironoquia punctatissima*, the only species of *Ironoquia* represented in Florida, was first described by Flint (1960). The larvae are characterized by the distinct dark spots and infuscations of the head and thoracic nota.

Ironoquia punctatissima appears to be uncommon in Florida; we have examined larvae from only two localities in the state: Ochlockonee River, near State Road 12 along the Leon/Gadsden county line, and St. Marks River, 1.5 km NE Chaires, Leon Co. Previously, one adult male specimen was collected from the Tall Timbers research station in Leon County and reported by Gordon (1984).

Little is known about the life history of *Ironoquia punctatissima* in Florida. The mature larvae were collected in February. The adult from Tall Timbers was collected in November. The species has been reported to have a univoltine life cycle in temporary streams (Unzicker et al., 1982), and adults have been collected in September in the Northeast (Flint, 1960) and in July to early October in North and South Carolina (Unzicker et al., 1982).

ADDITIONAL REFERENCES: Flint (1960); Wiggins (1977); Unzicker, Resh, and Morse (1982).

Genus *Pycnopsyche* Banks

DIAGNOSIS: Larvae of *Pycnopsyche* morphologically recognized by single and unbranched abdominal gills and presence of long sclerite adjacent to base of lateral hump on abdominal segment I (see figure in key to genera). Metanotal sa1 sclerites not fused (although often close together) along midline as in *Hydatophylax*. The variously shaped or occasionally 3-sided larval cases are constructed from twigs, leaves, sand, and gravel.

NOTES: Two species of *Pycnopsyche* are known to occur in Florida (*P. antica* and *P. indiana*). *Pycnopsyche antica* appears to be the most common of the two and has been reported from Leon Co. (Gordon, 1984), Gadsden and Okaloosa counties (Wojtowicz, 1982). *Pycnopsyche indiana* has been reported to occur in coastal plain blackwater streams, although the distribution in Florida is poorly understood.

Pycnopsyche scabripennis has also been reported to occur in Florida (Harris, 1982; Gordon, 1984); however, these identifications predated Wojtowicz's (1982) dissertation on *Pycnopsyche*, which included a revision of the *P. scabripennis* species complex, where he indicated that the species *P. scabripennis* southern most range is limited to the Virginias. Previous reports of *P. scabripennis* in Florida are very likely to be *P. antica*.

The previous report of *P. guttifera* in Florida by Gordon (1984) was in error. After a reexamination of *Pycnopsyche* adults reported by Gordon (1984) as *P. guttifera*, we discovered they had been misidentified and were actually *P. antica*.

The lack of reliable larval characters makes it very difficult to distinguish species of *Pycnopsyche*. Larval descriptions of *P. indiana* and *P. antica* by Wojtowicz (1982) indicated that these species cannot be reliably separated based on larval or case morphology. The case structure of *P. antica* and *P. indiana* is variable. *Pycnopsyche antica* constructs a case either of firmly attached wood pieces (see figure below) or of leaf fragments arranged to form a 3-sided case, or a combination of both. Likewise, the case structure of *P. indiana* is variable, composed either totally of plant material (similar to *P. antica*) or of a mix of plant and mineral materials (Wojtowicz, 1982).

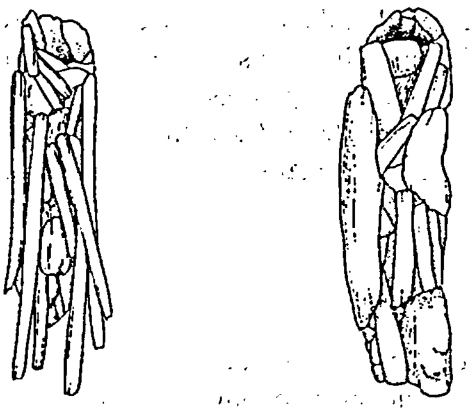


FIGURE: *Pycnopsyche antica*, larval cases.

Pycnopsyche appears geographically confined to the northern tier of the state. We have collected the larvae in moderate-sized streams (e.g., Burnt Mill Creek, Jefferson Co.) and medium-sized rivers (e.g., Aucilla and Econfina rivers, Taylor Co.; Chipola River, Jackson Co.) The larvae were collected with dipnets and Hester-Dendy plates near the shorelines of the streams and rivers where there was plenty of snags and other organic debris.

Except for the collection dates, the life history of *Pycnopsyche* in Florida is unknown. The adults of *P. antica* (identified as *P. scabripennis*) were collected along Rocky Creek, Walton Co., in November and December (Harris et al., 1982). Likewise, we collected adults of *P. antica* along the Apalachicola ravine streams, Liberty Co. in late October and early December.

ADDITIONAL REFERENCES: Ross (1944); Flint (1960); Wiggins (1977); Unzicker, Resh, and Morse (1982); Wojtowicz (1982).

FAMILY MOLANNIDAE

The family Molannidae is represented in the Nearctic Region by two genera, *Molanna* and *Molannodes*. The Florida fauna includes only the genus *Molanna*. The mature molannid larvae can be distinguished from other caddis families by the presence of reduced metatarsal claws (fig. 13A in family key) and case constructed of quartz pieces with a dorsal hood and lateral flanges (fig. 13 B in family key). Larvae are widespread across North Florida and occur in a wide range of lotic habitats.

Genus *Molanna* Curtis

DIAGNOSIS: Larva with tarsal claw of each metathoracic leg setose, and greatly reduced compared to those on fore- and mesothoracic legs; abdominal gill filaments have two to four branches; and tubular case with prominent lateral flange and dorsal hood over anterior end, giving case flattened appearance.

NOTES: The three species of *Molanna* in Florida include *M. blenda*, *M. tryphena*, and *M. ulmerina*. *Molanna blenda* is herein reported for the first time in the state. The larvae of both *M. blenda* and *M. tryphena* have been associated with the adults, while those of *M. ulmerina* are still unknown.

Sherberger and Wallace (1971) described the larvae of *M. blenda* and *M. tryphena*, and discussed their ecology and biology as well. The larvae of these species are distinguished morphologically by the development of the foretibial spine and the shape of the membranous frontal constrictions, as indicated in the following key to species. Both *M. blenda* and *M. tryphena* are lotic dwellers. Sherberger and Wallace (1971) indicated that larvae of *M. blenda* have been collected only in spring seeps and spring-fed streams with waters uniformly cool throughout the year, and larvae of *M. tryphena* occur in larger streams.

In Florida, we collected the larvae and adults of *M. blenda* from a small spring-fed stream in a ravine at the Florida A&M University Farm in Gadsden County. The water temperatures are relatively constant throughout the year, ranging from 17.5° - 20°C. The larvae were collected midstream where some snags and trapped organic debris were present. We also collected adults of *M. blenda* along the streams of the Apalachicola ravines in Liberty Co.

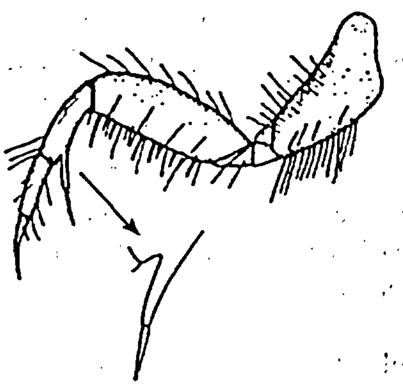
Molanna tryphena is more geographically widespread than *M. blenda* and less restricted in habitat. The geographic distribution of *Molanna ulmerina* in Florida is poorly understood. Harris et al. (1982) reported the species from Rocky Creek on Eglin Air Force Base; our only record of *M. ulmerina* is from Florida Caverns State Park, Jackson County.

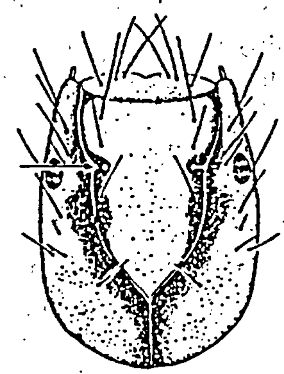
Little is known of the life history of *Molanna* spp. in Florida. Harris et al. (1982) reported flight dates for *M. tryphena* from March to September and November. We collected adults of *M. blenda* and *M. tryphena* throughout the spring and fall months.

ADDITIONAL REFERENCES: Ross (1944); Sherberger and Wallace (1971); Wiggins (1977).

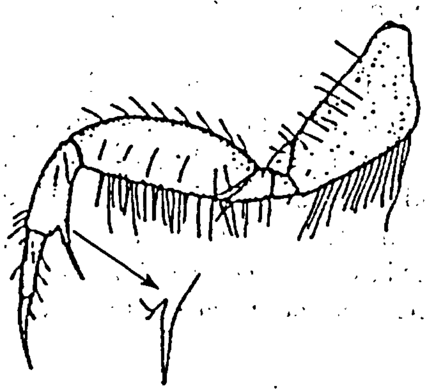
KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *MOLANNA* * **

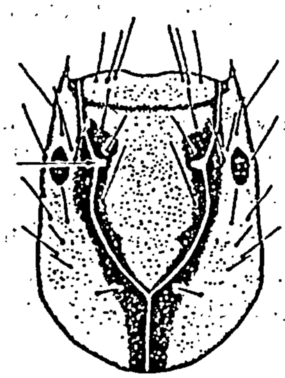
1. Apex of base of spine on fore tibia extending well past tibiotarsal joint; membranous area at constriction of frons capitate .... *M. blenda*





Apex of base of spine on fore tibia extending to or just past tibiotarsal joint; membranous area at constriction of frons quadrate .... *M. tryphena*





* key and figures to *Molanna* species adapted from Sherberger and Wallace (1971).

** key does not include *Molanna ulmerina*.

FAMILY ODONTOCERIDAE

The family Odontoceridae is represented in the Nearctic by six genera but only the genus *Psilotreta* extends its geographic range to Florida. The larvae are morphologically recognized by the following: anal proleg without cluster of dorsal setae posteromesad of lateral sclerite (fig. 17D, 17E in family key); foretrochantin small, apex not hook-shaped (fig. 17F in family key); and dorsal sclerites of metathorax entire. The larval case is constructed of coarse sand or small rock fragments tightly glued together. The larvae are generally lotic dwellers but are most common in springbrooks to medium-sized streams with substrates made up of mixtures of sand and gravel.

Genus *Psilotreta* Banks

DIAGNOSIS: Larvae distinguished by pointed anterolateral corners of pronotum and genae contiguous along most of median ventral ecdysial line of head. Cylindrical larval cases usually tapered and constructed of sand grains cemented together.

NOTES: Of the six Nearctic species of *Psilotreta*, only *P. frontalis* has been reported in Florida. It will be to no surprise if *P. labida* also occurs in the state because Harris et al. (1991) collected the adults near the Alabama-Florida line, and the geographic ranges of both *P. frontalis* and *P. labida* are largely sympatric (Parker and Wiggins, 1987). The larvae of these species are distinguished by the development of the anterolateral corner of the pronotum, the anteroventral angle of the mesepisternum, and the coloration of the frontoclypeus (see figures in key to species below).

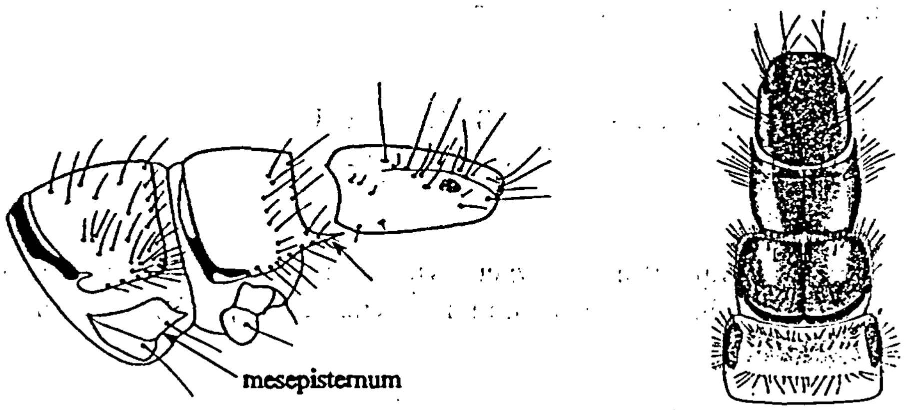
The larvae of *P. frontalis* have been collected primarily in well shaded spring-fed streams where the larvae are known to attack and feed on *Goniobasis* snails (Parker and Wiggins, 1987). In Florida we have collected the larvae only from small spring-fed and sand-bottomed streams such as the ones in the FAMU farm, Gadsden Co. and the Apalachicola ravines, Liberty County.

Knowledge of the life history of *P. frontalis* is limited. Unzicker et al. (1982) indicated that in North and South Carolina, adults of the species have been collected in May and June. In Florida we collected the larvae throughout most of the year and the adults throughout spring and fall months.

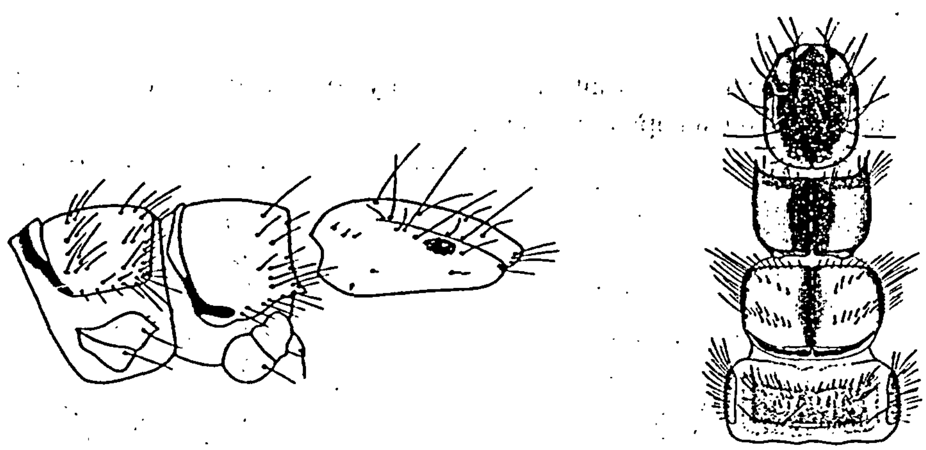
ADDITIONAL REFERENCES: Parker and Wiggins (1987).

KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *PSILOTRETA* *

1. Anterolateral corners of pronotum long and acute; anteroventral angles of mesepisternum generally pointed; head in dorsal aspect with broad black stripe of more or less uniform width throughout; frontoclypeus uniformly black
. . . . *P. labida*



Anterolateral corners of pronotum short; anteroventral angles of mesepisternum short; head in dorsal aspect with broad black stripe constricted anterior to eyes and narrowing gradually posteriorly; frontoclypeus black except for light areas at the anterolateral corners
. . . . *P. frontalis*



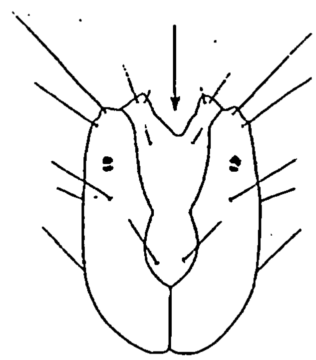
* key and figures to *Psilotreta* species adapted from Parker and Wiggins (1987).

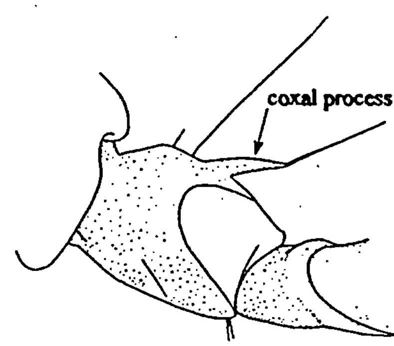
FAMILY PHILOPOTAMIDAE

Two of the three Nearctic genera of Philopotamidae, *Chimarra* and *Wormaldia*, are represented in Florida, the former a widespread genus in the state. Philopotamid larvae have a unique membranous and T-shaped labrum (fig. 9A in family key). The strictly lotic dwelling larvae spin tubular, sac-like, capture nets with fine mesh to filter particulate organic matter. The larvae have the distinction of constructing capture nets with the smallest known mesh openings of any net-spinning caddisflies (Wallace and Malas, 1976).

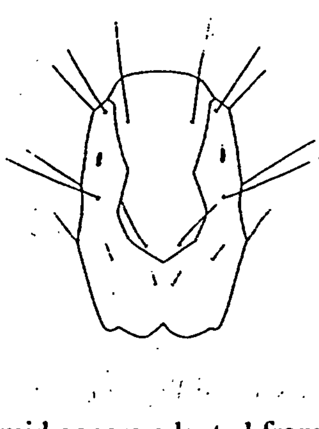
KEY TO GENERA AND SPECIES FOR MATURE LARVAE OF FLORIDA PHILOPOTAMIDAE*

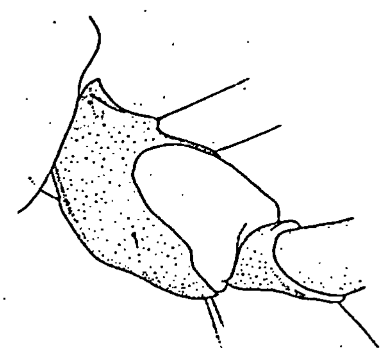
1. Anterior margin of frontoclypeus with prominent notch asymmetrically right of midline; prothoracic coxa with long, slender, subapical seta-bearing process
. . . . *Chimarra*





Anterior margin of frontoclypeus evenly convex, symmetrical; prothoracic coxa without long subapical process
. . . . *Wormaldia, W. moesta*





* key to philopotamid genera adapted from Morse and Holzenthal (1984).

Genus *Chimarra* Stephens

DIAGNOSIS: Larvae with anterior margin of frontoclypeus with prominent notch asymmetrically right of midline; and each prothoracic coxa with long slender seta-bearing process (see figures in key to genera).

NOTES: There are six species of *Chimarra* represented in Florida (*C. aterrima*, *C. falculata*, *C. florida*, *C. moselyi*, *C. obscura*, and *C. parasocia*). *Chimarra socia* has also been reported to occur in Florida, but because of the taxonomic confusion of *C. socia* with *C. parasocia*, previous Florida records for the former are properly applied to the latter (Lago and Harris, 1987). The occurrence of the species *C. argentella* (Ulmer, 1906) in Florida was reported by Milne (1936), but the accuracy of Milne's identification according to Morse (In Press) has never been confirmed, thus the validity of the Florida record is questionable. Ross (1944) provided a key to the larvae of some species of *Chimarra*, including those of *C. aterrima*, *C. obscura*, and *C. socia*, but we are unable to identify any of our *Chimarra* specimens using this key. It appears that additional characters other than the anterior margin of the frontoclypeus and mandibular incision are needed to identify the larvae with confidence. Until the larvae and adults are associated, caution must be exercised in identifying the larvae of Florida *Chimarra*. The larvae of *C. falculata*, *C. florida*, *C. moselyi*, and *C. parasocia* are undescribed.

As previously alluded, *Chimarra* is geographically widespread in the state, and we found that the larvae are very common in relatively clean, small and clear sand-bottomed streams in North Florida. The larvae were collected with dipnet and Hester-Dendy plates. The larvae appear to be most abundant near shorelines where moss and small pieces of limestone prevail.

The life histories of *Chimarra* spp. of Florida are unknown. We have collected larvae of various sizes throughout the year. Similarly, light-trap collections indicate that adults appear to emerge almost all year except in December-February. Whether *Chimarra* spp. have univoltine or multivoltine life cycles in Florida remains to be investigated. Elsewhere, species such as *C. moselyi* are bivoltine (Unzicker et al., 1982); others (for example, *C. aterrima*) are univoltine (Hilsenhoff et al., 1972).

ADDITIONAL REFERENCES: Ross (1944), Unzicker, Resh, and Morse (1982), Morse and Holzenthal (1984), Morse (In Press).

Genus *Wormaldia* MacLachlan

DIAGNOSIS: Larvae morphologically distinguished from *Chimarra* spp. by evenly convex and symmetrical anterior margin of frontoclypeus and absence of subapical process on each prothoracic coxa (see figures in key to genera). The capture net consists of several layers of mesh, each layer having elongate openings of variable sizes (Unzicker et al. (1982).

NOTES: Of the 16 known species of *Wormaldia*, only *W. moesta* is represented in Florida. Ross (1944) briefly described the larva and characterized the species by the absence of a stout coxal spine on each front leg and presence of inconspicuous transverse bars on the frons. The species is uncommon in Florida. We examined one larval specimen that was collected in Bridge Creek, a small tributary of the Chipola River, Jackson Co., and the adults have been collected with light traps beside Rocky Creek on Eglin Air Force Base in Walton County (Harris et al., 1982).

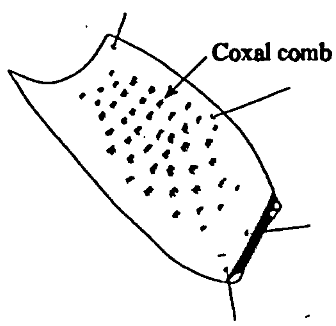
ADDITIONAL REFERENCES: Ross (1944); Unzicker, Resh, and Morse (1982).

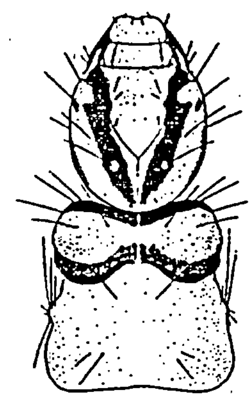
FAMILY PHRYGANEIDAE

The phryganeid caddisflies have nine genera in North America and three of the genera, *Agrypnia*, *Banksiola*, and *Ptilostomis*, are represented in Florida. The larvae are morphologically defined by the presence of a cluster of setae arising from a small rounded sclerite on metanotal sa3 and a well-developed prosternal horn (figs. 7A, 7B in family key). The larval cases are constructed primarily of plant materials in which the pieces are either fastened together to produce a continuous, spirally wound case, or fitted together to form discrete ring-like sections. The larvae inhabit an array of lentic and lotic habitats.

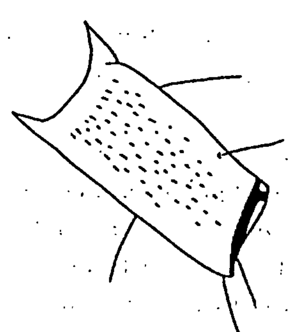
KEY TO GENERA AND SPECIES FOR MATURE LARVAE OF FLORIDA PHRYGANEIDAE*

1. Ventral combs of prothoracic coxae conspicuous, their teeth evident at 50X magnification; head and pronotum as shown in figure below
.... *Agrypnia*, *A. vestita*

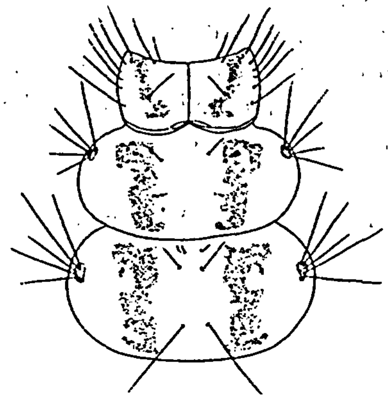




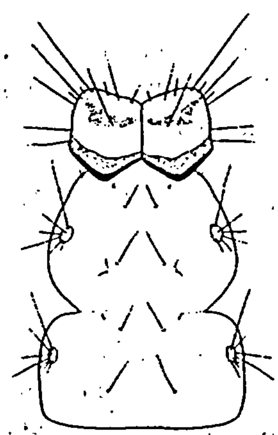
Ventral combs of prothoracic coxae small, each comb appearing as a tiny raised point at 50X magnification; head and pronotum not as above
.... 2



2(1) Meso- and metanota with pair of longitudinal, irregular, dark bands; case of spiral construction usually with trailing ends of plant material
.... *Banksiola, B. concatenata*



Meso- and metanota nearly uniform in color; case of spiral construction without trailing ends of plant material
.... *Ptilostomis*



* key to genera adapted from Morse and Holzenthal (1984); figure of *A. vestita*, head and pronotum, from Ross (1944).

Genus *Agrypnia* Curtis

DIAGNOSIS: Larvae morphologically characterized by conspicuous ventral combs of prothoracic coxae, coxal combs of mesothoracic legs each with basal axis both transverse and parallel to long axis of coxa, and prothoracic sternellum usually present. The spirally fashioned or ringed larval case is usually constructed of leaf and bark pieces.

NOTES: Only one species of *Agrypnia, A. vestita*, is represented in Florida. The larva was described by Ross (1944) and Wiggins (1960), and is morphologically distinguished by the absence of diagonal dark brown bandings on the pronotum, the relatively narrow dorsal banding on the head (see figure in key to genera), and the frontoclypeus usually without markings.

Agrypnia vestita is quite uncommon in Florida. The species has only been collected from a few localities. Gordon (1984) indicated the occurrence of the species in Leon, Liberty, and Okaloosa counties. The larvae have been collected in Roaring Creek, a tributary of the Suwannee River in Hamilton Co. The creek is medium-sized, and has a moderate flow and mostly sandy substrate with plenty of snags and leaf packs in some reaches (R. Frydenborg, pers. comm.).

The life history of *A. vestita* in Florida is unknown. The adults have been collected in April and October through November, and the larvae in January. The species has been reported to emerge in May to October in North and South Carolina (Unzicker et al., 1982).

ADDITIONAL REFERENCES: Ross (1944); Wiggins (1960, 1977); Unzicker, Resh, and Morse (1982).

Genus ***Banksiola*** Martynov

DIAGNOSIS: Larvae morphologically distinguished from *Agrypnia* and *Ptilostomis* by following combination of characters: ventral combs of prothoracic coxae inconspicuous and meso- and metanota with pair of prominent longitudinal dark bands (see figure in key to genera). The spiral larval cases usually have trailing ends of plant materials.

NOTES: *Banksiola* is represented in Florida by the species *B. concatenata.* The species has been reported from Alachua, Baker, and Leon counties (Gordon, 1984) and Walton Co. (Harris et al., 1982). The larva of this species is unknown.

ADDITIONAL REFERENCES: Wiggins (1960, 1977); Unzicker, Resh, and Morse (1982).

Genus ***Ptilostomis*** Koslenati

DIAGNOSIS: Similar to those of genus *Banksiola*, larvae of *Ptilostomis* with inconspicuous ventral combs of prothoracic coxa, but meso- and metanota almost uniform in color (see figure in key to genera). Spiral larval case slightly curved and constructed of plant materials with no trailing ends.

NOTES: One of the four known North American species of *Ptilostomis, P. postica*, is represented in Florida. Another species, *P. ocellifera*, has been collected near the Alabama-Florida line (Harris et al., 1991), and could very well also occur in Florida. The adults of *P. postica* were collected by light traps in Jefferson, Leon, and Suwannee counties (Gordon, 1984). The larvae of *Ptilostomis* have been collected in a backwater area of the Blackwater River, Okaloosa Co.; Dry Creek, a tributary of the Chipola River, Jackson Co.; and the Econfina River, Taylor County. Until larval-adult associations are made, the larvae remain unidentified to species.

Like the other Florida phryganeid caddisflies, information on the life histories of *Ptilostomis* spp. is limited. The adults of *P. postica* appear to emerge almost throughout the year, as light-trap collections indicate their flight in March through November. Unzicker et al. (1982) indicated that the adults fly in May through October in North and South Carolina. The larvae of the Florida material examined during this study were collected from January through April.

ADDITIONAL REFERENCES: Wiggins (1960, 1977); Unzicker, Resh, and Morse (1982).

FAMILY POLYCENTROPODIDAE

The diverse polycentropodids are represented in Florida by the genera *Cernotina*, *Cyrnellus*, *Neureclipsis*, *Paranyctiophylax*, and *Polycentropus*. The genus *Phylocentropus*, previously placed within Polycentropodidae, is now classified within the family Dipseudopsidae (Wells and Cartwright, 1993; Weaver and Malicky, 1994).

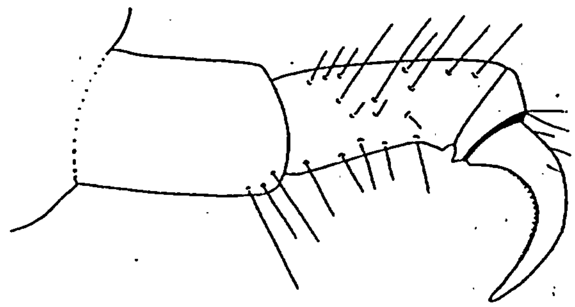
Polycentropodid larvae are most easily recognized by the pointed foretrochantin fused to the episternum without a separating suture and the elongate tarsi (fig. 11B in family key) which distinguish this family from the Dipseudopsidae. Larvae of this family generally occur in lotic habitats, although larvae of *Cernotina* and *Cyrnellus* species are also found in lentic habitats. The family is geographically widespread throughout the state. Larvae construct a variety of fixed retreats and capture nets with the materials, architecture, and placement of the retreats varying among genera.

KEY TO GENERA FOR MATURE LARVAE OF FLORIDA POLYCENTROPODIDAE*

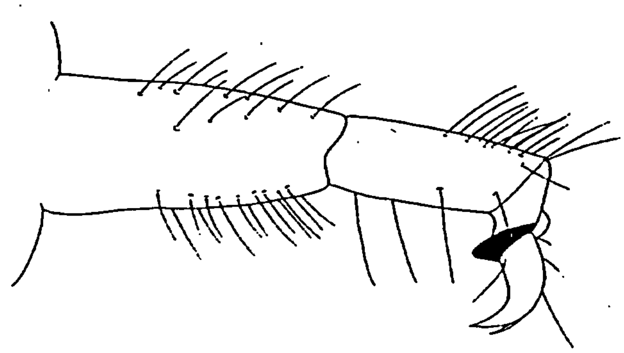
1. Anal claw with 6 or fewer ventral teeth; pronotum with short, stout bristle arising near each ventrolateral margin
. . . . *Paranyctiophylax*

Anal claw without ventral teeth or with 10 or more tiny ventral spines; pronotum without short, stout bristle near each ventrolateral margin
. . . . 2

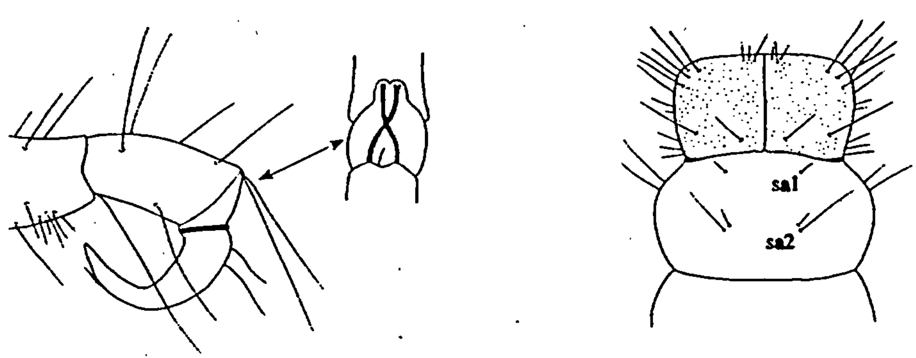
2(1) Basal segment of anal proleg about as long as distal segment and with only 2 or 3 apicoventral setae; anal claw with many tiny ventral spines .... *Neureclipsis* (p. 105)



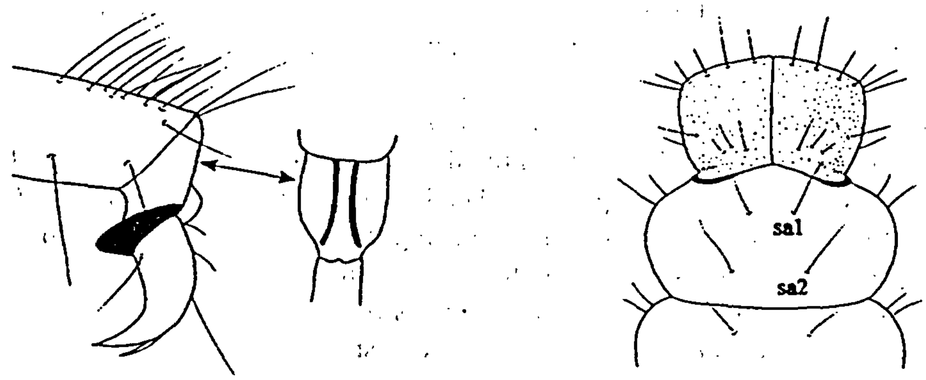
Basal segment of anal proleg longer than distal segment in mature larvae and with many setae scattered over most of its surface; anal claw without tiny ventral spines 3



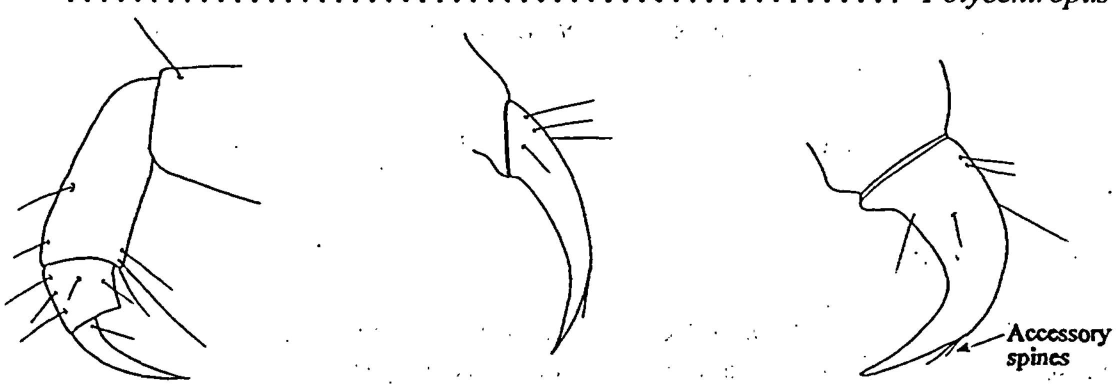
3(2) Dorsal region between anal claw and sclerite of distal segment of anal proleg with 2 mesally contiguous dark bands; meso- and metanotal sa1 setae short, not more than one-third as long as longest sa2 setae 4



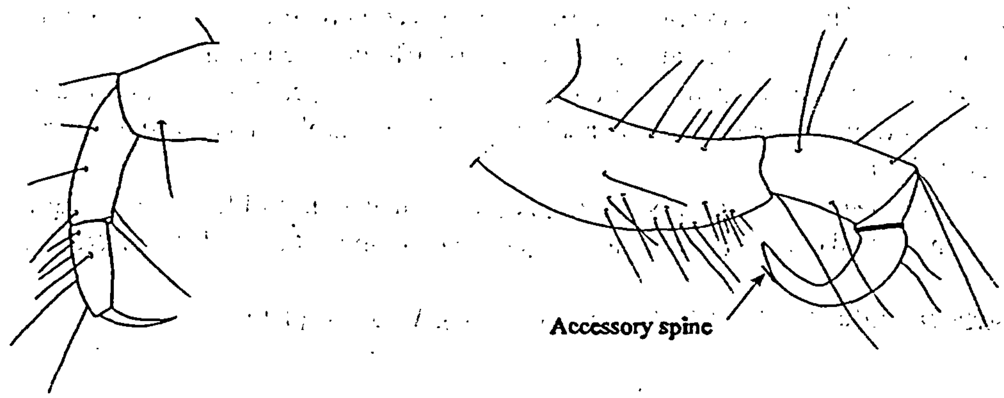
Dorsal region between anal claw and sclerite of distal segment of anal proleg with 2 mesally non-contiguous dark bands; meso- and metanotal sa1 setae about as long as longest sa2 setae
. . . . *Cyrnellus, C. fraternus*



4(3) Prothoracic tarsi each broad and only one-half as long as its prothoracic tibia, *or* anal claw obtusely curved, *or* anal claw with 2 or 3 dorsal accessory spines
. . . . *Polycentropus*



Prothoracic tarsi each narrow and at least two-thirds as long as its prothoracic tibia, *and* anal claw curved approximately 90°, *and* anal claw with only 1 dorsal accessory spine . . . . *Cernotina*



* key to polycentropodid genera adapted from Morse and Holzenthal (1984).

Genus *Cernotina* Ross

DIAGNOSIS: Larvae of *Cernotina* distinguished from other polycentropodid genera by following characters: mesally contiguous dark bands on dorsal region between anal claw and distal segment of anal proleg; narrow protarsi at least two-thirds as long as protibiae; anal claw curved approximately 90° and with only 1 dorsal accessory spine (see figure in key to genera).

NOTES: Larvae of *Cernotina* will run to *Polycentropus* using Wiggins's (1977) key. It was not until the work of Hudson et al. (1981), with the description of *C. spicata*, that the first positive larval association for this genus was accomplished. The larvae of *Cernotina* and *Polycentropus* species bear close resemblance and careful examination using the characters presented in the key is necessary to distinguish the two. Also it should be noted that the mature larvae of *C. spicata* are quite small, only 4-7 mm long, while mature larvae of *Polycentropus* species are much longer. It is likely that undescribed larvae of other *Cernotina* species are also small in size. Larvae are predaceous and occur in both lotic and lentic habitats where they construct silk tube retreats.

Three species of *Cernotina* have been reported in Florida (see Appendix A) based on adult collections. The geographic distribution of the genus appears to be widespread across the central and northern parts of the state. Morse (In Press) listed *C. truncona* as Rare although it has been recorded from a number of counties in the state. According to Morse (In Press) adult collections are sparse, suggesting small populations. *Cernotina spicata* and *C. calcea* are more common based on collection records of adult specimens.

ADDITIONAL REFERENCES: Wiggins (1977); Hudson, Morse, and Voshell (1981); Morse (In Press).

Genus *Cyrnellus* Banks

DIAGNOSIS: Larvae of *Cyrnellus* easily distinguished from other polycentropodid genera by presence of 2 non-contiguous dark bands on dorsal region between anal claw and lateral sclerite of distal segment of anal proleg; and meso- and metanotal sa1 setae as long as sa2 setae (see figures in key to genera).

NOTES: *Cyrnellus* contains a single Nearctic species, *C. fraternus*, first described in the larval stage by Flint (1964); it is widespread across the eastern United States. Larvae most closely resemble *Polycentropus* species but are not difficult to differentiate using the characters presented in the key. Larvae construct a silk retreat, roughly circular in outline, about 20mm in diameter, spun in shallow depressions on rock surfaces. The flat roof of the chamber has circular entrance and exit holes at the ends (Wiggins, 1977).

Cyrnellus fraternus is geographically widespread in Florida, ranging from the panhandle into southern Florida, and occurs in a wide range of lotic as well as lentic habitats.

ADDITIONAL REFERENCES: Flint (1964); Wiggins (1977).

Genus *Neureclipsis* MacLachlan

DIAGNOSIS: Larvae of *Neureclipsis* distinguished from those of other polycentropodid genera by basal segment of anal proleg about equal in length to distal segment with only few setae arising from basal segment; also anal claw with row of many tiny spines along ventral margin (see figures in key to genera).

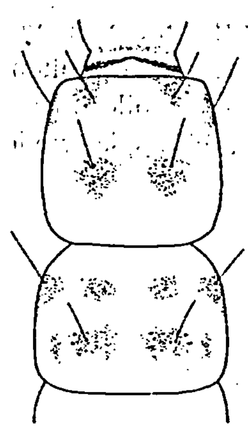
The row of tiny spines along the ventral margin of the anal claw are apparent at 40X magnification viewed from a lateral aspect. It is helpful to use illuminated base lighting as the light will transmit through the spines making them more apparent.

NOTES: Of the five species of *Neureclipsis* occurring in North America only two are found in the southeastern United States, *N. crepuscularis* and *N. melco*; both species have been reported from Florida. Of these two species, only *N. crepuscularis* has been described in the larval stage by Ross (1944). *Neureclipsis crepuscularis* is geographically widespread throughout the state, occurring in streams and rivers from the western panhandle to as far south as the Everglades. *Neureclipsis melco* appears to be more restricted, having been reported based upon adults collected from only the western portions of the panhandle. Based on the examinations of larvae collected throughout the state, it is apparent that the two species have a distinctive pigmentation pattern on the dorsal and lateral portions of the meso- and metathorax, and abdominal segments. Based on the larval description of *N. crepuscularis* by Ross (1944) and the geographic distribution of the species we feel confident larvae can be identified to species using the following key. The tentative assignment of *N. melco* in the key, while not based upon associated larvae, is consistent with the geographic distribution of adults (Gordon, 1984; Harris et al., 1982, 1991). The larvae we base this circumstantial association on were collected from the Escambia River in northern Escambia County.

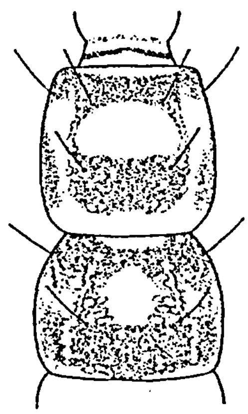
Larvae of *Neureclipsis* species construct a trumpet-shaped tube of silk up to 12 cm long with a flared anterior end which tapers to a slender tube in which the larva is concealed. The retreat is anchored so that the large anterior end faces the current, thus filtering food particles (Wiggins, 1977).

TENTATIVE KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *NEURECLIPSIS*

1. Areas of purplish pigmentation along dorsal and lateral margins of meso- and metathorax and abdominal segments broken into distinctly separate patches with unpigmented areas between patches .... *N. melco*



Areas of purplish pigmentation along dorsal and lateral margins of meso- and metathorax and abdominal segments not broken into distinctly separate patches but appear as more continuous bands across dorsum
. . . . *N. crepuscularis*

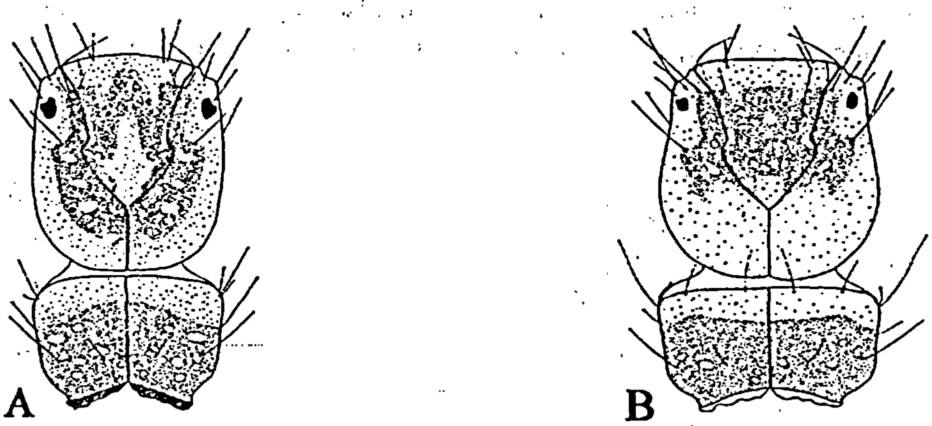


ADDITIONAL REFERENCES: Ross (1944); Wiggins (1977).

Genus *Paranyctiophylax* Tsuda

DIAGNOSIS: Larvae of *Paranyctiophylax* easily distinguished from other polycentropodid genera by presence of 6 or fewer conspicuous teeth on ventral margin of anal claw and presence of stout bristle arising near ventrolateral margin of pronotum (see figures in key to genera).

NOTES: Of the nine species of *Paranyctiophylax* known to occur in North America, four have been reported in Florida (see Appendix A) and a 5th species, *P. serratus*, is very likely to occur in the state based upon adults collected near the Florida-Alabama state line (Harris et al., 1991). To date only two of these five species have been described as larvae. Flint (1964) described the larvae of *P. celta* (as *Nyctiophylax vestita*) and *P. moestus* (as *Nyctiophylax* sp. A) (see figs. A and B below). We have examined larvae closely matching Flint's descriptions and illustrations of these species, but we feel that our species determinations remain questionable until additional associations for other *Paranyctiophylax* species have been done. We have examined numerous larvae collected from widespread localities in the state closely resembling Flint's description of *P. moestus* (*Nyctiophylax* sp. A). However, it is very possible that these larvae are *P. affinis*, since this species is considered closely related to *P. moestus* (Armitage and Hamilton, 1990) and is more widespread and common in Florida than *P. moestus* based upon adult collections. We have also examined larvae collected from the Suwannee River closely matching Flint's description of *P. celta* (as *N. vestitus*).



FIGURES: (Flint, 1964) - A. *Paranyctiophylax moestus*; B. *Paranyctiophylax celta.*

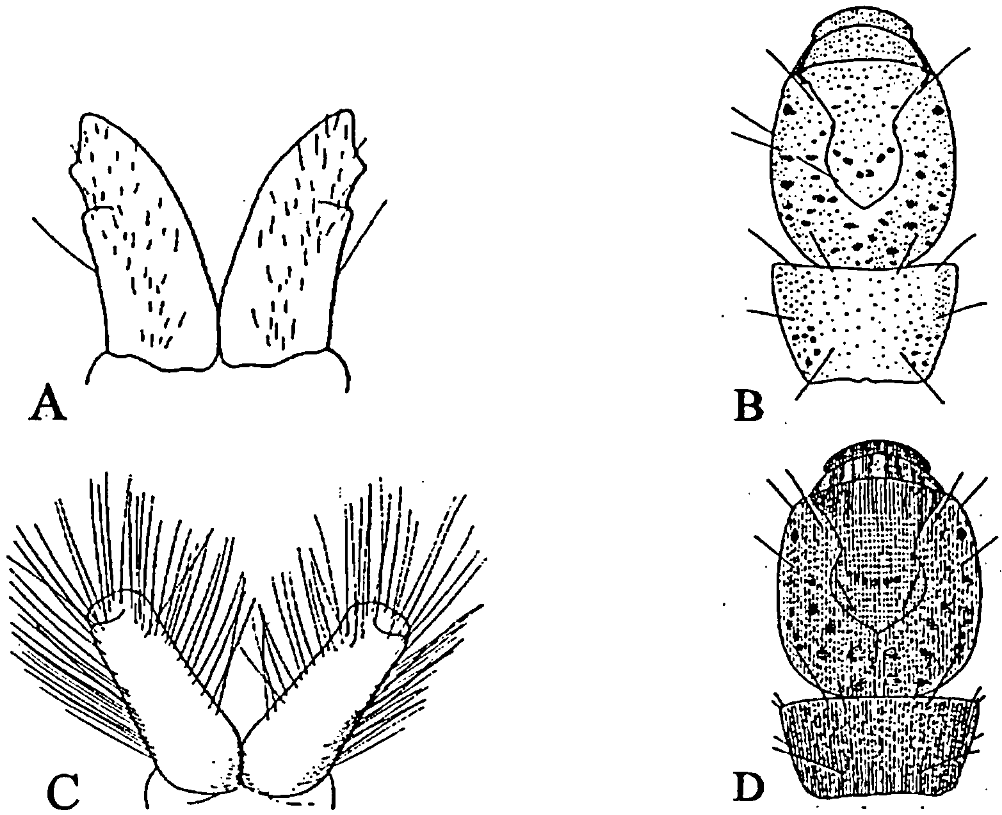
Larvae of *Paranyctiophylax* species construct a silk retreat consisting of an open ended chamber over a depression in rock or woody substrate. The floor of the retreat extends beyond the roof at each end as a threshold of silk threads (Wiggins, 1977). A loose network of threads float up from the threshold and the larva darts out of the chamber to capture small prey that have caused the threshold threads to move (Noyes, 1914).

ADDITIONAL REFERENCES: Flint (1964); Wiggins (1977).

Genus *Polycentropus* Curtis

DIAGNOSIS: Larvae of *Polycentropus* are most readily distinguished from the other polycentropodid genera (except *Cernotina*) by the presence of two mesally contiguous dark bands on the dorsal region between the anal claw and the distal segment of the anal proleg (see figure in key to genera). *Polycentropus* larvae may be distinquished from those of *Cernotina* by the following characters: prothoracic tarsi broad, one-half as long as prothoracic tibiae, *or* anal claw obtusely curved, *or* anal claw with 2 or 3 dorsal accessory spines (see figures in key to genera).

NOTES: Using the key to the genera of Polycentropodidae becomes rather complicated when trying to distinguish *Polycentropus* species from *Cernotina* species. Larvae of the two genera closely resemble each other and close examination is necessary to discriminate the two. Presently, the generic status of *Polycentropus* is questionable. European trichopterists and others consider North American *Polycentropus* to consist of three genera: *Holocentropus, Plectrocnemia* and *Polycentropus s. str.* The larval taxonomy of *Polycentropus* should become clearer as more species are described from the larval stage. Presently, five species of *Polycentropus* are known to occur in Florida with another two species we believe likely to occur in the state based upon their geographic distributions (See Appendix A). Of these seven species only two have been described as larvae [i. e., *P. cinereus* and *P. interruptus* by Ross (1944)]. *Polycentropus cinereus* was described as having the basal segment of the anal prolegs with fairly short setae distributed uniformly over the ventral surface and the spots on the posterior region of the frontoclypeus forming an angle (see figs. A and B below). *Polycentropus interruptus* was described as having the basal segment of the anal prolegs with longer setae grouped in two lateral linear areas and the head yellowish with distinct dark spots and most of the dorsum clouded with reddish brown; also, the anterior region of the frontoclypeus has a pale area around the base of the major pair of setae (not shown in figure) (See figs. C and D below).



FIGURES: (Ross, 1944) - A. *Polycentropus cinereus*, basal segment anal prolegs, ventral aspect; B. *Polycentropus cinereus*, head and pronotum; C. *Polycentropus interruptus*, basal segment anal prolegs, ventral aspect; D. *Polycentropus interruptus*, head and pronotum.

Gordon (1984) showed *P. cinereus* as being the most widespread species of *Polycentropus*, and our examinations of larvae matching the description of *P. cinereus* by Ross (1944) lead us to conclude that indeed it is probably the most widespread and common *Polycentropus* species in the state. *Polycentropus floridensis*, listed as a Threatened species by Morse (In Press), is known only from its type localities in Baldwin Co., Alabama and the headwaters of Rocky Creek, Walton Co., Florida (Lago and Harris, 1983). Gordon (1984) listed both *P. crassicornis* and *P. interruptus* as being recorded from single counties, Columbia and Walton counties, respectively. *Polycentropus blicklei* is herein reported for the first time from Florida. We collected an adult male specimen of *P. blicklei* in the month of March along Little Sweetwater Creek, a ravine stream in Liberty County.

Larvae of *Polycentropus* species construct silk retreats of two different types: either a silk tube flared at both ends with a network of silk trip lines for signalling the presence of prey or a bag-like structure expanded by the current (Wiggins, 1977).

ADDITIONAL REFERENCE: Ross (1944).

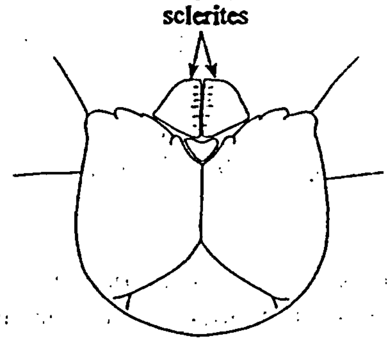
FAMILY PSYCHOMYIIDAE

This family is least common among the net-spinning caddisflies, within Florida as well as North America. The psychomyiids are represented in Florida by two genera: *Lype* (*Lype diversa*) and *Psychomyia* (*Psychomyia flavida*).

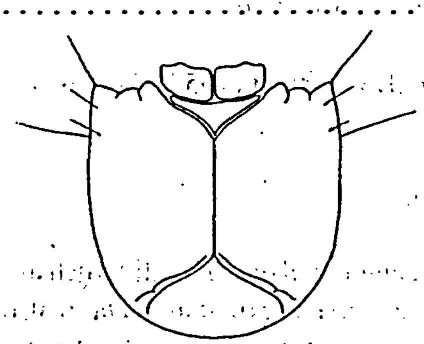
Psychomyiid larvae are readily distinguished from the other caddis families by the presence of a broad hatchet-shaped foretrochantin separated from the proepisternum by a basal suture (fig. 10A in family key). The labium, with the opening of the silk gland (spinnerette), extends beyond the anterior margin of the head, facilitating the application of silk within the retreats. Larvae occur in lotic habitats where they construct and live in fixed silken tubes or tunnels attached to rock and wood substrates.

KEY TO GENERA AND SPECIES FOR MATURE LARVAE OF FLORIDA PSYCHOMYIIDAE*

1. Anal claw with 3 or 4 conspicuous teeth along ventral, concave margin; paired submental sclerites on ventral surface of labium longer than broad
.... *Psychomyia*, *P. flavida*



Anal claw without teeth on ventral concave margin; paired submental sclerites on ventral surface of labium broader than long
.... *Lype*, *L. diversa*

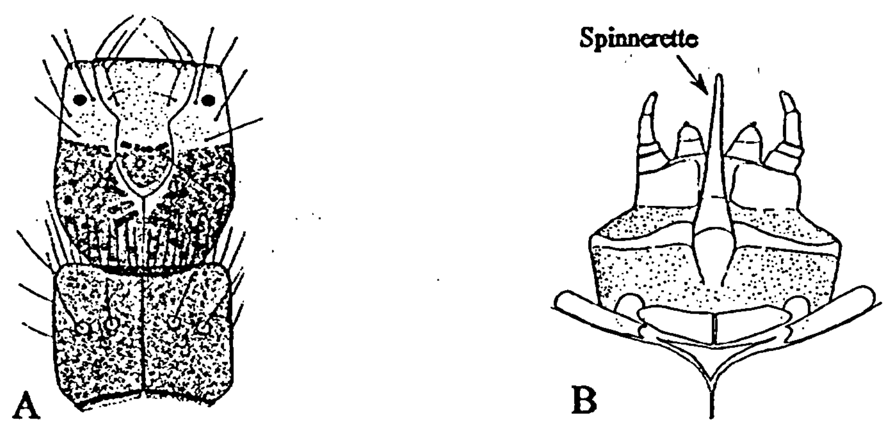


* key to psychomyiid genera and species adapted from Morse and Holzenthal (1984).

Genus *Lype* MacLachlan

DIAGNOSIS: Larvae of *Lype* easily distinguished from *Psychomyia* by absence of teeth on ventral margin of anal claw; also, paired submental sclerites of labium broader than long (see figure in generic key).

NOTES: The genus *Lype* contains a single North American species, *L. diversa*. The immature stages of this species were described by Flint (1959). The mature larva is 7-8 mm in length. The head coloration pattern is distinctive, with the anterior third yellowish and posterior two-thirds brown in color (Fig. A below). Also noteworthy is the long central spinnerette on the maxillo-labium (Fig. B below) which is characteristic of Dipseudopsidae and this family.



FIGURES: (Flint, 1959) - A. *Lype diversa*, head and pronotum; B. *Lype diversa*, maxillo-labium, ventral.

Lype diversa is geographically widespread across the northern half of the state. The larvae are most commonly found in small cool streams where they construct well-camouflaged retreats in the grooves of submerged wood. Specimens can be collected either by careful examination of wood substrate or by using artificial substrates such as Hester-Dendy multiplate samplers. Little is known of the life history for this species in Florida. In more northern areas of the United States the species is univoltine.

ADDITIONAL REFERENCES: Flint (1959); Wiggins (1977); Unzicker, Resh, and Morse (1982).

Genus *Psychomyia* Latreille

DIAGNOSIS: Larvae of genus *Psychomyia* distinguished from those of *Lype* by presence of 3 or 4 conspicuous teeth on concave margin of anal claw; also, submental sclerites on ventral surface of labium longer than broad (see figures in generic key).

NOTES: The genus *Psychomyia* contains three North American species of which only *P. flavida* occurs in Florida. The larva of this species was first described by Ross (1944) and then later by Flint (1964). Gordon (1984) reported *P. flavida* from Jackson Co. (no specific locality provided); we examined larval specimens collected from the Chipola River, Calhoun Co. This species is not known to occur anywhere else in the state and is quite possibly restricted to the Chipola River basin. Larvae construct silk tubes covered with sand on rocks (Wiggins, 1977) and feed on organic particles which they collect. *Psychomyia flavida* is believed to reproduce parthenogenetically, and light trap collections usually consist of large numbers of females with very few males (Swegman, 1978; Unzicker et al., 1982).

ADDITIONAL REFERENCES: Ross (1944); Flint (1964); Wiggins (1977); Unzicker, Resh, and Morse (1982).

FAMILY RHYACOPHILIDAE

The family Rhyacophilidae is represented in North America by two genera, but only the genus *Rhyacophila* occurs in the eastern United States, extending its geographic range from the Northeast to Florida. More than 100 rhyacophilid species occur in North America, with nearly all of the species belonging to the genus *Rhyacophila* (Dixon and Wrona, 1992).

Rhyacophilid larvae are morphologically recognized by the presence of a dorsal sclerite on abdominal segment IX , anal proleg which is almost entirely free from abdominal segment IX, and the lack of dorsal accessory hooks on the anal claw (fig. 8C in family key).

Unlike other caddisflies, which construct larval cases or retreats, rhyacophilid larvae are basically free living, and attachment to the substrate is facilitated by the secretion of a silk thread anchor line. The larvae are generally found in fast-flowing streams, and many species are predaceous while a few are herbivorous, feeding on living or dead plant tissues.

Genus *Rhyacophila* Pictet

DIAGNOSIS: Eastern Nearctic larvae usually without gill tufts, if present very sparse and only on few abdominal segments; and final instar larvae short, less than 30 mm long.

NOTES: Of the approximately 100 species of *Rhyacophila* known in North America, only the species *R. carolina* has been reported in Florida. Another species, *R. ledra*, may eventually appear in the state because it has recently been reported to occur near the Alabama-Florida line (Harris et al., 1991). Both species belong to the *R. carolina* species group, having larvae with edentate anal claws. The larva of *R. carolina*, however, can easily be distinguished from that of *R. ledra* by its more or less unicolorous golden yellow head, compared to the distinctive pattern of infuscation and muscle scars in the latter (see figure in key below).

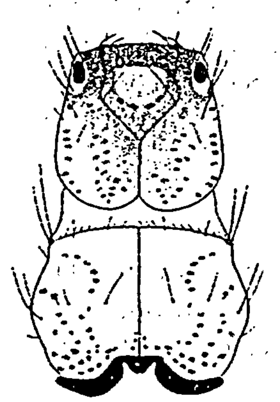
Knowledge of the life cycle of *R. carolina* is limited. Some species of *Rhyacophila* have been shown to have univoltine life cycles (Manuel and Folsom, 1982; Singh et al., 1984; Martin, 1985), and one species, *R. vofixa* from an Alaskan stream, appears to require several years to complete a life cycle (Irons, 1987). When ready to pupate, the larvae characteristically construct a silken cocoon inside a dome-like shelter of small stones, but no case or retreat is constructed before then. *Rhyacophila carolina* has been observed to fly in late April to October in North and South Carolina (Unzicker et al., 1982). In Florida we collected adults from March to December.

Rhyacophila carolina appears to be geographically confined to the panhandle section of the state. We have examined larval collections from McDavid Creek in the Escambia River basin, Santa Rosa Co., and collected the larvae and adults from several spring-fed ravine streams in Gadsden and Liberty counties.

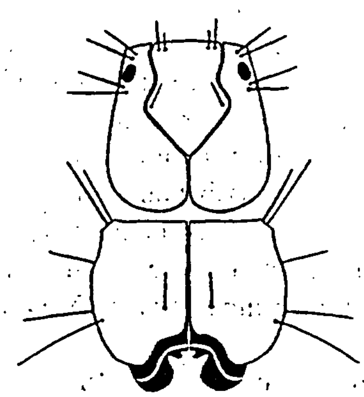
ADDITIONAL REFERENCES: Flint (1962); Weaver and Sykora (1979); Unzicker, Resh, and Morse (1982).

KEY TO SPECIES FOR MATURE LARVAE OF FLORIDA *RHYACOPHILA**

1. Head with distinct pattern of infuscations and muscle scars .... *R. ledra*



Head not as above, near unicolorously golden yellow .... *R. carolina*



* key to *Rhyacophila* species adapted from Flint (1962); figure of *R. ledra* from Flint (1962); figure of *R. carolina* from Weaver and Sykora (1979).

FAMILY SERICOSTOMATIDAE

The family Sericostomatidae is represented in North America by the genera *Agarodes*, *Fattigia*, and *Gumaga*. Only the genus *Agarodes*, the most widespread of the three genera, extends its geographic range to Florida.

The sericostomatid larvae are morphologically recognized by a cluster of setae (approximately 30 or more) posteromesad of the lateral sclerite of the anal proleg (figs. 17A, 17B in family key), and the large, and apically hooked foretrochantin (fig. 17C in family key). The larva constructs a curved and slightly tapered case, usually composed of medium to coarse sand with plant pieces mixed in.

Genus *Agarodes* Banks

DIAGNOSIS: Larvae of *Agarodes* spp. briefly defined by following combination of characters: pronotum with sharp-pointed anterolateral corners; dorsum of abdominal segment IX with about 4 major setae and about 10 shorter ones along posterior edge; head rounded dorsally with inconspicuous lateral carina.

NOTES: The genus is widespread throughout eastern North America from Canada to Florida and west to Wisconsin and Mississsippi (McEwan, 1980). The three species of *Agarodes* presently known in Florida include *A. crassicornis*, *A. libalis*, and *A. ziczac*. Additionally, we have recently collected the adults of a new species (*Agarodes* n. sp.) in a small spring-fed, sand-bottomed stream in Gadsden County. One of us (SCH) is in the process of describing the new taxon. The Florida *Agarodes* species are all geographically restricted to the northern region of the state. *Agarodes ziczac*, listed as Threatened by Morse (1982, In Press), appears to be endemic to the extreme northwestern panhandle. Of the *Agarodes* species known in Florida, only *A. libalis* has the larvae and adults associated. The key modifed from that of McEwan (1980), presented below, will separate larvae of the subgenus *Psiloneura* from those of the subgenus *Agarodes*.

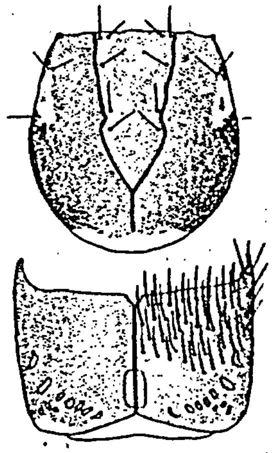
Except for the collection records, information on the life history of *Agarodes* in Florida is non-existent. We have collected the larvae in January, March, and May. The adults of *A. crassicornis* and *A. libalis* came to light in April and May, compared to March to September for *A. ziczac*. *Agarodes* n. sp. was also collected in May. Unzicker et al. (1982) indicated the flight of *A. crassicornis* and *A. libalis* from mid-June and mid-May to mid-August, respectively, in North and South Carolina.

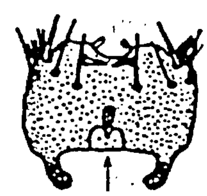
Larvae of *Agarodes* are mostly restricted to small streams with a medium current and a sandy bottom. We have collected larvae near the headwaters of Burnt Mill Creek, Jefferson Co.; FAMU farm stream, Gadsden Co.; and Little Sweetwater Creek, Liberty Co. We also examined larvae that were collected from the headwaters of Narrows Creek, Walton Co. and Goldhead Branch, Clay County.

ADDITIONAL REFERENCES: Ross and Wallace (1974); Ross and Scott (1974); McEwan (1980); Unzicker, Resh, and Morse (1982); Morse (In Press).

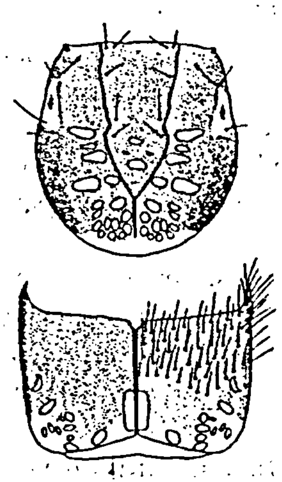
KEY TO SUBGENERA FOR MATURE LARVAE OF FLORIDA *AGARODES** **

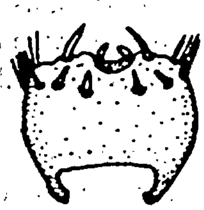
1. Head brown without gold or white contrasting muscle scars; labrum brown with paired dorso-basal white muscle scars; pronotum with brown muscle scars .... subgenus *Psiloneura*, *A. libalis*





Head brown with gold or white contrasting muscle scars; labrum whitish or gold without basal muscle scars; pronotum with white and gold muscle scars .... subgenus *Agarodes*, *A. crassicornis*, *A. ziczac*





* key and figures to *Agarodes* subgenera adapted from McEwan (1980).

** key does not include *Agarodes* n. sp.

FAMILY UENOIDAE

The family Uenoidae consists of two subfamilies, Uenoinae and Thremmatinae (Vineyard and Wiggins, 1988). Only the subfamily Thremmatinae is represented in Florida and of the three thremmatine genera presently recognized, only the genus *Neophylax* occurs in Florida.

The uenoid larvae are morphologically recognized by the rounded anterior margin of the pronotum (fig. 19A in family key); and basal seta of tarsal claw elongate, extending to near the tip of claw (fig. 19B in family key). The smooth and slender larval cases of most genera (except *Neophylax*) are constructed of fine mineral particles, sometimes of silk alone. The larvae are found in a wide array of lotic habitats.

Genus *Neophylax* MacLachlan

DIAGNOSIS: Larvae characterized by following combination of characters: pronotum distinctly wider posterad of transverse mid-point and with rounded anterior margin; mesonotal sclerite with deep anteromedian notch; abdominal segment I with well-developed middorsal hump; and most species with pair of ventral abdominal gills.

NOTES: *Neophylax* is represented in Florida by the species *N. concinnus*. The larva of the species was first described by Ross (1944) (as *N. autumnus*). Flint (1960) subsequently provided a key to the larvae of some of the species of *Neophylax* and characterized the larvae of *N. concinnus* by the short or barely noticeable setae along the anterior margin of the pronotum, the lack of a frontal tubercle on the head, and the presence of spicules on the entire dorsal surface of the head. *Neophylax* larvae construct cases which are short and thick, composed of coarse rock fragments with several larger ballast stones along each side (Wiggins, 1977).

Neophylax concinnus is uncommon in Florida and has been reported as occurring in Florida only by Harris et al. (1991). So far, we have collected only two immature larvae of *Neophylax* from the Aucilla River in December, after three years of extensive sampling of the various streams in North Florida, using both the Hester-Dendy and dipnet methods. The larvae were collected with dipnets near the river shoreline; the substrates consisted of mixtures of sand and silt with plenty of coarse particulate organic matter. The larvae are too small to identify to species.

Neophylax concinnus has been reported to have a univoltine life cycle (Clifford, 1966) The life history of the species in subtropical conditions like Florida is yet to be investigated. Unique to *Neophylax* is the life cycle of every species, including a long prepupal (spring-summer) diapause which varies in length from two to six months (Vineyard and Wiggins, 1988).

ADDITIONAL REFERENCES: Ross (1944); Flint (1960); Vineyard and Wiggins (1988).

LITERATURE CITED

Anderson, N. H. 1976. The distribution and biology of the Oregon Trichoptera. Agric. Exp. Tech. Bull. No. 134, Oregon State Univ., Corvallis. 152 pp.

Armitage, B. J. and S. W. Hamilton. 1990. Diagnostic atlas of the North American caddisfly adults. II. Ecnomidae, Polycentropodidae, and Xiphocentronidae. The Caddis Press. 152 pp.

Banks, N. 1907. Descriptions of new Trichoptera. Proc. Entomol. Soc. Washington. 8:117-133.

Barton, D. R., and H. B. N. Hynes. 1978. Wave-zone macrobenthos of the exposed Canadian shores of the St. Lawrence Great Lakes. J. Great Lakes Res. 4:27-45.

Benke, A. C., and J. B. Wallace. 1980. Trophic basis of production among net-spinning caddisflies in southern Appalachian stream. Ecology. 61:108-118.

Blickle, R. L. 1961. New species of Hydroptilidae (Trichoptera). Bull. Brooklyn Entomol. Soc. 56:131-134.

__________. 1962. Hydroptilidae (Trichoptera) of Florida. Florida Entomologist. 45:153-155.

__________. 1979. Hydroptilidae (Trichoptera) of North America North of Mexico. New Hampshire Agric. Exp. Sta. Univ. New Hampshire. Bull. 509. 97 pp.

Chen, Y. 1993. Revision of the *Oecetis* (Trichoptera: Leptoceridae) of the world. Ph.D. Dissertation, Clemson University. Clemson, South Carolina. 704 pp.

Chapin, J. W. 1978. Systematics of Nearctic *Micrasema* (Trichoptera: Brachycentridae). Ph.D. Dissertation, Clemson University. Clemson, South Carolina. 136 pp.

Clifford, H. P. 1966. The ecology of invertebrates in an intermittent stream. Invest. Indiana Lakes Streams. 7:57-98.

Daigle, J. J. and J. D. Haddock. 1981. The larval description and ecological notes of the caddisfly, *Nectopsyche tavara* (Ross) from the Central Florida refugium (Trichoptera: Leptoceridae). Pan-Pacific Entomologist. 57:327-331.

Denning, D. G. 1947. Hydroptilidae (Trichoptera) from southern United States. Can. Entomologist. 79:12-20.

____________. 1948a. New species of Trichoptera. Annals Entomol. Soc. Amer. 41:397-401.

____________. 1948b. Descriptions of eight new species of Trichoptera. Bull. Brooklyn

Entomol. Soc. 119-129.

____________. 1951. Records and descriptions of Nearctic caddisflies. Part III. J. Kansas Entomol. Soc. 24:157-162.

____________. 1971. A new genus and new species of Trichoptera. Pan-Pacific Entomologist. 47:202-210.

Dixon, R. W. J. and F. J. Wrona. 1992. Life history and production of the predatory caddisfly *Rhyacophila vao* Milne in a spring-fed stream. Freshwater Biology. 27:1-11.

Flint, O. S., Jr. 1959. The immature stages of *Lype diversa* (Banks) (Trichoptera, Psychomyiidae). Bull. Brooklyn Entomol. Soc. 54:44-47.

____________. 1960. Taxonomy and biology of Nearctic limnephilid larvae (Trichoptera), with special reference to species in eastern United States: Entomologia Americana. 40:1-117.

____________. 1962. Larvae of the caddis fly genus *Rhyacophila* in eastern North America (Trichoptera: Rhyacophilidae). Proc. U. S. Nat. Mus. 113:465-493.

____________. 1964. Notes on some Nearctic Psychomyiidae with special reference to their larvae (Trichoptera). Proc. U. S. Nat. Mus. 115:467-481.

____________. 1984. The genus *Brachycentrus* in North America, with a proposed phylogeny of the genera of Brachycentridae (Trichoptera): Smithsonian Contr. to Zoology. 398:1-58.

Flint, O. S., Jr., J. R. Voshell, and C. R. Parker, 1979. The *Hydropsyche scalaris* group in Virginia, with the description of two new species (Trichoptera:Hydropsychidae). Washington Biol. Soc. Proceedings. 92:837-862.

Floyd, M. A. 1994. Larvae of the caddisfly genus *Oecetis* (Trichoptera: Leptoceridae) in North America. Ph.D. Dissertation, Clemson University. Clemson, South Carolina. 152 pp.

Fremling, C. R. 1960. Biology and possible control of nuisance caddisflies of the Upper Mississippi River. Agric. Home Econ. Exp. Sta., Iowa State Univ. Res. Bull. No. 483:856-879.

Fuller, R. L. and R. J. Mackay. 1981. Effects of food quality on growth of three *Hydropsyche* species (Trichoptera:Hydropsychidae). Can. J. Zool. 59:1133-1140.

Glover, B. J. 1993. The taxonomy and biology of the larvae of the North American caddisflies in the genera *Triaenodes* and *Ylodes* (Trichoptera: Leptoceridae). Ph.D. Dissertation, University of Louisville. Louisville, Kentucky. 252 pp.

Gordon, E. A. 1974. A synopsis and phylogenetic outline of the Nearctic members of

Cheumatopsyche. Proc. Acad. Nat. Sci. Phil. 126:117-160.

__________. 1984. The Trichoptera of Florida: A preliminary survey. Pp. 161-166 *in* J. C. Morse, ed. Proceedings of the Fourth International Symposium on Trichoptera, Vol. 30. Dr. W. Junk Publishers, The Hague. 486 pp.

Gordon, E. A. and J. B. Wallace. 1975. Distribution of the family Hydropsychidae (Trichoptera) in the Savannah River Basin of North Carolina, South Carolina and Georgia. Hydrobiologia. 46:405-302.

Haddock, J. D. 1977. The biosystematics of the caddis fly *Nectopsyche* in North America with emphasis on the aquatic stages. Amer. Midl. Nat. 98:382-421.

Hamilton, S. W. 1985. The larva and pupa of *Beraea gorteba* Ross (Trichoptera: Beraeidae). Proc. Entomol. Soc. Washington. 87:783-789.

Harris, S. C. 1991. New caddisflies (Trichoptera) from Alabama and Florida. Bull. Alabama Mus. Nat. Hist. 11:11-16.

Harris, S. C. and B. J. Armitage. 1987. New Hydroptilidae (Trichoptera) from Florida. Ent. News. 98:106-110.

Harris, S. C., P. K. Lago, and J. F. Scheiring. 1982. Annotated list of Trichoptera of several streams of Eglin Air Force Base, Florida. Entomol. News. 93:79-84.

Harris, S. C., P. E. O'Neil, and P. K. Lago. 1991. Caddisflies of Alabama. Geological Survey of Alabama. Bull. No. 142. 442 pp.

Harris, T. L. and T. M. Lawrence. 1978. Environmental requirements and pollution tolerance of Trichoptera. EPA Environ. Monitoring Series. EPA-600/4-78-063. 307 pp.

Hilsenhoff, W. L. 1975. Aquatic insects of Wisconsin. Generic keys and notes on biology, ecology and distribution. Wisconsin Dept. Nat. Res. Tech. Bull. No. 89. 53 pp.

Hilsenhoff, W. L., J. L. Longridge, R. P. Narf, K. L. Tennessen, and C. P. Walton. 1972. Aquatic insects of the Pine Popple River, Wisconsin. Wisconsin Dept. Nat. Res. Tech. Bull. No. 54. 42 pp.

Holzenthal, R. W. 1982. The caddisfly genus *Setodes* in North America (Trichoptera: Leptoceridae). J. Kansas Entomol. Soc. 55:253-271.

Holzenthal, R. W. and R. W. Kelley. 1983. New micro-caddisflies from the southeastern United States (Trichoptera: Hydroptilidae). Florida Entomologist. 66:464-472.

Hudson, P. L., J. C. Morse, and J. R. Voshell, Jr. 1981. Larva and pupa of *Cernotina spicata*.

Ann. Entomol. Soc. Amer. 74:516-519.

Irons, J. G. III. 1987. Life history patterns and trophic ecology of Trichoptera in two Alaskan (U.S.A.) subarctic streams. Can. J. Zool. 66:1258-1265.

Irons, J. G., III, M. V. Oswood, and J. P. Bryant. 1988. Consumption of leaf detritus by a stream shredder: Influence of tree species and nutrient status. Hydrobiologia. 160:53-61.

Johnson, R. K., T. Wiederholm, and D. M. Rosenberg. 1993. Freshwater biomonitoring using individual organism, populations, and species assemblages of benthic macroinvertebrates. Pp. 40-158 *in* D. M. Rosenberg and V. H. Resh, eds. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, NY. 488 pp.

Kelley, R. W. 1981. New species of *Oxyethira* (Trichoptera: Hydroptilidae) from the southeastern United States. J. Georgia Entomol. Soc. 16:368-375.

__________. 1982. The micro-caddisfly genus *Oxyethira* (Trichoptera: Hydroptilidae): Morphology, biogeography, evolution and classification. Ph.D. Dissertation, Clemson University. Clemson, South Carolina. 436 pp.

Kingsolver, J. M., and H. H. Ross. 1961. New species of Nearctic *Orthotrichia* (Hydroptilidae, Trichoptera). Illinois Acad. Sci. Trans. 54:28-33.

Lago, P. K. and S. C. Harris. 1983. New species of Trichoptera from Florida and Alabama. Ann. Entomol. Soc. Amer. 76:663-667.

________________________. 1987. The *Chimarra* (Trichoptera: Philopotamidae) of eastern North America with descriptions of three new species. J. New York Entomol. Soc. 95:225-251.

Lenat, D. R. 1988. Water quality assessment of streams using qualitative collection method for benthic macroinvertebrates. J. N. Am. Benthol. Soc. 7:222-233.

Manuel, K. L. and T. C. Folsom. 1982. Instar sizes, life cycles, and food habits of five *Rhacophila* (Trichoptera: Rhyacophilidae) species from the Appalachian Mountains of South Carolina, U.S.A. Hydrobiologia. 97:281-285.

Martin, I. D. 1985. Microhabitat selection and life cycle patterns of two *Rhyacophila* species (Trichoptera: Rhyacophilidae) in southern Ontario streams. Freshwater Biology. 15:1-14.

Mattson, R. A. 1992. Characteristics of benthic macroinvertebrate communities of the Suwannee River drainage. Unpublished report. Suwannee River Water Management District, Live Oak, FL. 188 pp.

McEwan, E. 1980. Biology and life history of the genus *Agarodes* (Trichoptera:

Sericostomatidae) in the southeastern U.S. M.S. Thesis, Clemson University. Clemson, South Carolina. 67 pp.

Menking, D. E. 1978. Biology and life history of the caddisfly genus *Phylocentropus* (Polycentropodidae) with special references to influences of heated water. M.S. Thesis, Clemson University. Clemson, South Carolina. 28 pp.

Merrill, D. and G. B. Wiggins. 1971. The larva and pupa of the caddisfly genus *Setodes* in North America. Trichoptera; Leptoceridae). Life Sci. Occ. Papers, Royal Ontario Mus., No. 19. 12 pp.

Merritt, R. W., K. W. Cummins, and T. M. Burton. 1984. The role of aquatic insects in the processing and cycling of nutrients. Pp. 134-163 *in* V. H. Resh and D. M. Rosenberg, eds., The ecology of aquatic insects. Praeger, New York. 625 pp.

Merritt, R. W. and J. B. Wallace. 1981. Filter-feeding insects. Sci. Am. 244:132-144.

Milne, L. J. 1936. Studies in North American Trichoptera. Privately printed, Cambridge, Massachusetts. 3:56-158.

Morse, J. C. 1972. The genus *Nyctiophylax* in North America. J. Kansas Entomol. Soc. 45:172-181.

_________. 1975. A phylogeny and revision of the caddisfly genus *Ceraclea* (Trichoptera: Leptoceridae). Amer. Entomol. Institute Contr. 11:1-97.

_________. 1982. Order Trichoptera. Pp. 51-71 *in* R. Franz, ed. Invertebrates: Rare and endangered biota of Florida. Univ. Presses Florida. Vol. 16, 131 pp.

_________. 1993. A checklist of the Trichoptera of North America, including Greenland and Mexico. Trans. Amer. Entomol. Soc. 119:47-93.

_________. In Press. Order Trichoptera. Pp... *in* R. Franz, ed. Invertebrates. Rare and endangered biota of Florida. Univ. Presses of Florida.

Morse, J. C. and C. B. Barr. 1990. Unusual caddisfly (Trichoptera) fauna of Schoolhouse Springs, Louisiana, with description of a new species of *Diplectrona* (Hydropsychidae) Proc. Entomol. Soc. Washington. 92:58-65.

Morse, J. C. and R. W. Holzenthal. 1984. Trichoptera genera. Pp. 312-347 *in* R. W. Merritt, and K. W. Cummins, eds., An introduction to the aquatic insects of North America. Dubuque, Iowa: Kendall/Hunt Publishing Co. 720 pp.

Nations, V. L. 1994. A phylogenetic analysis of the North American species of *Setodes* (Trichoptera: Leptoceridae) with descriptions of the larvae and key to their identification.

M.S. Thesis, University of Alabama. Tuscaloosa, Alabama. 72 pp.

Nielsen, A. 1948. Postembryonic development and biology of the Hydroptilidae. Kgl. Danske Vidensk. Selsk. Biol. Skr. 5:1-200.

Nimmo, A. P. 1987. The adult Arctopsychidae and Hydropsychidae (Trichoptera) of Canada and adjacent United States. Quaestiones Entomologicae. 23:1-189.

Noyes, A. A. 1914. The biology of the net-spinning Trichoptera of Cascadilla Creek. Ann. Entomol. Soc. Amer. 7:251-272.

Osborne, L. L. and E. E. Herricks. 1987. Microhabitat characteristics of *Hydropsyche* (Trichoptera: Hydropsychidae) and the importance of body size. J. N. Am. Benthol. 6:115-124.

Parker, C. R. and G. B. Wiggins. 1987. Revision of the caddisfly genus *Psilotreta* (Trichoptera: Odontoceridae). Roy. Ontario Mus. Life Sciences Contr. 144. 55 pp.

Patterson, J. W., and R. L. Vannote. 1979. Life history and population dynamics of *Heteroplectron americanum*. Environ. Ent. 8:665-669.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. EPA, Assessment and Watershed Protection Division, Washington, D.C., EPA/4404-89-001.

Resh, V. H. 1976. The biology and immature stages of the caddisfly genus *Ceraclea* in eastern North America (Trichoptera: Leptoceridae). Ann. Entomol. Soc. Amer. 69:1039-1061.

Resh, V. H. and J. K. Jackson. 1993. Rapid bioassessment approaches to biomonitoring using benthic macroinvertebrates. Pp. 195-233 *in* D. M. Rosenberg and V. H. Resh, eds. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall. NY. 488 pp.

Resh, V. H., J. C. Morse, and I.D. Wallace. 1976. The evolution of the sponge feeding habit in the caddisfly genus *Ceraclea* (Trichoptera: Leptoceridae). Ann. Entomol. Soc. Amer. 69(5):937-941.

Resh, V. H. and J. D. Unzicker. 1973. Water quality monitoring and aquatic organisms: The importance of species identification. Water Pollution Control Federation. Jour. 47:9-19.

Ross, H. H. 1941. Descriptions and records of North American Trichoptera. Trans. Amer. Entomol. Soc. 67:35-126.

________. 1944. The caddis flies, or Trichoptera, of Illinois. Illinois Natural History Survey

Bull. 23:1-326.

_________. 1947. Descriptions and records of North American Trichoptera, with synoptic notes. Trans. Amer. Entomol. Soc. 73:125-168.

_________. 1948a. Notes and descriptions of Nearctic Hydroptilidae (Trichoptera). J. Wash. Acad. Sci. 38:201-206.

_________. 1948b. New Nearctic Rhyacophilidae and Philopotamidae (Trichoptera). Ann. Entomol. Soc. Amer. 51:17-26.

_________. 1959. The relationship of three new species of *Triaenodes* from Illinois and Florida (Trichoptera). Ent. News. 20:39-45.

_________. 1965. The evolutionary history of *Phylocentropus* (Trichoptera: Psychomyiidae). J. Kansas Entomol. Soc. 38:198-400.

Ross, H. H. and D. G. Gibbs. 1973. The subfamily relationships of the Dipseudopsinae (Trichoptera, Polycentropodidae). J. Georgia Entomol. Soc. 8:312-316.

Ross, H. H., J. C. Morse, and E. A. Gordon. 1971. New species of *Cheumatopsyche* from the southeastern United States (Hydropsychidae, Trichoptera). Proc. Biol. Soc. Washington. 84:301-306.

Ross, H. H. and D. C. Scott. 1974. A review of the genus *Agarodes* with descriptions of new species (Trichoptera: Sericostomatidae). J. Georgia Entomol. Soc. 9:147-155.

Ross, H. H. and J. B. Wallace. 1974. The North American genera of the family Sericostomatidae (Trichoptera). J. Georgia Entomol. Soc. 9:42-48.

Scheiring, J. F. 1985. Longitudinal and seasonal patterns of insect trophic structure in a Florida sand-hill stream. J. Kansas Ent. Soc. 58:207-219.

Schuster, G. A. and D. A. Etnier. 1978. A manual for the identification of the larvae of the caddisfly genera *Hydropsyche* Pictet and *Symphitopsyche* Ulmer in eastern and central North America (Trichoptera: Hydropsychidae): U.S. Environmental Protection Agency, Environmental Support Laboratory, EPA-600/4-78-060. 129 pp.

Schuster, G. A., and S. W. Hamilton. 1984. The genus *Phylocentropus* in North America. (Trichoptera: Polycentropodidae). Pp. 347-362 *in* J. C. Morse, ed. Proceedings of the Fourth International Symposium on Trichoptera. Vol. 30. Junk Publishers. 486 pp.

Scott, W. B. and E. L. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184:1-196.

Shefter, P. W., and G. B. Wiggins. 1986. A systematic study of the Nearctic larvae of the *Hydropsyche morosa* Group (Trichoptera: Hydropsychidae). Life Sci. Misc. Pub., Royal Ontario Mus., Toronto, Canada. 94 pp.

Sherberger, F. F., and J. B. Wallace. 1971. Larvae of the southeastern species of *Molanna*. J. Kansas Entomol. Soc. 44:217-224.

Singh, M. P., S. M. Smith, and A. D. Harrison. 1984. Life cycles, microdistribution, and food of two species of caddisflies (Trichoptera) in a wooded stream in southern Ontario. Can. J. Zool. 62:2582-2588.

Swegman, B. G. 1978. The occurrence of an intersex individual of *Psychomyia flavida* (Trichoptera). Ent. News. 89:187-188.

Sykora, J. L. and S. C. Harris. 1994. Five new species of *Hydroptila* from eastern United States (Insecta: Trichoptera: Hydroptilidae). Ann. Carnegie Mus. 63:67-75.

Unzicker, J. W., V. H. Resh, and J. C. Morse. 1982. Trichoptera. Pp. 9.1-9.138 *in* A. R. Brigham, W. V. Brigham, and A. Gnilka, eds. Aquatic insects and oligochaetes of North and South Carolina. Mahomet, Ill., Midwest Aquatic Enterprises. 837 pp.

Vaillant, F. 1965. Les larves de Trichopteres hydroptilides manguses de substrat. P. 165 *in* Proc. XII Int. Congr. Entomol. London. 1964.

Vineyard, F. F. and G. B. Wiggins. 1988. Further revision of the family Uenoidae (Trichoptera): Evidence for inclusion of Neophylacinae and Thremmatidae. Systematic Entomology. 13:361-372.

Wallace, J. B. 1975. Food partitioning in net-spinning Trichoptera larvae: *Hydropsyche venularis*, *Cheumatopsyche etrona*, and *Macronema zebratum* (Hydropsychidae). Ann. Entomol. Soc. Amer. 68:463-472.

Wallace, J. B. and D. Malas. 1976. The significance of the elongate, rectangular mesh found in capture nets of fine particle filter feeding Trichoptera larvae. Arch. Hydrobiol. 79:205-212.

Wallace, J. B. and F. F. Sherberger. 1970. The immature stage of *Anisocentropus pyraloides* (Trichoptera: Calamoceratidae). J. Georgia Entomol. Soc. 5:217-224.

______________________. 1974. The larval retreat and feeding net of *Macronema carolina* Banks (Trichoptera: Hydropsychidae). Hydrobiologia. 45:177-184.

Wallace, J. B., J. R. Webster, and T. F. Cuffney. 1982. Stream detritus dynamics: Regulation by invertebrate consumers. Oecologia (Berl.). 53: 197-200.

Wallace, J. B., J. R. Webster, and W. R. Woodall. 1977. The role of filter feeders in flowing waters. Arch. Hydrobiol. 79:506-532.

Wallace, J. B., W. R. Woodall, and A. A. Staats. 1976. The larval dwelling-tube, capture net and food of *Phylocentropus placidus* (Trichoptera: Polycentropodidae). Ann. Entomol. Soc. Amer. 69:149-154.

Weaver, J. S., III. 1988. A synopsis of the North American Lepidostomatidae (Trichoptera). Amer. Entomol. Institute Contr. 24:1-141.

Weaver, J. S., III and H. Malicky. 1994. The genus *Dipseudopsis* Walker from Asia (Trichoptera: Dipseudopsidae). Tijdschrift voor Entomologie. 137:95:142.

Weaver, J. S., III and J. C. Morse. 1986. Evolution of feeding and case-making behavior in Trichoptera. J. N. Am. Benthol. Soc. 5:150-158.

Weaver, J. S., III and J. L. Sykora. 1979. The *Rhyacophila* of Pennsylvania with larval descriptions of *R. banksi* and *R. carpenteri* (Trichoptera: Rhyacophilidae). Ann. Carnegie Mus. 48:403-425.

Wells, A. and D. Cartwright. 1993. Females and immatures of the Australian caddisfly *Hyalopsyche disjuncta* Neboiss (Trichoptera), and a new family placement. Trans. Roy. Soc. S. Aust. 117:97-104.

Wiggins, G. B. 1954. The caddisfly *Beraea* in North America (Trichoptera). Contr. Roy. Ontario Mus. Zool. Paleont. 39:1-18.

____________. 1960. A preliminary systematic study of the North American larvae of the caddisfly family Phryganeidae (Trichoptera). Can. J. Zool. 38: 1153-1170.

____________. 1977. Larvae of the North American caddisfly genera (Trichoptera): Toronto, Univ. of Toronto Press. 401 pp.

____________. 1984. Trichoptera. Pp. 271-311 *in* R. W. Merritt, and K. W. Cummins, eds., An introduction to the aquatic insects of North America. Dubuque, Iowa. Kendall/Hunt Publishing Co. 720 pp.

Wojtowicz, J. A. 1982. A review of the adults and larvae of the genus *Pycnopsyche* (Trichoptera: Limnephilidae) with revision of the *Pycnopsyche scabripennis* (Rambur) and *Pycnopsyche lepida* (Hagen) Complexes. Ph.D. dissertation, University of Tennessee. 292 pp.

APPENDIX A: CHECKLIST OF FLORIDA CADDISFLIES

The checklist includes both species that are known to occur in Florida, based on literature citations and material examined by us, and species that are likely to be found in the state based on their geographic distributions. The arrangement of taxa follows the scheme of classification proposed by Weaver and Morse (1986). **KEY: L**= larva known; **LU**= larva unknown; **?** = likely to occur in Florida; ??= erroneously reported.

Suborder **ANNULIPALPIA**
Infraorder **CURVIPALPIA**
Superfamily **HYDROPSYCHOIDEA**
Family **Dipseudopsidae**

Phylocentropus carolinus Carpenter	L
P. harrisi Schuster & Hamilton ?	LU
P. lucidus (Hagen)	L
P. placidus (Banks)	L

Family **Hydropsychidae**

Cheumatopsyche burksi Ross	LU
C. campyla Ross ?	LU
C. edista Gordon	LU
C. geora Denning ?	LU
C. gordonae Lago & Harris	LU
C. miniscula (Banks) ?	LU
C. pasella Ross	LU
C. petersi Ross, Morse, & Gordon	LU
C. pettiti (Banks)	LU
C. pinaca Ross	LU
C. sordida (Hagen) ?	LU
C. virginica Denning	LU
Diplectrona modesta Banks	L
Hydropsyche (H.) alabama Lago & Harris ?	LU
H. (H.) alvata Denning	LU
H. (H.) betteni Ross ?	L
H. (H.) decalda Ross	L
H. (H.) elissoma Ross	L
H. (H.) incommoda Hagen	L
H. (H.) mississippiensis Flint	L
H. (H.) orris Ross	LU
H. (H.) phalerata Hagen	L
H. (H.) rossi Flint, Voshell, & Parker	L
H. (H.) scalaris Hagen ?	L
H. (Ceratopsyche) sparna Hagen ?	L
H. (H.) venularis Banks ?	L
Macrostemum carolina (Banks)	L

Potamyia flava (Hagen)	L
Family **Polycentropodidae**	
Cernotina calcea Ross	LU
C. spicata Ross	L
C. truncona Ross	LU
Cyrnellus fraternus (Banks)	L
Neureclipsis crepuscularis (Walker)	L
N. melco Ross	LU
Paranyctiophylax affinis (Banks)	LU
P. celta (Denning)	L
P. moestus (Banks)	L
P. morsei (Lago & Harris)	LU
P. serratus (Lago & Harris) ?	LU
Polycentropus blicklei Ross & Yamamoto	LU
P. cinereus Hagen	L
P. clinei (Milne) ?	LU
P. crassicornis Walker	LU
P. floridensis Lago & Harris	LU
P. interruptus (Banks)	L
P. nascotius Ross?	LU
Family **Psychomyiidae**	
Lype diversa (Banks)	L
Psychomyia flavida Hagen	L
Superfamily **PHILOPOTAMOIDEA**	
Family **Philopotamidae**	
Chimarra argentella (Ulmer)??	L
C. aterrima Hagen	LU
C. falculata Lago & Harris	LU
C. florida Ross	LU
C. moselyi Denning	LU
C. obscura (Walker)	LU
C. parasocia Lago & Harris	LU
Wormaldia moesta (Banks)	L
Infraorder **SPICIPALPIA**	
Superfamily **HYDROTILOIDEA**	
Family **Glossosomatidae**	
Protoptila sp.(probably *palina* Ross)	LU
Family **Hydroptilidae**	
Hydroptila acadia Ross	LU
H. alabama Harris & Kelley ?	LU
H. armata Ross	LU
H. berneri Ross	LU
H. circangula Harris	LU

H. disgalera Holzenthal & Kelley ?	LU
H. gunda Milne ?	LU
H. hamata Morton	L
H. latosa Ross	LU
H. lloganae Blickle	LU
H. maculata Banks	LU
H. metteei Harris ?	LU
H. molsonae Blickle	LU
H. morsei Sykora & Harris	LU
H. novicola Blickle & Morse?	LU
H. parastrepha Kelley & Harris	LU
H. quinola Ross	LU
H. remita Blickle & Morse	LU
H. scheiringi Harris ?	LU
H. wakulla Denning	LU
H. waubesiana Betten	L
Mayatrichia ayama Mosely	LU
Neotrichia alabamensis Kelley & Harris	LU
N. armitagei Harris	LU
N. minutisimella (Chambers)	LU
N. mobilensis Harris ?	LU
N. okopa Ross	LU
N. vibrans Ross	LU
Ochrotrichia okaloosa Harris	LU
O. provosti Blickle	LU
O. tarsalis (Hagen)	LU
Orthotrichia aegerfasciella (Chambers)	LU
O. baldufi Kingsolver & Ross	LU
O. cristata Morton	LU
O. curta Kingsolver & Ross	LU
O. dentata Kingsolver & Ross	LU
O. instabilis Denning	LU
Oxyethira abacatia Denning	LU
O. anabola Blickle ?	LU
O. elerobi (Blickle)	LU
O. florida Denning	LU
O. glasa (Ross)	LU
O. janella Denning	LU
O. kelleyi Harris & Armitage	LU
O. kingi Holzenthal & Kelley	LU
O. lumipollex Kelley & Harris ?	LU
O. lumosa Ross	LU
O. maya Denning	LU
O. novasota Ross	LU
O. pallida (Banks)	LU

O. roberti Roy & Harper	LU
O. savanniensis Kelley & Harris	LU
O. setosa Denning	LU
O. sininsigne Kelley	LU
O. verna Ross	LU
O. zeronia Ross	LU
Stactobiella martynovi Blickle & Denning ?	LU
S. palmata (Ross) ?	L

Superfamily **RHYACOPHILOIDEA**

Family **Rhyacophilidae**

Rhyacophila carolina Banks	L
R. ledra Ross ?	L

Suborder **INTEGRIPALPIA**

Infraorder **PLENITENTORIA**

Superfamily **LIMNEPHILOIDEA**

Family **Brachycentridae**

Brachycentrus americanus (Banks)??	L
B. chelatus Ross	L
B. numerosus (Say)	L
Micrasema rusticum (Hagen)	L
M. wataga Ross	L
Micrasema n. sp.	L

Family **Lepidostomatidae**

Lepidostoma griseum (Banks)	LU
L. latipenne (Banks)	LU
L. morsei Weaver	LU
L. togatum (Hagen)?	LU
Lepidostoma sp. (nr. *serratum*)	LU

Family **Limnephilidae**

Ironoquia punctatissima (Walker)	L
Pycnopsyche guttifera (Walker) ??	L
P. indiana (Ross)	L
P. antica (Walker)	L

Superfamily **PHRYGANEOIDEA**

Family **Phryganeidae**

Agrypnia vestita (Walker)	L
Banksiola concatenata (Walker)	LU
Ptilostomis ocellifera (Walker)?	L
Ptilostomis postica (Walker)	LU

Family **Uenoidae**

Neophylax concinnus MacLachlan	L

Superfamily **LEPTOCEROIDEA**

Family **Calamoceratidae**

Anisocentropus pyraloides (Walker)	L
Heteroplectron americanum (Walker)	L

Family **Leptoceridae**

Ceraclea cancellata (Betten)	L
C. diluta (Hagen)	L
C. flava (Banks)	L
C. floridana (Banks)	LU
C. maculata (Banks)	L
C. nepha (Ross)	L
C. ophioderus (Ross)	LU
C. protonepha Morse & Ross	L
C. resurgens (Walker)	L
C. slossonae (Banks)	L
C. spongillovorax (Resh)	L
C. tarsipunctata (Vorhies)	L
C. transversa (Hagen)	L
Leptocerus americanus (Banks)	L
Nectopsyche albida (Walker)??	LU
N. candida (Hagen)	L
N. exquisita (Walker)	L
N. paludicola Harris	LU
N. pavida (Hagen)	L
N. spiloma (Ross)?	L
N. tavara (Ross)	L
Oecetis avara (Banks)	L
O. cinerascens (Hagen)	L
O. daytona Ross	LU
O. ditissa Ross	LU
O. floridanus (Banks)	LU
O. georgia Ross	L
O. inconspicua (Walker)	L
O. morsei Bueno-Soria	L
O. nocturna Ross	L
O. osteni Milne	L
O. parva (Banks)	L
O. persimilis (Banks)	L
O. porteri Ross	L
O. pratelia Denning	LU
O. sphyra Ross	L
Oecetis sp. A Floyd	L
Oecetis sp. C Floyd	L
Oecetis sp. F Floyd	L
Setodes dixiensis Holzenthal?	L

S. guttatus (Banks)	L
Setodes n. sp.	L
Triaenodes abus Milne	L
T. flavescens Banks	L
T. florida Ross	L
T. furcellus Ross	L
T. helo Milne	L
T. ignitus (Walker)	L
T. injustus (Hagen) ?	L
T. marginatus Sibley ?	L
T. melacus Ross ?	L
T. nox Ross	L
T. ochraceus (Betten & Mosely)	L
T. perna Ross	L
T. smithi Ross ?	LU
T. tardus Milne	L
Triaenodes n. sp. A	L
Triaenodes n. sp. C	L
Family **Molannidae**	
Molanna blenda Sibley	L
M. tryphena Betten	L
M. ulmerina Navas	LU
Family **Odontoceridae**	
Psilotreta frontalis Banks	L
P. labida Ross ?	L

Infraorder **BREVITENTORIA**

Superfamily **SERICOSTOMATOIDEA**

Family **Beraeidae**	
Beraea gorteba Ross ?	L
Family **Helicopsychidae**	
Helicopsyche borealis Hagen	L
Family **Sericostomatidae**	
Agarodes crassicornis (Walker)	LU
A. libalis Ross and Scott	L
A. ziczac Ross and Scott	LU
Agarodes n. sp.	LU

APPENDIX B: SPECIES DISTRIBUTION OF FLORIDA CADDISFLIES

Introduction:

The following appendix is intended as a supplement for the preceding manual. Since less than one half of the known caddisfly species in the state can be determined to species level from the larval stage, benthologists are often left to generic level determinations and only rough estimates of species richness. The data tables presented below are a survey of the collection localities and dates for the caddisfly species known to occur in Florida

Knowledge of the geographic distribution of caddisflies can be useful in number of ways. It can provide the biologist with a preliminary idea of what species may be likely to occur in a given study area and from this sampling strategies may then be selectively chosen for certain target species. The efficacy of the benthic sampling strategies can later be evaluated through the comparison of taxa sampled with past collection records. Additionally, the collection dates of the larval and alate forms often provides a general overview of the seasonality of the species, which is essential in any biomonitoring exercise.

The data tables presented below, one for each caddisfly family and arranged alphabetically, were extracted from the database which we are steadily updating as means to keep track of new collection records. There are approximately 1300 collection records compiled in the tables. The information sources we used to gather these data include the following: 1) larval material loaned to us and examined during the coarse of writing this manual; 2) caddisfly collections (adults & larvae) housed within the Florida A&M collection; and 3) records gleaned from the literature (largely taxonomic papers). With respect to all three of these sources, the data tables are a survey and not a completely exhaustive account.

Data fields for each family table include the following: **Species** (scientific names, arranged alphabetically); **Basin** (USGS basin where the collection was made); **Waterbody** (name of the river, stream, or lake where the species was collected); **County** (county where collected); **Stage** (Life stage collected, A=adult; L=larva; P=pupa); **Date Coll.** [(the month, day, and year the species was collected (if the record indicated a range of dates, one month or less, over which time the specimens were collected, then a mid-date was used)]; **Source** (source of the collection record, this includes: literature records enclosed in parentheses (see Literature Cited section for complete citation); the abbreviated names of the individual or agency which loaned us material; and caddisfly collections housed at Florida A&M, abbreviated as FAMU); **Lat. & Long.** [latitude and longitude of collection locality, often an approximation (useful for producing computer generated distribution maps)]; and **Additional Locality Info.** (other locality information which may be useful for more exactly determining the locality of the collection site).

The veracity and completeness of the following data records was dictated by the amount of information presented with the collection accounts and the locality labels of the given sources. In many cases complete collection information was not available and thus could not be included in the tables. Many times collection records are vague as to exact collection locality, and often in the past, collection accounts simply indicated the county where the specimen was collected, with no other locality information given.

Acknowledgement:

We extend our sincere thanks to Ellen McCarron (FDEP) for providing the computer software which was used in determining the latitude/longitude coordinates of the various collection localities.

TRICHOPTERA DATABASE: FLORIDA BRACHYCENTRIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Brachycentrus chelatus	Apalachicola R	Crooked Ck	Gadsden	L	7-8-1992	FDEP-Tallahassee	30 35 02	84 52 58	Hwy. 270
Brachycentrus chelatus	Blackwater R	Big Coldwater Ck	Santa Rosa	L	2-1-1969	(Flint, 1984)	30 42 33	86 58 18	Rt. S-191
Brachycentrus chelatus	Blackwater R	Blackwater R	Okaloosa	L	8-22-1974	FAMU Coll.	30 44 20	86 47 12	FAMU Biological Station
Brachycentrus chelatus	Blackwater R	Blackwater R	Okaloosa	L	9-14-1976	FDEP-Pensacola	30 50 00	86 44 02	Hwy. 4
Brachycentrus chelatus	Blackwater R	Blackwater R	Okaloosa	L	2-15-1977	FDEP-Pensacola	30 50 00	86 44 02	Hwy. 4
Brachycentrus chelatus	Blackwater R	Blackwater R	Santa Rosa	A	3-10-1972	(Flint, 1984)	30 42 00	86 53 00	Blackwater R State Forest
Brachycentrus chelatus	Blackwater R	Blackwater R	Santa Rosa	L	10-30-1971	(Flint, 1984)	30 43 04	86 48 35	Riley Landing, 3 mi. NW Holt
Brachycentrus chelatus	Blackwater R	Blackwater R	Santa Rosa	L	4-8-1972	(Flint, 1984)	30 43 04	86 48 35	Riley Landing, 3 mi. NW Holt
Brachycentrus chelatus	Blackwater R	Blackwater R	Santa Rosa	L	5-9-1972	(Flint, 1984)	30 43 04	86 48 35	Riley Landing, 3 mi. NW Holt
Brachycentrus chelatus	Chipola R	Juniper Ck	Calhoun	L	5-13-1976	FDEP-Pensacola	30 21 32	85 12 44	S.R. 73
Brachycentrus chelatus	Chipola R	Juniper Ck	Calhoun	L	11-22-1977	FDEP-Pensacola	30 21 32	85 12 44	S.R. 73
Brachycentrus chelatus	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Brachycentrus chelatus	Choctawhatchee Bay	Rocky Ck	Walton	A	3-14-1979	(Flint, 1984)	30 39 00	86 20 00	Eglin Air Force Base
Brachycentrus chelatus	Choctawhatchee Bay	Rocky Ck	Walton	A	4-20-1979	(Flint, 1984)	30 39 00	86 20 00	Eglin Air Force Base
Brachycentrus chelatus	Choctawhatchee Bay	Rocky Ck	Walton	A	5-11-1979	(Flint, 1984)	30 39 00	86 20 00	Eglin Air Force Base
Brachycentrus chelatus	Choctawhatchee Bay	Rocky Ck	Walton	L	7-14-1978	(Flint, 1984)	30 39 00	86 20 00	Eglin Air Force Base
Brachycentrus chelatus	Ochlockonee R	Ocklawaha Ck	Gadsden	L	2-5-1986	FAMU	30 27 03	84 38 36	CR-267
Brachycentrus chelatus	Ochlockonee R	Ocklawaha Ck	Gadsden	L	7-9-1986	FAMU	30 27 03	84 38 36	CR-267
Brachycentrus chelatus	Ochlockonee R	Ocklawaha Ck	Gadsden	L	12-3-1987	FAMU	30 27 03	84 38 36	CR-267
Brachycentrus chelatus	Ochlockonee R	Telogia Ck	Gadsden	L	7-1-1987	FAMU	30 35 40	84 42 36	CR-270A
Brachycentrus chelatus	Yellow R	Titi Ck	Okaloosa	L	11-22-1970	(Flint, 1984)	30 42 00	86 28 00	Rt. 211, Eglin Air Force Base
Brachycentrus numerosus	Choctawhatchee R	Holmes Ck	Washington	L	8-8-1979	FDEP-Pensacola	30 37 38	85 42 45	S.R. 79
Brachycentrus numerosus	Escambia R	Escambia R	Escambia	L	10-20-1977	FDEP-Pensacola	30 58 01	87 13 56	Hwy. 4
Brachycentrus numerosus	St. Andrews Bay	Econfina Ck	Bay	L	6-28-1993	FDEP-Pensacola	30 23 06	85 33 25	S.R. 388
Brachycentrus numerosus	Yellow R	Yellow R	Okaloosa	L	2-16-1978	FDEP-Pensacola	30 55 30	86 33 34	S.R. 189
Brachycentrus numerosus	Yellow R	Yellow R	Okaloosa	L	6-22-1993	FDEP-Pensacola	30 55 30	86 33 34	S.R. 189
Micrasema n. sp.	Blackwater R	Big Coldwater Ck	Santa Rosa	L	7-22-1972	(Chapin, 1978)	30 52 55	86 57 29	Rt. 4
Micrasema n. sp.	Blackwater R	Big Coldwater Ck	Santa Rosa	L	11-23-1976	FDEP-Pensacola	30 46 36	87 01 06	below confluence E and W fork
Micrasema n. sp.	Blackwater R	Big Coldwater Ck	Santa Rosa	L	5-4-1977	FDEP-Pensacola	30 52 55	86 57 29	E fork @ Hwy. 4
Micrasema n. sp.	Blackwater R	Big Juniper Ck	Santa Rosa	L	5-4-1977	FDEP-Pensacola	30 51 47	86 54 16	Hwy. 4
Micrasema n. sp.	Blackwater R	Blackwater R	Okaloosa	A	4-7-1968	(Chapin, 1978)	30 52 55	86 43 52	4.5 mi. NW Cannon Town
Micrasema n. sp.	Blackwater R	Blackwater R	Okaloosa	A	5-1-1970	(Chapin, 1978)	30 56 00	85 44 09	Kennedy Br., .6 mi. W Blackman

TRICHOPTERA DATABASE: FLORIDA BRACHYCENTRIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Micrasema n. sp.	Blackwater R	Blackwater R	Santa Rosa	L	3-10-1972	(Chapin, 1978)	30 42 00	86 53 00	Blackwater R St. Forest
Micrasema n. sp.	Blackwater R	Blackwater R	Santa Rosa	L	5-9-1972	(Chapin, 1978)	30 43 04	86 48 35	Riley Landing, 3 mi. NW Holt
Micrasema n. sp.	Blackwater R	Juniper Ck	Okaloosa	L	5-24-1977	FDEP-Pensacola	30 33 17	86 31 59	S.R. 123
Micrasema n. sp.	Choctawhatchee Bay	Alaqua Ck	Walton	L,P	1-12-1971	(Chapin, 1978)	30 33 25	86 10 22	Rt. 282
Micrasema n. sp.	Choctawhatchee Bay	Lafayette Ck	Walton	A		(Chapin, 1978)	30 31 07	86 02 55	Eglin A.F.B., 10 mi. W Rt. 81
Micrasema n. sp.	Choctawhatchee Bay	Lafayette Ck	Walton	A	12-14-1970	(Chapin, 1978)	30 29 35	86 07 31	Rt. 20
Micrasema n. sp.	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Micrasema n. sp.	Choctawhatchee R	Black Ck	Walton	A	5-3-1971	(Chapin, 1978)	30 28 27	85 59 17	Rt. 20
Micrasema n. sp.	Pensacola Bay	Turtle Ck	Okaloosa	A	11-21-1970	(Chapin, 1978)	30 32 24	86 39 54	Eglin A.F.B. 6 mi. W Rt. 85
Micrasema n. sp.	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Micrasema n. sp.	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Micrasema n. sp.	Yellow R	Turkey Hen Ck	Okaloosa	A	12-22-1970	(Chapin, 1978)	30 40 52	86 34 33	Eglin A.F.B. dirt rd. 211
Micrasema rusticum	St. Andrews Bay	Econfina Ck	Bay	L	11-24-1993	FDEP-Pensacola	30 33 20	85 26 06	Scott Rd
Micrasema rusticum	Yellow R	Shoal R	Okaloosa	L	2-22-1978	FDEP-Pensacola	30 47 26	86 25 07	C-393
Micrasema wataga	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Micrasema wataga	Blackwater R	Big Coldwater Ck	Santa Rosa	L	5-4-1977	FDEP-Pensacola	30 52 55	86 57 29	E fork @ Hwy. 4
Micrasema wataga	Blackwater R	Big Juniper Ck	Santa Rosa	L	5-4-1977	FDEP-Pensacola	30 51 47	86 54 16	Hwy. 4
Micrasema wataga	Blackwater R	Blackwater R	Okaloosa	L	4-12-1978	FDEP-Pensacola	30 50 00	86 44 02	Hwy. 4
Micrasema wataga	Santa Fe R	High Springs	Alachua	L	10-9-1976	(Chapin, 1978)	29 50 00	82 35 00	none
Micrasema wataga	Santa Fe R	Santa Fe R	Columbia	L	11-1-1975	(Chapin, 1978)	29 52 00	82 45 00	none
Micrasema wataga	Yellow R	Big Horse Ck	Okaloosa	L	6-23-1993	FDEP-Pensacola	30 55 20	86 35 44	S.R. 2

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA CALAMOCERATIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Anisocentropus pyraloides	Apalachicola R	Beaver Dam Ck	Liberty	A	3-22-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Beaver Dam Ck	Liberty	A	8-30-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Beaver Dam Ck	Liberty	L	12-7-1994	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Crooked Ck	Gadsden	L	7-8-1992	FAMU	30 34 58	84 53 02	Hwy 270
Anisocentropus pyraloides	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Kelley Branch	Liberty	L	3-11-1994	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Little Sweetwater Ck	Liberty	L	12-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Apalachicola R	Little Sweetwater Ck	Liberty	L	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Anisocentropus pyraloides	Blackwater R	Blackwater R	Okaloosa	L	3-18-1979	FAMU	30 50 00	86 44 02	Hwy 4 (Cotton bridge)
Anisocentropus pyraloides	Blackwater R	Coldwater Ck	Santa Rosa	L		(Wallace & Sherberger, 1970)	30 50 00	87 00 00	none
Anisocentropus pyraloides	Chipola R	unknown	Jackson	L		(Wallace & Sherberger, 1970)	30 37 32	85 09 11	3.5 mi N Altha
Anisocentropus pyraloides	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Anisocentropus pyraloides	Choctawhatchee Bay	Rocky Ck	Walton	L		(Scheiring, 1985)	30 39 00	86 20 00	Eglin Air Force Base
Anisocentropus pyraloides	Choctawhatchee R	Bruce Ck	Walton	L	9-6-1990	FDEP-Tallahassee	30 37 00	86 02 00	none
Anisocentropus pyraloides	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	3 mi NW Havana, C-159
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	A	10-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	A	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	A	5-7-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	8-14-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	10-15-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	12-5-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	2-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	4-8-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	6-10-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	8-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267

TRICHOPTERA DATABASE: FLORIDA CALAMOCERATIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	10-14-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	12-7-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	2-11-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	8-11-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	9-28-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	1-27-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	8-18-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	FAMU Farm St	Gadsden	L	3-30-1995	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Anisocentropus pyraloides	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU.	30 27 03	84 38 36	10 mi S Quincy, C-267
Anisocentropus pyraloides	Ochlockonee R	Ocklawaha Ck	Gadsden	L	12-3-1987	FAMU	30 27 03	84 38 36	10 mi S Quincy, C-267
Anisocentropus pyraloides	Ochlockonee R	Pittman Ck	Liberty	L	4-3-1974	FAMU	30 23 16	84 40 16	Hwy 20
Anisocentropus pyraloides	St. Andrews Bay	Econfina Ck	Bay	L	2-21-1995	FAMU	30 33 48	85 23 20	US Hwy. 231, 10 km N Fountain
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	A	5-19-1980	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	A	7-29-1980	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	A	8-14-1980	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	A	6-15-1981	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	10-10-1991	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	12-3-1991	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	2-5-1992	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	4-1-1992	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	8-5-1992	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	9-19-1992	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	9-29-1992	FAMU	30 24 30	84 03 50	US Hwy 27
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	11-2-1992	FAMU	30 24 30	84 03 50	US Hwy 27
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	12-2-1992	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	2-4-1993	FAMU	30 24 30	84 03 50	US Hwy 27
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	2-4-1993	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	St. Marks R	Burnt Mill Ck	Jefferson	L	4-1-1993	FAMU	30 25 31	84 01 11	CR-59
Anisocentropus pyraloides	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Anisocentropus pyraloides	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Heteroplectron americanum	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol

TRICHOPTERA DATABASE: FLORIDA CALAMOCERATIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Heteroplectron americanum	Apalachicola R	Kelley Branch	Liberty	L	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Heteroplectron americanum	Apalachicola R	Kelley Branch	Liberty	L	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Heteroplectron americanum	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Heteroplectron americanum	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Heteroplectron americanum	Apalachicola R	Little Sweetwater.Ck	Liberty	L	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol

END OF DATA TABLE

TRICHOPTERA DATABASE: FLORIDA DIPSEUDOPSIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Phylocentropus carolinus	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Phylocentropus carolinus	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Phylocentropus lucidus	Apalachicola R	Beaver Dam Ck	Liberty	A	3-22-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Phylocentropus lucidus	Apalachicola R	Beaver Dam Ck	Liberty	A	8-30-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Phylocentropus lucidus	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Phylocentropus lucidus	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Phylocentropus lucidus	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Phylocentropus lucidus	Apalachicola R	unnamed stream	Liberty	A	3-22-1995	FAMU	30 27 55	84 59 07	ABRP, 5 km N Bristol
Phylocentropus lucidus	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off SR-267
Phylocentropus lucidus	Ochlockonee R	FAMU Farm St	Gadsden	A	10-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off SR-267
Phylocentropus lucidus	Ochlockonee R	FAMU Farm St	Gadsden	A	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off SR-267
Phylocentropus lucidus	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off SR-267
Phylocentropus placidus	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Phylocentropus placidus	Apalachicola R	unnamed stream	Liberty	A	12-7-1994	FAMU	30 27 55	84 59 07	ABRP, 5 km N Bristol
Phylocentropus placidus	Aucilla R	Aucilla R	Jefferson	A	10-14-1993	FAMU	30 16 25	83 51 25	SR-257
Phylocentropus placidus	Chipola R	Chipola R	Calhoun	A	8-1-1972	FAMU	30 25 52	85 10 19	SR-20
Phylocentropus placidus	St. Johns R, lower	Pottsburg Ck	Duval	A	7-21-1960	FAMU	30 15 28	81 34 53	Belfort Rd.

END OF DATA TABLE

TRICHOPTERA DATABASE: FLORIDA GLOSSOSOMATIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Protoptila sp. (prob. palina)	Chipola R	Chipola R	Calhoun	L	9-2-1976	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274
Protoptila sp. (prob. palina)	Chipola R	Chipola R	Calhoun	L	7-19-1977	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274
Protoptila sp. (prob. palina)	Choctawhatchee R	Holmes Ck	Washington	L	7-21-1977	FDEP-Pensacola	30 37 38	85 42 45	SR-79, Vernon

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA HELICOPSYCHIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Helicopsyche borealis	Alapaha R	Alapaha R	Hamilton	L	8-9-1995	(J. Epler, pers. comm.)			just S of state line
Helicopsyche borealis	Chipola R	Chipola R	Calhoun	L	9-2-1976	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274
Helicopsyche borealis	Chipola R	Chipola R	Calhoun	L	7-19-1977	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274
Helicopsyche borealis	Santa Fe R	Santa Fe R	Gilchrist	A	5-6-1983	FAMU	29 50 11	82 41 58	Ginnie Springs campground
Helicopsyche borealis	Suwannee R, lower	Suwannee R	Gilchrist	L		SRWMD	29 47 42	82 55 11	Rock Bluff

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA HYDROPSYCHIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Cheumatopsyche burksi	Blackwater R	unknown	Okalossa	A		(Gordon, 1974)	30 44 00	86 47 00	NW Holt
Cheumatopsyche burksi	Charlotte Harbor	unknown	Charlotte	A	9-19-1968	FAMU	26 50 55	82 02 09	6 mi S Punta Gorda
Cheumatopsyche burksi	Everglades West Coast	unknown	Collier	A	4-8-1958	FAMU	25 54 07	81 18 14	Ochopee
Cheumatopsyche burksi	Kissimmee R	unknown	Highlands	A		(Gordon, 1974)	27 11 20	81 20 15	Archbold Biological Station
Cheumatopsyche burksi	Oklawaha R	unknown	Alachua	A	9-14-1972	FAMU	29 39 07	82 19 31	Gainesville
Cheumatopsyche burksi	Oklawaha R	unknown	Alachua	A	9-30-1972	FAMU	29 39 07	82 19 31	Gainesville
Cheumatopsyche burksi	Oklawaha R	unknown	Lake	A	3-23-1936	(Ross, 1941)	28 48 15	81 43 33	Tavares
Cheumatopsyche burksi	Peace R	Six mile Ck	Polk	A	3-7-1951	FAMU	27 47 05	81 49 31	none
Cheumatopsyche burksi	Peace R	unknown	Hardee	A	3-20-1951	FAMU	27 30 00	81 48 00	small stream @ US 17
Cheumatopsyche burksi	Peace R	unknown	Highlands	A		(Gordon, 1974)	27 28 23	81 31 41	Highlands Hammock State Park
Cheumatopsyche burksi	Peace R	unknown	Polk	A	8-9-1960	FAMU	28 01 20	81 43 58	Winter Haven
Cheumatopsyche burksi	Santa Fe R	Santa Fe R	Gilchrist	A	5-6-1983	FAMU	29 50 11	82 41 58	Ginnie Springs campground
Cheumatopsyche burksi	Southeast FL Coast	unknown	Palm Beach	A	11-18-1959	FAMU	26 42 55	80 03 13	West Palm Beach
Cheumatopsyche burksi	St. Johns R, upper	Juniper Springs	Marion	A		(Gordon, 1974)	29 10 43	81 42 29	Juniper Springs
Cheumatopsyche burksi	St. Johns R, upper	Rock Springs	Orange	A		(Gordon, 1974)	28 45 10	81 30 18	Rock Springs
Cheumatopsyche burksi	St. Johns R, upper	St. Johns R	Putnam	A	4-9-1964	FAMU	29 27 08	81 39 30	Welaka, UF reserve at fire tower
Cheumatopsyche burksi	unknown	unknown	Alachua	A	4-11-1958	FAMU	29 39 07	82 19 31	none
Cheumatopsyche burksi	unknown	unknown	Hillsborough	A	5-19-1960	FAMU	27 56 52	82 27 31	Tampa
Cheumatopsyche burksi	unknown	unknown	Hillsborough	A	3-22-1961	FAMU	27 56 52	82 27 31	Tampa
Cheumatopsyche burksi	unknown	unknown	Hillsborough	A	3-25-1963	FAMU	27 56 16	82 17 10	Brandon
Cheumatopsyche burksi	unknown	unknown	Lee	A	9-7-1961	FAMU	26 38 26	81 52 20	Fort Myers
Cheumatopsyche burksi	unknown	unknown	Santa Rosa	A		(Gordon, 1974)	30 45 00	87 00 00	none
Cheumatopsyche burksi	unknown	unknown	unknown	A		(Gordon, 1974)			Plamdale, Tamiami Trail
Cheumatopsyche edista	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159, 3 mi NW Havana
Cheumatopsyche edista	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	SR-12, 5 mi SW of Havana
Cheumatopsyche gordonae	Choctawhatchee Bay	Rocky Ck	Walton	A	4-20-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche gordonae	Choctawhatchee Bay	Rocky Ck	Walton	A	4-25-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche gordonae	Choctawhatchee Bay	Rocky Ck	Walton	A	5-11-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche gordonae	Choctawhatchee Bay	Rocky Ck	Walton	A	5-20-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche gordonae	Choctawhatchee Bay	Rocky Ck	Walton	A	6-8-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche gordonae	Yellow R	Bull Ck	Okaloosa	A	8-16-1979	(Lago & Harris, 1983)	30 40 17	86 25 56	Eglin Air Force Base
Cheumatopsyche gordonae	Yellow R	Bull Ck	Okaloosa	A	8-19-1979	(Lago & Harris, 1983)	30 40 17	86 25 56	Eglin Air Force Base
Cheumatopsyche pasella	Blackwater R	Blackwater R	Okaloosa	A	4-12-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Cheumatopsyche pasella	Blackwater R	Blackwater R	Okaloosa	A	4-13-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Cheumatopsyche pasella	Chipola R	unknown	Jackson	A	4-18-1963	FAMU	30 48 51	85 14 00	Florida Caverns State Park

TRICHOPTERA DATABASE: FLORIDA HYDROPSYCHIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Cheumatopsyche pasella	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 55	86 19 52	Eglin Air Force Base
Cheumatopsyche pasella	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	SR-12, 5 mi SW of Havana
Cheumatopsyche pasella	Ochlockonee R	unknown	Gadsden	A	4-20-1958	FAMU	30 35 15	84 35 00	Quincy
Cheumatopsyche petersi	Blackwater R	Blackwater R	Okaloosa	A		(Ross et al., 1971)	30 43 28	86 47 30	Bryant Bridge, 2.5 mi W of Holt
Cheumatopsyche petersi	Blackwater R	Blackwater R	Okaloosa	A	4-7-1968	(Ross et al., 1971)	30 52 54	86 43 52	4.5 mi NW Cannon Town
Cheumatopsyche petersi	Blackwater R	Blackwater R	Okaloosa	A	4-25-1970	(Ross et al., 1971)	30 52 54	86 43 52	Peadton Br., 4.5 mi NW Cannon Tow
Cheumatopsyche petersi	Blackwater R	Blackwater R	Okaloosa	A	5-1-1970	(Ross et al., 1971)	30 56 00	86 44 09	Kennedy Br., 6 mi W of Blackman
Cheumatopsyche petersi	Blackwater R	Blackwater R	Okaloosa	A	6-1-1970	(Ross et al., 1971)	30 45 00	86 47 00	Lily Bluff, 3 mi NW of Holt
Cheumatopsyche petersi	Blackwater R	Blackwater R	Okaloosa	A	4-13-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Cheumatopsyche petersi	Blackwater R	Blackwater R	Santa Rosa	A	4-24-1970	(Ross et al., 1971)	30 45 28	86 47 31	Field station 3.5 mi NW of Holt
Cheumatopsyche petersi	Blackwater R	Blackwater R	Santa Rosa	A	5-9-1970	(Ross et al., 1971)	30 45 28	86 47 31	Field station 3.5 mi NW of Holt
Cheumatopsyche petersi	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche pettiti	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche pettiti	Kissimmee R	Lake Placid	Highlands	A		(Gordon, 1974)	27 15 00	81 22 00	Lake Placid
Cheumatopsyche pettiti	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159
Cheumatopsyche pettiti	Oklawaha R	unknown	Alachua	A	9-7-1972	FAMU	29 39 07	82 19 31	Gainesville
Cheumatopsyche pettiti	Oklawaha R	unknown	Alachua	A	9-23-1972	FAMU	29 39 07	82 19 31	Gainesville
Cheumatopsyche pettiti	Suwannee R, upper	Suwannee R	Hamilton	A	9-22-1976	FAMU	30 19 33	82 44 20	Rt. 41
Cheumatopsyche pettiti	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Cheumatopsyche pettiti	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Cheumatopsyche pettiti	unknown	unknown	Alachua	A	4-15-1958	FAMU	29 39 07	82 19 31	none
Cheumatopsyche pettiti	unknown	unknown	Alachua	A	4-24-1977	FAMU	29 45 00	82 37 30	9 mi NW of Gainesville, UF hort.
Cheumatopsyche pettiti	unknown	unknown	Jefferson	A	4-8-1958	FAMU	30 32 43	83 52 13	Monticello
Cheumatopsyche pinaca	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159
Cheumatopsyche pinaca	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	SR-12, 5 mi SW of Havana
Cheumatopsyche pinaca	Oklawaha R	unknown	Alachua	A		(Gordon, 1974)	29 39 07	82 19 31	Gainesville
Cheumatopsyche pinaca	Santa Fe R	Santa Fe R	Gilchrist	A	5-6-1983	FAMU	29 50 11	82 41 58	Ginnie Springs campground
Cheumatopsyche pinaca	Santa Fe R	Santa Fe R	Gilchrist	A	5-7-1983	FAMU	29 50 11	82 41 58	Ginnie Springs campground
Cheumatopsyche pinaca	St. Johns R, upper	Juniper Springs	Marion	A		(Gordon, 1974)	29 10 43	81 42 29	Juniper Springs
Cheumatopsyche pinaca	St. Johns R, upper	Rock Springs	Orange	A		(Gordon, 1974)	28 45 10	81 30 18	Rock Springs
Cheumatopsyche pinaca	St. Johns R, upper	St. Johns R	Putnam	A	4-9-1964	FAMU	29 27 08	81 39 30	Welaka, UF reserve at fire tower
Cheumatopsyche pinaca	Suwannee R, upper	Suwannee R	Hamilton	A	9-22-1976	FAMU	30 19 33	82 44 20	Rt. 41
Cheumatopsyche pinaca	Upper Suwannee R	Suwannee R	Hamilton	A	3-29-1977	FAMU	30 19 54	82 46 01	Stephen Foster Memorial
Cheumatopsyche pinaca	Withlacoochee R, N.	Withlacoochee R	Madison	A	5-13-1952	FAMU			Beck Station 3
Cheumatopsyche pinaca	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Cheumatopsyche pinaca	unknown	unknown	Baker	A	4-12-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line nr Rt 90

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Cheumatopsyche pinaca	unknown	unknown	Baker	A	5-16-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line nr Rt 90
Cheumatopsyche pinaca	unknown	unknown	Baker	A	6-2-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line nr Rt 90
Cheumatopsyche pinaca	unknown	unknown	Baker	A	6-2-1977	FAMU	30 22 58	82 19 54	Osceola Nat. For., E forest tower
Cheumatopsyche pinaca	unknown	unknown	Baker	A	7-14-1977	FAMU	30 15 26	82 26 52	Osceola Nat. For., jct. I-10 & S-250
Cheumatopsyche pinaca	unknown	unknown	Columbia	A	4-12-1977	FAMU	30 12 00	82 30 00	Osceola Nat. For., jct.S-234 & Rt 90
Cheumatopsyche virginica	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Cheumatopsyche virginica	Kissimmee R	unknown	Highlands	A		(Gordon, 1974)	27 11 20	81 20 15	Archbold Biological Station
Cheumatopsyche virginica	Kissimmee R	unknown	Highlands	A		(Gordon, 1974)	27 14 42	81 17 54	Parker Island
Cheumatopsyche virginica	Oklawaha R	Redwater Lake	Putnam	A	4-23-1966	FAMU	29 34 00	82 01 00	Weems property
Cheumatopsyche virginica	Oklawaha R	unknown	Alachua	A	9-23-1972	FAMU	29 39 07	82 19 31	Gainesville
Cheumatopsyche virginica	Peace R	unknown	Highlands	A		(Gordon, 1974)	27 28 23	81 31 41	Highlands Hammock State Park
Cheumatopsyche virginica	Peace R	unknown	Polk	A	8-9-1960	FAMU	28 01 20	81 43 58	Winter Haven
Cheumatopsyche virginica	Santa Fe R	unknown	Alachua	A	3-30-1954	FAMU	29 47 47	82 29 42	Alachua
Cheumatopsyche virginica	St. Johns R, upper	St. Johns R	Putnam	A	4-9-1964	FAMU	29 27 08	81 39 30	Welaka, UF reserve at fire tower
Cheumatopsyche virginica	St. Johns R, upper	St. Johns R	Putnam	A	4-9-1964	FAMU	29 27 08	81 39 30	Welaka, UF reserve at sawmill
Cheumatopsyche virginica	Suwannee R, upper	Suwannee R	Hamilton	A	3-29-1977	FAMU	30 19 54	82 46 01	Stephen Foster Memorial
Cheumatopsyche virginica	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Cheumatopsyche virginica	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Cheumatopsyche virginica	unknown	unknown	Baker	A	4-6-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line nr Rt 90
Cheumatopsyche virginica	unknown	unknown	Baker	A	4-12-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line nr Rt 90
Cheumatopsyche virginica	unknown	unknown	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For.,OceanPond rec.ar
Cheumatopsyche virginica	unknown	unknown	Baker	A	4-20-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line nr Rt 90
Cheumatopsyche virginica	unknown	unknown	Baker	A	5-16-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For.,OceanPond rec.ar
Cheumatopsyche virginica	unknown	unknown	Columbia	A	4-12-1977	FAMU	30 12 00	82 30 00	Osceola Nat. For., jct.S-234 & Rt 90
Diplectrona modesta	Apalachicola R	Beaver Dam Ck	Liberty	L	4-7-1994	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Diplectrona modesta	Apalachicola R	Kelley Branch	Liberty	L	3-11-1994	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Diplectrona modesta	Apalachicola R	Kelley Branch	Liberty	L	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Diplectrona modesta	Apalachicola R	Little Sweetwater Ck	Liberty	L	3-11-1994	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Diplectrona modesta	Apalachicola R	Little Sweetwater Ck	Liberty	L	12-7-1994	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Diplectrona modesta	Apalachicola R	Sweetwater Ck	Liberty	L	4-18-1995	FAMU	30 31 58	84 58 03	CR-270
Diplectrona modesta	Apalachicola R	unnamed	Liberty	L	3-11-1994	FAMU	30 27 55	84 59 07	ABRP, just NE of bluff overlook
Diplectrona modesta	Apalchicola R	Crooked Ck	Gadsden	L	7-8-1992	FDEP-Tallahassee	30 35 02	84 52 58	Hwy 270
Diplectrona modesta	Blackwater R	Big Juniper Ck	Santa Rosa	L	12-16-1978	FAMU	30 51 47	86 54 16	Hwy 4
Diplectrona modesta	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Diplectrona modesta	Choctawhatchee Bay	Rocky Ck	Walton	L		(Scheiring, 1985)	30 39 00	86 20 00	Eglin Air Force Base
Diplectrona modesta	Ochlockonee	FAMU Farm St	Gadsden	L	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267

TRICHOPTERA DATABASE: FLORIDA HYDROPSYCHIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	6-12-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	8-14-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	10-15-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	12-5-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	2-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	4-8-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	6-10-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	8-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	10-14-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	12-7-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	2-11-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	4-7-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	9-28-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	1-27-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	FAMU Farm St	Gadsden	L	8-18-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Diplectrona modesta	Ochlockonee R	Mule Ck	Liberty	L	7-7-1992	FDEP-Tallahassee	30 30 41	84 49 42	Hwy 12
Diplectrona modesta	Ochlockonee R	Turkey Ck	Gadsden	L	8-21-1994	FAMU	30 31 15	84 34 53	headwaters, 5 km S Quincy
Diplectrona modesta	St. Marks R	Burnt Mill Ck	Jefferson	L	7-31-1991	FAMU	30 25 31	84 01 11	CR-59
Diplectrona modesta	St. Marks R	Burnt Mill Ck	Jefferson	L	2-4-1993	FAMU	30 25 31	84 01 11	CR-59
Diplectrona modesta	St. Marks R	Burnt Mill Ck	Jefferson	L	4-1-1993	FAMU	30 25 31	84 01 11	CR-59
Diplectrona modesta	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Diplectrona modesta	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Diplectrona modesta	unknown	North Pretty Branch	Escambia	L	12-10-1979	FDEP-Pensacola	30 41 47	87 18 28	S of Molino
Hydropsyche alvata	Chipola R	unknown	Jackson	A	4-18-1963	FAMU	30 48 51	85 14 00	Florida Caverns State Park
Hydropsyche betteni						(Harris & Lawrence, 1978)			[no specific locality mentioned]
Hydropsyche decalda	Aucilla R	Aucilla R	Jefferson	L	8-28-1991	FAMU	30 29 34	83 43 52	US Hwy 90
Hydropsyche decalda	Aucilla R	Aucilla R	Jefferson	L	8-26-1992	FAMU	30 29 34	83 43 52	US Hwy 90
Hydropsyche decalda	Aucilla R	Aucilla R	Jefferson	L	10-28-1992	FAMU	30 29 34	83 43 52	US Hwy 90
Hydropsyche decalda	Aucilla R	Aucilla R	Jefferson	L	12-16-1992	FAMU	30 29 34	83 43 52	US Hwy 90
Hydropsyche decalda	Aucilla R	Aucilla R	Jefferson	L	2-25-1993	FAMU	30 29 34	83 43 52	US Hwy 90
Hydropsyche decalda	Aucilla R	Aucilla R	Jefferson	L	4-28-1993	FAMU	30 29 34	83 43 52	US Hwy 90
Hydropsyche decalda	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Hydropsyche decalda	Kissimmee R	Carter Ck	Highlands	L	7-9-1979	FDEP-Punta Gorda	27 31 57	81 23 14	Arbuckle Ck Road
Hydropsyche decalda	Ochlockonee R	Mule Ck	Liberty	L	7-7-1992	FDEP-Tallahassee	30 30 41	84 49 42	Hwy 12
Hydropsyche decalda	Peace R	drainage ditch	Highlands	L	2-18-1987	FDEP-Punta Gorda	27 24 20	81 32 00	Sun & Lake Estates
Hydropsyche decalda	St. Andrews Bay	Bear Ck	Bay	L	10-23-1990	FDEP-Tallahassee	30 19 13	85 27 22	US Hwy 231

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Hydropsyche decalda	St. Marks R	Black Ck	Leon	L	6-13-1990	FDEP-Tallahassee	30 30 04	84 04 51	Baum Road
Hydropsyche elisoma	Blackwater R	Blackwater R	Okaloosa	A	3-23-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Hydropsyche elisoma	Blackwater R	Blackwater R	Okaloosa	A	4-12-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Hydropsyche elisoma	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Hydropsyche elisoma	Choctawhatchee Bay	Rocky Ck	Walton	L		(Scheiring, 1985)	30 39 00	86 20 00	Eglin Air Force Base
Hydropsyche elisoma	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Hydropsyche elisoma	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Hydropsyche incommoda	Chipola R	unknown	Jackson	A	4-13-1960	FAMU	30 48 51	85 14 00	Florida Caverns State Park
Hydropsyche incommoda	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Hydropsyche incommoda	Escambia R	Escambia R	Escambia	L	11-21-1978	FDEP-Pensacola	30 58 01	87 13 56	Hwy 4
Hydropsyche incommoda	Peace R	unknown	De Soto	A	4-29-1954	FAMU	27 12 58	81 51 30	Arcadia
Hydropsyche incommoda	Santa Fe R	Santa Fe R	Alachua	A	5-4-1958	FAMU	29 50 00	82 36 00	near city of High Springs
Hydropsyche incommoda	St. Marys R	St. Marys R	Nassau	L	8-27-1979	FDEP-Jacksonville	30 44 28	81 41 20	US Hwy 17
Hydropsyche incommoda	Suwannee R, upper	Suwannee R	Suwannee	A	5-6-1977	FAMU	30 24 01	83 09 30	Suwannee River State Park
Hydropsyche incommoda	Withlacoochee R, S.	Withlacoochee R	Pasco	A	4-7-1955	FAMU	28 19 00	82 04 00	none
Hydropsyche incommoda	Yellow R	Yellow R	Okaloosa	L	2-16-1978	FDEP-Pensacola	30 55 30	86 33 34	SR-189
Hydropsyche incommoda	unknown	unknown	Alachua	A	5-8-1958	FAMU	29 37 07	82 19 31	none
Hydropsyche incommoda	unknown	unknown	Alachua	A	6-23-1959	FAMU	29 37 07	82 19 31	none
Hydropsyche incommoda	unknown	unknown	Jefferson	A	4-8-1958	FAMU	30 32 43	83 52 13	Monticello
Hydropsyche mississippiensis	Apalachicola R	Flat Ck	Gadsden	L	8-13-1992	FDEP-Tallahassee	30 37 43	84 50 06	Hwy 269
Hydropsyche mississippiensis	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159, 3 mi NW of Havana
Hydropsyche mississippiensis	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	SR-12, 5 mi SW of Havana
Hydropsyche orris	Apalachicola R	unknown	Liberty	A	5-15-1964	FAMU	30 34 09	84 56 51	Torreya State Park
Hydropsyche orris	Apalachicola R	unknown	Liberty	A	7-19-1980	FAMU	30 34 09	84 56 51	Torreya State Park
Hydropsyche phalerata	unknown					(Flint et al., 1979)			[no specific locality mentioned]
Hydropsyche phalerata	unknown					(Nimmo, 1987)			[no specific locality mentioned]
Hydropsyche rossi	Chipola R	Blue Springs Ck	Jackson	A	6-5-1940	(Flint et al., 1979)	30 45 13	85 11 36	3 mi E Marianna
Hydropsyche rossi	Oklawaha R	unknown	Lake	A	3-23-1936	(Flint et al., 1979)	28 48 15	81 43 33	Tavares
Hydropsyche rossi	Santa Fe R	Santa Fe R	Columbia	A	5-31-1966	(Flint et al., 1979)	29 55 00	82 35 00	O'Leno State Park
Hydropsyche rossi	Santa Fe R	Santa Fe R	Gilchrist	A	5-6-1983	FAMU	29 50 11	82 41 58	Ginnie Springs campground
Hydropsyche rossi	St. Johns R, upper	Juniper Springs	Marion	A	4-28-1970	(Flint et al., 1979)	29 10 43	81 42 29	Juniper Springs
Hydropsyche rossi	Suwannee R, lower	Suwannee R	Suwannee	A	9-26-1976	FAMU	30 04 18	83 05 02	7.7 mi W O'Brien on SR-349
Hydropsyche rossi	Suwannee R, upper	Suwannee R	Hamilton	A	3-29-1977	FAMU	30 19 54	82 46 01	Stephen Foster Memorial
Hydropsyche rossi	Yellow R	Yellow R	Okaloosa	L	2-16-1978	FDEP-Pensacola	30 55 30	86 33 34	SR-189
Hydropsyche rossi	unknown	unknown	Alachua	A	7-6-1965	FAMU	29 37 07	82 19 31	none
Hydropsyche rossi	unknown	unknown	Alachua	A	4-20-1967	(Flint et al., 1979)	29 37 07	82 19 31	none

TRICHOPTERA DATABASE: FLORIDA HYDROPSYCHIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Hydropsyche rossi	unknown	unknown	Alachua	A	5-28-1968	FAMU	29 37 07	82 19 31	none
Hydropsyche rossi	unknown	unknown	Alachua	A	9-23-1972	FAMU	29 37 07	82 19 31	none
Macrostemum carolina	Apalachicola R	Apalachicola R	unknown	L		(Wallace & Sherberger, 1974)			none
Macrostemum carolina	Apalachicola R	Mosquito Ck	Gadsden	L	7-28-1978	FAMU	30 39 51	84 44 00	none
Macrostemum carolina	Apalachicola R	unknown	Calhoun	A	5-27-1954	FAMU	30 26 36	85 02 43	Blountstown
Macrostemum carolina	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Macrostemum carolina	Escambia R	Escambia R	Escambia	L	10-24-1952	FAMU			none
Macrostemum carolina	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159
Macrostemum carolina	Ochlockonee R	Turkey Ck	Gadsden	A	8-21-1994	FAMU	30 31 15	84 34 53	headwaters, 5 km S Quincy
Macrostemum carolina	Ochlockonee R	unknown	Gadsden	A	5-15-1956	FAMU	30 35 15	84 35 00	Quincy, N.F.E.S.
Macrostemum carolina	Ochlockonee R	unknown	Gadsden	A	5-6-1958	FAMU	30 35 15	84 35 00	Quincy
Macrostemum carolina	Oklawaha R	unknown	Alachua	A	8-23-1972	FAMU	29 39 07	82 19 31	Gainesville, Doyle Conner Bldg.
Macrostemum carolina	Oklawaha R	unknown	Alachua	A	9-7-1972	FAMU	29 39 07	82 19 31	Gainesville
Macrostemum carolina	Perdido Bay	Bayou Marcus Ck	Escambia	L	4-1-1953	FAMU	30 26 02	87 19 25	none
Macrostemum carolina	Perdido Bay	Bayou Marcus Ck	Escambia	L	9-18-1990	FSU	30 26 02	87 19 25	none
Macrostemum carolina	Santa Fe R	Santa Fe R	Columbia	L	7-10-1952	FAMU	29 55 00	82 35 00	Oleno
Macrostemum carolina	St. Andrews Bay	Bear Ck	Bay	L	8-27-1991	FDEP-Tallahassee	30 19 17	85 29 20	Camp Flower Rd
Macrostemum carolina	Suwannee R	Suwannee R	Suwannee	L	9-23-1952	FAMU			none
Macrostemum carolina	Suwannee R, upper	Suwannee R	Hamilton	A	9-22-1976	FAMU	30 19 33	82 44 20	Rt. 41
Macrostemum carolina	Suwannee R, upper	Suwannee R	Hamilton	L	3-10-1953	FAMU	30 21 00	82 41 10	NE White Springs
Macrostemum carolina	Suwannee R, upper	Suwannee R	Hamilton	L	1-29-1975	FDEP-Jacksonville	30 19 41	82 45 35	US Hwy 136, White Springs
Macrostemum carolina	Suwannee R, upper	Suwannee R	Hamilton	L	6-26-1991	FAMU	30 33 54	82 43 27	7.5 km N of SR-6
Macrostemum carolina	Suwannee R, upper	Suwannee R	Hamilton	L	6-24-1992	FAMU	30 33 54	82 43 27	7.5 km N of SR-6
Macrostemum carolina	Suwannee R, upper	Suwannee R	Suwannee	L	6-24-1992	FAMU	30 23 35	82 55 57	0.5 km E of US Hwy 129
Macrostemum carolina	Suwannee R, upper	Suwannee R	Suwannee	L	10-28-1992	FAMU	30 23 35	82 55 57	0.5 km E of US Hwy 129
Macrostemum carolina	Waccasassa R	Waccasassa R	Levy	L	6-4-1961	FAMU	29 17 00	82 44 00	none
Macrostemum carolina	Withlacoochee R, N.	Withlacoochee R	Madison	L	7-1-1952	FAMU			Beck Station 9
Macrostemum carolina	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Macrostemum carolina	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Macrostemum carolina	Yellow R	Yellow R	Okaloosa	L	2-16-1978	FDEP-Pensacola	30 55 30	86 33 34	SR-189
Macrostemum carolina	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Macrostemum carolina	unknown	unknown	Baker	A	6-2-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line nr Rt 90
Macrostemum carolina	unknown	unknown	Baker	A	6-2-1977	FAMU	30 22 58	82 19 54	Osceola Nat. For., E forest tower
Potamyia flava	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Potamyia flava	unknown	unknown	Liberty			(Gordon, 1984)			[no specific locality mentioned]

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA HYDROPTILIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Hydroptila acadia									[no specific localities]
Hydroptila armata									[no specific localities]
Hydroptila berneri	Santa Fe R	Santa Fe R	Alachua	A		(Blickle, 1962)	29 49 37	82 35 48	High Springs
Hydroptila berneri	Santa Fe R	Santa Fe R	Alachua	A	3-4-1939	(Ross, 1941)			none
Hydroptila circangula						(Harris et al., 1991)			panhandle Florida
Hydroptila hamata	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Hydroptila latosa	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	3-15-1957	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	3-29-1957	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	4-19-1957	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	4-21-1957	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	4-23-1957	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	5-3-1957	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	5-21-1957	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Apalachicola R	unknown	Gadsden	A	6-13-1958	(Blickle, 1961)	30 42 19	84 50 35	Chattahoochee
Hydroptila llogonae	Hillsborough R	unknown	Hillsborough	A	12-27-1957	(Blickle, 1961)	28 02 09	82 23 23	Temple Terrace
Hydroptila llogonae	Hillsborough R	unknown	Hillsborough	A	4-11-1958	(Blickle, 1961)	28 02 09	82 23 23	Temple Terrace
Hydroptila llogonae	Hillsborough R	unknown	Hillsborough	A	4-29-1958	(Blickle, 1961)	28 02 09	82 23 23	Temple Terrace
Hydroptila llogonae	Hillsborough R	unknown	Hillsborough	A	6-13-1958	(Blickle, 1961)	28 02 09	82 23 23	Temple Terrace
Hydroptila llogonae	Peace R	unknown	Highlands	A	9-13-1957	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	9-15-1957	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	9-25-1957	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	10-15-1957	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	10-25-1957	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	3-22-1958	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	4-25-1958	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	5-9-1958	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	Peace R	unknown	Highlands	A	6-13-1958	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila llogonae	unknown	unknown	unknown	A	5-9-1958	(Blickle, 1961)			Goose Prairie
Hydroptila maculata	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Hydroptila maculata	Indian River South	unknown	Indian River	A		(Blickle, 1962)	27 46 05	80 36 05	Fellsmere

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Hydroptila maculata	Southeast FL Coast	unknown	Dade	A		(Blickle, 1962)	25 32 18	80 24 32	Princeton
Hydroptila maculata	Southeast FL Coast	unknown	Martin	A		(Blickle, 1962)	26 59 16	80 36 18	Port Mayaca
Hydroptila molsonae	Peace R	unknown	Highlands	A	9-25-1958	(Blickle, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila morsei	Kissimmee R	unknown	Highlands	A	3-6-1964	(Sykora & Harris, 1994)	27 11 20	81 20 15	Archbold Biological Station
Hydroptila parastrepha	unknown	unknown	unknown	A		(Harris et al., 1991)			common in northern Florida
Hydroptila quinola	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Hydroptila quinola	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Hydroptila quinola	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Hydroptila quinola	Ochlockonee R	Telogia Ck	Liberty	A		FAMU	30 27 00	84 51 43	C-271 (bridge)
Hydroptila quinola	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Hydroptila quinola	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Hydroptila remita	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Hydroptila remita	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Hydroptila remita	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Hydroptila remita	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila remita	St. Johns R, lower	unknown	Clay	A		(Blickle, 1962)	29 47 09	82 01 55	Keystone Heights
Hydroptila wakulla	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Hydroptila wakulla	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park
Hydroptila wakulla	Santa Fe R	unknown	Alachua	A		(Blickle, 1962)	29 49 37	82 35 48	High Springs
Hydroptila wakulla	St. Marks R	Wakulla Springs	Wakulla	A		(Blickle, 1962)	30 14 01	84 18 19	Wakulla Springs
Hydroptila wakulla	St. Marks R	Wakulla Springs	Wakulla	A	10-23-1945	(Denning, 1947)	30 14 01	84 18 19	Wakulla Springs
Hydroptila waubesiana	Apalachicola R	Apalachicola R	Gadsden	A		(Blickle, 1962)	30 42 28	84 51 38	Jim Woodruff Dam
Hydroptila waubesiana	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Hydroptila waubesiana	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Hydroptila waubesiana	Hillsborough R	unknown	Polk	A		(Blickle, 1962)	28 02 39	81 57 24	Lakeland
Hydroptila waubesiana	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Hydroptila waubesiana	Yellow R	unknown	Okaloosa	A		(Blickle, 1962)	30 57 58	86 27 35	Laurel Hill
Hydroptila waubesiana	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Hydroptila waubesiana	unknown	unknown	unknown	A		(Blickle, 1962)			Goose Prairie
Mayatrichia ayama	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Mayatrichia ayama	Peace R	Peace R	Desoto	L	2-4-1980	FDEP-Punta Gorda	27 14 00	81 53 00	Peace R above Rt. 72

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Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Mayatrichia ayama	Suwannee R, upper	Suwannee R	Hamilton	L	9-6-1974	FDEP-Jacksonville	30 19 41	82 45 35	US Hwy 136, White Springs
Mayatrichia ayama	Suwannee R, upper	Suwannee R	Suwannee	L	10-28-1992	FAMU	30 24 13	83 09 30	Suwannee River State Park
Mayatrichia ayama	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	8-28-1991	FAMU	30 30 13	83 14 32	3 km N SR-6
Mayatrichia ayama	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Mayatrichia ayama	unknown	unknown	Madison	A		(Blickle, 1962)	30 28 10	83 24 47	Madison
Neotrichia alabamensis	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159, 3 mi NW Havana
Neotrichia alabamensis	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	10 mi S Quincy, C-267
Neotrichia armitagei	Choctawhatchee Bay	Rogue Ck	Okaloosa	A	8-14-1985	(Harris, 1991)	30 33 22	86 33 44	5.3 km NW Niceville, Base Rd. 233
Neotrichia armitagei	Choctawhatchee Bay	unnamed trib.Turkey Ck	Okaloosa	A	8-14-1985	(Harris, 1991)	30 35 00	86 35 00	8 km NW Niceville, Base Rd. 603
Neotrichia armitagei	Yellow R	Turkey Gobble Ck	Okaloosa	A	8-15-1985	(Harris, 1991)	30 38 00	86 38 00	11.2 km NW Niceville, Base Rd. 211
Neotrichia minutisimella	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park
Neotrichia minutisimella	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Neotrichia okopa	unknown	unknown	unknown	A		(Blickle, 1979)			[listed as occurring in FL]
Neotrichia vibrans	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Neotrichia vibrans	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Neotrichia vibrans	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159, 3 mi NW Havana
Neotrichia vibrans	Southeast FL Coast	unknown	Dade	A	5-10-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Neotrichia vibrans	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Neotrichia vibrans	unknown	unknown	Madison	A		(Blickle, 1962)	30 28 10	83 24 47	Madison
Ochrotrichia okaloosa	Choctawhatchee Bay	Turkey Ck	Okaloosa	A	8-14-1985	(Harris & Armitage, 1987)	30 33 43	86 32 11	5.0 mi NW Niceville, Base Rd. 233
Ochrotrichia provosti	Hillsborough R	unknown	Hillsborough	A	7-12-1957	(Blickle, 1961)	28 02 09	82 23 23	Temple Terrace
Ochrotrichia tarsalis	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Orthotrichia aegerfasciella	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Orthotrichia aegerfasciella	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 28	84 51 38	Jim Woodruff Dam
Orthotrichia aegerfasciella	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Orthotrichia aegerfasciella	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Orthotrichia aegerfasciella	Hillsborough R	unknown	Polk	A		(Blickle, 1962)	28 02 39	81 57 24	Lakeland
Orthotrichia aegerfasciella	Indian River, South	unknown	Indian River	A		(Blickle, 1962)	27 46 05	80 36 05	Fellsmere
Orthotrichia aegerfasciella	Indian River, South	unknown	St. Lucie	A		(Blickle, 1962)	27 31 15	80 21 11	Indrio
Orthotrichia aegerfasciella	Oklawaha R	unknown	Lake	A		(Blickle, 1962)	28 48 42	81 52 41	Leesburg
Orthotrichia aegerfasciella	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park

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Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Orthotrichia aegerfasciella	Southeast FL Coast	unknown	Dade	A	5-10-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Orthotrichia aegerfasciella	Southeast FL Coast	unknown	Dade	A	10-2-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Orthotrichia aegerfasciella	Southeast FL Coast	unknown	Dade	A	10-21-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Orthotrichia aegerfasciella	Southeast FL Coast	unknown	Dade	A	11-15-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Orthotrichia aegerfasciella	Southeast FL Coast	unknown	Dade	A	2-5-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Orthotrichia aegerfasciella	Southeast FL Coast	unknown	Dade	A	3-15-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Orthotrichia aegerfasciella	Southeast FL Coast	unknown	Martin	A		(Blickle, 1962)	26 59 16	80 36 18	Port Mayaca
Orthotrichia aegerfasciella	St. Johns R, lower	unknown	Clay	A		(Blickle, 1962)	29 47 09	82 01 55	Keystone Heights
Orthotrichia aegerfasciella	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Orthotrichia aegerfasciella	unknown	unknown	unknown	A		(Blickle, 1962)			Goose Prairie
Orthotrichia baldufi	Apalachicola R	unknown	Gadsden	A	6-19-1957	(Kingsolver & Ross, 1961)	30 42 19	84 50 35	Chattahoochee
Orthotrichia cristata	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Orthotrichia cristata	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Orthotrichia cristata	Florida Keys	unknown	Monroe	A		(Blickle, 1962)	24 41 00	81 22 00	Big Pine Key
Orthotrichia cristata	Indian R, South	unknown	Indian River	A		(Blickle, 1962)	27 46 05	80 36 05	Fellsmere
Orthotrichia cristata	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159, 3 mi NW Havana
Orthotrichia cristata	Southeast FL Coast	unknown	Dade	A	4-10-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Orthotrichia curta	Hillsborough R	unknown	Hillsborough	A	6-13-1958	(Kingsolver & Ross, 1961)	28 02 09	82 23 23	Temple Terrace
Orthotrichia curta	Peace R	unknown	Highlands	A		(Kingsolver & Ross, 1961)	27 28 23	81 31 41	Highlands Hammock State Park
Orthotrichia curta	unknown	unknown	unknown	A		(Kingsolver & Ross, 1961)			Goose Prairie
Orthotrichia dentata	Hillsborough R	unknown	Hillsborough	A	4-23-1957	(Kingsolver & Ross, 1961)	28 02 09	82 23 23	Temple Terrace
Orthotrichia dentata	Hillsborough R	unknown	Hillsborough	A	4-1-1958	(Kingsolver & Ross, 1961)	28 02 09	82 23 23	Temple Terrace
Orthotrichia instabilis	St. Johns R, upper	unknown	Orange	A	5-16-1940	(Denning, 1948a)	28 36 00	81 20 21	Winter Park
Oxyethira abacatia	Apalachicola R	Apalachicola R	Gadsden	A		(Blickle, 1962)	30 42 28	84 51 38	Jim Woodruff Dam
Oxyethira abacatia	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Oxyethira abacatia	St. Johns R, lower	unknown	Clay	A		(Blickle, 1962)	29 47 09	82 01 55	Keystone Heights
Oxyethira elerobi	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oxyethira elerobi	Yellow R	unknown	Okaloosa	A	4-30-1957	(Blickle, 1961)	30 57 58	86 27 35	Laurel Hill
Oxyethira florida	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Oxyethira florida	Southeast FL Coast	unknown	Dade	A	10-1-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira florida	Southeast FL Coast	unknown	Dade	A	10-21-1944	(Denning, 1947)	25 46 28	80 11 38	Miami

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Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Oxyethira florida	Southeast FL Coast	unknown	Dade	A	11-23-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira florida	Southeast FL Coast	unknown	Dade	A	2-1-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira florida	Southeast FL Coast	unknown	Dade	A	2-5-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira florida	Southeast FL Coast	unknown	Dade	A	3-8-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Oxyethira glasa	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Oxyethira glasa	Caloosahatchee R	unknown	Lee	A		(Blickle, 1962)	26 38 26	81 52 21	Fort Myers
Oxyethira glasa	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oxyethira glasa	Florida Keys	unknown	Monroe	A		(Blickle, 1962)	24 41 00	81 22 00	Big Pine Key
Oxyethira glasa	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Oxyethira glasa	Hillsborough R	unknown	Polk	A		(Blickle, 1962)	28 02 39	81 57 24	Lakeland
Oxyethira glasa	Indian R South	unknown	Indian River	A		(Blickle, 1962)	27 38 19	80 23 50	Vero Beach
Oxyethira glasa	Indian River, South	unknown	Indian River	A		(Blickle, 1962)	27 46 05	80 36 05	Fellsmere
Oxyethira glasa	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park
Oxyethira glasa	Peace R	unknown	Polk	A		(Blickle, 1962)	27 54 03	81 35 04	Lake Wales
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	2-15-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	2-26-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	11-23-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	12-4-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	12-14-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	12-20-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	2-5-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Dade	A	3-8-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira glasa	Southeast FL Coast	unknown	Martin	A		(Blickle, 1962)	26 59 16	80 36 18	Port Mayaca
Oxyethira glasa	St. Johns R, lower	unknown	Clay	A		(Blickle, 1962)	29 47 09	82 01 55	Keystone Heights
Oxyethira glasa	Withlacoochee R, S.	unknown	Citrus	A		(Blickle, 1962)	28 50 09	82 19 37	Inverness
Oxyethira glasa	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Oxyethira glasa	unknown	unknown	unknown	A		(Blickle, 1962)			Goose Prairie
Oxyethira janella	Aucilla R	Aucilla R	Jefferson	A	10-14-1993	FAMU	30 16 25	83 51 25	SR-257
Oxyethira janella	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oxyethira janella	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159, 3 mi NW of Havana

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Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Oxyethira janella	St. Johns R, upper	unknown	Orange	A	5-16-1940	(Denning, 1948a)	28 36 00	81 20 21	Winter Park
Oxyethira kelleyi	Choctawhatchee Bay	Rogue Ck	Okaloosa	A	8-14-1985	(Harris & Armitage, 1987)	30 33 22	86 33 44	3.3 mi NW Niceville, Base Rd 233
Oxyethira kelleyi	Choctawhatchee Bay	Turkey Ck	Okaloosa	A	8-14-1985	(Harris & Armitage, 1987)	30 33 43	86 32 11	5.0 mi NW Niceville, Base Rd 233
Oxyethira kelleyi	Choctawhatchee Bay	unnamed trib. Turkey Ck	Okaloosa	A	8-14-1985	(Harris & Armitage, 1987)	30 35 00	86 35 00	4.6 mi NW Niceville, Base Rd 619
Oxyethira kingi	Southeast FL Coast	unknown	Dade	A	12-21-1964	(Holzenthal & Kelley, 1983)	25 46 28	80 11 38	Plant Inspection Station
Oxyethira lumosa	Apalachicola R	Apalachicola R	Gadsden	A		(Blickle, 1962)	30 42 28	84 51 38	Jim Woodruff Dam
Oxyethira lumosa	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Oxyethira lumosa	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Oxyethira lumosa	East Coast, Upper	unknown	Volusia	A		(Blickle, 1962)	29 12 40	81 01 23	Daytona Beach
Oxyethira lumosa	East Coast, Upper	unknown	Volusia	A		(Ross, 1948a)	29 12 40	81 01 23	Daytona Beach
Oxyethira lumosa	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Oxyethira lumosa	Hillsborough R	unknown	Polk	A		(Blickle, 1962)	28 02 39	81 57 24	Lakeland
Oxyethira lumosa	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park
Oxyethira lumosa	Peace R	unknown	Polk	A		(Blickle, 1962)	27 54 03	81 35 04	Lake Wales
Oxyethira lumosa	St. Johns R, lower	unknown	Clay	A		(Blickle, 1962)	29 47 09	82 01 55	Keystone Heights
Oxyethira lumosa	Withlacoochee R, S.	unknown	Citrus	A		(Blickle, 1962)	28 50 09	82 19 37	Inverness
Oxyethira lumosa	Yellow R	unknown	Okaloosa	A		(Blickle, 1962)	30 57 58	86 27 35	Laurel Hill
Oxyethira lumosa	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Oxyethira lumosa	unknown	unknown	unknown	A		(Blickle, 1962)			Goose Prairie
Oxyethira maya	Apalachicola R	Apalachicola R	Gadsden	A		(Blickle, 1962)	30 42 28	84 51 38	Jim Woodruff Dam
Oxyethira maya	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Oxyethira maya	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Oxyethira maya	Indian R, South	unknown	Indian River	A		(Blickle, 1962)	27 46 05	80 36 05	Fellsmere
Oxyethira maya	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Oxyethira novasota	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Oxyethira novasota	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Oxyethira novasota	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oxyethira novasota	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159, 3 mi NW of Havana
Oxyethira novasota	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oxyethira pallida	Apalachicola R	Apalachicola R	Gadsden	A		(Blickle, 1962)	30 42 28	84 51 38	Jim Woodruff Dam
Oxyethira pallida	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee

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Oxyethira pallida	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Oxyethira pallida	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Oxyethira pallida	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Oxyethira roberti	Ochlockonee R	unknown	Leon	A	5-29-1973	(Kelley, 1981)	30 39 00	84 13 00	Tall Timbers Research Station
Oxyethira savanniensis	unknown	unknown	unknown	A		(Harris et al., 1991)			none
Oxyethira setosa	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oxyethira sininsigne	St. Johns R, lower	unknown	Clay	A	3-22-1957	(Kelley, 1981)	29 47 09	82 01 55	Keystone Heights
Oxyethira sininsigne	St. Marks R	Dog Lake	Leon	A	4-20-1975	(Kelley, 1981)	30 22 38	84 23 44	4 mi SW of Tallahassee
Oxyethira verna	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Oxyethira verna	Apalachicola R.	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Oxyethira verna	Caloosahatchee R	unknown	Lee	A		(Blickle, 1962)	26 38 26	81 52 21	Fort Myers
Oxyethira verna	Caloosahatchee R	unknown	Lee	A		(Blickle, 1962)	26 40 02	81 52 48	North Fort Myers
Oxyethira verna	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Oxyethira verna	Hillsborough R	unknown	Polk	A		(Blickle, 1962)	28 02 39	81 57 24	Lakeland
Oxyethira verna	Indian R, South	unknown	Indian River	A		(Blickle, 1962)	27 46 05	80 36 05	Fellsmere
Oxyethira verna	Indian R, South	unknown	St. Lucie	A		(Blickle, 1962)	27 31 15	80 21 11	Indrio
Oxyethira verna	Oklawaha R	unknown	Lake	A		(Blickle, 1962)	28 48 42	81 52 41	Leesberg
Oxyethira verna	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	2-15-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	2-23-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	4-10-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	10-21-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	11-23-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	12-4-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	12-14-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	12-20-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	2-5-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	3-23-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Dade	A	10-2-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira verna	Southeast FL Coast	unknown	Martin	A		(Blickle, 1962)	26 59 16	80 36 18	Port Mayaca
Oxyethira verna	St. Johns R, lower	unknown	Clay	A		(Blickle, 1962)	29 47 09	82 01 55	Keystone Heights

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Oxyethira verna	Withlacoochee R, S.	unknown	Citrus	A		(Blickle, 1962)	28 50 09	82 19 37	Inverness
Oxyethira verna	unknown	unknown	Madison	A		(Blickle, 1962)	30 28 10	83 24 47	Madison
Oxyethira verna	unknown	unknown	unknown	A		(Blickle, 1962)			Goose Prairie
Oxyethira zeronia	Apalachicola R	Apalachicola R	Gadsden	A		(Blickle, 1962)	30 42 28	84 51 38	Jim Woodruff Dam
Oxyethira zeronia	Apalachicola R	unknown	Gadsden	A		(Blickle, 1962)	30 42 19	84 50 35	Chattahoochee
Oxyethira zeronia	Apalachicola R	unknown	Jackson	A		(Blickle, 1962)	30 42 28	84 55 28	Sneads
Oxyethira zeronia	Caloosahatchee R	unknown	Lee	A		(Blickle, 1962)	26 38 26	81 52 21	Fort Myers
Oxyethira zeronia	Caloosahatchee R	unknown	Lee	A		(Blickle, 1962)	26 40 02	81 52 48	North Fort Myers
Oxyethira zeronia	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oxyethira zeronia	Florida Keys	unknown	Monroe	A		(Blickle, 1962)	24 41 00	81 22 00	Big Pine Key
Oxyethira zeronia	Hillsborough R	unknown	Hillsborough	A		(Blickle, 1962)	28 02 09	82 23 23	Temple Terrace
Oxyethira zeronia	Indian R, South	unknown	Indian River	A		(Blickle, 1962)	27 46 05	80 36 05	Fellsmere
Oxyethira zeronia	Peace R	unknown	Highlands	A		(Blickle, 1962)	27 28 23	81 31 41	Highlands Hammock State Park
Oxyethira zeronia	Southeast FL Coast	unknown	Dade	A		(Blickle, 1962)	25 46 28	80 11 38	Miami
Oxyethira zeronia	Southeast FL Coast	unknown	Dade	A	5-10-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira zeronia	Southeast FL Coast	unknown	Dade	A	11-15-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira zeronia	Southeast FL Coast	unknown	Dade	A	11-30-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira zeronia	Southeast FL Coast	unknown	Dade	A	12-20-1944	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira zeronia	Southeast FL Coast	unknown	Dade	A	3-15-1945	(Denning, 1947)	25 46 28	80 11 38	Miami
Oxyethira zeronia	St. Johns R, lower	unknown	Clay	A		(Blickle, 1962)	29 47 09	82 01 55	Keystone Heights
Oxyethira zeronia	unknown	unknown	Jackson	A		(Blickle, 1962)			River Road
Oxyethira zeronia	unknown	unknown	unknown	A		(Blickle, 1962)			Goose Prairie

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA LEPIDOSTOMATIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Lepidostoma griseum	Apalachicola R	Beaver Dam Ck	Liberty	A	10-26-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Lepidostoma griseum	Apalachicola R	Kelley Branch	Liberty	A	10-26-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Lepidostoma griseum	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Lepidostoma latipenne	Apalachicola R	Beaver Dam Ck	Liberty	A	12-7-1994	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Lepidostoma latipenne	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Lepidostoma latipenne	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Lepidostoma latipenne	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Lepidostoma morsei	Choctawhatchee Bay	Little Alaqua Ck	Walton	A	10-18-1970	(Weaver, 1988)	30 33 00	86 11 00	none
Lepidostoma sp. (nr. serratum)	Ochlockonee R	FAMU Farm Stream	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lepidostoma sp. (nr. serratum)	Ochlockonee R	Turkey Ck headwaters	Gadsden	A	10-14-1994	FAMU	30 31 15	84 34 53	4 mi S Quincy off C-267A

END OF DATA TABLE

TRICHOPTERA DATABASE: FLORIDA LEPTOCERIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Ceraclea cancellata	Apalachicola R	unknown	Liberty	A	5-18-1966	FAMU	30 34 09	84 56 51	Torreya State Park
Ceraclea cancellata	Apalachicola R	unknown	Liberty	A	5-8-1968	FAMU	30 34 09	84 56 51	Torreya State Park
Ceraclea cancellata	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	S-12 @ bridge, 5 mi SW Havana
Ceraclea cancellata	Ochlockonee R	Telogia Ck	Liberty	A	7-2-1986	FAMU	30 25 36	84 55 39	2.5 mi E Bristol, S-20(bridge)
Ceraclea cancellata	Ochlockonee R	Telogia Ck	Liberty	A	6-20-1990	FAMU	30 27 00	84 51 43	C-271 @ 10 km NW Hosford
Ceraclea cancellata	Oklawaha R	Red Water Lake	Putnam	A	4-23-1966	FAMU	29 34 00	82 01 00	Weems property
Ceraclea cancellata	Santa Fe R	Santa Fe R	Gilchrist	A	5-7-1983	FAMU	29 50 11	82 41 58	Ginnie Springs campground
Ceraclea cancellata	Santa Fe R	unknown	Alachua	A	3-30-1954	FAMU	29 47 47	82 29 42	Alachua
Ceraclea diluta	Ochlockonee R	Telogia Ck	Liberty	A	4-29-1987	FAMU	30 25 36	84 55 39	S-20 @ br. 2.5 mi E of Bristol
Ceraclea diluta	Yellow R	Shoal R	Okaloosa	L	2-22-1978	FDEP-Pensacola	30 47 26	86 25 07	SR-393
Ceraclea flava	Ochlockonee R	Camp Ck	Gadsden	A	5-20-1987	FAMU	30 30 50	84 39 16	C-274, 13 km SW Quincy
Ceraclea floridana	Southeast FL Coast	Biscayne Bay	Dade	A		(Morse, 1975)	25 46 28	80 11 38	Biscayne Bay
Ceraclea maculata	Apalachicola R	Apalachicola R	Liberty	L	7-27-1976	FDEP-Pensacola	30 25 52	85 10 19	Bristol Hwy. 20
Ceraclea maculata	Chipola R	Chipola R	Calhoun	L	9-2-1976	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274
Ceraclea maculata	Chipola R	unknown	Jackson	A	4-18-1963	FAMU	30 48 51	85 14 00	Florida Caverns State Park
Ceraclea maculata	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Ceraclea maculata	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	3 mi NW Havana, C-159
Ceraclea maculata	Ochlockonee R	Little R	Gadsden	A	6-10-1986	FAMU	30 30 45	84 31 24	6.5 mi SE Quincy, C-268
Ceraclea maculata	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	S-12 @ bridge, 5 mi SW Havana
Ceraclea maculata	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	10 mi S Quincy, C-267
Ceraclea maculata	Ochlockonee R	Telogia Ck	Liberty	A	7-2-1986	FAMU	30 25 36	84 55 39	2.5 mi E Bristol @ S-20 bridge
Ceraclea maculata	Ochlockonee R	Willacoochee Ck	Gadsden	A	4-26-1990	FAMU	30 40 15	84 32 34	S-65 & C-65A @ 10 km N Quincy
Ceraclea maculata	Oklawaha R	unknown	Alachua	A	9-23-1972	FAMU	29 39 07	82 19 31	Gainesville
Ceraclea maculata	Suwannee R, upper	Suwannee R	Hamilton	A	9-22-1976	FAMU	30 19 33	82 44 20	Rt. 41
Ceraclea maculata	unknown	Ocean Pond	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Ceraclea maculata	unknown	Ocean Pond	Baker	A	5-16-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Ceraclea maculata	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Ceraclea nepha	Chipola R	unknown	Jackson	A	4-13-1960	FAMU	30 48 51	85 14 00	Florida Caverns State Park
Ceraclea nepha	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Ceraclea ophioderus	Apalachicola R	unknown	Liberty	A	5-18-1966	FAMU	30 34 09	84 56 51	Torreya State Park
Ceraclea ophioderus	Apalachicola R	unknown	Liberty	A	5-20-1966	FAMU	30 34 09	84 56 51	Torreya State Park
Ceraclea ophioderus	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	S-12 @ bridge, 5 mi SW Havana
Ceraclea protonepha	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	5 km N Bristol
Ceraclea protonepha	Apalachicola R	unknown	Liberty	A	4-17-1963	FAMU	30 34 09	84 56 51	Torreya State Park

TRICHOPTERA DATABASE: FLORIDA LEPTOCERIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Ceraclea protonepha	Apalachicola R	unknown	Liberty	A	5-8-1968	FAMU	30 34 09	84 56 51	Torreya State Park
Ceraclea protonepha	Blackwater R	Blackwater R	Okaloosa	A	4-24-1970	(Morse, 1975)	30 43 28	86 47 30	2.5 mi W Holt
Ceraclea protonepha	Blackwater R	Blackwater R	Okaloosa	A	4-25-1970	(Morse, 1975)	30 52 55	86 43 52	4.5 mi NW Cannon Town
Ceraclea protonepha	Blackwater R	Blackwater R	Okaloosa	A	4-12-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Ceraclea protonepha	Blackwater R	Blackwater R	Okaloosa	A	4-13-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Ceraclea protonepha	Chipola R	unknown	Jackson	A	4-13-1960	FAMU	30 48 51	85 14 00	Florida Caverns State Park
Ceraclea protonepha	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Ceraclea protonepha	Suwannee R, upper	Suwannee R	Hamilton	A	3-29-1977	FAMU	30 19 54	82 46 01	Stephen Foster Memorial
Ceraclea protonepha	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Ceraclea protonepha	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Ceraclea resurgens	Ochlockonee R	Telogia Ck	Liberty	A	3-4-1987	FAMU	30 25 36	84 55 39	S-20 (bridge)
Ceraclea slossonae	Escambia R	Escambia R	Escambia	A	9-14-1976	FDEP-Pensacola	30 58 01	87 13 56	Hwy. 4
Ceraclea spongillovorax	Kissimmee R	Lake Annie	Highlands	L		FDEP-Punta Gorda	28 00 00	81 36 00	none
Ceraclea spongillovorax	Kissimmee R	Lake Josephine	Highlands	L	7-25-1985	FDEP-Punta Gorda	27 24 00	81 25 00	none
Ceraclea spongillovorax	Kissimmee R	Lake Viola	Highlands	L		FDEP-Punta Gorda	27 36 48	81 29 44	none
Ceraclea spongillovorax	Ochlockonee R	Ochlockonee R	Leon	A	4-29-1981	FAMU	30 31 43	84 23 23	Tower Rd. N Tallahassee
Ceraclea tarsipunctata	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	5 km N Bristol
Ceraclea tarsipunctata	Chipola R	unknown	Jackson	A	4-13-1960	FAMU	30 48 51	85 14 00	Florida Caverns
Ceraclea tarsipunctata	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Ceraclea tarsipunctata	Ochlockonee R	Camp Ck	Gadsden	A	5-20-1987	FAMU	30 30 50	84 39 16	C-274, 13 km SW Quincy
Ceraclea tarsipunctata	Ochlockonee R	Ochlockonee R	Leon	A	4-29-1981	FAMU	30 31 43	84 23 23	Tower Rd. N Tallahassee
Ceraclea tarsipunctata	Ochlockonee R	Willacoochee Ck	Gadsden	A	4-26-1990	FAMU	30 40 15	84 32 34	S-65 & C-65A @ 10 km N Quincy
Ceraclea transversa	Blackwater R	Blackwater R	Okaloosa	A	4-12-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Ceraclea transversa	Blackwater R	Blackwater R	Okaloosa	A	4-13-1973	FAMU	30 44 20	86 47 12	FAMU Biological Station
Ceraclea transversa	Chipola R	unknown	Jackson	A	4-13-1960	FAMU	30 48 51	85 14 00	Florida Caverns
Ceraclea transversa	Ochlockonee R	Little R	Gadsden	A	5-13-1987	FAMU	30 35 15	84 29 48	S-12 @ bridge, 5 mi SW Havana
Ceraclea transversa	Ochlockonee R	Ochlockonee R	Leon	A	4-29-1981	FAMU	30 31 43	84 23 23	Tower Rd. N Tallahassee
Ceraclea transversa	Oklawaha R	unknown	Alachua	A	4-14-1960	FAMU	29 39 07	82 19 31	Gainesville
Ceraclea transversa	unknown	unknown	Hillsborough	A	5-19-1960	FAMU	27 56 52	82 27 31	Tampa
Leptocerus americanus	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Leptocerus americanus	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Leptocerus americanus	Ochlockonee R	FAMU Farm St	Gadsden	A	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Leptocerus americanus	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Leptocerus americanus	Ochlockonee R	Telogia Ck	Liberty	A	4-28-1987	FAMU	30 25 36	84 55 39	S-20, 2.5 mi E Bristol

TRICHOPTERA DATABASE: FLORIDA LEPTOCERIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Leptocerus americanus	Ochlockonee R	Turkey Ck	Gadsden	A	4-24-1994	FAMU	30 31 15	84 34 53	5 km S Quincy, off Hwy. 267A
Leptocerus americanus	Ochlockonee R	Willacoochee Ck	Gadsden	A	4-26-1990	FAMU	30 40 15	84 32 34	none
Leptocerus americanus	Santa Fe R	Lake Rowell	Bradford	L	11-18-1994	FDEP	29 55 41	82 09 12	none
Leptocerus americanus	unknown	unknown	Baker	A	5-16-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., nr Rt. 90
Leptocerus americanus	unknown	unknown	Baker	A	5-16-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Nectopsyche candida	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Nectopsyche candida	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Nectopsyche candida	Ochlockonee R	Camp Ck	Gadsden	A	5-20-1987	FAMU	30 30 50	84 39 16	C-274, 13 km SW Quincy
Nectopsyche candida	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	S-12, 5 mi SW Havana
Nectopsyche candida	Ochlockonee R	Little R	Gadsden	A	5-13-1987	FAMU	30 35 15	84 29 48	S-12, 5 mi SW Havana
Nectopsyche candida	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	C-267, 10 mi S Quincy
Nectopsyche candida	Ochlockonee R	Telogia Ck	Liberty	A	7-2-1986	FAMU	30 25 36	84 55 39	S-20, 2.5 mi E Bristol
Nectopsyche candida	Ochlockonee R	Willacoochee Ck	Gadsden	A	4-26-1990	FAMU	30 40 15	84 32 34	none
Nectopsyche exquisita	Apalachicola R	unknown	Liberty	A	4-17-1963	FAMU	30 34 09	84 56 51	Torreya State Park
Nectopsyche exquisita	Apalachicola R	unknown	Liberty	A	5-15-1964	FAMU	30 34 09	84 56 51	Torreya State Park
Nectopsyche exquisita	Blackwater R	Blackwater R	Okaloosa	L	1-30-1971	FAMU	30 59 22	86 43 15	1st bridge S Alabama line
Nectopsyche exquisita	Chipola R	unknown	Jackson	A	4-18-1963	FAMU	30 48 51	85 14 00	Florida Caverns State Park
Nectopsyche exquisita	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Nectopsyche exquisita	Kissimmee R	Carter Ck	Highlands	L	2-21-1979	FDEP-Punta Gorda	27 31 57	81 23 14	@ Arbuckle Ck Rd.
Nectopsyche exquisita	Myakka R	Myakka R	Manatee	L	1-26-1984	FDEP-Punta Gorda	27 21 00	82 10 00	Myakka City Park
Nectopsyche exquisita	Ochlockonee R	Ochlockonee R	Leon	A	4-29-1981	FAMU	30 31 43	84 23 23	Tower Rd. N Tallahassee
Nectopsyche exquisita	Ochlockonee R	unknown	Gadsden	A	4-21-1958	FAMU	30 35 15	84 35 00	Quincy
Nectopsyche exquisita	Oklawaha R	unknown	Alachua	A	4-23-1963	FAMU	29 39 07	82 19 31	Gainesville
Nectopsyche exquisita	Oklawaha R	unknown	Alachua	A	5-28-1968	FAMU	29 39 07	82 19 31	Gainesville
Nectopsyche exquisita	Perdido R	Perdido R	Escambia	L	8-24-1976	FDEP-Pensacola	30 36 14	87 24 15	Hwy 184
Nectopsyche exquisita	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Nectopsyche exquisita	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Nectopsyche paludicola						(Harris et al., 1991)			[no specific locality given]
Nectopsyche pavida	Aucilla R	Aucilla R	Jefferson	A	8-24-1967	FAMU			none
Nectopsyche pavida	Kissimmee R	Lake Damon	Highlands	L	12-31-1985	FDEP-Punta Gorda	27 38 00	81 31 00	none
Nectopsyche pavida	Kissimmee R	Lake Damon	Highlands	L	6-18-1986	FDEP-Punta Gorda	27 38 00	81 31 00	none
Nectopsyche pavida	Myakka R	Myakka R	Manatee	L	7-17-1984	FDEP-Punta Gorda	27 21 00	82 10 00	Myakka City Park
Nectopsyche pavida	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Nectopsyche pavida	Ochlockonee R	Camp Ck	Gadsden	A	5-20-1987	FAMU	30 30 50	84 39 16	C-274, 13 km SW Quincy

TRICHOPTERA DATABASE: FLORIDA LEPTOCERIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Nectopsyche pavida	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	S-12, 5 mi SW Havana
Nectopsyche pavida	Ochlockonee R	Little R	Gadsden	A	5-13-1987	FAMU	30 35 15	84 29 48	S-12, 5 mi SW Havana
Nectopsyche pavida	Ochlockonee R	Ochlockonee R	Leon	A	4-29-1981	FAMU	30 31 43	84 23 23	Tower Rd. N Tallahassee
Nectopsyche pavida	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	C-267, 10 mi S Quincy
Nectopsyche pavida	Ochlockonee R	Telogia Ck	Liberty	A	7-2-1986	FAMU	30 25 36	84 55 39	S-20, 2.5 mi E Bristol
Nectopsyche pavida	Ochlockonee R	Telogia Ck	Liberty	A	6-20-1990	FAMU	30 27 00	84 51 43	C-271, 10 km NW Hosford
Nectopsyche pavida	Ochlockonee R	Willacoochee Ck	Gadsden	A	4-26-1990	FAMU	30 40 15	84 32 34	none
Nectopsyche pavida	Ochlockonee R	Willacoochee Ck	Gadsden	L	8-19-1987	FAMU	30 40 15	84 32 34	C-161, 6 mi NE Quincy
Nectopsyche pavida	Oklawaha R	Cabbage Ck	Putnam	L	6-24-1991	FDEP-Tallahassee	29 33 00	81 56 00	none
Nectopsyche pavida	Peace R	Horse Ck	DeSoto	L	2-17-1981	FDEP-Punta Gorda	27 12 00	81 59 17	@ Rt. 72
Nectopsyche pavida	Perdido R	Perdido R	Escambia	L	3-31-1976	FDEP-Pensacola	30 36 14	87 24 15	Hwy 184
Nectopsyche pavida	St. Marks R	Burnt Mill Ck	Jefferson	A	8-14-1980	FAMU	30 25 31	84 01 11	SR-59
Nectopsyche pavida	Yellow R	Narrows Ck	Walton	L	5-24-1977	FDEP-Pensacola	30 47 00	86 12 00	headwaters
Nectopsyche pavida	unknown	unknown	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Nectopsyche pavida	unknown	unknown	Baker.	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Nectopsyche tavara	Kissimmee R	Lake Istokpoga	Highlands	L	10-9-1984	FDEP-Punta Gorda	27 22 30	81 15 00	boat ramp
Nectopsyche tavara	Kissimmee R	Lake Lotela	Highlands	L	12-19-1985	FDEP-Punta Gorda	27 35 00	81 29 00	none
Nectopsyche tavara	Kissimmee R	Lake Placid	Highlands	A		(Daigle & Haddock, 1981)	27 15 00	81 22 00	none
Nectopsyche tavara	Kissimmee R	Lake Placid	Highlands	L	9-18-1985	FDEP-Punta Gorda	27 15 00	81 22 00	none
Nectopsyche tavara	Lake Okeechobee	Lake Okeechobee	Glades	L	4-23-1987	FDEP	27 03 30	80 58 20	Station 30
Nectopsyche tavara	Oklawaha R	unknown	Lake	A	3-23-1936	(Ross, 1944)	28 48 15	81 43 33	Tavares
Nectopsyche tavara	Santa Fe R	Lake Samson	Bradford	L	11-16-1994	FDEP	29 56 00	82 11 00	none
Nectopsyche tavara	Southeast FL Coast	unknown	Broward	A	7-27-1979	FAMU	26 07 19	80 08 42	Ft. Lauderdale, citrus
Nectopsyche tavara	St. Johns R, upper	unknown	Orange	A		(Ross, 1944)	28 36 00	81 20 21	Winter Park
Nectopsyche tavara	Withlacoochee R, S.	unknown	Citrus	A	11-6-1965	FAMU	28 54 03	82 22 29	Hernando
Nectopsyche tavara	unknown	Lake Conway	unknown	A,L		(Daigle & Haddock, 1981)			none
Nectopsyche tavara	unknown	Lake Fredrica	unknown	A,L		(Daigle & Haddock, 1981)			none
Nectopsyche tavara	unknown	Prairie Lake	Seminole	A		(Daigle & Haddock, 1981)			none
Nectopsyche tavara	unknown	unknown	Levy	A	7-17-1938	(Ross, 1944)	29 30 14	82 52 20	Chiefland
Oecetis avara	Chipola R	Chipola R	Calhoun	L	9-2-1976	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274
Oecetis cinerascens	Caloosahatchee R	Caloosahatchee R	Glades	L	9-9-1981	FDEP-Punta Gorda			canal at Moore Haven
Oecetis cinerascens	Chipola R	Chipola R	Jackson	L	7-19-1977	FDEP-Pensacola	30 52 16	85 15 15	below SR-162
Oecetis cinerascens	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oecetis cinerascens	Kissimmee R	Arbuckle Ck	Highlands	L	12-12-1977	FDEP-Punta Gorda			below Arbuckle Ck Rd.

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Oecetis cinerascens	Kissimmee R	Kissimmee R	Glades	L	5-26-1987	FDEP-Punta Gorda			at Rt. 78
Oecetis cinerascens	Kissimmee R	Kissimmee R	Osceola	L	4-18-1984	FDEP-Punta Gorda			canal above Lock 65A
Oecetis cinerascens	Kissimmee R	Lake June-in-winter	Highlands	L	2-7-1985	FDEP-Punta Gorda			none
Oecetis cinerascens	Kissimmee R	Lake Lotela	Highlands	L	6-11-1986	FDEP-Punta Gorda			none
Oecetis cinerascens	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Oecetis cinerascens	Ochlockonee R	Lake Jackson	Leon	L	6-7-1977	FAMU	30 32 00	84 19 00	dead end Fuller Rd.
Oecetis cinerascens	Ochlockonee R	Lake Jackson	Leon	L	6-17-1977	FAMU	30 32 00	84 19 00	dead end Fuller Rd.
Oecetis cinerascens	Ochlockonee R	Lake Jackson	Leon	L	6-27-1977	FAMU	30 32 00	84 19 00	dead end Fuller Rd.
Oecetis cinerascens	Ochlockonee R	Lake Jackson	Leon	L	4-6-1978	FAMU	30 32 00	84 19 00	dead end Fuller Rd.
Oecetis cinerascens	Ochlockonee R	Lake Jackson	Leon	L	5-8-1978	FAMU	30 32 00	84 19 00	dead end Fuller Rd.
Oecetis cinerascens	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	S-12 at bridge, 5 mi SW Havana
Oecetis cinerascens	Southeast FL Coast	Canal C-13	Broward	L	8-1-1960	FAMU			New Basin
Oecetis cinerascens	Southeast FL Coast	Canal C-13	Broward	L	1-16-1961	FAMU			New Basin, Sta. Pkwy
Oecetis cinerascens	St. Johns R, lower	Strawberry Ck	Duval	L	7-16-1952	FAMU			Lone Star
Oecetis cinerascens	St. Marks R	Burnt Mill Ck	Jefferson	A	6-15-1981	FAMU	30 25 31	84 01 11	Hwy. 59
Oecetis cinerascens	Suwannee R, upper	Suwannee R	Hamilton	A	6-22-1976	FAMU	30 19 33	82 44 20	Int. Rt. 41
Oecetis cinerascens	unknown	Ocean Pond	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For.
Oecetis daytona			Alachua	A		(Floyd, 1994)			[no specific locality mentioned]
Oecetis daytona			Columbia	A		(Floyd, 1994)			[no specific locality mentioned]
Oecetis daytona			Duval	A		(Floyd, 1994)			[no specific locality mentioned]
Oecetis daytona			Lee	A		(Floyd, 1994)			[no specific locality mentioned]
Oecetis daytona	East Coast, upper	unknown	Volusia	A	7-27-1945	(Ross, 1947)	29 12 40	81 01 23	Daytona Beach
Oecetis ditissa	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Oecetis ditissa	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Oecetis ditissa	Ochlockonee R	FAMU Farm St	Gadsden	A	10-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis ditissa	Ochlockonee R	FAMU Farm St	Gadsden	A	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis ditissa	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis floridanus	Southeast FL Coast	Biscayne Bay	Dade	A		(Morse, In Press)	25 46 28	80 11 38	none
Oecetis georgia	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Oecetis georgia	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Oecetis georgia	Ochlockonee R	Telogia Ck	Gadsden	L	7-1-1987	FAMU	30 35 40	84 42 36	Rt. 270A (bridge)
Oecetis georgia	Steinhatchee R	Econfina R	Taylor	L	6-19-1991	FAMU	30 15 01	83 42 04	US Hwy 27
Oecetis georgia	Steinhatchee R	Econfina R	Taylor	L	8-21-1991	FAMU	30 15 01	83 42 04	US Hwy 27
Oecetis georgia	Steinhatchee R	Fenholloway R	Taylor	L	5-29-1991	FAMU	30 04 37	83 29 46	@ Fenholloway

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Oecetis georgia	Steinhatchee R	Fenholloway R	Taylor	L	8-31-1991	FAMU	30 04 37	83 29 46	@ Fenholloway
Oecetis georgia	Suwannee R, upper	Suwannee R	Hamilton	L	9-22-1976	FAMU	30 19 33	82 44 20	Int. Rt. 41
Oecetis georgia	Suwannee R, upper	Suwannee R	Hamilton	L	3-29-1977	FAMU	30 19 54	82 46 01	nr. S.F. Mem.
Oecetis georgia	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Oecetis inconspicua	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Oecetis inconspicua	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Oecetis inconspicua	Apalachicola R	small stream	Liberty	A	5-8-1968	FAMU	30 34 09	84 56 51	Torreya St. Park
Oecetis inconspicua	Apalachicola R	unnamed stream	Liberty	A	7-18-1990	FAMU	30 34 09	84 56 51	Torreya St. Park
Oecetis inconspicua	Aucilla R	Aucilla R	Jefferson	L	6-26-1991	FAMU	30 29 34	83 43 52	US 90 bridge
Oecetis inconspicua	Aucilla R	Aucilla R	Jefferson	P	6-19-1991	FAMU	30 29 34	83 43 52	US 90 bridge
Oecetis inconspicua	Escambia R	Escambia R	Escambia	L	3-28-1953	FAMU			E. Basin
Oecetis inconspicua	Everglades-W. Coast	Canal #846	Collier	L	6-8-1960	FAMU			5 mi W US 41
Oecetis inconspicua	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Oecetis inconspicua	Ochlockonee R	Burnt Mill Ck	Jefferson	A	5-19-1990	FAMU	30 25 31	84 01 11	Hwy. 59
Oecetis inconspicua	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis inconspicua	Ochlockonee R	FAMU Farm St	Gadsden	A	10-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis inconspicua	Ochlockonee R	FAMU Farm St	Gadsden	A	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis inconspicua	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis inconspicua	Ochlockonee R	FAMU Farm St	Gadsden	L	8-2-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis inconspicua	Ochlockonee R	Lake Jackson	Leon	L	6-7-1977	FAMU	30 32 00	84 19 00	dead end Fuller Rd
Oecetis inconspicua	Ochlockonee R	Lake Jackson	Leon	L	6-17-1977	FAMU	30 32 00	84 19 00	dead end Fuller Rd
Oecetis inconspicua	Ochlockonee R	Lake Jackson	Leon	L	6-27-1977	FAMU	30 32 00	84 19 00	dead end Fuller Rd
Oecetis inconspicua	Ochlockonee R	Lake Jackson	Leon	L	7-3-1978	FAMU	30 32 00	84 19 00	dead end Fuller Rd
Oecetis inconspicua	Ochlockonee R	Little R	Gadsden	A	6-10-1986	FAMU	30 30 45	84 31 24	C-268, 6.5 mi SE Quincy
Oecetis inconspicua	Ochlockonee R	Little R	Gadsden	A	6-26-1986	FAMU	30 35 15	84 29 48	S-12, 5 Mi SW Havana
Oecetis inconspicua	Ochlockonee R	Ochlockonee R	Leon	A	4-29-1981	FAMU	30 31 43	84 23 23	Wildlife Mgnt. Area, N Tallahassee
Oecetis inconspicua	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	CR-267, 10 mi S Quincy
Oecetis inconspicua	Ochlockonee R	Telogia Ck	Liberty	A	4-29-1989	FAMU	30 25 36	84 55 39	S-20 at br. 2.5 mi E Bristol
Oecetis inconspicua	Peace R	Bear St	Polk	L	3-6-1951	FAMU			none
Oecetis inconspicua	Perdido R	Jack's Branch	Escambia	L	10-27-1952	FAMU			none
Oecetis inconspicua	Southeast FL Coast	Canal C-13	Broward	L	8-1-1960	FAMU			New Basin
Oecetis inconspicua	Southeast FL Coast	Plantation Canal	Broward	L	2-9-1960	FAMU			New Basin
Oecetis inconspicua	Southeast FL Coast	S new River Canal	Broward	L	8-10-1959	FAMU			none
Oecetis inconspicua	St. Marks R	St. Marks R	Leon	L	7-31-1991	FAMU	30 26 36	84 06 11	1.5 km NE Chaires

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Oecetis inconspicua	Steinhatchee R	Fenholloway R	Taylor	L	7-31-1991	FAMU	30 04 19	83 39 39	SR 356
Oecetis inconspicua	Suwannee R, upper	Suwannee R	Hamilton	A	4-13-1977	FAMU	30 19 33	82 44 20	SR 41
Oecetis inconspicua	Suwannee R, upper	Suwannee R	Suwannee	A	4-13-1977	FAMU	30 24 01	83 09 30	Suwannee R State Park
Oecetis inconspicua	Waccasassa R	Waccasassa R	Levy	L	10-17-1951	FAMU			none
Oecetis inconspicua	Withlacoochee R, S.	Withlacoochee R	Pasco	L	5-26-1953	FAMU			W Basin
Oecetis inconspicua	Withlacoochee R, S.	Withlacoochee R	Pasco	L	5-11-1954	FAMU			W Basin
Oecetis inconspicua	unknown	Ocean Pond	Baker	A	9-22-1976	FAMU	30 13 00	82 26 00	Osceola Nat. Forest
Oecetis inconspicua	unknown	Ocean Pond	Baker	A	2-6-1977	FAMU	30 22 58	82 19 54	Osceola Nat. For. E fire Tower
Oecetis inconspicua	unknown	Ocean Pond	Baker	A	4-14-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For. Rt. 90
Oecetis inconspicua	unknown	Ocean Pond	Baker	A	5-16-1977	FAMU	30 12 00	82 30 00	Osceola Nat. For. jct. Rt. 90
Oecetis inconspicua	unknown	Ocean Pond	Baker	L	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For. Rec. Area
Oecetis morsei	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Oecetis nocturna	Escambia R	Escambia R	Escambia	L	7-7-1977	FDEP-Pensacola	30 58 01	87 13 56	Hwy. 4, live corbicula
Oecetis nocturna	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Oecetis nocturna	Ochlockonee R	FAMU Farm St	Gadsden	A	10-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis nocturna	Ochlockonee R	Little R	Gadsden	A	6-10-1986	FAMU	30 30 45	84 31 24	C-268, 6.5 Mi SE Quincy
Oecetis nocturna	Ochlockonee R	Oklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	C-267, 10 mi S Quincy
Oecetis nocturna	St. Johns R, upper	L. Wekiva R	Seminole	L		FAMU			none
Oecetis nocturna	St. Johns R, upper	Sweetwater Branch	Flager	L	8-15-1951	FAMU			none
Oecetis nocturna	St. Marks R	St. Marks R	Leon	L	7-31-1991	FAMU	30 24 36	84 05 41	1 km S US-27
Oecetis osteni	Apalachicola R	small stream	Liberty	A	5-8-1968	FAMU	30 34 09	84 56 51	Torreya State Park
Oecetis osteni	Aucilla R	Aucilla R	Jefferson	A	8-24-1967	FAMU			none
Oecetis osteni	Blackwater R	Blackwater R	Okaloosa	A	4-13-1973	FAMU	30 44 20	86 47 12	FAMU Bio. Sta., 4.5 mi NW Holt
Oecetis osteni	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oecetis osteni	Ochlockonee R	Attapulgus Ck	Gadsden	A	4-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Oecetis osteni	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis osteni	Ochlockonee R	Little R	Gadsden	A	6-10-1986	FAMU	30 30 45	84 31 24	C-268, 6.5 mi SE Quincy
Oecetis osteni	Ochlockonee R	Oklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	C-267, 10 mi S Quincy
Oecetis osteni	Ochlockonee R	Rocky Comfort Ck	Gadsden	L	1-14-1987	FAMU			SR-12 bridge
Oecetis osteni	Suwannee R, upper	Suwannee R	Hamilton	A	3-29-1977	FAMU	30 19 54	82 46 01	nr. S. Foster Mem.
Oecetis osteni	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Oecetis osteni	unknown	Ocean Pond	Baker	A	5-16-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For.
Oecetis osteni	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For.
Oecetis parva	Choctawhatchee R	Lucas Lake	Washington	L		(Floyd, 1994)			public boat ramp, 9 km SSE Vernon

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Oecetis parva	unknown	unknown	Osceola	A		(Banks, 1907)			Kissimmee
Oecetis persimilis	Aucilla R	Aucilla R	Jefferson	L	6-19-1991	FAMU	30 08 51	83 58 14	US 98
Oecetis persimilis	Ochlockonee R	Little R	Gadsden	A	6-10-1986	FAMU	30 30 45	84 31 24	C-268, 6.5 mi SE Quincy
Oecetis persimilis	Ochlockonee R	Quincy Ck	Gadsden	L	9-23-1987	FAMU	30 35 15	84 35 00	nr. Quincy
Oecetis persimilis	Ochlockonee R	Telogia Ck	Gadsden	L	7-1-1987	FAMU			@ 65D bridge
Oecetis persimilis	Peace R	Bear Branch Stream	Polk	L,P	1-9-1951	FAMU			none
Oecetis persimilis	Perdido R	Perdido R	Escambia	L	8-24-1976	FDEP-Pensacola	30 36 14	87 24 15	Hwy. 184
Oecetis persimilis	Santa Fe R	Santa Fe R	Alachua	L	7-14-1952	FAMU			none
Oecetis persimilis	St. Johns R, lower	Black Ck	Clay	L	1-4-1952	FAMU			none
Oecetis persimilis	St. Johns R, lower	small stream	Clay	L	6-25-1951	FAMU			none
Oecetis persimilis	St. Johns R, upper	Oklawaha R	Marion	L	3-13-1952	FAMU			none
Oecetis persimilis	St. Marks R	Burnt Mill Ck	Jefferson	A	5-19-1980	FAMU	30 25 31	84 01 11	St. Hwy. 59
Oecetis persimilis	St. Marks R	Burnt Mill Ck	Jefferson	A	7-29-1980	FAMU	30 25 31	84 01 11	St. Hwy. 59
Oecetis persimilis	St. Marks R	Burnt Mill Ck	Jefferson	A	8-17-1980	FAMU	30 25 31	84 01 11	St. Hwy. 59
Oecetis persimilis	St. Marks R	Burnt Mill Ck	Jefferson	L	6-29-1991	FAMU	30 25 31	84 01 11	St. Hwy. 59
Oecetis persimilis	St. Marks R	Burnt Mill Ck	Jefferson	L	7-31-1991	FAMU	30 25 31	84 01 11	St. Hwy. 59
Oecetis persimilis	Steinhatchee R	Econfina R	Taylor	L	6-19-1991	FAMU	30 08 33	83 51 58	US-98
Oecetis persimilis	Steinhatchee R	Fenholloway R	Taylor	L	9-12-1951	FAMU			none
Oecetis persimilis	Suwannee R, lower	small stream	Lafayette	L	7-7-1953	FAMU			none
Oecetis persimilis	Suwannee R, upper	Suwannee R	Hamilton	A	9-22-1976	FAMU	30 19 33	82 44 20	Rt. 41
Oecetis persimilis	Suwannee R, upper	Suwannee R	Hamilton	L	6-10-1953	FAMU			none
Oecetis persimilis	Suwannee R, upper	small stream	Hamilton	L	3-10-1991	FAMU			none
Oecetis persimilis	Withlacoochee R, S.	Withlacoochee R	Pasco	L	5-11-1954	FAMU			W. Basin
Oecetis persimilis	Withlacoochee R, S.	Withlacoochee R	Pasco	P	3-9-1955	FAMU			W. Basin
Oecetis persimilis	unknown	Ocean Pond	Baker	A	5-16-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For.
Oecetis persimilis	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	jct. S-241& S-241E
Oecetis porteri	Kissimmee R	Lake Clay	Highlands	L	9-8-1981	FDEP-Punta Gorda			none
Oecetis porteri	Kissimmee R	Lake Josephine	Highlands	L	1-29-1985	FDEP-Punta Gorda	27 24 00	81 25 00	none
Oecetis porteri	Peace R	Lake McCloud	Polk	L	8-8-1951	FAMU			Eloise
Oecetis porteri	Santa Fe R	Santa Fe Lake	Alachua	L	2-21-1992	J. H. Epler			none
Oecetis porteri	Southeast FL Coast	unknown	Dade	A	11-20-1945	(Ross, 1947)	25 46 28	80 11 38	Miami
Oecetis porteri	unknown	Ocean Pond	Baker	A	4-12-1977	FAMU			Osceola Nat. For.
Oecetis pratelia	unknown	unknown	Hendry	A	7-16-1939	(Denning, 1948b)			LaBelle
Oecetis sp. A Floyd	Caloosahatchee R	Roberts Canal	Hendry	L	1-30-1987	FDEP-Punta Gorda			none

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Oecetis sp. A Floyd	Choctawhatchee Bay	Lafayette Ck	Walton	L	2-20-1978	FDEP-Pensacola	30 29 35	86 07 31	Rt. 20
Oecetis sp. A Floyd	Fisheating Ck	Fisheating Ck	Glades	L	8-30-1983	FDEP-Punta Gorda			at Rt. 27
Oecetis sp. A Floyd	Peace R	Peace R	De Soto	L	3-3-1981	FDEP-Punta Gorda			above Rt. 72
Oecetis sp. A Floyd	Perdido Bay	Elevenmile Ck	Escambia	L	1-4-1978	FDEP-Pensacola	30 30 00	87 20 00	above Hwy 90 & landfill
Oecetis sp. C Floyd	Kissimmee R	Lake Grassy	Highlands	L	9-26-1985	FDEP-Punta Gorda			none
Oecetis sp. C Floyd	Kissimmee R	Lake Placid	Highlands	L	12-11-1984	FDEP-Punta Gorda			none
Oecetis sp. C Floyd	Santa Fe R	Santa Fe Lake	Alachua	L	2-25-1991	J. H. Epler			none
Oecetis sp. C Floyd	unknown	Hutchinson Lake	Clay	L	3-15-1992	(Floyd, 1994)			off Rt. 214, 2.5 km S L. Geneva
Oecetis sp. C Floyd	unknown	unnamed pond	Clay	L	3-15-1993	(Floyd, 1994)			off Duval Rd., 5 km SW Kingsley L.
Oecetis sp. F Floyd	Blackwater R	Blackwater R	Okaloosa	L	7-6-1977	FDEP-Pensacola	30 50 00	86 44 02	Hwy. 4
Oecetis sp. F Floyd	Caloosahatchee R	Gator Slough Canal	Charlotte	L	10-8-1985	FDEP-Punta Gorda			none
Oecetis sp. F Floyd	Caloosahatchee R	Roberts Canal	Hendry	L	1-30-1984	FDEP-Punta Gorda			none
Oecetis sp. F Floyd	Caloosahatchee R	wet marsh	Charlotte	L		FDEP-Punta Gorda			none
Oecetis sp. F Floyd	Kissimmee R	Haw Branch Ck	Highlands	L	7-5-1984	FDEP-Punta Gorda			none
Oecetis sp. F Floyd	Kissimmee R	Lake Tohopekaliga	Osceola	L	3-16-1993	(Floyd, 1994)			@ Southport Pk., off Rt. 531
Oecetis sp. F Floyd	Lake Okeechobee	Lake Okeechobee	Okeechobee	L		FDEP-Punta Gorda			from Vallisneria
Oecetis sphyra	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Oecetis sphyra	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Oecetis sphyra	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Oecetis sphyra	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Oecetis sphyra	Ochlockonee R	Oklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	C-267, 10 mi S Quincy
Oecetis sphyra	Suwannee R, upper	Suwannee R	Hamilton	A	9-22-1976	FAMU	30 19 33	82 44 20	Rt. 41
Oecetis sphyra	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Setodes guttatus	Chipola R	Chipola R	Calhoun	A	6-28-1972	FAMU	30 25 52	85 10 19	Hwy. 20
Setodes n. sp.	Chipola R	Chipola R	Calhoun	A	6-28-1972	FAMU	30 25 52	85 10 19	Hwy. 20
Triaenodes abus	unknown	unknown	Columbia	A	4-12-1977	FAMU	30 12 00	82 30 00	Osceola Nat. For.,jct S-234 & US90
Triaenodes flavescens	St. Marks R	St. Marks R	Wakulla	L	6-22-1962	FAMU			none
Triaenodes flavescens	St. Marks R	St. Marks R	Wakulla	L	12-9-1991	FAMU	30 12 14	84 10 38	US-98 at Newport
Triaenodes flavescens	St. Marks R	St. Marks R	Wakulla	L	12-9-1992	FAMU	30 12 14	84 10 38	US-98 at Newport
Triaenodes florida	Choctawhatchee R	unknown	Washington	A	5-30-1940	(Ross, 1941)			Ebro
Triaenodes florida	Kissimmee R	Lake Annie	Highlands	L	4-23-1985	FDEP-Punta Gorda			none
Triaenodes florida	Oklawaha R	Red Water Lake	Putnam	A	4-23-1966	FAMU			none
Triaenodes florida	unknown	unknown	Alachua	A	4-2-1939	(Ross, 1941)	29 39 07	82 19 31	Gainesville
Triaenodes florida	unknown	unknown	Alachua	A	6-20-1948	FAMU	29 39 07	82 19 31	Gainesville

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Triaenodes florida	unknown	unknown	Levy	A	6-3-1954	FAMU			none
Triaenodes furcellus	Charlotte Harbor	Alligator Ck	Charlotte	L	10-18-1983	FDEP-Punta Gorda			North Prong
Triaenodes furcellus	Fisheating Ck	Fisheating Ck	Glades	L	4-29-1987	FDEP-Punta Gorda			@ Rt. 78
Triaenodes furcellus	Kissimmee R	Arbuckle Ck	Highlands	L	12-12-1977	FDEP-Punta Gorda			below Arbuckle Ck Rd.
Triaenodes furcellus	Kissimmee R	Kissimmee R	Highlands	L	5-5-1961	FAMU			along US 98
Triaenodes furcellus	Kissimmee R	Lake Placid	Highlands	L	9-18-1985	FDEP-Punta Gorda			none
Triaenodes furcellus	St. Johns R, upper	unknown	Putnam	A		(Ross, 1959)	29 23 31	81 38 20	Georgetown
Triaenodes furcellus	unknown	unknown	Hillsborough	A	4-19-1960	FAMU			none
Triaenodes furcellus	unknown	unknown	Orange	A	5-5-1944	(Ross, 1959)			Orlando
Triaenodes helo	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Triaenodes helo	Peace R	tributary	Highlands	L	3-16-1993	(Glover, 1993)	27 28 23	81 31 41	Highlands Hammock State Park
Triaenodes helo	St. Johns R, lower	trib. of Six Mile Ck	Duvall	L	3-15-1993	(Glover, 1993)			none
Triaenodes helo	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Triaenodes helo	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Triaenodes ignitus	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Triaenodes ignitus	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Triaenodes ignitus	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Triaenodes ignitus	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Triaenodes ignitus	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Triaenodes ignitus	Apalachicola R	Little Sweetwater Ck	Liberty	L	8-30-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Triaenodes ignitus	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Triaenodes ignitus	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	3 mi NW Havana
Triaenodes ignitus	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Triaenodes ignitus	Ochlockonee R	FAMU Farm St	Gadsden	A	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Triaenodes ignitus	Ochlockonee R	Little R	Gadsden	A	6-10-1986	FAMU	30 30 45	84 31 24	C-268, 6.5 mi SE Quincy
Triaenodes ignitus	Ochlockonee R	Oklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	C-267, 10 mi S Quincy
Triaenodes ignitus	Peace R	Horse Ck	DeSoto	L	2-17-1981	FAMU			@ Rt. 72
Triaenodes ignitus	St. Andrews Bay	Sweetwater Ck	Bay	L	2-21-1995	FAMU			@ US Hwy 231, 6 km N Fountain
Triaenodes ignitus	St. Marks R	Burnt Mill Ck	Jefferson	A	7-17-1980	FAMU	30 25 31	84 01 11	at bridge St. Hwy 59
Triaenodes ignitus	St. Marks R	Burnt Mill Ck	Jefferson	L	6-3-1992	FAMU	30 25 31	84 01 11	CR-59
Triaenodes ignitus	St. Marks R	Burnt Mill Ck	Jefferson	L	9-29-1992	FAMU	30 25 31	84 01 11	CR-59
Triaenodes ignitus	St. Marks R	Burnt Mill Ck	Jefferson	L	12-2-1992	FAMU	30 24 30	84 03 50	US Hwy 27
Triaenodes ignitus	St. Marks R	Burnt Mill Ck	Jefferson	L	12-2-1992	FAMU	30 25 31	84 01 11	CR-59
Triaenodes ignitus	St. Marks R	Burnt Mill Ck	Jefferson	L	2-4-1993	FAMU	30 25 31	84 01 11	CR-59

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Triaenodes ignitus	St. Marks R	Burnt Mill Ck	Jefferson	L	4-1-1993	FAMU	30 25 31	84 01 11	CR-59
Triaenodes ignitus	St. Marks R	St. Marks R	Wakulla	L	6-22-1955	FAMU			none
Triaenodes ignitus	Steinhatchee R	Fenholloway R	Taylor	A	7-4-1953	FAMU			none
Triaenodes ignitus	Suwannee R, lower	Suwannee R	Lafayette	L	11-12-1953	FAMU			none
Triaenodes ignitus	Suwannee R, upper	Suwannee R	Hamilton	A	9-22-1976	FAMU	30 19 33	82 44 20	@ Rt. 41
Triaenodes ignitus	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Triaenodes ignitus	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Triaenodes ignitus	unknown	unknown	Columbia	A	4-12-1977	FAMU	30 12 00	82 30 00	Osceola Nat. For, jct S-234 & Rt 90
Triaenodes n. sp. A						(Glover, 1993)			[no specific locality mentioned]
Triaenodes n. sp. C						(Glover, 1993)			[no specific locality mentioned]
Triaenodes nox	Ochlockonee R	Ochlockonee R	Leon	A	4-29-1981	FAMU	30 31 43	84 23 23	Wildlife mgnt. area, nr Tower Rd.
Triaenodes nox	St. Marks R	Lake Miccosukee	Jefferson	L	4-11-1951	FAMU			nr US 90
Triaenodes ochraceus	Aucilla R	Aucilla R	Jefferson	L	2-25-1993	FAMU	30 29 34	83 43 52	US Hwy 90
Triaenodes ochraceus	Ochlockonee R	Attapulgus Ck	Gadsden	A	4-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Triaenodes ochraceus	St. Johns, lower	trib. Six Mile Ck	Duval	L	3-15-1993	(Glover, 1993)			none
Triaenodes perna	Aucilla R	Aucilla R	Jefferson	L	12-16-1991	(Glover, 1993)	30 22 22	83 48 21	at US 27 bridge
Triaenodes perna	Chipola R	Chipola R	Jackson	L	12-15-1991	(Glover, 1993)	30 48 51	85 14 00	Florida Caverns State Park
Triaenodes perna	St. Johns R, upper	Lake Howell	Seminole	L	10-13-1959	(Glover, 1993)			none
Triaenodes tardus	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L	7-27-1977	(Glover, 1993)	30 32 00	84 19 00	none
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L	12-7-1977	(Glover, 1993)	30 32 00	84 19 00	none
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L	1-4-1978	(Glover, 1993)	30 32 00	84 19 00	none
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L	2-3-1978	(Glover, 1993)	30 32 00	84 19 00	none
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L	3-10-1978	(Glover, 1993)	30 32 00	84 19 00	none
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L	4-28-1978	(Glover, 1993)	30 32 00	84 19 00	none
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L	5-8-1978	(Glover, 1993)	30 32 00	84 19 00	none
Triaenodes tardus	Ochlockonee R	Lake Jackson	Leon	L,P	8-5-1978	(Glover, 1993)	30 32 00	84 19 00	none

END OF DATA TABLE

TRICHOPTERA DATABASE: FLORIDA LIMNEPHILIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Ironquia punctatissima	Ochlockonee R	Ochlockonee R	Leon	L	2-10-1977	FDEP-Pensacola	30 40 08	84 18 23	SR-12
Ironquia punctatissima	Ochlockonee R	unknown	Leon	A	11-15-1967	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Ironquia punctatissima	St. Marks R	St. Marks R	Leon	L	2-5-1992	FAMU	30 26 36	84 06 11	1.5 km NE of Chaires
Pycnopsyche antica	Apalachicola R	Beaver Dam Ck	Liberty	A	12-7-1994	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Pycnopsyche antica	Apalachicola R	Beaver Dam Ck	Liberty	A	10-26-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Pycnopsyche antica	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Pycnopsyche antica	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Pycnopsyche antica	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Pycnopsyche antica	Ochlockonee R	unknown	Gadsden	A	10-13-1958	FAMU	30 35 15	84 35 00	Quincy
Pycnopsyche antica	Ochlockonee R	unknown	Gadsden	A	11-3-1958	FAMU	30 35 15	84 35 00	Quincy
Pycnopsyche antica	Ochlockonee R	unknown	Leon	A	10-20-1967	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Pycnopsyche antica	Ochlockonee R	unknown	Leon	A	11-15-1967	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Pycnopsyche antica	Suwannee R, upper	Rocky Ck	Suwannee	A	10-20-1976	FAMU	30 18 58	82 50 41	S-136
Pycnopsyche antica	unknown	unknown	Baker	A	11-10-1976	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line, Hwy 90
Pycnopsyche antica	unknown	unknown	Gadsden	A		(Wojtowicz, 1982)			none
Pycnopsyche antica	unknown	unknown	Jefferson	A	11-13-1958	FAMU	30 32 43	83 52 13	Monticello
Pycnopsyche antica	unknown	unknown	Okaloosa	A		(Wojtowicz, 1982)			none
Pycnopsyche indiana	unknown	unknown	unknown			(Wojtowicz, 1982)			Coastal Plain streams

END OF DATA TABLE

TRICHOPTERA DATABASE: FLORIDA MOLANNIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Molanna blenda	Apalachicola R	Beaver Dam Ck	Liberty	A	3-22-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Molanna blenda	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Molanna blenda	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Molanna blenda	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Molanna blenda	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Molanna blenda	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Molanna blenda	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Molanna blenda	Ochlockonee R	FAMU Farm Stream	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Molanna blenda	Ochlockonee R	FAMU Farm Stream	Gadsden	L	8-18-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Molanna tryphena	Apalachicola R	Beaver Dam Ck	Liberty	A	12-7-1994	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Molanna tryphena	Apalachicola R	Beaver Dam Ck	Liberty	A	3-22-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Molanna tryphena	Apalachicola R	Beaver Dam Ck	Liberty	A	10-26-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N Bristol
Molanna tryphena	Apalachicola R	Little Sweetwater Ck	Liberty	A	4-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Molanna tryphena	Apalachicola R	Little Sweetwater Ck	Liberty	A	12-7-1994	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Molanna tryphena	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Molanna tryphena	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Molanna tryphena	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Molanna tryphena	Blackwater R	Bone Ck	Okaloosa	L	12-17-1978	FAMU	30 44 00	86 45 00	none
Molanna tryphena	Choctawhatchee Bay	Eagle Ck	Walton	L	4-27-1977	FDEP-Pensacola	30 27 50	86 22 37	Hwy. 20
Molanna tryphena	Choctawhatchee Bay	Lafayette Ck	Walton	L	1-8-1972	FAMU	30 29 35	86 07 31	Hwy. 20
Molanna tryphena	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Molanna tryphena	St. Marks R	Burnt Mill Ck	Jefferson	L	12-2-1992	FAMU	30 24 30	84 03 50	US Hwy 27
Molanna tryphena	Steinhatchee R	Econfina R	Taylor	L	6-16-1991	FAMU	30 15 01	83 42 04	US Hwy 27
Molanna tryphena	Steinhatchee R	Econfina R	Taylor	L	10-22-1991	FAMU	30 15 01	83 42 04	US Hwy 27
Molanna tryphena	Steinhatchee R	Econfina R	Taylor	L	12-9-1991	FAMU	30 15 01	83 42 04	US Hwy 27
Molanna tryphena	Steinhatchee R	Econfina R	Taylor	L	12-9-1992	FAMU	30 15 01	83 42 04	US Hwy 27
Molanna tryphena	Steinhatchee R	Econfina R	Taylor	L	2-18-1993	FAMU	30 15 01	83 42 04	US Hwy 27
Molanna tryphena	Steinhatchee R	Fenholloway R	Taylor	L	7-31-1991	FAMU	30 04 37	83 29 46	@ Fenholloway
Molanna tryphena	Suwannee R, upper	Suwannee R	Hamilton	L	12-17-1991	FAMU	30 33 54	82 43 27	7.5 km N SR-6
Molanna tryphena	Suwannee R, upper	Suwannee R	Hamilton	L	6-24-1992	FAMU	30 33 54	82 43 27	7.5 km N SR-6
Molanna tryphena	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Molanna tryphena	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Molanna tryphena	unknown	Black Branch	Clay	L	6-13-1990	FDEP-Tallahassee	29 57 00	81 54 00	Camp Blanding
Molanna ulmerina	Chipola R	unknown	Jackson	A	4-13-1960	FAMU	30 48 51	85 14 00	Florida Caverns
Molanna ulmerina	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA ODONTOCERIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Psilotreta frontalis	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	Kelley Branch	Liberty	A	10-26-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	Kelley Branch	Liberty	L	3-11-1994	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	Little Sweetwater Ck	Liberty	L	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	Little Sweetwater Ck	Liberty	L	10-26-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Psilotreta frontalis	Apalachicola R	unnamed stream	Liberty	A	3-22-1995	FAMU	30 27 55	84 59 07	ABRP, just NE of bluff overlook
Psilotreta frontalis	Ochlockonee R	Bear Ck	Gadsden	A	5-13-1970	(Parker & Wiggins, 1987)	30 28 16	84 35 32	1 mi. N Hwy 65C
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	A	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	12-5-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	2-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	6-10-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	10-14-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	4-7-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	9-28-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	1-27-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	4-19-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	FAMU Farm St	Gadsden	L	8-18-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Psilotreta frontalis	Ochlockonee R	Turkey Ck	Gadsden	A	4-24-1994	FAMU	30 31 15	84 34 53	4 mi. S Quincy, off Hwy 267A

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA PHILOPOTAMIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Chimarra aterrima	Apalachicola R	Beaver Dam Ck	Liberty	A	3-22-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Chimarra aterrima	Apalachicola R	Beaver Dam Ck	Liberty	A	8-30-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Chimarra aterrima	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Chimarra aterrima	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Chimarra aterrima	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Chimarra aterrima	Apalachicola R	unnamed stream	Liberty	A	3-22-1995	FAMU	30 27 55	84 59 07	ABRP, 5 km N of Bristol
Chimarra aterrima	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Chimarra aterrima	Ochlockonee R	Turkey Ck	Gadsden	A	8-21-1994	FAMU	30 31 15	84 34 53	headwaters, 5 km S Quincy
Chimarra aterrima	Oklawaha R	Hogtown Ck	Alachua	A	5-31-1958	FAMU	29 39 07	82 19 31	wooded ravine, Gainesville
Chimarra aterrima	Oklawaha R	unknown	Alachua	A	3-20-1964	FAMU	29 39 07	82 19 31	Devil's Millhopper, Gainesville
Chimarra aterrima	Suwannee R, upper	Rocky Ck	Suwannee	A	9-28-1976	FAMU	30 18 57	82 50 42	SR-136
Chimarra aterrima	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Chimarra aterrima	unknown	unknown	Alachua	A	3-8-1955	FAMU			none
Chimarra aterrima	unknown	unknown	Clay	A	5-20-1961	FAMU			Camp Crystal, ravine stream
Chimarra falculata	Apalachicola R	Beaver Dam Ck	Liberty	A	8-30-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Chimarra falculata	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Chimarra falculata	Apalachicola R	Kelley Branch	Liberty	A	10-26-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Chimarra falculata	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Chimarra falculata	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Chimarra falculata	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Chimarra falculata	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Chimarra falculata	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Chimarra falculata	Choctawhatchee Bay	Rocky Ck	Walton	A	3-14-1979	(Lago & Harris, 1987)	30 39 00	86 20 00	4 mi SW Mossy Head
Chimarra falculata	Choctawhatchee Bay	Rocky Ck	Walton	A	4-25-1979	(Lago & Harris, 1987)	30 39 00	86 20 00	4 mi SW Mossy Head
Chimarra falculata	Choctawhatchee Bay	Rocky Ck	Walton	A	5-11-1979	(Lago & Harris, 1987)	30 39 00	86 20 00	4 mi SW Mossy Head
Chimarra falculata	Choctawhatchee Bay	Rocky Ck	Walton	A	6-8-1979	(Lago & Harris, 1987)	30 39 00	86 20 00	4 mi SW Mossy Head
Chimarra falculata	Choctawhatchee Bay	Rocky Ck	Walton	A	8-16-1979	(Lago & Harris, 1987)	30 39 00	86 20 00	4 mi SW Mossy Head
Chimarra falculata	Choctawhatchee Bay	Rocky Ck	Walton	A	9-19-1979	(Lago & Harris, 1987)	30 39 00	86 20 00	4 mi SW Mossy Head
Chimarra falculata	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	10 mi S Quincy, C-267
Chimarra falculata	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Chimarra falculata	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Chimarra florida	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol

TRICHOPTERA DATABASE: FLORIDA PHILOPOTAMIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Chimarra florida	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Chimarra florida	Apalachicola R	unnamed stream	Liberty	A	3-22-1995	FAMU	30 27 55	84 59 07	ABRP, 5 km N of Bristol
Chimarra florida	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Chimarra florida	Choctawhatchee Bay	unknown	Walton	A	4-3-1938	(Ross, 1944)	30 30 15	86 08 10	Freeport
Chimarra florida	Kissimmee R	unknown	Highlands	A	3-8-1958	FAMU	27 29 44	81 26 28	Sebring
Chimarra florida	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	CR-159
Chimarra florida	Ochlockonee R	Telogia Ck	Liberty	A		FAMU	30 27 00	84 51 43	C-271
Chimarra florida	Ochlockonee R	Telogia Ck	Liberty	A	4-29-1987	FAMU	30 25 36	84 55 39	S-20
Chimarra florida	Oklawaha R	unknown	Alachua	A	9-23-1972	FAMU	29 39 07	82 19 31	Gainesville
Chimarra florida	Suwannee R, upper	Suwannee R	Hamilton	A	3-29-1977	FAMU	30 19 54	82 46 01	Stephen Foster Memorial
Chimarra florida	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Chimarra florida	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. Forest
Chimarra moselyi	Apalachicola R	unnamed stream	Liberty	A	3-22-1995	FAMU	30 27 55	84 59 07	ABRP, 5 km N of Bristol
Chimarra moselyi	Ochlockonee R	Turkey Ck	Gadsden	A	8-21-1994	FAMU	30 31 15	84 34 53	headwaters, 5 km S Quincy
Chimarra moselyi	Santa Fe R	Santa Fe R	Alachua	A	3-12-1938	(Ross, 1948b)	29 49 33	82 38 55	Santa Fe R @ Poe Springs
Chimarra moselyi	Santa Fe R	Santa Fe R	Alachua	A	4-6-1940	(Ross, 1948b)			[no specific locality]
Chimarra obscura	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Chimarra obscura	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Chimarra obscura	Santa Fe R	Santa Fe R	Columbia	A	5-4-1958	FAMU	29 55 00	82 35 00	O'Leno State Park
Chimarra parasocia						(Lago & Harris, 1987)			[previous records of C. socia]
Wormaldia moesta	Chipola R	Bridge Ck	Jackson	L	2-23-1993	FDEP-Pensacola	30 43 52	85 11 07	Hwy 71
Wormaldia moesta	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA PHRYGANEIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Agrypnia vestita	Apalachicola R	unknown	Liberty	A	4-17-1963	FAMU	30 34 09	84 56 51	Torreya State Park
Agrypnia vestita	Ochlockonee R	unknown	Leon	A	10-20-1967	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Agrypnia vestita	Ochlockonee R	unknown	Leon	A	11-15-1967	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Agrypnia vestita	Suwannee R, upper	Roaring Ck	Hamilton	L	1-17-1994	J. Epler	30 26 00	82 41 00	none
Agrypnia vestita	unknown	unknown	Okaloosa	A	9-29-1960	FAMU			none
Banksiola concatenata	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Banksiola concatenata	Ochlockonee R	unknown	Leon	A	4-4-1968	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Banksiola concatenata	Oklawaha R	unknown	Alachua	A	4-4-1967	FAMU	29 37 07	82 19 31	Gainesville
Banksiola concatenata	Oklawaha R	unknown	Alachua	A	4-5-1967	FAMU	29 37 07	82 19 31	Gainesville
Banksiola concatenata	Suwannee R, upper	unknown	Suwannee	A	4-13-1977	FAMU	30 24 01	83 09 30	Suwannee R State Park
Banksiola concatenata	unknown	Ocean Pond	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond rec. area
Ptilostomis postica	Blackwater R	Blackwater R	Okaloosa	A	5-1-1977	FAMU	30 44 20	86 47 12	FAMU Biological Station, 4.5 mi NW Holt
Ptilostomis postica	Ochlockonee R	unknown	Leon	A	10-20-1967	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Ptilostomis postica	Ochlockonee R	unknown	Leon	A	4-4-1968	FAMU	30 39 00	86 45 00	Tall Timbers Research Station
Ptilostomis postica	Suwannee R, upper	unknown	Suwannee	A	4-25-1977	FAMU	30 24 01	83 09 30	Suwannee R State Park
Ptilostomis postica	unknown	unknown	Jefferson	A	4-7-1959	FAMU	30 32 43	83 52 13	Monticello
Ptilostomis postica	unknown	unknown	Jefferson	A	4-27-1959	FAMU	30 32 43	83 52 13	Monticello
Ptilostomis postica	unknown	unknown	Jefferson	A	5-5-1959	FAMU	30 32 43	83 52 13	Monticello
Ptilostomis postica	unknown	unknown	Jefferson	A	5-2-1960	FAMU	30 32 43	83 52 13	Monticello
Ptilostomis postica	unknown	unknown	Jefferson	A	4-25-1961	FAMU	30 32 43	83 52 13	Monticello

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA POLYCENTROPODIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Cernotina calcea	Aucilla R	Aucilla R	Jefferson	A	10-14-1993	FAMU	30 16 25	83 51 25	SR-257, 8 mi S of Lamont
Cernotina calcea	Chipola R	Bridge Ck	Jackson	A	5-4-1995	FAMU	30 43 52	85 11 07	Hwy. 71
Cernotina calcea	Chipola R	Chipola R	Calhoun	A	8-1-1972	FAMU	30 25 52	85 10 19	Hwy. 20
Cernotina calcea	unknown	unknown	Alachua	A		(Gordon, 1984)			none
Cernotina spicata	Ochlockonee R	Attapulgus Ck	Gadsden	A	5-14-1986	FAMU	30 39 46	84 27 48	C-159, 3 mi NW Havana
Cernotina truncona	East Coast, Upper	unknown	Volusia	A	6-27-1945	(Ross, 1947)	29 12 40	81 01 23	Daytona Beach
Cernotina truncona	unknown	unknown	Alachua	A		(Gordon, 1984)			none
Cernotina truncona	unknown	unknown	Baker	A		(Gordon, 1984)			none
Cernotina truncona	unknown	unknown	Pasco	A		(Gordon, 1984)			none
Cernotina truncona	unknown	unknown	Putnam	A		(Gordon, 1984)			none
Cyrnellus fraternus	Apalachicola R	Apalachicola R	Jackson	L	9-25-1990	FDEP-Tallahassee			Scholz up A
Cyrnellus fraternus	Chipola R	Chipola R	Calhoun	A	8-1-1972	FAMU	30 25 52	85 10 19	SR-20
Cyrnellus fraternus	Fisheating Ck	Fisheating Ck	Glades	L	8-6-1985	FDEP-Punta Gorda	26 55 59	81 18 56	Rt. 27 in Palmdale
Cyrnellus fraternus	Ochlockonee R	Little R	Gadsden	L	8-27-1991	FAMU	30 33 12	84 30 52	US Hwy. 90, 4.5 mi E Quincy
Cyrnellus fraternus	Ochlockonee R	Ocklawaha Ck	Gadsden	A	8-24-1986	FAMU	30 27 03	84 38 36	10 mi S Quincy, C-267
Cyrnellus fraternus	Oklawaha R	Redwater Lake	Putnam	A	5-27-1967	FAMU	29 34 00	82 01 00	Redwater Lake
Cyrnellus fraternus	Peace R	Bear Branch Stream	Polk	L	7-27-1955	FAMU			none
Cyrnellus fraternus	Santa Fe R	Santa Fe R	Suwannee	L	6-4-1992	SRWMD	29 54 43	82 51 38	CR-129
Cyrnellus fraternus	St. Johns R, lower	Dunn's Ck	Putnam	L	3-5-1974	FDEP-Jacksonville	29 34 40	81 37 35	US-17
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Hamilton	L	6-26-1991	FAMU	30 33 54	82 43 27	7.5 km N SR-6
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Hamilton	L	2-26-1992	FAMU	30 33 54	82 43 27	7.5 km N SR-6
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	6-26-1991	FAMU	30 23 35	82 55 57	0.5 km E US Hwy. 129
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	9-19-1991	FAMU	30 23 35	82 55 57	0.5 km E US Hwy. 129
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	9-19-1991	FAMU	30 24 13	83 09 30	Suwannee R State Park
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	10-29-1991	FAMU	30 23 35	82 55 57	0.5 km E US Hwy. 129
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	10-29-1991	FAMU	30 24 13	83 09 30	Suwannee R State Park
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	12-17-1991	FAMU	30 24 13	83 09 30	Suwannee R State Park
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	2-26-1992	FAMU	30 23 35	82 55 57	0.5 km E US Hwy. 129
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	6-24-1992	FAMU	30 23 35	82 55 57	0.5 km E US Hwy. 129
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	8-26-1992	FAMU	30 24 13	83 09 30	Suwannee R State Park
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	10-28-1992	FAMU	30 24 13	83 09 30	Suwannee R State Park
Cyrnellus fraternus	Suwannee R, upper	Suwannee R	Suwannee	L	4-28-1993	FAMU	30 23 35	82 55 57	0.5 km E US Hwy. 129

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Cyrnellus fraternus	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	4-22-1992	FAMU	30 30 13	83 14 32	3 km N SR-6
Cyrnellus fraternus	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	8-26-1992	FAMU	30 30 13	83 14 32	3 km N SR-6
Cyrnellus fraternus	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	10-28-1992	FAMU	30 30 13	83 14 32	3 km N SR-6
Cyrnellus fraternus	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	12-16-1992	FAMU	30 30 13	83 14 32	3 km N SR-6
Cyrnellus fraternus	Withlacoochee R, S.	Withlacoochee R	Citrus	L	9-16-1993	FDEP-Tampa	28 59 19	82 21 00	Stokes Ferry
Cyrnellus fraternus	Withlacoochee R, S.	Withlacoochee R	Pasco	L	3-9-1955	FAMU			none
Cyrnellus fraternus	unknown	Ocean Pond	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Cyrnellus fraternus	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., campground
Cyrnellus fraternus	unknown	unknown	Hillsborough	A	5-19-1960	FAMU	27 56 52	82 27 31	Tampa
Neureclipsis crepuscularis	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N Bristol
Neureclipsis crepuscularis	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N Bristol
Neureclipsis crepuscularis	Apalachicola R	unnamed stream	Liberty	A	3-22-1995	FAMU	30 27 55	84 59 07	ABRP, 5 km N Bristol
Neureclipsis crepuscularis	Apalachicola R	unnamed stream	Liberty	A	10-26-1995	FAMU	30 27 55	84 59 07	ABRP, 5 km N Bristol
Neureclipsis crepuscularis	Aucilla R	Aucilla R	Jefferson	L	8-21-1991	FAMU	30 22 22	83 48 21	US 27-19
Neureclipsis crepuscularis	Aucilla R	Aucilla R	Jefferson	L	6-17-1992	FAMU	30 08 51	83 58 14	US-98
Neureclipsis crepuscularis	Aucilla R	Aucilla R	Jefferson	L	12-16-1992	FAMU	30 29 34	83 43 52	US-90
Neureclipsis crepuscularis	Aucilla R	Aucilla R	Jefferson	L	4-14-1993	FAMU	30 08 51	83 58 14	US-98
Neureclipsis crepuscularis	Blackwater R	Blackwater R	Okaloosa	L	1-30-1971	FAMU	30 59 22	86 43 15	1st bridge S Alabama line
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	5-29-1991	FAMU	30 24 30	84 03 50	US Hwy 27
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	10-10-1991	FAMU	30 25 31	84 01 11	CR-59
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	12-3-1991	FAMU	30 25 31	84 01 11	CR-59
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	4-1-1992	FAMU	30 25 31	84 01 11	CR-59
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	6-3-1992	FAMU	30 25 31	84 01 11	CR-59
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	9-29-1992	FAMU	30 24 30	84 03 50	US Hwy 27
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	9-29-1992	FAMU	30 25 31	84 01 11	CR-59
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	12-2-1992	FAMU	30 24 30	84 03 50	US Hwy 27
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	12-2-1992	FAMU	30 25 31	84 01 11	CR-59
Neureclipsis crepuscularis	St. Marks R	Burnt Mill Ck	Jefferson	L	2-4-1993	FAMU	30 25 31	84 01 11	CR-59
Neureclipsis crepuscularis	Steinhatchee R	Econfina R	Taylor	L	6-19-1991	FAMU	30 08 33	83 51 58	US Hwy 98
Neureclipsis crepuscularis	Suwannee R, upper	Suwannee R	Hamilton	L	6-26-1991	FAMU	30 33 54	82 43 27	7.5 km N of SR-6
Neureclipsis crepuscularis	Suwannee R, upper	Suwannee R	Hamilton	L	9-19-1991	FAMU	30 33 54	82 43 27	7.5 km N of SR-6
Neureclipsis crepuscularis	Suwannee R, upper	Suwannee R	Hamilton	L	2-25-1993	FAMU	30 33 54	82 43 27	7.5 km N of SR-6

TRICHOPTERA DATABASE: FLORIDA POLYCENTROPODIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Neureclipsis crepuscularis	Suwannee R, upper	Suwannee R	Suwannee	L	9-19-1991	FAMU	30 23 35	82 55 57	0.5 km E of US Hwy 129
Neureclipsis crepuscularis	Suwannee R, upper	Suwannee R	Suwannee	L	2-25-1993	FAMU	30 23 35	82 55 57	0.5 km E of US Hwy 129
Neureclipsis crepuscularis	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	6-26-1991	FAMU	30 30 13	83 14 32	3 km N SR-6
Neureclipsis crepuscularis	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	10-29-1991	FAMU	30 30 13	83 14 32	3 km N SR-6
Neureclipsis crepuscularis	Withlacoochee R, N.	Withlacoochee R	Hamilton	L	12-16-1992	FAMU	30 30 13	83 14 32	3 km N SR-6
Neureclipsis melco	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Neureclipsis melco	Escambia R	Escambia R	Escambia	L	8-2-1977	FDEP-Pensacola			Escambia R, upper bluffs
Neureclipsis melco	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Neureclipsis melco	Yellow R	Turkey Gobbler Ck	Okaloosa	A	8-15-1985	FAMU	30 38 00	86 38 00	Eglin AFB Rd 211, W Hwy 85
Paranyctiophylax affinis	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Paranyctiophylax affinis	Santa Fe R	Santa Fe R	Gilchrist	A	5-6-1983	FAMU	29 50 11	82 41 58	Ginnie Springs campground
Paranyctiophylax affinis	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base
Paranyctiophylax affinis	unknown	Ocean Pond	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Paranyctiophylax affinis	unknown	Ocean Pond	Baker	A	6-2-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Paranyctiophylax affinis	unknown	unknown	Baker	A	5-16-1977	FAMU	30 12 23	82 27 25	Osceola Nat. For., co. line
Paranyctiophylax celta	Oklawaha R	unknown	Alachua	A	3-19-1966	FAMU	29 39 07	82 19 31	Gainesville
Paranyctiophylax celta	unknown	unknown	unknown	A		(Morse, 1972)			western panhandle
Paranyctiophylax moestus	unknown	unknown	unknown			(Armitage & Hamilton, 1990)			[listed as occurring in Florida]
Paranyctiophylax moestus	unknown	unknown	unknown			(Harris & Lawrence, 1978)			[listed as occurring in Florida]
Paranyctiophylax morsei	Choctawhatchee Bay	Rocky Ck	Walton	A	4-2-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	headwaters, 4 mi SW Mossy Head
Paranyctiophylax morsei	Choctawhatchee Bay	Rocky Ck	Walton	A	4-25-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	headwaters, 4 mi SW Mossy Head
Paranyctiophylax morsei	Choctawhatchee Bay	Rocky Ck	Walton	A	5-11-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	headwaters, 4 mi SW Mossy Head
Paranyctiophylax morsei	Yellow R	Bull Ck	Okaloosa	A	9-19-1979	(Lago & Harris, 1983)	30 40 17	86 25 56	10 mi ESE Crestview
Polycentropus blicklei	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	5 km N of Bristol
Polycentropus cinereus	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Polycentropus cinereus	unknown	Ocean Pond	Baker	A	4-12-1977	FAMU	30 13 00	82 26 00	Osceola Nat. For., Ocean Pond
Polycentropus crassicornis						(Banks, 1907)			
Polycentropus floridensis	Choctawhatchee Bay	Rocky Ck	Walton	A	5-11-1979	(Lago & Harris, 1983)	30 39 00	86 20 00	headwaters, 4 mi SW Mossy Head
Polycentropus interruptus	unknown	unknown	Walton	A		(Gordon, 1984)			none

END OF DATA TABLE

TRICHOPTERA DATABASE: FLORIDA PSYCHOMYIIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Lype diversa	Apalachicola R	Beaver Dam Ck	Liberty	A	3-22-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	Beaver Dam Ck	Liberty	A	10-26-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	Little Sweetwater Ck	Liberty	A	10-26-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Lype diversa	Apalachicola R	unnamed stream	Liberty	A	12-7-1994	FAMU	30 27 55	84 59 07	ravine just N of ABRP overlook
Lype diversa	Chipola R	Bridge Ck	Jackson	A	5-4-1995	FAMU	30 43 52	85 11 07	Hwy 71
Lype diversa	Chipola R	Chipola R	Calhoun	A	1-8-1972	FAMU	30 25 52	85 10 19	Hwy. 20
Lype diversa	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	6-12-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	10-15-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	12-5-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	2-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	4-8-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	6-10-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	8-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	10-14-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	12-7-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	2-11-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	4-7-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	6-16-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	9-28-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	1-27-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	FAMU Farm Stream	Gadsden	L	8-18-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Lype diversa	Ochlockonee R	Mule Ck	Liberty	L	7-7-1992	FDEP-Tallahassee	30 30 41	84 49 42	Hwy 12
Lype diversa	Ochlockonee R	Telogia Ck	Liberty	L	9-4-1986	FAMU	30 25 36	84 55 39	S-20 bridge
Lype diversa	Ochlockonee R	unnamed stream	Liberty	L	2-25-1974	FAMU	30 23 17	84 40 05	Hwy 20, 1 mi. W of Ochlockonee R
Lype diversa	St. Andrews Bay	Bear Ck	Bay	L	10-23-1990	FDEP-Tallahassee	30 19 13	85 27 22	US Hwy 231
Lype diversa	St. Johns R, lower	Black Ck	Clay	L	1-4-1952	FAMU			Beck Staton C
Lype diversa	St. Johns R, lower	Black Ck	Clay	L	6-13-1991	FDEP-Tallahassee			downstream of Camp Blanding
Lype diversa	Suwannee R, lower	Suwannee R	Gilchrist	L	6-4-1992	SRWMD	29 47 42	82 55 11	@ Rock Bluff
Psychomyia flavida	Chipola R	Bridge Ck	Jackson	A	5-4-1995	FAMU	30 43 52	85 11 07	Hwy 71
Psychomyia flavida	Chipola R	Chipola R	Calhoun	L	9-2-1976	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274

TRICHOPTERA DATABASE: FLORIDA PSYCHOMYIIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Psychomyia flavida	Chipola R	Chipola R	Calhoun	L	2-7-1977	FDEP-Pensacola	30 33 05	85 10 17	boat ramp N of SR-274
Psychomyia flavida	Chipola R	Chipola R	Calhoun	L	8-13-1992	FDEP-Tallahassee	30 32 03	85 09 54	Hwy 274
Psychomyia flavida	Chipola R	Chipola R	Calhoun	L	5-4-1995	FAMU	30 33 05	85 10 17	boat ramp 5 km W of Altha
Psychomyia flavida	Chipola R	Rocky Ck	Jackson	A	5-4-1995	FAMU	30 39 27	85 09 45	Hwy 71

END OF DATA TABLE

TRICHOPTERA DATABASE: FLORIDA RHYACHOPHILIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Rhyacophila carolina	Apalachicola R	Beaver Dam Ck	Liberty	A	12-7-1994	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Beaver Dam Ck	Liberty	A	3-22-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Beaver Dam Ck	Liberty	A	8-30-1995	FAMU	30 29 13	84 59 04	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Kelley Branch	Liberty	A	3-22-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Kelley Branch	Liberty	A	8-30-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Kelley Branch	Liberty	A	10-26-1995	FAMU	30 28 08	84 57 51	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Little Sweetwater	Liberty	A	12-7-1994	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Little Sweetwater Ck	Liberty	A	3-22-1995	FAMU	30 28 47	84 57 01	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	Little Sweetwater Ck	Liberty	A	8-30-1995	FAMU	30 28 21	84 59 08	ABRP, 5 km N of Bristol
Rhyacophila carolina	Apalachicola R	unnamed stream	Liberty	A	12-7-1994	FAMU	30 27 55	84 59 07	ABRP, just N of bluff overlook
Rhyacophila carolina	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	A	5-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	A	10-6-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	L	8-14-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	L	12-5-1991	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	L	2-12-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	L	4-8-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	L	6-10-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	L	12-7-1992	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Ochlockonee R	FAMU Farm Stream	Gadsden	L	4-7-1993	FAMU	30 39 27	84 36 50	8 km N Quincy, off CR-267
Rhyacophila carolina	Perdido R	McDavid Ck	Escambia	L	6-21-1993	FDEP-Pensacola	30 44 21	87 26 57	CR-99
Rhyacophila carolina	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base

*****END OF DATA TABLE*****

TRICHOPTERA DATABASE: FLORIDA SERICOSTOMATIDAE

Species	Basin	Waterbody	County	Stage	Date Coll.	Source	Lat.	Long.	Additional Locality Info.
Agarodes crassicornis	Blackwater R	Blackwater R	Okaloosa	A	5-1-1976	FAMU	30 44 20	86 47 12	FAMU Biological Station, 4.5 mi NW Holt
Agarodes crassicornis	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Agarodes libalis	Blackwater R	Blackwater R	Okaloosa	A	4-25-1976	FAMU	30 44 20	86 47 12	FAMU Biological Station, 4.5 mi NW Holt
Agarodes libalis	Ochlockonee R	Bear Ck	Gadsden	A	5-13-1970	(Ross & Scott, 1974)	30 28 16	84 35 32	1 mi. N Hwy 65C, Rockwood Farm
Agarodes libalis	unknown	Dead Hog Ck	Alachua	L	6-4-1978	(McEwan, 1980)	29 44 00	82 27 00	San Felasco Hammock State Preserve
Agarodes n. sp.	Ochlockonee R	FAMU Farm St	Gadsden	A	5-17-1994	FAMU	30 39 27	84 36 50	8 km N Quincy, off C-267
Agarodes ziczac	Blackwater R	Blackwater R	Okaloosa	A	4-24-1970	(Ross & Scott, 1974)	30 43 29	86 47 27	2.5 mi W Holt
Agarodes ziczac	Choctawhatchee Bay	Rocky Ck	Walton	A		(Harris et al., 1982)	30 39 00	86 20 00	Eglin Air Force Base
Agarodes ziczac	Yellow R	Bull Ck	Okaloosa	A		(Harris et al., 1982)	30 40 17	86 25 56	Eglin Air Force Base
Agarodes ziczac	Yellow R	Ramer Branch	Okaloosa	A		(Harris et al., 1982)	30 40 09	86 24 32	Eglin Air Force Base

END OF DATA TABLE

The Chamber
Chamber of Commerce of St. Joseph County

South Bend/Mishawaka/St. Joseph County Community Profile

Granger * Lakeville * New Carlisle
North Liberty * Osceola * Roseland * Walkerton

Regional Center for Business, Higher Education, Health and Tourism (updated 12/03)

Population

Census Year	South Bend	Mishawaka	County
1980	109,727	40,201	241,617
1990	105,511	42,635	247,052
2000	107,789	46,557	265,559

St. Joseph County: fourth largest in Indiana
South Bend: fourth largest city in state
Michiana area (11 counties) population: 959,700
Household population: 357,000

Location

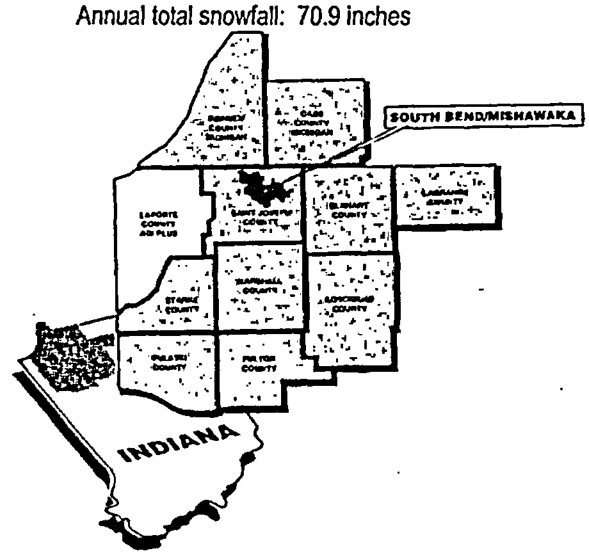
North Central Indiana
South Bend is just south of the Michigan state line
Area: 467 square miles in county
Distance and direction to other major cities:

Chicago, IL	(west)	96 miles
Indianapolis, IN	(south)	138 miles
Fort Wayne, IN	(east)	82 miles

Located along St. Joseph River:
flows north and empties into Lake Michigan
Lake Michigan: 26 miles
Time zone: Eastern Standard year round

Climate

Four full seasons
Coldest month: January
Average temperature: 24.4
Warmest month: July
Average temperature 73.3
Annual total precipitation: 36.52 inches
Annual total snowfall: 70.9 inches



ACCRA Cost of Living Index - 3rd Quarter - 2003

	Composite	Grocery	Housing	Utilities	Transportation	Health Care	Misc. Goods/Services
Boston, MA	135.9	119.1	180.5	145.1	109.7	128.1	109.9
Cleveland, OH	104.5	112.6	97.9	120.9	107.0	109.0	100.7
Minneapolis/St. Paul, MN	109.8	101.4	115.6	114.3	101.5	128.1	107.1
Chicago, IL	132.8	120.8	177.4	115.4	114.7	133.1	109.4
Indianapolis, IN	97.6	94.2	92.3	101.6	109.3	94.0	99.3
South Bend/Mishawaka, IN	97.1	90.0	97.0	108.4	93.5	96.9	97.7

Housing Cost/Median Sales Price for Single Family Home/3rd Quarter 2002*

United States	$158,300	Detroit, MI	Not Available
Midwest	$136,000	Indianapolis, IN	$120, 400
Chicago, IL	$230,200	**South Bend, IN**	**$ 94,600**

*Greater South Bend/Mishawaka Association of Realtors

Taxes

* Indiana Sales and Use Tax: 6%
* Individual Adjusted Gross Income Tax: 3.4% after exemptions
* Property Tax on all Tangible Property: 33.3%
* County Income Tax (COIT/CEDIT) Resident: .0075/Non-Resident: .003375

Educational Facilities in St. Joseph County (July 2002)

- **Day Care:** over 70 facilities for all ages
- ***Public Elementary and Secondary:***

	Total Enrollment:
43 Elementary, 17 Middle, 9 High Schools	
South Bend Community School Corp.	21,477
Mishawaka School Corp.	5,086
Penn-Harris-Madison School Corp.	10,018
John Glenn School Corp. (Walkerton)	1,707
New Prairie United School Corp. (New Carlisle)	2,642
Union-North United School Corp. (Lakeville & Lapaz)	1,298

- **Private Catholic Schools:**

South Bend and Mishawaka: 2 high schools, 16 elementary	5,971

- **Private Independent Schools:** 15 schools including one for special education
- **Colleges and Universities:**

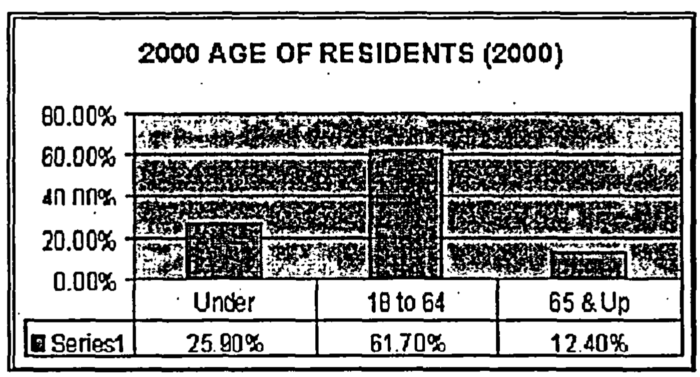
	Total Enrollment:
University of Notre Dame *[also offer graduate programs]*	11,054
Indiana University South Bend (IUSB) *[also offer graduate programs]*	7,200
Saint Mary's College	1,571
Bethel College *[also offer graduate programs]*	1,746
Holy Cross College	496
Purdue University Statewide Technology Programs	275
Tri-State University	100
Davenport University	555

- **Technical Colleges:**

Indiana Institute of Technology	350
Ivy Tech State College	5,069
Michiana College	543

Medical Facilities:

- Hospitals/specialty hospitals provide 1500+ beds. The three major hospitals are:
  - **Memorial Hospital** - 525 beds; regional referral centers for heart, OB/GYN, newborn, rehabilitation, cancer medical services, and 24-hour emergency
  - **Saint Joseph Regional Medical Center - South Bend Campus** - 303 beds; emergency/trauma, heart, cancer, rehabilitation, pediatrics, kidney dialysis, orthopedic, critical care and OB/GYN
  - **Saint Joseph Regional Medical Center - Mishawaka Campus** - 120 beds; full range acute care services, Genesis Birth Center, diagnostic services, 24-hour emergency, Transitional Care Center, and comprehensive diabetes education program
- Six outpatient medical clinics and surgicenters
- One psychiatric hospital and one disabilities center
- Ambulance service: available 24 hours
- Nursing and personal care facilities: 28



Income (2000 Estimates)

Per Capita	$27,335
Median Household	40,420
Average Wage	29,652

Education Level (%) 2000

High School Graduates	82.4%
Bachelor's Degree	23.6%

2000 Population Categories

Hispanic or Latino (of any race)	4.7%
White	82.45%
Black or African American	11.4%
American Indian and Alaska Native	0.4%
Asian	1.3%
Native Hawaiian and Other Pacific Islander	0.1%
Some other race	2.5%
Two or more races	2.0%

(Source: U.S. Census Bureau)

Recreation/Things to Do

- Bowling Alleys: nine
- Campgrounds: four
- Churches: more than 350 various denominations
- County Parks: Bendix Woods, Ferrettie/Baugo Creek, Place Trail Marsh, St. Joseph County Fair Grounds, St.Patrick's, Spicer Lake Nature Preserve
- Country Clubs: three
- Fitness Centers: 13
- Golf Courses: 11 and disc golf
- Libraries: 3 public/5 university
- Movie Theaters: five multi-screen complexes
- Pools: four
- State Park: Potato Creek

Sports

- South Bend Silver Hawks, Class A: Stanley Coveleski Regional Baseball Stadium (5,000 seats)
- College Football: Notre Dame Stadium (80,012)
- Joyce Center - Notre Dame (11,345 seats)
- Leagues: Ice Hockey, Soccer, Softball, Little League Baseball

Shopping Malls/Centers/Corridors

South Bend

- Scottsdale Mall
- Belleville Shopping Center
- LaSalle Square
- Portage Corridor
- Broadmoor
- Granger Station
- Ireland Rd. Corridor
- Erskine Plaza

Mishawaka

- Princess City Plaza
- University Park Mall
- Indian Ridge/Wilshire
- McKinley Town & Country
- University Center
- Value City Center
- Grape Rd, Corridor
- Indiana Ridge Blvd. Corr.
- University Crossings

Attractions

- Century Center: includes exhibit halls, meeting rooms, two theaters and Island Park
- College Football Hall of Fame
- Copshaholm, The Oliver Mansion
- East Race Waterway
- Farmers' Market
- Hannah Lindahl Children's Museum
- Healthworks! Kids' Museum
- Morris Conservatory/Muessel-Ellison Tropical Gardens
- Northern Indiana Center for History
- The Palais Royale Ballroom
- Potawatomi Zoo
- Shiojiri Niwa (Japanese Garden)
- Studebaker National Museum
- University of Notre Dame

Art Museums

- South Bend Regional Museum of Art
- The Snite Museum at Notre Dame
- IUSB Art Gallery
- Moreau, Hammes and Galleries at Saint Mary's College

Fine Arts/Theater

- Morris Performing Arts Center (2,600 seats)
- South Bend Symphony Orchestra with the Chamber and Pops Orchestras
- Southold Dance Theater
- Patchwork Dance Company
- Broadway Theater League
- Firefly Performing Arts Festival
- Osceola Players
- Saint Mary's College - Little Theatre
- South Bend Civic Theater
- University of Notre Dame, Washington Hall

HERE IS THE INFORMATION YOU REQUESTED!

The Chamber
Chamber of Commerce of St. Joseph County

401 East Colfax Ave., Suite 310
P.O. Box 1677
South Bend, IN 46634-1677
574-234-0051 FAX 574-289-0358
www.sjchamber.org

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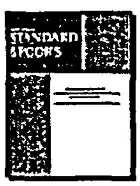

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SES "Error Band" Method Report

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Great Lakes Fishery Commission

ESTABLISHED BY CONVENTION BETWEEN CANADA AND THE UNITED STATES TO IMPROVE AND PERPETUATE FISHERY RESOURCES

PROTECTING AND RESTORING THE GREAT LAKES FISHERY

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Statement before the
Senate Committee on Environment and Public Works
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Mr. Chairman and members of the committee, my name is Roy Stein. I am the Vice-Chair of the Great Lakes Fishery Commission. I am also a professor in the Department of Evolution, Ecology, and Organismal Biology at The Ohio State University. On behalf of my Great Lakes Fishery Commission colleagues, I am pleased to be here today to discuss the Great Lakes fishery and to outline some challenges ahead for restoration of this invaluable resource. I commend Senator Voinovich for holding this hearing on the shores of the Great Lakes. The lakes require care and attention and we appreciate all you have done to help protect them for today and for future generations.

THE VALUABLE GREAT LAKES FISHERY

The Great Lakes fishery is a treasure shared by Canada and the United States. The lakes contain 20% of the world's supply of fresh water. The fishery draws millions of anglers to the shores of the lakes each year, supports tribal fishing, and creates tens of thousands jobs in the commercial fishing industry. The fishery generates up to $4 billion in economic revenue to the people of the region each year. Moreover, healthy fish communities are an integral part of a healthy Great Lakes environment. Without the fish communities and a healthy fishery, the Great Lakes lose their luster.

Nevertheless, today, like many shared natural resources, the Great Lakes fishery is stressed. Fish stocks require careful management to prevent depletion, native fish stocks require rehabilitation to levels of self-sustainability, the influx of invasive species that disrupt the ecosystem must stop, and sea lamprey control—the backbone of a healthy environment—must improve. Fishery managers at all levels of government must work together closely to coordinate their activities. The lakes are indeed shared resources and cooperation among managers is the key to ensuring a sustained fishery.

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The Great Lakes is a complex system that spans a large geographical area. As such, it is very difficult to answer a seemingly simple question like "What is the state of the fishery?" The answer to such a question depends on where you are in the basin and in what species you are interested. The following are brief snapshots of the state of the fishery, on a lake-by-lake basis, based on reports from federal, provincial, state, and tribal management agencies.

Lake Superior

Lake Superior supports a significant recreational fishery throughout the basin, and being more sparsely populated than the other Great Lakes, has the fewest recreational anglers. Lake trout comprise the lion's share of the recreational harvest in Lake Superior, though other species, including chinook and coho salmon, rainbow trout, and brown trout are also popular. The lake also supports important tribal and commercial fisheries, mainly of herring, whitefish, and lake trout. Commercial fishing peaked in the 1940s and today, is about one-fifth of what it once was.

Walleye was once an important species in Lake Superior, providing a harvest of thousands of pounds each year. Today, walleye harvest is negligible due to degraded habitat, poor water quality in the walleye's habitat, hydro-electric dams, and disruptions in recruitment. The management agencies on Lake Superior have established a goal to maintain, enhance, and rehabilitate self-sustaining populations of walleye and their habitat throughout their historical range.

The Lake Superior fish community has been permanently altered by invasive species and remains at risk from future introductions. Disruptions in the lower food web are implicated in the poor condition of lake whitefish. Lake Superior, despite its relatively pristine state, remains quite vulnerable to human-induced alterations in habitat and water quality.

Despite these and other problems, Lake Superior has seen some spectacular successes in fishery management. The fish community is reverting to a more natural state, resembling historical conditions and requiring less management intervention. Lake whitefish, a staple of the Lake Superior fishery, remain at high abundances, though concern exists about the overall condition of whitefish. Moreover, the decades-long effort to rehabilitate lake trout in Lake Superior has paid off. Thanks to careful stocking, limited harvest, and sea lamprey control, lake trout are now self-sustaining in most of the lake to the degree that stocking is no longer necessary

Lake Michigan

Lake Michigan supports commercial, recreational, and tribal fishing. Whitefish is the primary commercial species, though at one time, the lake supported smelt, yellow perch, bloater, and alewife fisheries as well. Salmon, trout, yellow perch, and walleye are the most popular sport species and lake trout and whitefish comprise the tribal fisheries.

Total harvest from Lake Michigan peaked in 1985 at 56.6 million pounds. Today, harvest averages 21.6 million pounds, illustrating a downward trend since the late 1980s. One major reason for this downward trend has been a significant imbalance between predators (e.g., salmon, lake trout) and prey (e.g., alewives, sculpins). Since the mid-1990s, management agencies have been working successfully with their stakeholders to strike a balance between salmon stocking and the lake's ability to sustain these predators.

Despite these trends, sport anglers today are relatively pleased with the state of the Lake Michigan fishery. The balance between predators and prey have resulted in more salmon and generally bigger fish. The lake supports a thriving charter boat industry.

The lake does have some significant problems, however. Like the other Great Lakes, disruptions in the lower food web threaten to undermine the success of the fishery. For instance, the sharp declines in *Diporeia*—a native organism that serves as food for larger fish—are linked to invasive species and might be the cause of declines in whitefish abundances and condition. Yellow perch remain at troublingly low levels, thus prohibiting a resumption of commercial yellow perch fishing in Lake Michigan. And lake trout rehabilitation is experiencing extremely slow progress. Sea lamprey abundances (discussed below) remain higher than desired in Lake Michigan, which limits the success of the fishery are impairing rehabilitation.

Overall, the Lake Michigan fishery remains strong and popular. Management agencies work hard to balance salmon predators with their prey. Large-scale changes in the ecosystem, however, threaten to further disrupt an already fragile fish community.

Lake Huron

The Lake Huron fishery is dominated by chinook salmon, lake trout, brown trout, whitefish, and burbot. Alewives and smelt are the main prey fish. Predators and prey in Lake Huron seem balanced, though agencies are monitoring the fish community closely to ensure that the prey abundances are able to support the stocked trout and salmon. Agencies are working to bolster the mix of species in the lake by establishing diverse salmon and trout communities, improving walleye and yellow perch abundances, managing whitefish at sustainable levels, and rehabilitating sturgeon.

Habitat loss in Lake Huron remains a major concern. Agencies are working to protect and enhance fish habitat and to rehabilitate degraded areas with a goal of no net loss of habitat. Agencies also are concerned about the poor condition of whitefish and the high abundances of sea lampreys (discussed below) in Lake Huron, as sea lampreys are having a significant impact on the Lake Huron fish communities. The Great Lakes Fishery Commission has reduced the number of sea lampreys in Lake Huron, and agencies remain confident that the commission's recent treatments on the St. Marys River will further reduce sea lamprey populations. Disruptions in the lower food web, likely caused by invasive species, continues to threaten the fishery. Encouragingly, natural reproduction of lake trout is increasing.

Lake Erie

The Lake Erie fishery is best known for its walleye and yellow perch. Indeed, these popular fish species attract millions of anglers to the lake each year and support a lucrative commercial fishery. Strong year classes of yellow perch in the years 1996, 1998, and 1999 have helped sustain the yellow perch fishery in the lake. Yellow perch fishing – both sport and commercial – in 2002 was very good in all jurisdictions and the management agencies on the lake expect the good fishing to continue through 2003. However, a long, cold spring in 2002 resulted in poor yellow perch spawning success. Agencies anticipate reductions in yellow perch catch limits in 2004 in response to these poor spawning results.

The management agencies on Lake Erie reported that walleye spawning had been poor in 2000 and 2002 and recommended reducing the walleye catch limit in 2004. All agencies will be closely monitoring the success of walleye spawning in 2003 (early indications are that this will be a successful year for reproduction), though agencies anticipate significant reductions in the 2004 and 2005 allowable harvest.

A major issue affecting the Lake Erie fishery is a recent outbreak of botulism. Tens of thousands of primarily near shore, bottom-feeding fishes (including smallmouth bass, sheepshead, rock bass, stonecats, round gobies, sturgeon, and channel catfish) apparently succumbed to botulism. Gobies and dreissenid mussels appear to have played a role in recent mortalities attributed to botulism. Current thinking is that dreissenid mussels concentrate the toxin. Round gobies feed on the mussels, which are then eaten by fish and migratory birds. Though this is a plausible hypothesis, research is needed to identify the etiology for Type E botulism. There have been no human fatalities in recent years, but the possibility exists. (Indeed, type E botulism from improperly prepared Great Lakes fish caused several fatalities in the 1960s.) The botulism outbreak in Lake Erie is indicative of serious problems in the lake; problems relating to anoxia and the impact of invasive species such as zebra mussels.

The five jurisdictions along the lake have worked together in a highly successful and cooperative manner. The jurisdictions have expressed a great deal of concern about the recent major changes occurring within the ecosystem of Lake Erie, particularly changes driven by disruptions to the lower food web, probably caused by invasive species like zebra mussels. These changes have a profound influence on both the composition and productivity of the fish communities within the lake.

Lake Ontario

Lake Ontario supports a sport fishery comprised mainly of chinook salmon, coho salmon, lake trout, brown trout, and rainbow trout. Other popular species—fished primarily in shallow water—include yellow perch, walleye, smallmouth bass, and northern pike. Lake Ontario also supports some commercial fishing, though primarily in Ontario waters. Commercial species include lake whitefish and yellow perch, though harvest today is a fraction of its historical high in the early 20^{th} century. Fishing in Lake Ontario is dominated by recreational anglers.

The recruitment of American eel, is a major concern in Lake Ontario. America eels have been reduced to 1% of historic recruitment levels. The rehabilitation of this important top predator will require an immediate and coordinated international effort, as American ells are highly migratory (they swim thousands of miles from the Great Lakes during their lives) and are extremely vulnerable during many of their life stages.

Charter fishing on Lake Ontario is extremely popular and the number of charter trips (nearly 8000 per year) remains steady. Although harvest of coho and chinook salmon and brown trout is currently lower than it was in the 1980s, harvest has remained steady for most of the 1990s to today, indicating a relatively stable fishery. Lake trout harvest is a fraction of its peak in the mid-1980s and efforts to rehabilitate the species have yet to be realized. Other popular species, such as smallmouth bass, yellow perch, and walleye, fluctuate in abundance from year to year, but harvest has remained relatively strong and stable. Sea lamprey abundances in Lake Ontario remain extremely low, indicating a successful control program.

COORDINATED FISHERY MANAGEMENT ON THE GREAT LAKES

Like any resource that is shared and stressed, careful management helps ensure equitable use for today and sustainability for the future. The Great Lakes present a management challenge as the lakes are shared by two nations, eight states, the Province of Ontario, and tribal authorities. An international border runs through the center of four of the five Great Lakes. The challenge all agencies face is managing a biologically connected fishery through a politically fragmented regime.

State, provincial, and tribal authority

Primary fishery management on the Great Lakes rests with the states, the province of Ontario, and two U.S. intertribal agencies. Each of these sub-national entities has an independent right to manage its portion of the fishery in the manner it chooses. This sub-national management authority has been long established, through common law and court cases. For instance, although the British North America Act gives the Canadian federal government control over inland fisheries, the provinces retain ownership of lake and river beds and, it has been ruled, the riparian rights to the fish. Through the federal Fisheries Act, the Canadian government maintains the right to make and enforce fisheries regulations and policies pertaining to the conservation of fish stocks within Canadian waters. Much of the authority to implement these policies and to enforce these regulations has been granted to Ontario. In the United States, early Supreme Court decisions have upheld the states' ownership of lake and riverbeds and, thus, the fish in those waters.

In the U.S., tribes have management authority on their reservations and in waters ceded through treaties. In Canada, there are still many unresolved and emerging issues with First Nations' fishery management and, thus, the rights of First Nations to manage their own fishing activities is less developed than in the United States.

Great Lakes Fishery Commission

Because the lakes are shared by the United States and Canada, binational governance is required. As such, in 1955, the two nations created the Great Lakes Fishery Commission by treaty. The commission has management authority for sea lampreys but limited authority over the Great Lakes fisheries, largely because, for decades, the states and the province were reluctant to cede management authority to a bi-national body. The commission is made up of 4 Canadians appointed by the Privy Council and 4 American (plus one alternate) appointed by the President of the United States.

It was largely the destructive power of the sea lamprey (described below) in the mid 20th Century that prompted the governments to seek a binational fishery management treaty. The Great Lakes Fishery Commission is charged with several responsibilities including: coordinating fisheries research on the Great Lakes; carrying out sea lamprey control; making recommendations to governments about fish stocks of common concern; and, at the request of the sub-national governments, facilitating the implementation of *A Joint Strategic Plan for Management of Great Lakes Fisheries* (Joint Strategic Plan), discussed below.

Federal Authority

The federal governments of Canada and the United States also have a management authority on the Great Lakes. Several federal agencies in both nations work with the sub-national agencies to support the management of the fishery.

The commission conducts sea lamprey control by contract with federal agencies. Under state approval, the federal agencies carry out rehabilitation initiatives, most notably, lake trout stocking. The federal agencies contribute to the generation of information through scientific research. They also negotiate bi-national agreements, support the common good through budget and other initiatives, and have the trust responsibility toward tribes.

Cooperative management

Through the Joint Strategic Plan, the Great Lakes Fishery Commission has the responsibility to facilitate cooperative management on the Great Lakes. Indeed, the commission is keenly interested in helping all management agencies on the Great Lakes develop shared fishery objectives and manage the lakes as an ecosystem.

Together, the bi-national, national, and sub-national management agencies approach the Great Lakes from the same general perspective and with the same goals in mind. These perspectives and goals include:

- Working to sustain the Great Lakes fish stocks;
- Protecting diversity;
- Understanding and maintaining the balance between predators and prey;
- Adhering to science-based management; and
- Balancing the interests of stakeholders, including sport anglers, commercial fishers, tribal fishers, the environmental community, and many others.

Despite a generally common approach to Great Lakes fishery management, the various agencies had managed the Great Lakes fishery with little or no formal cooperation for decades. With the states, the province, the tribes, and the federal governments often doing their own thing, it is not difficult to envision a situation where consultation was minimal, common objectives non-existent, and agencies working at cross purposes, even, at times, on the same lake.

By the late 1970s, the agencies realized that some mechanism was needed to facilitate cooperation among the jurisdictions. In 1978, the eight states and the province of Ontario joined with the Great Lakes Fishery Commission to develop the Joint Strategic Plan. The plan was adopted in 1981 and has been updated regularly, most recently in 1997.

In recent decades, particularly under the Joint Strategic Plan's direction, fishery agencies have been successful in resolving—or partially resolving—many fisheries management problems. Even so, many issues remain unresolved and new issues continually emerge. To assist fishery and environmental agencies in dealing with these problems, agencies, through the Joint Strategic Plan, have identified broad procedures that foster cooperation. The procedures suggested in the Joint Strategic Plan are:

- Consensus
- Accountability
- Information Sharing
- and Ecosystem Management.

Consensus: Agencies agree to reach consensus on management practices before they implement major initiatives. To help achieve consensus, agencies have developed common fish community objectives accompanied by operational plans, plans against which management decisions can be weighed. These objectives outline the goals for the fishery and how to achieve those goals. Agencies also agree that any change in fishery management practice that affects other jurisdictions must be agreed to by the other jurisdictions. In the rare instance where consensus cannot be achieved, the Joint Strategic Plan contains provisions for conflict resolution through the Great Lakes Fishery Commission or third parties.

Accountability: Fishery managers are accountable for implementing the decisions made under the Joint Strategic Plan. They implement the decisions through their own agencies. To promote accountability, the Joint Strategic Plan calls for the production of a decision record—primarily through the publication of meeting minutes. The Joint Strategic Plan also highlights the need for agencies to submit periodic reports about initiatives on each lake and the need for regular reports on progress toward reaching agency objectives.

Information Sharing: Information useful to management is something all agencies need. Information sharing has been difficult at times because the jurisdictions have a history of generating a variety of data in a variety of formats. To maximize information sharing, the Joint Strategic Plan calls for the development and implementation of standards for recording and maintaining fishery management and assessment data. Access to information is critical to the management agencies and to the public. The Joint Strategic Plan calls for agencies and the Great Lakes Fishery Commission to take the steps necessary to publish information and make it available through convenient means, such as the internet. Finally, under the Joint Strategic Plan, agencies pledge to share their data with other agencies.

Ecosystem Management: A guiding principle on the Great Lakes is that managers must look at the Great Lakes as a whole. This means that fishery mangers need to look beyond fishery management activities and respond to all issues that affect the Great Lakes. In particular, the Joint Strategic Plan calls for a heightened interest in environmental issues—such as Lakewide Management Plans or the Great Lakes Water Quality Agreement—in developing, achieving, and assessing the progress on fish community objectives. The Joint Strategic Plan also recognizes the incredible problem the entire ecosystem faces with exotic species and calls upon the agencies to promote procedures to protect the resource.

With these four procedures for cooperative fishery management in mind, how, exactly, does the Joint Strategic Plan function? Long before the Joint Strategic Plan, each lake had its own "Lake Committee," a loose set of Great Lakes Fishery Commission committees designed informally to help the commission and agencies focus on particular issues on each lake. When the agencies produced the Joint Strategic Plan in 1981, they decided to expand the use of the lake committees and use them as more formal means to carry out the Joint Strategic Plan.

Under the Joint Strategic Plan, high-ranking managers from agencies on each lake meet as a committee to address the issues of importance to that lake. For example, managers from jurisdictions on Lake Huron—which include Ontario, Michigan, and the Chippewa-Ottawa Resource Authority—meet as the Lake Huron Committee. A Council of Lake Committees—comprising all members of the lake committees—looks at Great Lakes fishery issues from a basin wide perspective.

The Joint Strategic Plan is designed to be a bottom-up process, where management decisions are driven by science generated by field researchers. To foster that design, each lake committee has a technical subcommittee to conduct and digest research and to report those findings to lake committee members. This structure allows the field researchers and assessment biologists to come to a common understanding of the science, free from policy issues considered by the lake committees. Lake committee members then use that bottom-up-produced science as the basis for their management decisions.

The Joint Strategic Plan also provides for a coordinated approach to law enforcement. While each national and sub-national jurisdiction maintains its own law enforcement capabilities and responsibilities, there is considerable need on the Great Lakes for law enforcement agencies to work together. Indeed, because the Great Lakes is an ecosystem, it would make little sense for agencies to stop their pursuit of lawbreakers at a political line. To facilitate coordinated law enforcement, a Law Enforcement Committee develops and works to implement common law enforcement initiatives. This committee reports to the Council of Lake Committees.

Finally, to facilitate interagency cooperation, the Great Lakes Fishery Commission also supports the Great Lakes Fish Health Committee and the Fish Habitat Conservation Committee. The Fish Health Committee studies issues relating to fish disease spread, prevention, and mitigation. The Fish Habitat Conservation Committee—whose members are appointed by the commission—comprises government and non-government habitat experts to study and recommend measures for ensuring fish habitat protection.

Lake committee meetings are held annually, in public. They serve as a forum to develop common objectives for the lake, to share scientific information, and to allow agencies a place to make decisions on such things as stocking, harvest, law enforcement, and environmental management. It is important to note that all decisions made through the lake committee process must still be implemented by the individual agencies. That is, managers agree to take lake committee actions back to their own jurisdictions for implementation. Thus, the consensus-based lake committee process is non-binding and only as successful as the willingness of the individual agencies to adhere to the collective decisions. Even so, this process is highly effective as it serves to maximize cooperative management and minimize conflict. Figure 1 illustrates the lake committee structure.

Figure 1: Lake Committee Organization

The Great Lakes are widely viewed as the best example of cooperative fishery management anywhere on earth. Lake committees are clearly the strength of the Joint Strategic Plan. As expected with any shared resource, issues about fairness of the allocation of the fishery, management responsibilities, and transparency arise on the Great Lakes. The Joint Strategic Plan and the lake committee process are capable of handling these challenges. In the absence of this process, agencies would retreat to parochialism, with management chaos ensuing.

INVASIVE SPECIES: THE PRIMARY THREAT TO THE GREAT LAKES FISHERY

One particularly important issue facing the Great Lakes Fishery Commission and the lake committees is invasive species. Invasive species—undesirable plants and animals not native to a system—have been increasing steadily in numbers, particularly as commerce in the Great Lakes region has become more global and dynamic. Invasive species cause enormous ecological and economic damage to the region. Invasive species such as sea lampreys, zebra mussels, Eurasian ruffe, *Bythotrephes*, and round gobies have changed the very nature of the Great Lakes forever.

According to published reports, 162 non-native species have become established in the Great Lakes region since the late 1800s. Twelve of these species have entered the Great Lakes since 1990, around the time ballast water exchange—designed to protect the lakes against invasion—went into effect. Once a species invades and takes hold, the species becomes a permanent fixture of the ecosystem.

Since the 1950s, when the St. Lawrence Seaway opened the lakes to direct foreign shipping, ballast water has become a dominant means by which new species enter the system. Today, the vast majority of invasive species in the Great Lakes originate from Eurasia and arrive in ship ballast. Invasive species have the potential to enter the lakes through other channels as well, including the Chicago Sanitary and Ship Canal and through the commerce of live food, bait, and aquarium fish.

Concurrent reports from the United States General Accounting Office and the Auditor General of Canada, released in October, 2002, brought major attention to the invasive species problem. The reports provide little reason for optimism. Among the findings of both reports:

- The federal governments of Canada and the United States have not responded effectively to the invasive species threat;
- Invasive species are a leading cause of biodiversity loss and economic loss, costing billions of dollars each year;
- Measures put into place to prevent aquatic introductions (such as ballast water monitoring and ballast water exchange) have not prevented new introductions;
- Canada and the U.S. have neither a binational approach to invasive species nor do they have a single agency in charge of managing the problem; and
- Effective ballast water management techniques may require at least 10 years to develop and implement.

The Great Lakes remain extremely vulnerable to new invaders, underscoring the critical need to (1) prevent the introduction of new organisms, (2) address the ballast water vector, (3) stop transmigration of species through the Chicago Sanitary and Ship Canal, and (4) address the trade of live organisms from outside and within the region. As one view of the importance of this problem, most scientists and stakeholders working in the Great Lakes today will list invasive species as the most pressing issue the region faces.

The Great Lakes Fishery Commission is deeply encouraged by the introduction of the National Aquatic Invasive Species Act (NAISA—S. 525, H.R. 1080 and H.R 1081). I join with my fellow commissioners in commending Senator Levin and Congressmen Ehlers and Gilchrest for introducing these important bills and thanking Senator Voinovich for being an original co-sponsor of the Senate legislation.

These bills, if passed as written, will be a major step forward in efforts to address the invasive species problem. In particular, the commission believes NAISA includes important safeguards for the Great Lakes, establishes clear deadlines for action, and addresses vital needs such as strong ballast standards for ocean-going vessels, investigation of invasion pathways, rapid response, the construction of a dispersal barrier system near Chicago, and research, just to name a few.

The commission strongly urges Congress to pass this legislation. The sooner the bills are passed, the sooner we will be addressing these pressing problems. We cannot afford to wait a day longer: The next oceanic vessel entering the Great Lakes could have the next "zebra mussel" on board. Asian carp are swimming their way steadily towards the Great Lakes. Millions of potentially harmful fish are sold live in the Great Lakes basin. This legislation will address these and other problems, but we must act now.

The commission also notes that the International Joint Commission (IJC), in its previous two biennial reports, has requested a reference from governments to address the invasive species problem. The commission believes the IJC is an appropriate body to investigate this issue on a binational level and, therefore, urges the governments of Canada and the United States to grant this reference to the IJC.

SEA LAMPREYS AND THEIR DEVASTATION

Let us focus, now, on one particular invasive species: the sea lamprey. Among the more than 162 exotic species that have become established in the Great Lakes basin, the most detrimental to the basin's fisheries has been the sea lamprey, a parasitic fish native to the Atlantic Ocean. Sea lampreys entered the Great Lakes in the early part of the

20th century through federally constructed shipping canals and by 1937 had infested waters of all of the Great Lakes. Unlike the other invasive species we contend with, sea lampreys can be controlled.

During its lifetime, each sea lamprey, by attaching to fish and feeding on their body fluids, can kill and consume 40 or more pounds of fish. By the mid-1940s, sea lamprey predation, combined with overfishing and other problems, destroyed many extremely valuable fisheries in the Great Lakes. Losing predators such as lake trout and burbot and subsequent sea lamprey predation on other species, has led to catastrophic declines in the economic value of Great Lakes fisheries.

The declines in the Great Lakes fishery can hardly be exaggerated. Before sea lamprey control began in the 1950s, nearly 85% of the fish in the Great Lakes exhibited sea lamprey wounds and the harvest, which had been about 20 million pounds of fish annually before the sea lamprey invasion, collapsed.

The sea lamprey literally destroyed a way of life for the people of the Great Lakes region and threw the environment into chaos. Even with sea lamprey control measures in place, the lampreys continue to pose a significant threat to the fish. In some areas, sea lampreys still kill more fish than are harvested by humans. We also know that if sea lamprey control were to be relaxed—even briefly—the species would spring back quickly and in deadly fashion.

Sea Lamprey Control

By the early 1950s, the governments of Canada and the United States, in addition to the province of Ontario and the states, agreed that the sea lamprey problem must be addressed at the highest level if the Great Lakes fishery were to survive. To that end, the federal governments negotiated and ratified the 1955 *Convention on Great Lakes Fisheries*, which created the Great Lakes Fishery Commission. The commission was charged with developing and implementing a sea lamprey control program and with coordinating fisheries research, duties the commission maintains to this day.

The commission actively manages the program and works in partnership with Fisheries and Oceans Canada, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers to deliver sea lamprey control. The commission continues to insure that fishery management on the Great Lakes is carried out on an ecosystem basis and in the spirit of binational cooperation. The *Convention* remains a highly successful blueprint for cooperative fishery management. Canada and the United States each consider the working relationship on the Great Lakes to be a model of successful binational resource management.

Sea lampreys are controlled on the Great Lakes using a number of innovative, effective techniques. The primary management tool is a lampricide, called TFM. TFM is applied in Great Lakes streams where sea lampreys live as larvae. The lampricide is selective to lampreys, meaning it kills lampreys with little to no impact on non-target species. TFM has been applied to Great Lakes streams since 1958 and is fully registered with the Environmental Protection Agency. Streams with sea lampreys present require TFM treatments every 3-6 years, depending on the stream's productivity. Between 60 and 70 streams are treated annually with TFM.

The commission also relies on other alternative, non-chemical techniques to control sea lampreys. Sea lamprey barriers are used to prevent sea lampreys from reaching their spawning grounds. Once a barrier is constructed in a stream, the stream generally does not require lampricide treatments above the barrier. Sea lamprey traps are used to remove lampreys from the system before they spawn. The lampreys caught in traps are used in the innovative sterile-male-release-technique, a technique where spawning male sea lampreys (which are past their feeding stage and, therefore, are not actively destroying fish) are sterilized and released back into the system. The sterilized males compete with fertile males to spawn, thus wasting the female's spawning potential.

Together, these sea lamprey control techniques comprise the tools in the commission's arsenal to combat this destructive pest.

The Success Of Sea Lamprey Control

The commission's sea lamprey control program has been a tremendous success—probably successful beyond the expectations of those who negotiated the *Convention on Great Lakes Fisheries*, and stands as one outstanding example of environmental damage mitigation.

In the Great Lakes, sea lamprey abundances are near or below target levels in Lakes Ontario and Erie. Sea lamprey abundances are slightly above targets in Lakes Superior and Michigan and significantly above target in Lake Huron. The high abundances of sea lampreys in Lakes Michigan and Huron are because of high sea lamprey production in the St. Marys River. The commission began an aggressive, on-going sea lamprey suppression program for the St. Marys River in 1999 and expects the sea lamprey abundances in Lakes Michigan and Huron to approach acceptable levels. Sea lamprey abundances in Lake Superior are a bit higher than we find acceptable and, therefore, the commission will be stepping up its treatment work in that lake.

Overall, the sea lamprey control program has been a phenomenal success. The Great Lakes Fishery Commission and its partners have reduced sea lamprey populations by about 90 percent from their historical abundance. Because sea lamprey eradication is impossible, the control effort is ongoing.

The successful sea lamprey control program is the cornerstone of a healthy and vibrant fishery. Sea lamprey control allows provincial, state, federal, and tribal fishery management agencies to stock fish and implement other restoration activities with confidence, knowing that their fish will likely survive to reproduce or be caught by humans.

Sea lamprey control allows agencies to make substantial progress in their efforts to re-establish self-sustaining populations of our rare, valuable, native species.

Sea lamprey control promotes a healthier Great Lakes fishery, creates a more stable environment, and provides significant economic and recreational benefits to the people of the region.

Sea lamprey control has increased the popularity of sportfishing in the Great Lakes since the early 1960s, protects tribal fishing, and supports thousands of commercial fishing jobs.

Sea lamprey control is indeed the foundation of a fishery that has rebounded from the most dire conditions of the 1940s. Today, the fishery again is a highly valued resource to the people of North America. The millions of people who fish the Great Lakes recreationally, tribally, and commercially demand the delivery of an effective sea lamprey control program. Investments in sea lamprey control are investments not only in today's fishery, but also are investments in the fishery that future generations will enjoy.

Alternative Sea Lamprey Control And The Lampricide Reduction Goal

Despite the importance of the lampricide TFM in the sea lamprey control effort, the commission set a goal to reduce lampricide use by 50 percent by the year 2010. Lampricides are costly and the commission is sensitive to concerns about the use of pesticides, even safe and proven pesticides like TFM. Furthermore, successful pest management programs rely on several techniques working together to achieve target levels of suppression.

To reach its lampricide reduction goal, the commission has invested in alternative, non-chemical means to control lampreys including the aforementioned barriers, traps, and the sterile-male-release technique. Already, the commission has reduced lampricide use by more than 35% from the peak use of the 1980s.

Achieving the lampricide reduction goal is possible, but only through continued investment in alternative controls. The commission has been committed to making that investment by devoting greater percentages of the lamprey control budget to alternative techniques. In 2003, the commission will apply approximately 25 percent of its sea lamprey budget to alternative controls. This is an increase from only about 15% devoted to alternative controls just a few years ago.

Reductions in lampricides through the research into and the development of alternative techniques is providing real program savings today. Lampricide reductions since the late 1980s are now saving the commission more than $1 million per year in lampricide and treatment costs, while still allowing for the same level of sea lamprey control. Furthermore, sea lamprey control on the St. Marys River depends on alternative controls. Continued reductions in the amount of lampricides used will take place and the commission will remain vigilant that these reductions do not compromise the effectiveness of sea lamprey suppression.

The commission also has a vision to develop and implement at least one new sea lamprey control technique by the end of the decade. The commission is highly encouraged by the success of alternative control techniques (e.g., the sterile-male-release-technique) and believes it is imperative to research and develop new techniques.

New research into sea lamprey pheromones—another major initiative—will help the commission reach its goal. Pheromones are natural attractants sea lampreys use to indicate to spawning lampreys which streams are suitable for spawning or to attract mates once in the spawning stream. By understanding how sea lampreys use pheromones, scientists seek to direct lampreys into traps or disrupt sea lamprey spawning behavior in some fashion. The commission believes pheromones have much promise to transform sea lamprey control in the Great Lakes basin and, therefore, views enhancing its development and application as a high priority. The commission will undertake major field trials for pheromones as soon as spring 2004.

Sea lamprey control is only as successful as the governments' willingness to fund the effort. Currently, the program receives enormous support in both Canada and the United States, though the control effort is still underfunded. The commission received $12.2 million in fiscal 2003, nearly $1 million less than the fiscal 2002 level and a full $4 million less than was requested by the commission to deliver a full program. The commission requires adequate funding if it is to maintain the successful sea lamprey control effort and devote full attention to lampricide reduction.

ASIAN CARP: AN IMPENDING INVASION

Sea lampreys have been the bane of the Great Lakes for more than 80 years. Asian carp, which are at our doorstep, threaten to be the next "sea lamprey." Two species of Asian carp are making their way toward the Great Lakes—the silver and bighead carp. A third species of concern—the black carp—escaped into the Mississippi River in 1994, but to date, only one has been detected in the wild. Biologists are monitoring the resource carefully for occurrences of the black carp.

The silver and bighead carps were imported, in the early 1970s from Asia by fish farmers in southern states, to control plankton blooms in channel catfish production ponds. Both species escaped into the Mississippi River in the 1980s. Biologists believe that major floods in the early and mid-1990s allowed the carp to significantly expand their range. Currently, bighead and silver carp are found near the Chicago Sanitary and Ship Canal, which connects the Mississippi River to the Great Lakes. The carp are now within 50 miles of Lake Michigan. The silver and bighead carp have a remarkable ability to spread and proliferate. In some areas of the Mississippi, Asian carp now already comprise 95% of the biomass.

In addition to the Chicago canal system as a vector, fish are routinely imported live into the region for sale as food and are a popular fish at live-fish markets in the Great Lakes basin. For instance, more than 900,000 pounds of live Asian carp are trucked each year into Ontario from the United States, to be sold at fish markets on the shores of the Great Lakes. Fish markets exist, for instance, in Toronto, Chicago, and New York.

Moreover, millions of juvenile fish are sold as baitfish or as aquarium fish in the Great Lakes basin. Like the carp sold in fish markets, aquarium and baitfish are trucked into the basin (and in some cases reared in the basin) and sold live. Once these live fish are sold, they are out of the control of the sellers. For example, there is a serious risk that once an angler is finished fishing for the day, the angler might release invasive fish (such as Asian carp) that are mixed in with the rest of his or her unused bait.

If the Asian carp are allowed into the lakes, they will likely become a permanent, noxious feature of the Great Lakes environment. They have several characteristics that make them "invasive." They are fecund and they grow rapidly. They are well suited to the climate of the Great Lakes; their native range in Asia is similar to the conditions in the

Great Lakes region. There is little doubt that the carp will survive in the Great Lakes and compete directly with the lakes' native fish for zooplankton (small animals in the water column that form the base of the food web).

Tremendous efforts are underway to prevent an Asian carp invasion. To date, these efforts have centered on blocking the migration of carp from the Mississippi River system into Lake Michigan. An experimental electric barrier constructed by the U.S. Army Corps of Engineers to control invasive species migration began operation on April 9, 2002. This electrical barrier serves as the only line of defense against the Asian carp. A second barrier is currently being built through a partnership with the Great Lakes Fishery Commission, the International Joint Commission, the U.S. Army Corps of Engineers, and the State of Illinois.

In addition to work on the Chicago canal system, there is also significant work to prevent entry via the trade of live organisms. The Council of Lake Committees (composed of provincial, state, and tribal management authorities), and the Great Lakes Law Enforcement Committee (provincial, state, federal, and tribal law enforcement officials, have been working with governments to encourage sub-national laws banning the possession of live Asian carp (and other potentially injurious exotic species). Already, several states have banned the possession.

The U.S. federal government, along with state and local governments, have spent millions of dollars to help prevent the Asian carp invasion. These investments in the Chicago Sanitary and Ship Canal, while costly, are necessary to the protection of the entire Great Lakes basin and are a fraction of the economic harm these carp could cause to both nations if they are allowed into the system. The commission has several specific recommendations to address the Asian carp problem:

1. Support an annual appropriation (from the U.S. Army Corps of Engineers' budget) for operations and maintenance of the existing invasive species barrier on the Chicago Sanitary and Ship Canal.

2. Support the construction of a second dispersal barrier by supporting section 107 of the National Aquatic Invasive Species Act, by inserting language into the Water Resources Development Act, or by supporting language in the Energy and Water appropriations bill that authorizes the second barrier at full federal cost. (This authorization should appear in the legislative vehicle most likely to move quickly through Congress.)

3. Support research into a permanent and innovative biological separation of the Great Lakes and Mississippi River watersheds.

4. Support the provision in the National Aquatic Invasive Species Act that calls upon the Corps of Engineers to investigate the effectiveness of dispersal barriers in preventing the spread of invasive species via canals.

5. Support the provision in the National Aquatic Invasive Species Act that establishes a screening process for the importation of new organisms.

6. Support applying the Lacey Act to list as injurious the three species of Asian carp—the black, silver, and bighead carps—in order to ban the importation and transportation of these species.

7. Support the development of a "clean list" (as opposed to a "black list") of species acceptable for live trade. This puts the onus on the importer to prove that the species will do no harm, as opposed to the onus being on society to prove that it will.

8. Urge the states and the Province of Ontario to ban immediately the possession of live Asian carp and other species (e.g., the snakehead) that have the potential to invade the Great Lakes system.

9. Support the application of the Canadian Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (WAPPRIITA) and the Ontario Fish and Wildlife Conservation Act, to prohibit the importation of live Asian carp into Ontario. Seek the application of these laws to other species.

GREAT LAKES RESTORATION AND THE CORPS OF ENGINEERS

The Great Lakes are our region's treasures and they deserve restoration. The Great Lakes fishery, which remains stressed, stands to benefit tremendously from a comprehensive restoration effort. Although significant progress has been made in cleaning up and protecting the Great Lakes, a recent report by the General Accounting Office (GAO) concluded that binational, federal, and state strategies to restore the lakes are underfunded and not coordinated as well as they should be. The report points out that restoration efforts in other.regions of the country—particularly efforts to protect the Everglades and the Chesapeake Bay—are more sophisticated than restoration efforts in the Great Lakes region and are guided by more effective strategies. The Great Lakes Fishery Commission concurs with the GAO's conclusions and has strongly supported the development of a Great Lakes restoration strategy.

One major fishery restoration initiative is the Great Lakes Fishery and Ecosystem Restoration Program (GLFER), a program authorized by the *Water Resources Development Act of 2000*. The commission notes that Senator Voinovich was the principal author of this provision and we commend the Senator for his vision to restore the Great Lakes fishery. The program authorizes the Corps of Engineers (COE) to partner with federal, state, and local agencies and the Great Lakes Fishery Commission to plan, implement, and evaluate projects supporting the restoration of the fishery, ecosystem, and beneficial uses of the Great Lakes. The COE has an authorization to spend up to $100,000,000 for this program. Examples of projects might include removal of unnecessary barriers in Great Lakes tributaries, creation of fish passage devices, riparian habitat stabilization, and restoration and creation of wetlands.

Particularly noteworthy about this program is that the COE is directed to work with signatories of *A Joint Strategic Plan for Management of Great Lakes Fisheries* and with the Great Lakes Fishery Commission to identify and implement restoration projects. In formulating this program, the COE is also directed to use existing documents (such as the Fish Community Objectives, Lake Management Plans, and Remedial Action Plans) as the foundation for identifying priorities.

Since the passage of this legislation, the Great Lakes Fishery Commission has worked closely with the COE to get the program up and running. The commission has been very proud to be the local sponsor for the development of the support plan, the first step in implementing this program. The development of the support plan, as called-for in the legislation, has been done in close consultation with federal, state, and tribal agencies. The management agencies signatory to the Joint Strategic Plan are quite enthused about this program.

As of this date, the support plan is in the final stages of its internal review. Once this support plan is completed, restoration projects may commence. It is envisioned that the signatories to the Joint Strategic Plan will identify priority projects, similar to how they identify projects under the successful *Fish and Wildlife Restoration Act*.

This program is an enormous opportunity for the Great Lakes. The program will rely on the Joint Strategic Plan process for its success, a major recognition of the importance of cooperative management. The commission urges Congress to appropriate at least $10 million per year under this authorization so that the COE and the management agencies can partner on restoration efforts.

CONCLUSION

The Great Lakes fishery defines our region and is a key indicator of the overall health of the system. Indeed, the first question people often ask about the Great Lakes is "how are the fish?" Management agencies and the Great Lakes Fishery Commission work very hard to sustain the fishery for today and for the future, to improve the habitat upon which the fish depend, to stop the influx of invasive species, to control sea lampreys, and advance our scientific understanding of the resource.

Sportfishing on the Great Lakes remains extremely popular; commercial fishing remains economically viable. The lakes need constant attention from Congress if they are to sustain this $4 billion fishery, keep sea lampreys in check, and stop the biological invasion that is taking place. New initiatives like the Great Lakes Fishery and Ecosystem Restoration Program and the National Aquatic Invasive Species Act aim to improve and protect the resource. Time-honored institutions like the Great Lakes Fishery Commission and the *Joint Strategic Plan for Management of Great*

Lakes Fisheries strive to maintain the cooperation that is so critical to the ecosystem approach to management. And a commitment to the resource—to the fishery and the environment—by the millions of people who live in the Great Lakes basin will help ensure that the lakes' resources are passed on to future generations.

We thank the committee for focusing its attention on the Great Lakes and we look forward to working with Congress on ways in which we can—together—restore these invaluable treasures.

SOURCES

1979. Minutes of the annual meeting of the Council of Lake Committees, *In* G. L. F. Commission, (ed.). Great Lakes Fishery Commission, Ann Arbor, MI.

DesJardine, R.L., T. Gorenflo, R.N. Payne, and J.D. Schrouder. 1995. Fish-Community objectives for Lake Huron. Great Lakes Fishery Commission, Ann Arbor.

Dochoda, Margaret R., and Michael L. Jones. 2002. Managing Great Lakes fisheries under multiple and diverse authorities. In *Sustaining North American salmon: Perspectives across regions and disciplines*, edited by K. D. Lynch, M. L. Jones and W. Taylor. Bethesda: American Fisheries Society Press.

Eshenroder, R.L., M.E. Holey, T. Gorenflo, and R.D. Clark. 1995. Fish-community objectives for Lake Michigan Special publication 95-3. Great Lakes Fishery Commission, Ann Arbor.

GLFC. 1997. A Joint Strategic Plan for Management of Great Lakes Fisheries. Ann Arbor: Great Lakes Fishery Commission.

GLFC. 2002. A Joint Strategic Plan for Management of Great Lakes Fisheries: Cooperation at its best (Brochure). Ann Arbor: Great Lakes Fishery Commission.

Horns, W.H., C.R. Bronte, T.R. Busiahn, M. Ebener, R.L. Eshenroder, T. Gorenflo, N. Kmiecik, W. Mattes, J.W. Peck, M. Petzold, and D.R. Schreiner. 2003. Fish-community objectives for Lake Superior. Great Lakes Fishery Commission, Ann Arbor.

Mills, E.L., J.H. Leach, J. Carlton, and C. Secor. 1993. Exotic species in the Great Lakes: A history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19:1-54.

Piper, Don. 1967. *The international law of the Great Lakes.* Durham, NC: Duke University Press.

Rasmussen, J.L. 2002. The Cal-Sal and Chicago Sanitary and Ship Canal: A perspective on the spread and control of selected aquatic nuisance fish species. U.S. Fish and Wildlife Service, Rock Island, IL.

Reid, D., H.J. MacIsaac, J.E. Gannon, and J. Hartig. 2002. Research and management priorities for aquatic invasive species in the Great Lakes [Online]. Available by International Association for Great Lakes Research http://www.iaglr.org/scipolicy/ais/ais_iaglr02.pdf.

Ricciardi, A. 2001. Facilitative interactions among aquatic invaders: Is an 'invasional meltdown' occurring in the Great Lakes? Canadian Journal of Fisheries and Aquatic Science 58:2513-2525.

Ryan, P.A., R. Knight, R. MacGregor, G. Towns, R. Hoopes, and W. Culligan. 2003. Fish-community objectives for Lake Erie. Great Lakes Fishery Commission, Ann Arbor.

Stewart, T.J., R.E. Lange, S.D. Orsatti, C.P. Schneider, A. Mathers, and M.E. Daniels. 1999. Fish-Community objectives for Lake Ontario Special Publication 99-1. Great Lakes Fishery Commission, Ann Arbor.

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293,974,052

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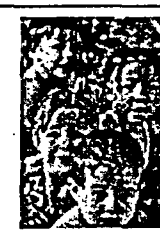

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County Business Patterns

ATTENTION: County Business Patterns 2002 is scheduled for release in September 2004. County Business Patterns 2003 is scheduled for release in Spring 2005.

County Business Patterns is an annual series that provides subnational economic data by industry. The series is useful for studying the economic activity of small areas; analyzing economic changes over time; and as a benchmark for statistical series, surveys, and databases between economic censuses. Businesses use the data for analyzing market potential, measuring the effectiveness of sales and advertising programs, setting sales quotas, and developing budgets. Government agencies use the data for administration and planning.

County Business Patterns covers most of the country's economic activity. The series excludes data on self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees. Beginning in 1998, data are tabulated by industry as defined in the *North American Industry Classification System: United States, 1997 (NAICS)*. Data for 1997 and earlier years are based on the Standard Industrial Classification (SIC) System. For more information on the relationship between the two systems, see the Bridge Between NAICS and SIC

This series has been published annually since 1964 and at irregular intervals dating back to 1946. The comparability of data over time may be affected by definitional changes in establishments, activity status, and industrial classifications.

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Also, see information about recent changes to County Business Patterns.

For more information, contact us at (301)763-2580 or by email.

For information on businesses with no paid employees, see Nonemployer Statistics.

For more frequently requested Census Bureau information at the national, state and county level, see State and County QuickFacts.

Source: U.S. Census Bureau, EPCD, County Business Patterns.
Last revised: June 08 2004

Local Area Personal Income

For help and instructions, downloadable files, and other information please read the notes below.

Step 1. Select a series. This will change options below.

- (•) Personal income and population summary estimates (CA1-3)
- ( ) Detailed income and employment tables by NAICS industry, 2001-2002 (CA05 and CA25)
- ( ) Detailed income and employment tables by SIC industry, 1969-2000 (CA05 and CA25)
- ( ) Detailed tables of regional profiles, personal current tranfers, farm income, 1969-2002 (CA30-CA45)
- ( ) Wage and salary summary estimates (CA34)
- ( ) Single line of data for all counties (3183 rows returned; please limit years selected to speed process)

CA1-3 — personal income summary estimates

Step 2. *Select one estimate, one area, and one or more years.* (help)

Personal income
Personal income, percent change
Population
Per capita personal income
Per capita personal income, percent of US

U.S., States, and regions
Metropolitan Statistical Areas*
BEA Economic Areas
State Metro/Nonmetro Portions**
Alabama
Alaska
Arizona
Arkansas
California
Colorado

2002
2001
2000
1999
1998
1997
1996
1995
1994
1993

**December 2003 OMB metropolitan area definitions, released by OMB in February 2004.*
***Nonmetropolitan state portion includes micropolitan counties.*

Step 3. *Press Display to view a table, or Download to retrieve comma-separated-value text.*

Display Download

NOTES:

- The Series buttons at the top of the page control table selections. Click on different series buttons to get different table options.
- To view county-level information first display a State. Use the CTRL and/or Shift keys to select multiple years. Press *Display* to display your selection in HTML tables, and *Download* to download a comma-separated-value text file. After displaying a table, you have the option to show one estimate for all counties and MSAs in that State by clicking on the line code next to the estimate. If you select *Download* it is recommended that you specify an output file name with a CSV extension. If you select *Download* you need to do the following after the information is displayed:
    - Select your browser's "Save As" menu item

- Select a file type of "Text file"
- Name your file with a CSV, PRN, or TXT extension.

- The greater the number of years selected, the slower the request will be. A submission that requests too much information has the possibility of timing out. If you are displaying information, you will want to consider how large your table will be; a table with a lot of years (columns) may be difficult to read because of its large width.
- The local area estimates in the above tables also appear on the Regional Economic Information System (REIS) CD-ROM, which, although not yet available to order, is available as a large download.

Additional files

- CA1-3— Personal income, per capita personal income, and population, compressed comma-separated-value (CSV) files
- Personal income and per capita personal income, 2000-2002, with year 2002 **rankings of per capita personal income.**
  Choose an area from this list—

  Metropolitan Statistical Areas*
  BEA Economic Areas
  Alabama
  Alaska
  Arizona
  Arkansas
  California
  Display

- BEARFACTS, a narrative about an area's personal income using current estimates, growth rates, and a breakdown of the sources of personal income.
- Journey to Work— the number of commuters from a county of residence to a county of work, for 1970, 1980, and 1990.
- Map of U.S. counties showing percent of U.S. per capita personal income 1969-2002
- 250 highest and lowest per capita personal incomes of the 3111 counties in the United States, 2002.
- CA34— County and MSA total wage and salary disbursements, total wage employment, and average wage per job
- The REIS CD-ROM is available for ordering and download.

New estimates of 2002 county personal income and revised estimates for 1969-2001 were released May 25, 2004. These estimates incorporate the results of the comprehensive revision to the national income and product accounts (NIPAs) released December 10, 2003, and to state personal income released April 27,2004. The revised estimates also reflect the new and revised county-level source data. These estimates incorporate new OMB metropolitan area definitions released June 2003 (with revisions released February 2004).

United States
CA1-3 Personal income
(thousands of dollars)

FIPS	Area name	1997	1998	1999	2000	2001	2002
00000	United States	6,907,332,000	7,415,709,000	7,796,137,000	8,422,074,000	8,703,023,000	8,900,007,
01000	Alabama total	91,419,381	97,011,788	100,662,426	105,806,693	110,970,011	114,427,
02000	Alaska total	16,402,151	17,085,208	17,556,559	18,741,427	20,142,479	21,040,
04000	Arizona total	103,557,083	113,370,224	120,857,125	132,557,859	138,029,372	143,428,
05000	Arkansas total	50,954,947	53,810,406	56,051,799	58,726,196	62,111,208	63,749,
06000	California total	860,544,880	936,008,661	999,228,183	1,103,841,912	1,135,847,818	1,154,684,
08000	Colorado total	107,873,315	118,492,917	128,859,584	144,393,687	150,593,713	151,789,
09000	Connecticut total	115,134,004	123,917,725	129,807,075	141,570,257	146,056,711	146,880,
10000	Delaware total	19,895,348	21,565,371	22,416,280	24,276,962	25,056,229	25,862,
11000	District of Columbia total	19,579,959	20,562,335	21,114,995	23,102,223	25,934,857	26,636,
12000	Florida total	372,093,817	402,454,015	423,833,681	457,539,355	478,341,768	496,706,
13000	Georgia total	182,867,714	198,781,765	212,081,463	230,355,758	239,713,863	246,247,
15000	Hawaii total	31,001,852	31,756,672	32,645,715	34,450,883	35,146,770	37,064,
16000	Idaho total	25,366,848	27,286,926	29,068,140	31,289,782	32,962,594	34,217,
17000	Illinois total	337,897,021	360,094,542	373,384,640	400,373,280	410,338,426	416,018,
18000	Indiana total	138,794,324	149,335,984	154,841,764	165,285,059	169,204,025	172,591,
19000	Iowa total	68,297,439	71,703,788	73,285,490	77,762,743	80,217,287	82,465,
20000	Kansas total	63,355,579	67,800,281	70,158,367	74,569,739	76,936,308	78,382,
21000	Kentucky total	82,435,707	87,850,643	91,461,710	98,845,348	101,495,313	104,263,
22000	Louisiana total	91,431,716	96,677,099	98,199,625	103,150,742	109,493,920	113,231,
23000	Maine total	27,829,739	29,709,976	31,016,020	33,173,133	34,888,611	36,306,
24000	Maryland total	147,842,522	157,783,778	167,074,691	181,957,207	190,331,297	197,868,
25000	Massachusetts total	189,884,749	203,986,701	216,220,842	240,208,628	249,243,450	250,993,
26000	Michigan total	248,821,337	265,097,783	278,061,682	294,226,742	295,145,826	299,449,
27000	Minnesota total	128,387,851	139,553,134	146,721,641	157,963,755	163,125,163	167,434,
28000	Mississippi total	51,513,791	54,819,857	56,718,896	59,836,915	62,776,404	64,645,
29000	Missouri total	129,992,334	137,619,251	142,924,849	152,722,183	157,431,497	161,648,
30000	Montana total	17,688,260	18,856,628	19,372,564	20,716,220	21,775,704	22,605,
31000	Nebraska total	40,576,462	43,314,148	45,116,028	47,328,771	49,357,953	50,414,
32000	Nevada total	47,388,150	52,370,705	56,462,368	61,427,864	63,565,423	66,235,
33000	New Hampshire total	32,420,019	35,149,444	37,124,806	41,429,037	42,516,497	43,310,
34000	New Jersey total	263,419,789	282,721,327	294,385,353	323,553,551	332,316,255	338,387,
35000	New Mexico total	34,960,814	37,045,765	38,045,599	40,318,443	43,766,634	45,974,
36000	New York total	557,023,833	591,847,125	619,658,834	663,005,163	679,558,058	685,110,
37000	North Carolina total	180,163,072	193,222,654	203,186,797	218,668,022	225,373,508	230,777,
38000	North Dakota total	13,439,930	14,810,400	14,933,720	16,096,687	16,435,241	17,021,
39000	Ohio total	278,049,245	294,291,500	304,463,599	320,538,414	325,938,635	333,078,
40000	Oklahoma total	69,720,438	74,117,517	77,565,113	84,310,444	88,230,421	90,507,
41000	Oregon total	80,854,187	85,628,707	89,873,232	96,401,727	99,012,343	101,358,
42000	Pennsylvania total	311,508,972	330,160,524	342,610,883	364,837,901	372,860,029	383,618,
44000	Rhode Island total	25,983,431	27,500,515	28,568,304	30,696,701	31,878,774	32,967,
45000	South Carolina total	81,004,483	86,854,395	91,715,570	98,270,171	101,765,939	104,652,
46000	South Dakota total	16,335,233	17,523,096	18,366,619	19,437,807	20,376,074	20,506,
47000	Tennessee total	124,698,853	133,619,641	140,395,190	148,833,423	154,655,832	159,864,
48000	Texas total	466,182,076	507,681,346	539,660,991	593,139,424	617,655,281	631,208,
49000	Utah total	43,667,135	47,018,856	49,342,572	53,561,211	55,594,428	57,133,
50000	Vermont total	13,737,871	14,787,819	15,649,530	16,883,009	17,767,630	18,346,
51000	Virginia total	179,653,618	191,710,830	204,585,792	220,845,445	232,522,077	238,990,
53000	Washington total	150,118,526	163,761,546	175,491,324	187,853,404	193,395,290	198,017,
54000	West Virginia total	35,004,858	36,721,626	37,557,062	39,582,040	41,560,476	42,945,
55000	Wisconsin total	129,098,510	138,667,104	144,702,139	153,547,595	158,700,854	163,463,
56000	Wyoming total	11,458,827	12,188,952	13,049,769	14,063,058	14,908,724	15,474,
	BEA Regions						
91000	New England region	404,989,813	435,052,180	458,386,577	503,960,765	522,351,673	528,805,
92000	Mideast region	1,319,270,423	1,404,640,460	1,467,261,036	1,580,733,007	1,626,056,725	1,657,483,
93000	Great Lakes region	1,132,660,437	1,207,486,913	1,255,453,824	1,333,971,090	1,359,327,766	1,384,601,
94000	Plains region	460,384,828	492,324,098	511,506,714	545,881,685	563,879,523	577,872,
95000	Southeast region	1,523,241,957	1,633,534,719	1,716,450,011	1,840,460,108	1,920,780,319	1,980,502,

96000	Southwest region	674,420,411	732,214,852	776,128,828	850,326,170	887,681,708	911,118,
97000	Rocky Mountain region	206,054,385	223,844,279	239,692,629	264,023,958	275,835,163	281,220,
98000	Far West region	1,186,309,746	1,286,611,499	1,371,257,381	1,502,717,217	1,547,110,123	1,578,401,

Footnotes for Table CA1-3

1. Census Bureau midyear population estimates. Estimates for 2000-2002 reflect county population estimates available as of April 2004.
2. Per capita personal income was computed using Census Bureau midyear population estimates. Estimates for 2000-2002 reflect county population estimates available as of April 2004. See footnote 1.
3. Estimates for 1979 forward reflect Alaska Census Areas as defined by the Census Bureau; those for prior years reflect Alaska Census Divisions as defined in the 1970 Decennial Census. Estimates from 1988 forward separate Aleutian Islands Census Area into Aleutians East Borough and Aleutians West Census Area. Estimates for 1991 forward separate Denali Borough from Yukon-Koyukuk Census Area and Lake and Peninsula Borough from Dillingham Census Area. Estimates from 1993 forward separate Skagway-Yakutat-Angoon Census Area into Skagway-Hoonah-Angoon Census Area and Yakutat Borough.
4. Virginia combination areas consist of one or two independent cities with populations of less than 100,000 combined with an adjacent county. The county name appears first, followed by the city name (s). Separate estimates for the jurisdictions making up the combination areas are not available.
5. La Paz County, AZ was separated from Yuma County on January 1, 1983. The Yuma, AZ MSA contains the area that became La Paz County, AZ through 1982 and excludes it beginning with 1983.
6. Cibola, NM was separated from Valencia in June 1981, but in these estimates, Valencia includes Cibola through the end of 1981.
7. Shawano, WI and Menominee, WI are combined as Shawano (incl. Menominee), WI for the years prior to 1989.
8. Broomfield County, CO, was created from parts of Adams, Boulder, Jefferson, and Weld counties effective November 15, 2001. Estimates for Broomfield county begin with 2002.

- All state and local area dollar estimates are in current dollars (not adjusted for inflation).
- (N) Data not available for this year.

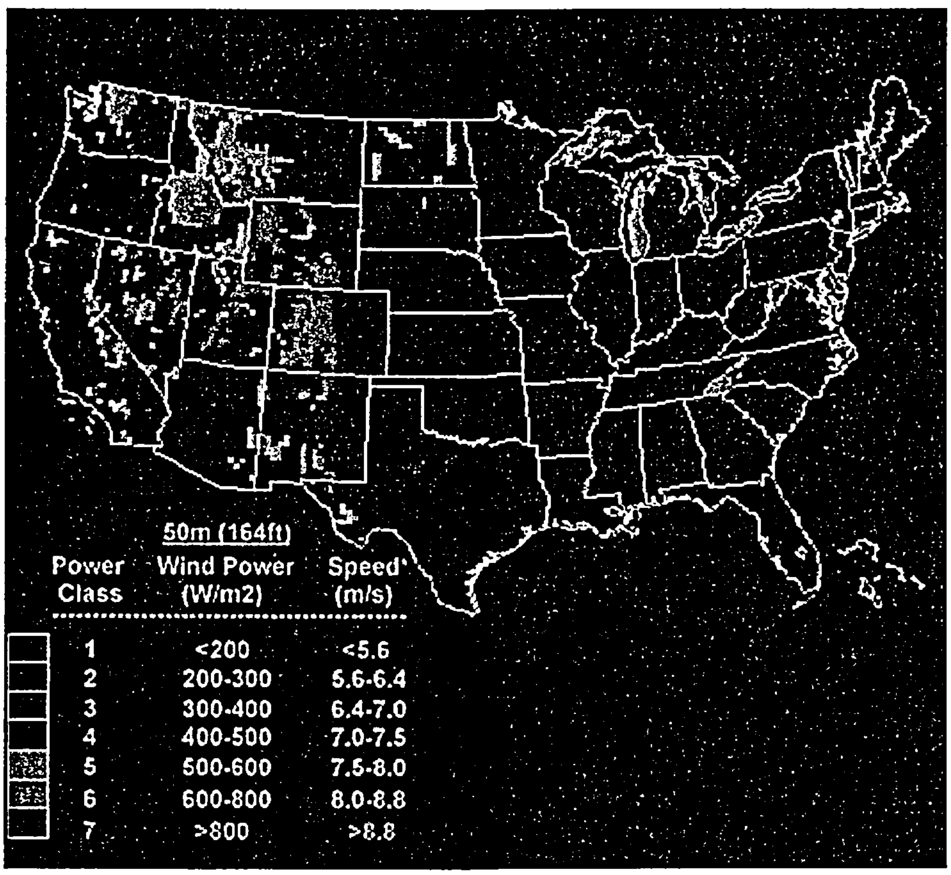
Regional Economic Information System
Bureau of Economic Analysis
Table CA1-3
May 2004

U.S. Department of Energy - Energy Efficiency and Renewable Energy
Wind and Hydropower Technologies Program

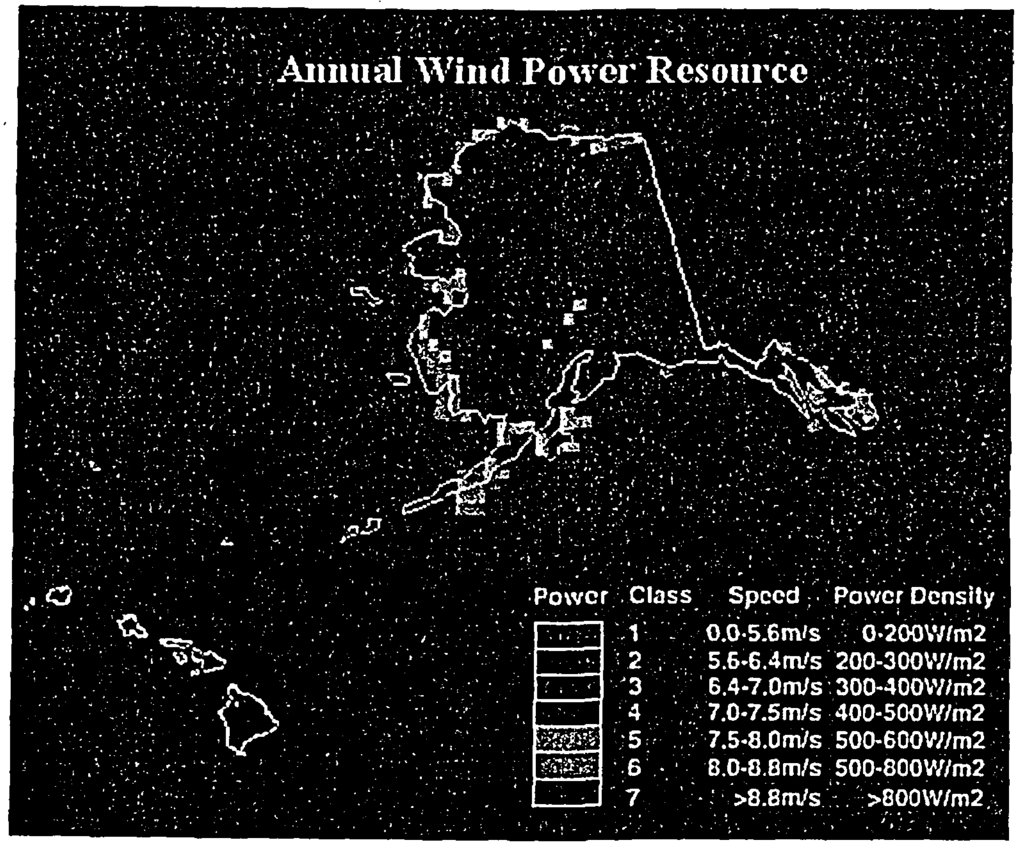
Wind Energy Resource Potential

Good wind areas, which cover 6% of the contiguous U.S. land area, have the potential to supply more than one and a half times the current electricity consumption of the United States.

Estimates of the wind resource are expressed in wind power classes ranging from class 1 to class 7, with each class representing a range of mean wind power density or equivalent mean speed at specified heights above the ground. Areas designated class 4 or greater are suitable with advanced wind turbine technology under development today. Power class 3 areas may be suitable for future technology. Class 2 areas are marginal and class 1 areas are unsuitable for wind energy development.

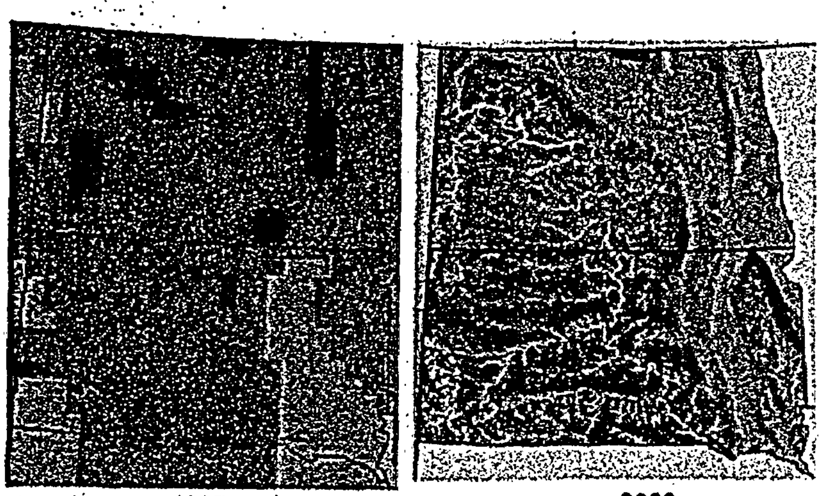


U.S. Annual Wind Power Resource and Wind Power Classes - Contiguous U.S. States.



U.S. Annual Wind Power Resource and Wind Power Classes - Alaska and Hawaii.

Because techniques of wind resource assessment have improved greatly in recent years, work began in 2000 to update the U.S. wind atlas. The work will produce regional-scale maps of the wind resource with resolution down to one square kilometer. The new atlas will take advantage of modern techniques for mapping. It will also incorporate new meteorological, geographical, and terrain data. The program's advanced mapping of the wind resource is another important element necessary for expanding wind-generating capacity in the United States.



1987 2000

1987 U.S. Wind Atlas Map vs. 2000 High-Resolution (1-km^2) Wind Map of North and South Dakota

Visit the Wind Powering America State Wind Map page to see if your state or area of interest has a newer, more detailed map available.

Phosphoric Acid Fuel Cell Technology

Phosphoric acid fuel cells were the first fuel cells to cross the commercial threshold in the electric power industry. Close to 300 of these "first generation" power units were placed in operation in stationary power applications in the United States and overseas. Most are the 200-kilowatt PC25 fuel cell manufactured by United Technologies Corporation and its subsidiaries, including one that powers a police station in New York City's Central Park and another that provides supplemental power to the Conde Nast Building at 4 Times Square in New York.


A 250-kilowatt phosphoric acid fuel cell powers a police station and electric vehicle recharging station in New York's Central Park.

As the name implies, these fuel cells use liquid phosphoric acid as the electrolyte. The electrodes are made of carbon paper coated with a finely-dispersed platinum catalyst. The catalyst strips electrons off the hydrogen-rich fuel at the anode. Positively charged hydrogen ions then migrate through the electrolyte from the anode to the cathode. Electrons generated at the anode travel through an external circuit, providing direct current electric power, and return to the cathode. There the electrons, hydrogen ions and oxygen form water, which is discharged from the cell.

Phosphoric acid fuel cells operate at around 150 to 200 degrees C (about 300 to 400 degrees F), above the boiling point of water. (This is one reason why phosphoric acid is preferred although it is a less efficient conductor of electricity than other acidic electrolytes Other acid electrolytes that require water for conductivity don't have this capability.)

At a phosphoric acid fuel cell's operating temperatures, the expelled water can be converted to steam for space and water heating. In this combined heat and power application, overall efficiencies can approach 80 percent. Yet the actual electricity-generating efficiency is relatively low, only 37 to 42%.

In a phosphoric acid fuel cell, hydrogen must be extracted from fuels such as natural gas outside the fuel cell (a process called "external reforming"). If the hydrocarbon fuel is gasoline, sulfur must be removed or it will damage the platinum catalyst. Material costs are also high. A typical phosphoric acid fuel cell costs between $4,000 and $4,500 per kilowatt. Because of their high cost, phosphoric fuel cells may not continue to be manufactured commercially. Their introduction, however, served to demonstrate the environmental and power quality benefits of fuel cell technology.

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Page updated on: August 02, 2004

Solid State Energy Conversion Alliance

Despite the technical success of fuel cell research and development efforts, fuel cells remain a "niche market" application due primarily to their high costs. Where premium-quality, reliable, and clean onsite power is critical to a business function – for example, at a bank, an airport, a computer data warehouse, etc. – customers may be willing to pay the $1,500 to as much as $4,500 per kilowatt for a fuel cell. Unfortunately, incremental improvements to existing systems appear unlikely to reduce costs below $1,000 per kilowatt in the near future.

SECA

The Department of Energy has set its R&D sights on a much more dramatic reduction in fuel cell costs. It has formed the Solid State Energy Conversion Alliance (SECA) with a goal of producing a core solid-state fuel cell module that could be produced at a cost of no more than $400 per kilowatt. At this cost, fuel cells would compete with gas turbine and diesel generators and likely gain widespread market acceptance.

MORE INFO
- Download SECA Brochure [320kB PDF]
- Download SECA R&D Program Plan [1.5MB PDF]
- Link to SECA Web Site

The key to the ambitious cost reductions will be the development of a compact, lightweight, 3-10 kilowatt "building block" module that can be mass-produced using many of the same manufacturing advances that have dramatically lowered costs in the electronics industry.

The modularity of the system will permit the individual units to be clustered into a variety of custom-build stacks for a wide variety of applications – from small portable military power sources to multi-megawatt central generating stations. The system could also be a prime option for powering tomorrow's electric vehicles and auxiliary power units.

SECA is made up of several government agencies, fuel cell developers, universities and national laboratories. It is headed by the Energy Department's National Energy Technology Laboratory (NETL) and its Pacific Northwest National Laboratory (PNNL). The SECA program is currently structured to include competing industry teams supported by a crosscutting core technology program. These teams are headed by: FuelCell Energy, Delphi Battelle, General Electric Company, Siemens Westinghouse, Acumentrics, and Cummins Power Generation and SOFCo.

SECA Industry Teams

SECA has six industry teams working on competing designs for the distributed generation and auxiliary power applications. The SECA industry teams receive core technology support from leading researchers at small businesses, universities and

News & Events
- New Fuel Cell Projects to Continue Progress to Zero-Emissions Energy

More Related Techlines >

Project Info
- Database of Fuel Cell R&D Projects
- National Energy Technology Laboratory Web Site

Program Contacts:
- Samuel Biondo
  Office of Fossil Energy (FE-22)
  U.S. Dept. of Energy
  DC, Washington 20585
  301-903-5910
- Mark Williams
  National Energy Technology Laboratory
  PO Box 880
  U.S. Dept. of Energy
  WV, Morgantown 26507
  304-285-4747

national laboratories.

Delphi and Acumentrics, two of the SECA industry teams, have built and tested complete operating fuel cell systems. These systems don't yet meet all of the SECA requirements, but demonstrate the commitments of the developers who are aggressively pursuing the SECA goals.

Leading manufacturers of power generation equipment, such as General Electric and Siemens Westinghouse, and major automotive and truck manufacturers are investing in fuel cell business ventures to pursue growth in distributed generation and auxiliary power applications.

For example, Delphi, the world's largest maker of auto parts, is collaborating with BMW to use SECA fuel cells for auxiliary power in BMW cars. Delphi is also collaborating with PACCAR, the manufacturer of heavy-duty, on- and off-road Class 8 trucks sold around the world under the Kenworth, Peterbilt, DAF and Foden nameplates, to use SECA auxiliary power units in Kenworth trucks. BMW and PACCAR expect to have commercial products by 2007.

Delphi, in partnership with Battelle, is developing a 5-kilowatt fuel cell for the distributed generation and auxiliary power unit markets. Delphi is applying its expertise in system integration, high volume manufacturing and cost reduction. Delphi has demonstrated great progress making a very compact and lightweight system suitable for auxiliary power in transportation applications through innovation such as combining the combustor, heat exchanger, and fuel processor into one component. The Delphi Generation-2 fuel cell stack is one-third the weight and volume of the first generation prototype demonstrated in a BMW automobile. Delphi is demonstrating SECA fuel cell versatility by powering its SECA Generation-2 SOFC using fuel gas extracted from coal. The demonstration began in June 2003 at the Power Systems Development Facility coal-gasification plant in Wilsonville, Alabama.

GE is evaluating several fuel cell stack designs with particular interest in large hybrid systems, combining SECA fuel cells with turbines. GE has been exceptionally impressive in fuel cell power density and improving fuel utilization using low-cost, conventional materials. These improvements are critical to lower cost with high efficiency. GE innovations also include multiple designs that minimize or eliminate difficult seal areas.

Cummins and SOFCo are developing SECA fuel cell products for recreational vehicles (RVs) that will run on propane using a compact fuel processing technology to convert the propane fuel to a hydrogen rich fuel stream The team has produced a conceptual design for a fuel cell stack assembled from low cost "building blocks," that can be fabricated using ceramic manufacturing techniques used by the computer industry.

Siemens Westinghouse Power Corporation is changing their cylindrical fuel cell design to dramatically increase cell power levels. The new flattened cells have twice the power output compared to their current cylindrical tubes. The new design will reduce the size of the fuel cell so it can also be used for a wider range of applications, possibly even auxiliary power units.

FuelCell Energy, the successful developer of second-generation fuel cells, brings twenty years of fuel cell experience to the SECA program. One promising approach to reducing solid oxide fuel cell cost is the use of less expensive materials by reducing the temperature. FuelCell Energy expects to achieve cost reduction by operating at lower temperatures using less expensive materials. FuelCell Energy's team includes world class researchers from the University of Utah, Materials and Systems Research, Inc. and Pacific Northwest National Laboratory. FuelCell Energy has jumpstarted their design using a University of Utah fuel cell, which has operated successfully for 10,000 hours. This industry team is targeting small stationary applications followed by military portable power applications, with an emphasis on multi-fuel capability.

Acumentrics has already attracted commercial interest in its fuel cells. ChevronTexaco, in need of a uninterruptible power source, purchased one Acumentrics fuel cell in October 2002 and ordered five more in January 2003. In order to meet the SECA fuel cell cost target of $400 per kilowatt, Acumentrics, together with General Dynamics, is developing small tubular cell geometry with superior ruggedness and fast start capability. This team is focusing on development of a 10-kilowatt module that will target the communications, residential, military and light commercial markets.

SECA Core Technology Program

Over 30 SECA R&D projects are generating new scientific and engineering knowledge, creating technology breakthroughs by addressing technical risks and barriers that currently limit achieving SECA performance and cost goals. The performance of fuel cell electrodes has been doubled through work by PNNL, Argonne National Laboratory, the University of Utah, and others in early SECA research through better materials and improved manufacture and design. Delphi used core technology to advance its Generation-2 prototype, and Siemens Westinghouse, General Electric, and Cummins are evaluating new core technology materials and designs for their fuel cells.

Fuel processing work at Los Alamos National Laboratory, Argonne National Laboratory, PNNL, and NETL is making dramatic progress in reducing the amount of water required to process heavy fuels such as diesel by a factor of three. This work is critical to using SECA fuel cells as auxiliary power units and other applications where water is scarce or not available.

Computer design tools, which are essential to creating low-cost, reliable designs, have been developed by PNNL, University of Florida, Oak Ridge National Lab, and Georgia Tech. These new tools are in use and are expected to save industry millions of dollars by reducing the need to test expensive hardware to failure.

Additional core technology advances are about to emerge from the R&D pipeline. For example, a new electrode material developed at PNNL has demonstrated oxygen, sulfur, and carbon tolerance resulting in eliminating as many as four system components. This will greatly reduce cost and increase efficiency.

The proposed solid state design will leverage numerous recent advances, such as the production of thin-film solid electrolyte materials and precise, automated manufacturing technologies developed largely in the semi-conductor industry.

SECA's goal is to have this ultra-low cost fuel cell concept ready for commercial application by 2010.

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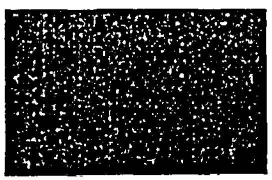

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States Michigan

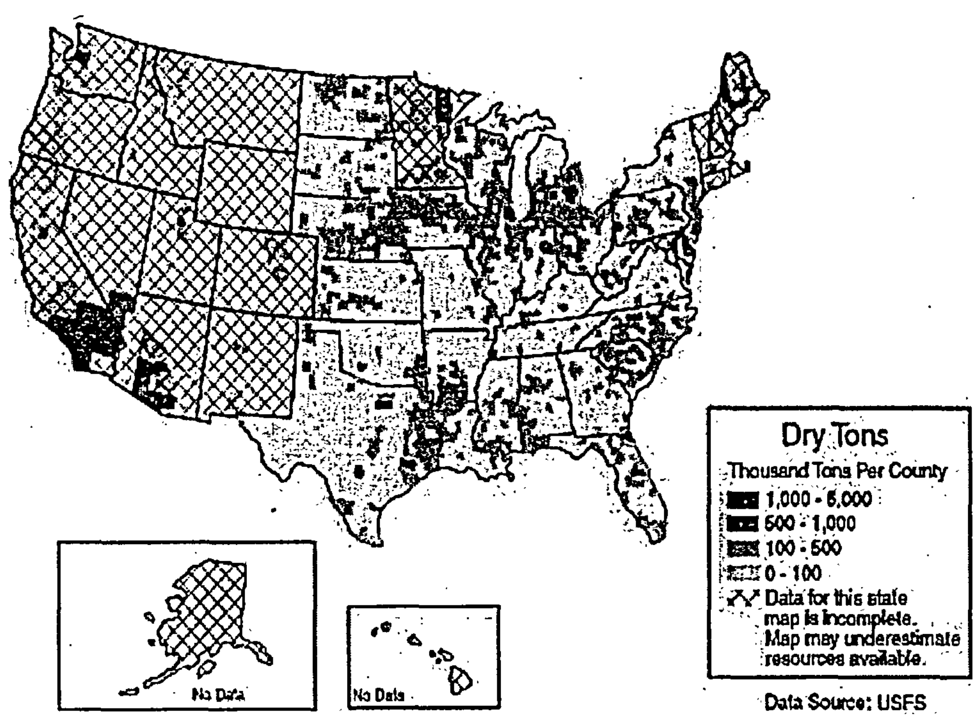
Michigan Bioenergy Resources

All plant or plant-derived material—"biomass"—from trees and grasses, agricultural crops, agricultural or forestry residues, and waste materials from plant products can be used to produce "bioenergy."

For heating applications or electricity generation, biomass can be burned in its solid form, or first converted into liquid or gaseous fuels for energy sources. Biomass power technologies convert renewable biomass fuels into heat and electricity using modern boilers, gasifiers, turbines, generators, fuel cells, and other methods.

For transportation use, liquid fuels made from biomass (biofuels), fill the bill best. The two most common biofuels used in the United States today are ethanol and biodiesel. While they can each be used as alternative fuels, both are more frequently used as additives to conventional fuels to reduce toxic air emissions and improve performance.

Biomass materials that are byproducts from activities such as wood products manufacturing, construction, agriculture, and forest harvesting or management are referred to as "residues." Residues can be inexpensive and clean sources of biomass. Using biomass residues as a fuel can avoid fossil-fuel purchases while reducing the costs and environmental impacts of disposal. In the future, fast growing grasses, shrubs, and trees (also referred to as "energy crops") could be grown specifically for use as fuels to meet a growing demand for sustainable electricity and transportation fuels.



United States - Biomass Resource

Data Source: USFS
USEPA
NREL

Please note that biomass availability can vary significantly from one locality to the next. These maps and data are intended to provide a general indication of a region's biomass availability. Only municipal waste, mill and forest residues and select crop residues are considered in this map. Some areas not shown on the map that are near urban or manufacturing centers, or areas with agricultural residues that have not been considered, may have excellent biomass resource availability.

Michigan Biomass Power Resources

Recent studies indicate that Michigan has a good biomass resource potential.

An estimated 17.7 billion kWh of electricity could be generated using renewable biomass fuels in Michigan. This is enough electricity to fully supply the annual needs of 1,769,000 average homes, or 62 percent of the residential electricity use in Michigan. These biomass resource supply figures are based on estimates for five general categories of biomass: urban residues, mill residues, forest residues, agricultural residues, and energy crops. Of these potential biomass supplies and the quantities cited below, most forest residues, agricultural residues, and energy crops are not presently economic for energy use. New tax credits or incentives, increased monetary valuation of environmental benefits, or sustained high prices for fossil fuels could make these fuel sources more economic in the future.

Wood is the most commonly used biomass fuel for heat and power. The most economic sources of wood fuels are usually urban residues and mill residues. **Urban residues** used for power generation consist mainly of chips and grindings of clean, non-hazardous wood from construction activities, woody yard and right-of-way trimmings, and discarded wood products such as waste pallets and crates. Local governments can encourage segregation of clean wood from other forms of municipal waste to help ensure its re-use for mulch, energy, and other markets. Using clean and segregated biomass materials for electricity generation recovers their energy value while avoiding landfill disposal. **Mill residues**, such as sawdust, bark, and wood scraps from paper, lumber, and furniture manufacturing operations are typically very clean and can be used as fuel by a wide range of biomass energy systems. The estimated supplies of urban and mill residues available for energy uses in Michigan are 826,000 and 1,564,000 dry tons per year, respectively. For a report on supplies of low-cost biomass residues in the United States, click the following link: Urban Wood Waste (PDF 1.13 MB). Download Acrobat Reader.

Forest residues include underutilized logging residues, imperfect commercial trees, dead wood, and other non-commercial trees that need to be thinned from crowded, unhealthy, fire-prone forests. Because of their sparseness and remote location, these residues are usually more expensive to recover than urban and mill residues. The estimated supply of forest residues for Michigan is 1,328,000 dry tons per year.

Agricultural residues are the biomass materials remaining after harvesting agricultural crops. These residues include wheat straw, corn stover (leaves, stalks, and cobs), orchard trimmings, rice straw and husks, and bagasse (sugar cane residue). Due to the high costs for recovering most agricultural residues, they are not yet widely used for energy purposes; however, they can offer a sizeable biomass resource if supply infrastructures are developed to economically recover and deliver them to energy facilities. An estimated 4,266,000 dry tons per year is available from corn stover and wheat straw in Michigan.

Energy crops are crops developed and grown specifically for fuel. These crops are carefully selected to be fast-growing, drought and pest resistant, and readily harvested alternative crops. Energy crops include fast-growing trees, shrubs, and grasses such as hybrid poplars, hybrid willows, and switchgrass, respectively. In addition to environmental benefits, energy crops can provide income benefits for farmers and rural land owners. For Michigan, the production potential for energy crops is estimated at 4,179,000 dry tons per year.

Michigan Biofuel Resources

A detailed estimate of Michigan's biofuel resources will be available on this site in the near future. In general, current U.S. ethanol production is based largely on the starch in kernels of field corn, the nation's largest agricultural crop. (The predominant use of field corn is for animal feed. Current ethanol production uses only about 7% of the crop.) Any starch or sugar crop, however, can now be used to make ethanol.

As commercialization of advanced bioethanol technology makes possible ethanol production from biomass other than starch and sugar, vast additional resources will become available to supplement ethanol production from corn kernels. The first advanced bioethanol technology plants will likely use "opportunity" feedstocks such as paper mill or food processing wastes, that are from concentrated sources and now have low value or must be disposed. In the intermediate future, ethanol can be made from agricultural residues such as corn stover (stalks and husks—roughly equivalent in mass to the corn grain crop), or forestry residues such as from lumber mills or from forest thinning to reduce fire danger near urban areas. In the long term, ethanol could be made from dedicated energy crops of fast-growing trees and grasses such as poplars and switchgrass.

Current U.S. biodiesel production is based largely on oil from soybeans and recycled restaurant cooking oils. Both of these are currently in surplus and biodiesel production uses only a very minor fraction of available supply. Any animal fat or vegetable oil, however, can be used to make biodiesel.

Additional Bioenergy Resource Information

For information on bioenergy resources and projects in your area, contact your regional biomass energy program representative.

For more information about biomass feedstocks and supplies in the United States, click here, or go to the Bioenergy Feedstock Development Program home page. The data cited above on biomass potential for Michigan (and other states in the U.S.) were obtained from the following reference:
Biomass Feedstock Availability in the United States: 1999 State-Level Analysis Marie E. Walsh, et. al., Oak Ridge National Laboratory, Oak Ridge, TN, April 30, 1999, Updated January, 2000.

To see USDA maps of biomass resource concentrations in the United States, click one of the following:

- Dominant Land Cover/Use for the U.S.
- Tree Coverage in the U.S.
- Grass/Herbaceous Cover in the U.S.
- Crop Cover in the U.S.
- Shrub Cover in the U.S.
- Total Animal Units in the U.S. from which Manure is Recoverable
- Beef Density in the U.S.
- Dairy Density in the U.S.
- Swine Density in the U.S.
- Poultry Density in the U.S.

See other USDA land-use maps.

Content Last Updated: 21 July 2004

U.S. Department of Labor
Bureau of Labor Statistics

Bureau of Labor Statistics Data

www.bls.gov

- About the Tools
- Overall Most Requested BLS Statistics
- Series Report--*Already know the series identifier for the statistic you want? Use this shortcut to retrieve your data.*
- Discontinued BLS Databases

Employment & Unemployment

	SPECIAL NOTICES	MOST REQUESTED STATISTICS	CREATE CUSTOMIZED TABLES (ONE SCREEN)	CREATE CUSTOMIZED TABLES (MULTIPLE SCREENS)	FLAT FILES
Labor Force Statistics from the Current Population Survey					BLS FTP
Access to Historical Data for the "A" Tables of the Employment Situation Release.					
Employment, Hours, and Earnings from the Current Employment Statistics survey (National)					BLS FTP
Access to Historical Data for the "B" Tables of the Employment Situation Release.					
Employment, Hours, and Earnings from the Current Employment Statistics survey (State and Metro Area)					BLS FTP
State and County Employment and Wages from the Quarterly Census of Employment and Wages (2001 forward)					BLS FTP
Business Employment Dynamics					BLS FTP
Local Area Unemployment Statistics					BLS FTP
Create Customized Maps -- Unemployment Rates					
Geographic Profile of Employment and Unemployment					BLS FTP
Mass Layoff Statistics					BLS FTP
National Longitudinal Surveys					BLS FTP
Job Openings and Labor Turnover Survey					BLS FTP

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Prices & Living Conditions

	SPECIAL NOTICES	MOST REQUESTED STATISTICS	CREATE CUSTOMIZED TABLES (ONE SCREEN)	CREATE CUSTOMIZED TABLES (MULTIPLE SCREENS)	FLAT FILES
CPI-All Urban Consumers (Current Series)					BLS FTP
CPI-Urban Wage Earners and Clerical Workers (Current Series)					BLS FTP
CPI-Average Price Data					BLS FTP
CPI-Department Store Inventory Price Index					BLS FTP
Chained CPI-All Urban Consumers					BLS FTP
Producer Price Index Industry Data					BLS FTP
Producer Price Index Commodity Data					BLS FTP
Import/Export Price Indexes					BLS FTP
Consumer Expenditure Survey					BLS FTP

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Compensation & Working Conditions

	SPECIAL NOTICES	MOST REQUESTED STATISTICS	CREATE CUSTOMIZED TABLES (ONE SCREEN)	CREATE CUSTOMIZED TABLES (MULTIPLE SCREENS)	FLAT FILES
National Compensation Survey					BLS FTP
Employee Benefits Survey					BLS FTP
Employment Cost Index					BLS FTP
Employer Cost for Employee Compensation					BLS FTP
Work Stoppage Data					BLS FTP
NEW Nonfatal cases involving days away from work: selected characteristics (2002)					BLS FTP
Nonfatal cases involving days away from work: selected characteristics (1992-2001)					BLS FTP
Census of Fatal Occupational Injuries					BLS FTP
NEW Occupational injuries and illnesses: industry data (2002)					

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Productivity & Technology

	SPECIAL NOTICES	MOST REQUESTED STATISTICS	CREATE CUSTOMIZED TABLES (ONE SCREEN)	CREATE CUSTOMIZED TABLES (MULTIPLE SCREENS)	FLAT FILES
Major Sector Productivity and Costs Index					
Major Sector Multifactor Productivity Index					
Industry Productivity and Costs					
Foreign Labor Statistics					

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Regional Resources

	SPECIAL NOTICES	MOST REQUESTED STATISTICS	CREATE CUSTOMIZED TABLES (ONE SCREEN)	CREATE CUSTOMIZED TABLES (MULTIPLE SCREENS)	FLAT FILES
New England Information Office (Boston, MA)					
New York-New Jersey Information Office (New York, NY)					
Mid-Atlantic Information Office (Philadelphia, PA)					
Southeast Information Office (Atlanta, GA)					
Midwest Information office (Chicago, IL)					
Southwest Information Office (Dallas, TX)					
Mountain-Plains Information Office (Kansas City, MO)					
Western Information Office (San Francisco, CA)					

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About the Tools

-- Important Notices.

-- allows users to quickly retrieve BLS time series data from lists of those most commonly requested.

this application (previously called **"Public Data Query"**) requires a Java-enabled browser.

-- Choose the data you want from BLS databases on a simple, one-screen form.

-- a form-based query application which allows you to obtain BLS time series data based on choices you make (previously called "**Selective Access**")

BLS FTP -- a link to the BLS FTP server. Given the limitations on the amount of data which can be extracted using any of the applications provided on the Web site, the FTP server can be ideal for those users requiring large volumes of time series data.

OTHER TYPES OF DATA ACCESS INCLUDE:

Economic News Releases -- these news releases present the latest data produced by various BLS programs and surveys. News releases are grouped according to major BLS statistical categories (for example, Employment and Unemployment, Prices and Living Conditions, etc.) for quick reference and contain pre-formatted data tables along with text explanations provided by BLS economic staff.

Series Report --this application uses BLS time series identifiers as input in extracting data from each survey-specific database, according to a specified set of date ranges and output options. Primarily for use by experienced users of BLS time series data, this application provides the most efficient path for those users who are familiar with the format of each survey-specific time series identifier and do not require any further assistance in formulating a query.

Economy At a Glance -- tables which contain current data, organized by geography and by industry, on the various economic indicators produced by BLS.

More Sources of Data

U.S. Bureau of Labor Statistics
Postal Square Building
2 Massachusetts Ave., NE
Washington, DC 20212-0001

Phone: (202) 691-5200
Fax-on-demand: (202) 691-6325
Data questions: blsdata_staff@bls.gov
Technical (web) questions: webmaster@bls.gov
Other comments: feedback@bls.gov

U.S. Environmental Protection Agency

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Partners

Lake Michigan Lake Wide Management Plan (LaMP 2000)

available as portable document files
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Lake Michigan LakeWide Management Plan (LaMP) 2002

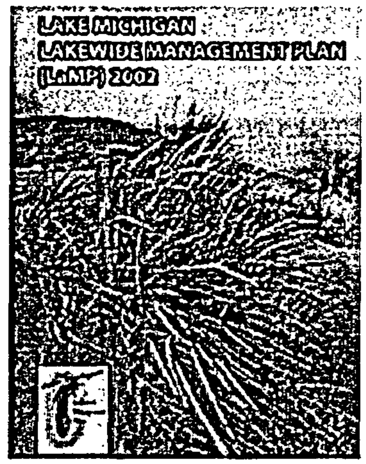
Habitat and Land Use Management Toolbox

Lake Michigan LaMP Highlights 2002

Introduction

The purpose of this Lakewide Management Plan (LaMP) 2002 is to provide:

- An executive summary of the status of the Lake Michigan ecosystem;
- A report on the progress in achieving the Lake Michigan goals described in LaMP 2000 and examples of significant activities completed in the past two years;
- A summary of the current Lake Michigan mass balance data and findings;
- Links to more detailed information in LaMP 2000 or other sources;
- An opportunity to comment on targets and plans for pollution reduction and ecosystem restoration;
- A proposal to identify additional pollutants to be addressed by the LaMP in the future.



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What is the Status of the Lake?

"Lake Michigan is an outstanding natural resource of global significance, under stress and in need of special attention." LaMP 2000

Since the release of LaMP 2000, several key indicators point to the continuing concern for the health of the ecosystem.

- Last year's beach season exhibited a growing number of beach closings.
- Studies revealed that a critical layer of the Lake Michigan aquatic food web appears to be disappearing, and with the discovery of two new aquatic nuisance species–there are now a total of 160 in the Great Lakes ecosystem–the integrity of the food web of Lake Michigan is in question.
- Mercury in fish is such a prevalent problem that 41 states now have mercury fish advisories, and a national advisory has been issued for certain ocean fish pointing to a problem of global proportions.
- Climatic pattern changes, whether temporary or permanent, are lowering lake levels as well as raising concerns about groundwater and lake interaction and diversion.
- Following the September 11, 2001 terrorist attacks, the issue of protecting the lake's vast supply of fresh drinking water has become a higher priority.

Despite these concerns, Lake Michigan supports many beneficial uses. For example, it provides drinking water for 10 million people; has internationally significant habitat and natural features; supports food production and processing; supplies fish for food, sport, and culture; has valuable commercial and recreational uses; and is the home of the nation's third-largest population center. Furthermore, significant progress is being made to remediate the legacy of contamination in the basin. Specifically, ongoing actions to restore the Areas of Concern (AOC) have been successful and are outlined in Appendix B.

Background on the LaMP

Under the Great Lakes Water Quality Agreement (GLWQA), as amended in 1987, the United States and Canada agreed " to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." To achieve this objective, the parties agreed to develop and implement, in consultation with state and provincial governments, LaMPs for open waters. In the case of Lake Michigan, the only one of the Great Lakes wholly within the borders of the United States, the Clean Water Act (Section 118c) holds the U.S. Environmental Protection Agency (EPA) accountable for the LaMP.

Work on the Lake Michigan LaMP began in the early 1990s with a focus on critical pollutants affecting the lake. At that time, monitoring data showed that point source regulatory controls established in the 1970s and 1980s were reducing the levels of persistent toxic substances such as polychlorinated biphenyls (PCB), DDT, and other pesticides. Monitoring results also indicated that nonpoint sources of pollution such as runoff and air deposition, as well as aquatic nuisance species, were stressing the Lake Michigan ecosystem. The LaMP states that "pathogens, fragmentation and destruction of terrestrial and aquatic habitats, aquatic nuisance species, uncontrolled runoff and erosion are among the stressors contributing to ecosystem impairments."

It has been documented that core regulatory programs at the federal, state, tribal, and local levels have effectively controlled many pollutants. Increased water quality protection is now being addressed with the adoption of higher water quality standards for the Great Lakes basin by each Great Lakes state, with the goal of having the new standards reflected in all permits by 2006. What remains is a set of difficult, persistent, and multifaceted problems. In response, agencies must develop new tools, refocus their strategies and methods, and continually obtain new data. As the 1994 State of the Lakes Ecosystem Conference reported, "governments have traditionally addressed human activities on a piecemeal basis, separating decision making on environmental quality from decision making on natural resources management or on social or economic issues...." In addition, decisions at different levels of government or across political boundaries are being made unilaterally without regard to watershed or ecosystem alignment.

What is LaMP 2000?

The publication of LaMP 2000 was the beginning of a basinwide dialogue on which pollutants and stressors should be prioritized for control, what reduction targets should be applied to them, and which ecologically rich areas should be identified for restoration and protection. Some issues, such as aquatic nuisance species, legacy sites, and drinking water protection, require immediate attention. Others will continue to be the subject of public dialogue, while still other issues may arise that require additional research. In 2000, the Binational Executive Committee determined that an adaptive management approach would guide the LaMP process, making it an iterative approach. This status report provides new information, responds to input received, and sets targets and objectives for public comment.

What was Accomplished and What Challenges Remain?

Areas that were highlighted in LaMP 2000 and have been accomplished include the following:

- Setting targets for reduction of critical pollutants and stressors,
- Reviewing the LaMP list of contaminants and stressors,
- Filling data gaps, including the Lake Michigan Mass Balance Project,
- Identifying ecologically rich areas and habitats,
- Developing the concept of the area of stewardship, and

- Convening public conferences and workshops for development of a Total Maximum Daily Load (TMDL) strategy, beach management, and monitoring issues.

Progress made on accomplishing these objectives is outlined in this status report. More detailed sections on TMDLs, mass balance, and adaptive management implementation will become supplements to LaMP 2000 by 2003.

Areas of LaMP Work that Remain a Challenge

Finalization of a monitoring plan and prioritization of indicators are still in progress. A draft monitoring plan was issued along with a set of recommendations in August 2000. To prioritize indicators and gather missing data, two major initiatives have begun that are focused on wetlands and the importance of the "coastal area." The results of these efforts will provide not only new data but also refined indicators for wetlands by 2004, and the LaMP will utilize this work in finalizing a set of LaMP indicators.

What is the LaMP? How and by Whom is it Used?

The LaMP issued in April 2000 is both a large reference document and a set of iterative proposals or strategic agendas for remediating past errors and achieving sustainable integrity in the Lake Michigan basin ecosystem. It was prepared collaboratively and is designed to be used by any number of Lake Michigan entities or individuals. See the back cover of this document for a list of Lake Michigan partners who collaborated on the LaMP.

The LaMP document is being utilized as a guide for decision making on policy issues and to help guide funding like EPA's Coastal Environmental Management Program and the Great Lakes National Program Office grant process. At the state level, for example, Michigan has utilized it for the Clean Michigan Initiative grant program. A number of universities are using it as a text book. Results from grants and research provide the information used in determining the lake status as reported in this 2002 status report.

How is the Process Utilized?

The list of goal, subgoals and activities have produced projects like the Cook County PCB/ Mercury Clean Sweep Project. Other issues have highlighted the need to convene and train managers from around the basin resulting in sessions on the Federal Beach Bill and a number of monitoring conferences. LaMP partners have also participated in the TMDL strategy discussion. For education and outreach, materials have not only been produced, but distribution opportunities have been supported like the State of Lake Michigan 2001 Conference and the Making Lake Michigan Great Boat Tour.

The goal of going beyond regulation requires a focus on ecosystems, partnerships and innovation, shared information, and the future.

A Focus on Ecosystems

In 1995, the Federal Interagency Ecosystem Management Task Force defined an ecosystem as "an interconnected community of living things, including humans, and the physical environment with which they interact. As such, ecosystems form the cornerstone of sustainable economies." With regard to ecosystem management, the Task Force explained that "the goal of the ecosystem approach is to restore and maintain the health, sustainability, and biological diversity of ecosystems while supporting sustainable economies and communities. Based on a collaboratively developed vision of desired future conditions, the ecosystem approach integrates ecological, economic, and social factors that affect a management unit defined by ecological–not political–boundaries."

In 1998, the Lake Michigan Management Committee adopted the ecosystem approach. The significance for the Lake Michigan LaMP was the intent to address not only the 10 areas that had been formally designated AOCs by the 1987 GLWQA amendments, but also other areas that were responsible for impairing the lake's ecosystem. The prime example was the Chicago area.

Because of the rerouting of the Chicago River into the Mississippi River system, Chicago's surface water has been diverted out of the basin; however, groundwater from the Chicago area has not been diverted, and the city's large airshed has been shown to be a source of pollutants that are deposited in and affect the lake.

A Focus on Partnerships and Innovation

As the LaMP 2000 points out, this framework "also develops partnerships of organizations brought together to solve problems too large or complex to be dealt with by one agency with a limited mission. This approach also has the potential to leverage and direct local, state and federal, and private resources into a coordinated effort. The challenge is to create the framework for participating organizations to contribute their expertise and resources, often on an uneven basis, but in a manner that allows all partners to participate in the decision making on an even basis."

A Focus on Shared Information

A key to engaging the necessary partners is a common, accessible, and scientifically sound body of knowledge. Lake Michigan protection and restoration requires open dialogue between academia and government agencies, as well as a collaborative monitoring plan to provide a current database. Reporting of current data and conclusions to the public is an important component of this system. This component presents many challenges, as data quality plans improve data accuracy but hinder the speed of reporting. Current management decisions are often made with gaps in both data and interpretation. These gaps may lead to incorrect problem assessments or incorrect response actions. The Lake Michigan LaMP has formed a basinwide coordinating and monitoring council to coordinate and promote common protocols and comparability in monitoring. The goal is to facilitate data sharing across agencies as well as among academic and research disciplines. Lake Michigan as a studied object is a moving target, and to provide adaptive management, there is a continuing need for monitoring and reporting of the lakes's current status.

A Focus on the Future: Sustainability and Stewardship

While partnerships can leverage resources, they also must be led and supported. Setting shared goals, objectives, and indicators in alignment helps to conserve resources but does not do away with resource needs. The interdependencies inherent in the ecosystem approach require a balance among three fundamental elements: environmental integrity, economic vitality, and sociocultural well-being. The ability of these elements to function in balance over time is one measure of sustainability. Complex ecological processes link organisms and their environment. These processes are often referred to as "ecological services" because they perform functions that combine to sustain life in the ecosystem. The significant natural features of Lake Michigan, such as its encompassing the world's largest collection of freshwater sand dunes, supporting 43 percent of the Great Lakes' large sport fishing industry, and providing drinking water for over 10 million residents, means billions of dollars not only to the economies of the four states that share the lake but also to the nation as a whole.

Last updated on Tuesday, May 21st, 2002
URL: http://www.epa.gov/glnpo/lakemich/lm02/index.html

Criteria Pollutants — Metropolitan Area Trends

This chapter presents status and trends in criteria pollutants for metropolitan statistical areas (MSAs) in the United States. The MSA status and trends give a local picture of air pollution and can reveal regional patterns of trends. Such information can allow individuals to gauge the air pollution situation where they live. Not all areas in the country are in MSAs, and not all MSAs are included here.

Worth Noting:

- Out of 296 metropolitan statistical areas, 36 have significant upward trends.
- Of these, only trends involving ozone had values over the level of air quality standards.

A complete list of MSAs and their boundaries can be found in the Statistical Abstract of the United States.[1] The status and trends of MSAs are based on four tables found in Appendix A (A-15 through A-18). Table A-15 gives the 2000 peak statistics for all MSAs, providing the status of that year. It also shows 10-year trends for the 263 MSAs having data that meet the trends requirements explained in Appendix B. Table A-16 lists these MSAs and reports criteria pollutant trends as "upward," "downward," or "not significant." These categories are based on a statistical test, known as the Theil test, described later in this chapter.

Another way to assess trends in MSAs is to examine Air Quality Index (AQI) values.[2, 3, 4] The AQI is used to present daily information to the public on one or more criteria pollutants in an easily understood format and in a timely manner. EPA periodically lists the number of days with AQI values greater than 100 for the nation's 94 largest metropolitan areas (population greater than 500,000). Recent lists of AQI values based on ozone alone can be found on the Air Trends website's Factbook page. The tables listing Pollutant Standards Index (PSI) data from previous reports may not agree with the tables in this report because of the new way to calculate the AQI. These changes are presented in more detail later in this chapter.

A new technique for displaying air quality information is also described. This technique presents visual clues as to the status of different MSAs.

Not every MSA appears in these tables. Some do not appear because the population is so small or the air quality is so good that AQI reporting is not currently required. Ambient monitoring for a particular pollutant may not be conducted if there is no problem, thus some MSAs have no ongoing air quality monitoring for one or more of the criteria pollutants. In addition, there are also MSAs with too little monitoring data for trends analysis purposes (see Appendix B).

Status: 2001

The air quality status for MSAs is provided in Table A-15, which lists peak statistics for all criteria pollutants measured in an MSA. As discussed above, not all criteria pollutants are measured in all MSAs, hence the "ND" (no data) listings in Table A-15. Examining Table A-15 shows that 140 areas had peak concentrations exceeding standard levels for at least one criteria pollutant. The number of these areas increased by 4 the count from 2000 (136 areas). These 140 areas are home to 56 percent of the U.S.

population. Similarly, there were 60 areas (with 36 percent of the population) that had peak statistics that exceeded two or more standards. Six areas -- Bakersfield, CA, Riverside-San Bernardino, CA, Fresno, CA, Birmingham, AL, St. Louis, MO, and Visalia-Tulare-Porterville, CA (with 3 percent of the U.S. population) -- had peak statistics from three pollutants that exceeded the respective standards. There was one area that violated four or more standards (St. Louis, MO).

Trends Analysis

Table A-16 displays air quality trends for MSAs. The data in this table are average statistics of pollutant concentrations from the subset of ambient monitoring sites that meet the trends criteria explained in Appendix B. A total of 246 MSAs have at least one monitoring site that meets these criteria. As stated previously, not all pollutants are measured in every MSA. From 1992-2001, statistics based on the standards were calculated for each site and pollutant with available data. Spatial averages were obtained for each of the 246 MSAs by averaging these statistics across all sites in an MSA. This process resulted in one value per MSA per year for each pollutant. Although there are seasonal patterns of high values for some pollutants in some locations, the averages for every MSA and year provide a consistent indicator with which to assess trends.

Because air pollution levels are affected by variations in meteorology, emissions, and day-to-day activities of populations in MSAs, trends in air pollution levels are not always well defined. To assess upward or downward trends, we applied a statistical significance test to these data. An advantage of using the statistical test is the ability to test whether or not the upward or downward trend is real (significant) or just a chance product of year-to-year variation (not significant). Because the underlying pollutant distributions do not meet the usual assumptions required for common significance tests, the test was based on a nonparametric method commonly referred to as the Theil test.[5, 6, 7, 8] By using linear regression to estimate the trend from changes during the entire 10-year period, we can detect an upward or downward trend even when the concentration level of the first year equals the concentration level of the last year.

Table 3-1. Summary of MSA Trend Analyses by Pollutant, 1990-1999

	Trend Statistic	Total # MSAs	# MSAs Up	# MSAs Down	# MSAs with No Significant Trend
CO	second max 8-hour	134	0	104	30
Pb	max quarterly mean	35	1	12	22
NO_2	arithmetic mean	97	3	37	57
O_3	fourth max 8-hour	202	17	10	175
O_3	second daily max 1-hour	202	12	15	175
PM_{10}	90th percentile	164	4	41	119
PM_{10}	weighted annual mean	164	7	60	97
SO_2	arithmetic mean	139	4	70	65
SO_2	second max 24-hour	139	2	62	75

Table 3-1 summarizes the trend analysis performed on the 246 MSAs. It shows that there were no upward trends in carbon monoxide (CO). PM_{10} and sulfur dioxide had upward trends in 7 MSAs over the past decade, NO_2 had upward trends in 3 MSAs, while SO_2 had upward trends in 4 MSAs. Lead had an upward trend in 1 MSA. Further examination of Table A-16 shows that, of the 246 MSAs, (1) 180 had downward trends in at least one of the criteria pollutants, (2) 36 had upward trends (of these 36, 25 also had downward trends in other pollutants, leaving 9 MSAs with exclusively upward trends), and (3) only 2 MSAs had no significant trends. A closer look at the 36 MSAs with upward trends reveals that 13 were exceeding the level of the 8-hour ozone standard, and 3 were above the 1-hour standard. For all other pollutants with upward trends in any MSA, the levels observed were well below standard levels. Taken as a whole, these results still demonstrate significant improvements in urban air quality over the past decade for the nation; however, the number of MSAs with upward trends is increasing when compared to numbers in previous reports.

The Air Quality Index

The AQI provides information on pollutant concentrations for ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Formerly known as the PSI, this nationally uniform air quality index is used by state and local agencies for reporting daily air quality to the public. In 1999, EPA updated the AQI to reflect the latest science on air pollution health effects and to make it more appropriate for use in contemporary news media, thereby enhancing the public's understanding of air pollution across the nation. Currently, the AQI may be found in national media such as *USA Today* and on the Weather Channel, as well as in local newspapers and broadcasts across the country. It also serves as a basis for community-based programs that encourage the public to take action to reduce air pollution on days when levels are projected to be of concern. An Internet web site, AIRNOW (http://www.epa.gov/airnow), which presents "real time" air quality data and forecasts of summertime smog levels for most states, uses the AQI to communicate information about air quality. The index has been adopted by many other countries (e.g., Mexico, Singapore, and Taiwan) and is used around the world to provide the public with information on air pollutants.

AQI values for each of the pollutants are derived from concentrations of that pollutant. The index is "normalized" across each pollutant so that, generally, an index value of 100 is set at the level of the short-term, health-based standard for that pollutant. An index value of 500 is set at the significant harm level, which represents imminent and substantial endangerment to public health.[9] The higher the index value, the greater the level of air pollution and health risk.

To make the AQI as easy to understand as possible, EPA has divided the AQI scale into six general categories that correspond to a different level of health concern:

- **Good** (0-50): Air quality is considered satisfactory, and air pollution poses little or no risk.
- **Moderate** (51-100): Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very
- small number of individuals. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **Unhealthy for Sensitive Groups** (101-150): Certain groups of people may be particularly sensitive to the harmful effects of certain air pollutants. This means they are likely to be affected at lower levels than is the general public. For example, people with respiratory disease are at greater risk from exposure to ozone, while people with respiratory disease or heart disease are at greater risk from particulate matter. When the AQI is in this range, members of sensitive groups may experience health effects, but the general public is not likely to be affected.
- **Unhealthy** (151-200): Everyone may begin to experience health

effects. Members of sensitive groups may experience more serious health effects.

- **Very Unhealthy** (201-300): Air quality in this range triggers a health alert, meaning everyone may experience more serious health effects.
- **Hazardous** (over 300): Air quality in this range triggers health warnings of emergency conditions. The entire population is more likely to be affected.

Because different groups of people are sensitive to different pollutants, there are pollutant-specific health effects and cautionary statements for each category in the AQI.

An AQI report will contain an index value, category name, and the pollutant of concern and is often featured on local television or radio news programs and in newspapers, especially when values are high. For national consistency and ease of understanding, if the AQI is reported using color, there are specific, required colors associated with each category. Examples of the use of color in AQI reporting include the color bars that appear in many newspapers and the color contours of the ozone map. The six AQI categories, their respective health effects descriptors, colors, index ranges, and corresponding concentration ranges are shown in Table 3-2. EPA has also developed an AQI logo (Figure 3-1) to increase the awareness of the AQI in media reports and also to indicate that the AQI is uniform throughout the country.

Table 3-2. AQI Categories, Colors, and Ranges

Category	AQI	O_3 (ppm) 8-hour	O_3 (ppm) 1-hour	$PM_{2.5}$ (µg/m3)	PM_{10} (µg/m3)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)
Good	0-50	0.000-0.064	(b)	0.0-15.4	0-54	0.0-4.4	0.000-0.034	(c)
Moderate	51-100	0.065-0.084	(b)	15.5-40.4	55-154	4.5-9.4	0.035-0.144	(c)
Unhealthy for Sensitive Groups	101-150	0.085-0.104	0.125-0.164	40.5-65.4	155-254	9.5-12.4	0.145-0.224	(c)
Unhealthy	151-200	0.105-0.124	0.165-0.204	65.5 - 150.4	255-354	12.5-15.4	0.225-0.304	(c)
Very unhealthy	201-300	0.125-0.374	0.205-0.404	150.5-250.4	355- 424	15.5-30.4	0.305-0.604	0.65-1.24
Hazardous	301-400	(a)	0.405-0.504	250.5-350.4	425-504	30.5-40.4	0.605-0.804	1.25-1.64
	401-500	(a)	0.505-0.604	350.5-500.4	505-604	40.5-50.4	0.805-1.004	1.65-2.04

a. No health effects information for these levels—use 1-hour concentrations.
b. 1-hour concentrations provided for areas where the AQI is based on 1-hour values might be more cautionary.
c. NO_2 has no short-term standard but does have a short-term "alert" level.

The AQI integrates information on pollutant concentrations across an entire monitoring network into a single number that represents the worst daily air quality experienced in an urban area. For each of the pollutants, concentrations are converted into index values between 0 and 500. The level of the pollutant with the highest index value is reported as the AQI level for that day. There is a new AQI requirement to report any pollutant with an index value above 100. In addition, when the AQI is above 100, a pollutant-specific statement indicating what specific groups are most at risk must be reported. For example, when the index value is above 100 for ozone, the AQI report will state "children and people with asthma are most at risk." The AQI must be reported in all MSAs with air quality problems and populations greater than 350,000 according to the 2000 census. Previously, urbanized areas with populations greater than 200,000 were required to report the index.

Figure 3-2. Number of days with AQI values >100, as a percentage of 1990 value.

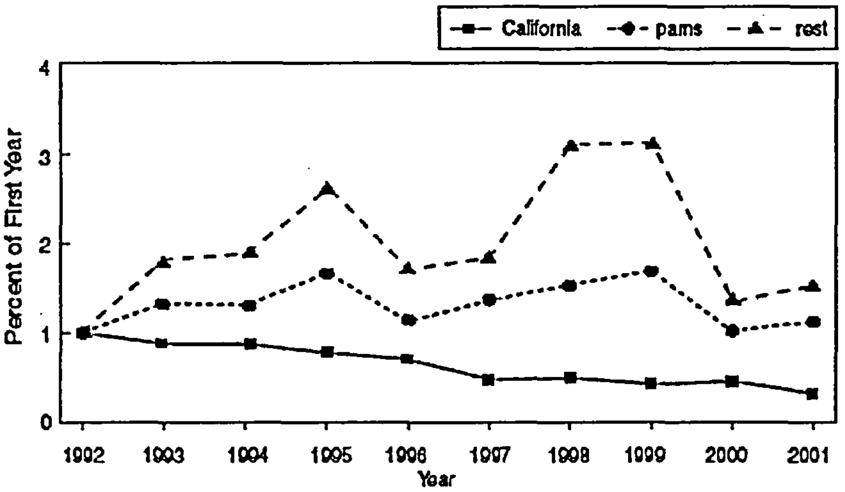
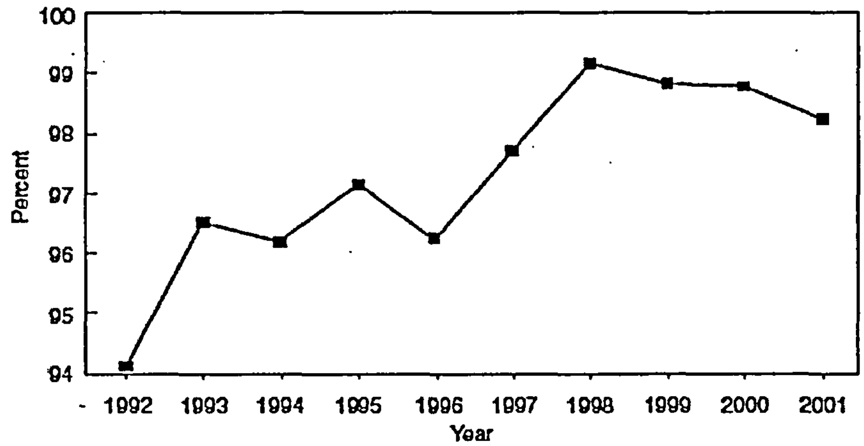


Figure 3-3. Percentage of days over 100 due to ozone.



Summary of AQI Analyses

Of the five criteria pollutants used to calculate the AQI, only four (CO, O_3, PM_{10}, and SO_2) generally contribute to the AQI value. In recent years, nitrogen dioxide has never been the highest pollutant measured because it does not have a short-term standard and can be included only when the index reaches a value of 200 or greater. Ten-year AQI trends are based on daily maximum pollutant concentrations from the subset of ambient monitoring sites that meet the trends requirements in Appendix B (PDF 714KB).

Because an AQI value greater than 100 indicates that at least one criteria pollutant has reached levels at which people in sensitive groups are likely to suffer health effects, the number of days with AQI values greater than 100 provides an indicator of air quality in urban areas. Figure 3-2 shows the trend in the number of days with AQI values greater than 100 summed across the nation's largest metropolitan areas. This number is expressed as a percentage of the days in the first year (1992). Because of their magnitude, AQI totals for Los Angeles, CA, Riverside, CA, Bakersfield, CA, Ventura CA, Orange County, CA, and San Diego, CA, are shown separately as California. Plotting these values as a percentage of 1992 values allows trends of different magnitudes to be compared on the same graph. The long-term air quality improvement in California urban areas is evident in this figure. Between 1992 and 2001, the total number of days with AQI values greater than 100 decreased more than 50 percent. The variability in the remaining major cities across the United States makes it difficult to interpret the change over the same period (labeled as rest in Figure 3-2), though it does appear to be rising. Other areas that had serious, severe, or extreme ozone problems (labeled as pams in Figure 3-2) show almost no change.

Although five criteria pollutants can contribute to the AQI, the index is driven mostly by ozone. AQI estimates depend on the number of pollutants monitored as well as the number of monitoring sites where data are collected. The more pollutants measured and the more sites that are available in an area, the better the estimate of the AQI for a given day. Historically, ozone accounts for the majority of days, with AQI values above 100. Soon, $PM_{2.5}$ will also be monitored and reported on a regular basis, which [4] will reduce the percentage of days that ozone is the greatest AQI pollutant. Table A-18 shows the number of days with AQI values greater than 100 that are attributed to ozone alone. Comparing Tables A-17 and A-18, the number of days with an AQI above 100 are increasingly due to ozone. In fact, the percentage of days with an AQI above 100 due to ozone have increased from 94 percent in 1992 to 98 percent in 2001 (Figure 3-3). This increase reveals that ozone increasingly accounts for those days above the 100 level and, therefore, reflects the success in achieving lower CO and PM_{10} concentrations. However, the typical 1-in-6 day sampling schedule for most PM_{10} sites limits the number of days that PM_{10} can factor into the AQI determination, which may, in some places, account for the predominance of ozone. In the future, $PM_{2.5}$ may challenge ozone as the dominant pollutant.

A New Display Technique

As more and more information about air pollution and its effect on our health is being presented to the public through various media channels, a need has arisen to provide the general public with a simple, visual method for assessing the degree of air pollution in their communities. To meet this need, EPA is exploring a new technique for displaying air quality information that is designed to allow the general public to quickly and easily review the degree of air pollution in the 319 MSAs across the United States. This technique would use color-coded circles to show levels of each criteria pollutant in each MSA relative to its levels in the other MSAs. A solid blue circle indicates fewer days of unhealthy air (meaning that MSA had fewer AQI days over 100 for, say, ozone than most of the other MSAs had for ozone). On the other end of the spectrum, a black circle indicates more days of unhealthy air.

Figure 3-4. Sample from the new display technique.

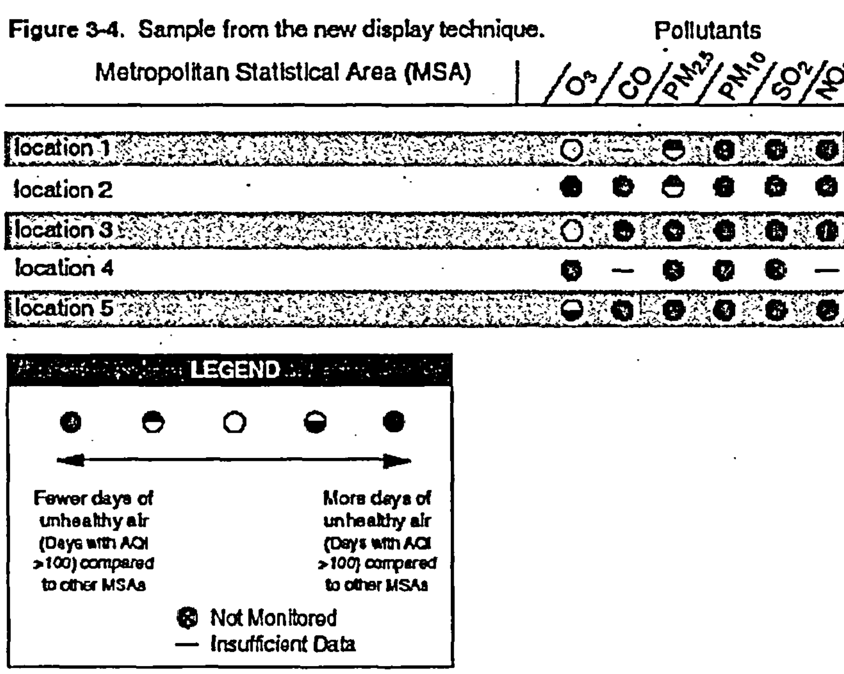


Figure 3-4 presents an example of how this new display technique might appear. The legend in Figure 3-4 explains how the color-coded symbols could be used to quickly and easily provide information about air quality and air pollutants. The new display technique would not provide new or additional air quality data, nor would it be used as a rating system or show trends in air quality over time. Rather, its purpose would be to provide a simplified, visual tool for interpreting air quality information in selected MSAs for a specific year for each of the selected pollutants. EPA is continuing to assess the feasibility of the new technique and to explore additional capabilities that might be added, such as a Web-based application that would allow users to sort and query information to generate customized reports about health-related air quality issues, as well as components relating to multi-year displays and visibility.

Additional information on this new display technique is presented in a discussion paper in the Special Studies section of this report.

References and Notes

1. *Statistical Abstracts of the United States, 2000,* U.S. Department of Commerce, U.S. Bureau of the Census.

2. *Air Quality Index, A Guide to Air Quality and Your Health,* EPA-454/ R-00-005, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, June 2000.

3. *Code of Federal Regulations,* 40 CFR Part 58, Appendix G.

4. *Guideline for Reporting of Daily Air Quality—Air Quality Index (AQI)*, EPA-454/R-99-010, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1999.

5. *Note*: Although the results are summarized in the report for comparison purposes, the intent of publishing Tables A-16 through A-18 is to present information on a localized basis, to be used on a localized basis (i.e., one MSA at a time). Therefore, no attempt was made to adjust the Type I error to a table-wide basis. All the tests for trends were conducted at the 5 percent significance level. No inference has been made from the tables as a whole.

6. T. Fitz-Simons and D. Mintz, *Assessing Environmental Trends with Nonparametric Regression in the SAS Data Step*, American Statistical Association 1995 Winter Conference, Raleigh, NC, January, 1995.

7. Freas, W.P. and E.A. Sieurin, *A Nonparametric Calibration Procedure for Multi-Source Urban Air Pollution Dispersion Models,* presented at the Fifth Conference on Probability and Statistics in Atmospheric Sciences, American Meteorological Society, Las Vegas, NV, November 1977.

8. M. Hollander and D.A. Wolfe, *Nonparametric Statistical Methods*, John Wiley and Sons, Inc., New York, NY, 1973.

9. Based on the short-term standards, federal episode criteria, and significant harm levels, the AQI is computed for PM (particulate matter), SO_2, CO, O_3, and NO_2. Lead is the only criteria pollutant not included in the index because it does not have a short-term standard, federal episode criteria, or significant harm level.

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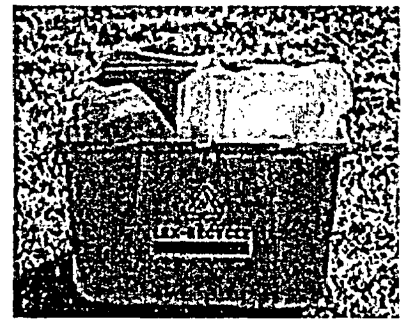
Last updated on Tuesday, June 15th, 2004
URL: http://www.epa.gov/airtrends/metro.html

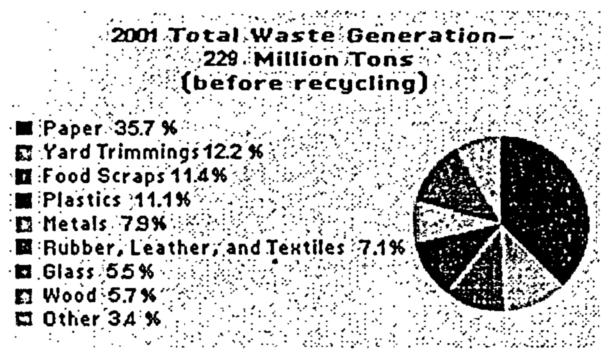
Basic Facts



Municipal Solid Waste (MSW)

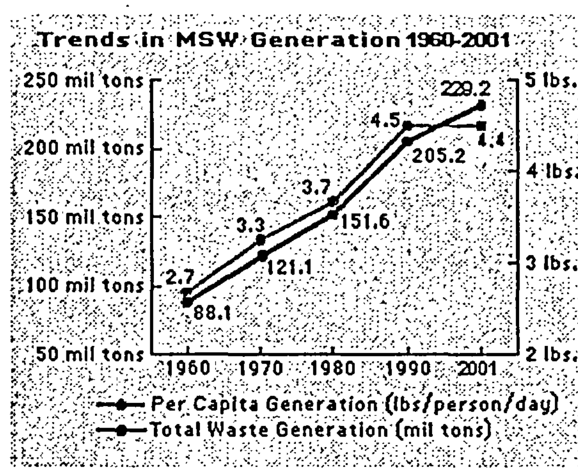
MSW—more commonly known as trash or garbage—consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. To learn more about MSW, view our interactive presentation about Milestones in Garbage: 1990–Present.

In 2001, U.S. residents, businesses, and institutions produced more than 229 million tons of MSW, which is approximately 4.4 pounds of waste per person per day, up from 2.7 pounds per person per day in 1960.



Several MSW management practices, such as source reduction, recycling, and composting, prevent or divert materials from the wastestream. Source reduction involves altering the design, manufacture, or use of products and materials to reduce the amount and toxicity of what gets thrown away. Recycling diverts items, such as paper, glass, plastic, and metals, from the wastestream. These materials are sorted, collected, and processed and then manufactured, sold, and bought as new products. Composting decomposes organic waste, such as food scraps and yard trimmings, with microorganisms (mainly bacteria and fungi), producing a humus-like substance.

Other practices address those materials that require disposal. Landfills are engineered areas where waste is placed into the land. Landfills usually have liner systems and other safeguards to prevent groundwater contamination. Combustion is another MSW practice that has helped reduce the amount of landfill space needed. Combustion facilities burn MSW at a high temperature, reducing waste volume and generating electricity.



Solid Waste Hierarchy

EPA has ranked the most environmentally sound strategies for MSW. Source reduction (including reuse) is the most preferred method, followed by recycling and composting, and, lastly, disposal in combustion facilities and landfills.

Currently, in the United States, 30 percent is recovered and recycled or composted, 15 percent is burned at combustion facilities, and the remaining 56 percent is disposed of in landfills.

Source Reduction (Waste Prevention)

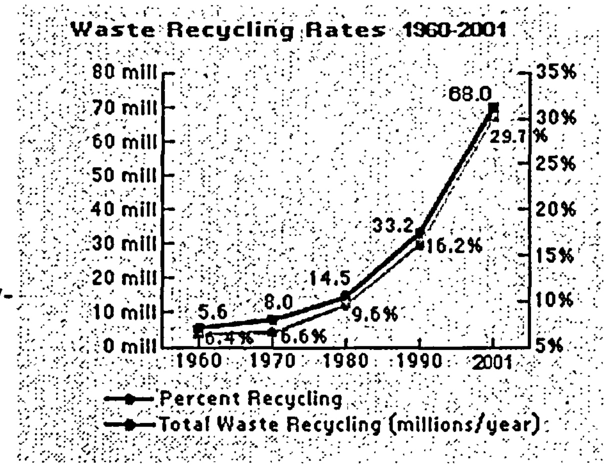
Source reduction can be a successful method of reducing waste generation. Practices such as grasscycling, backyard composting, two-sided copying of paper, and transport packaging reduction by industry have yielded substantial benefits through source reduction.

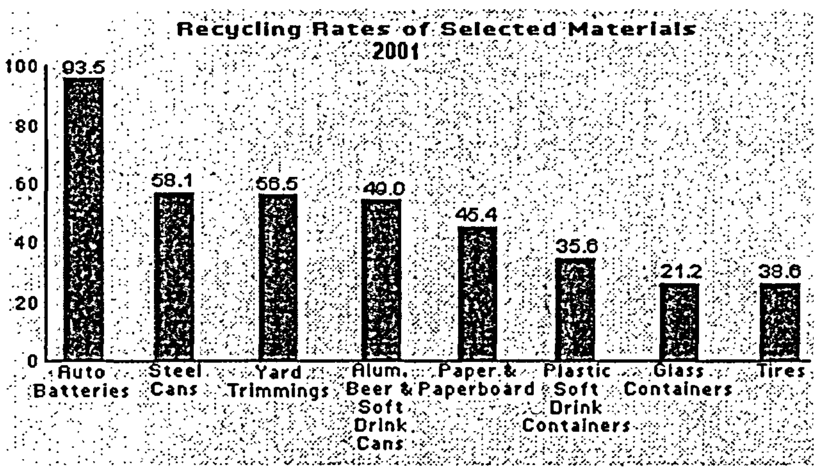
Source reduction has many environmental benefits. It prevents emissions of many greenhouse gases, reduces pollutants, saves energy, conserves resources, and reduces the need for new landfills and combustors.

Recycling

Recycling, including composting, diverted 68 million tons of material away from landfills and incinerators in 2001, up from 34 million tons in 1990.

Typical materials that are recycled include batteries, recycled at a rate of 94%, paper and paperboard at 45%, and yard trimmings at 57%. These materials and others may be recycled through curbside programs, drop-off centers, buy-back programs, and deposit systems.





Recycling prevents the emission of many greenhouse gases and water pollutants, saves energy, supplies valuable raw materials to industry, creates jobs, stimulates the development of greener technologies, conserves resources for our children's future, and reduces the need for new landfills and combustors.

Recycling also helps reduce greenhouse gas emissions that affect global climate. In 1996, recycling of solid waste in the United States prevented the release of 33 million tons of carbon into the air—roughly the amount emitted annually by 25 million cars.

Combustion/Incineration

Burning MSW can generate energy while reducing the amount of waste by up to 90 percent in volume and 75 percent in weight.

EPA's Office of Air and Radiation is primarily responsible for regulating combustors because air emissions from combustion pose the greatest environmental concern.

In 2001, in the United States, there were 97 combustors with energy recovery with the capacity to burn up to 95,000 tons of MSW per day.

Landfills

Under the Resource Conservation and Recovery Act (RCRA), landfills that accept MSW are primarily regulated by state, tribal, and local governments. EPA, however, has established national standards these landfills must meet in order to stay open. Municipal landfills can, however, accept household hazardous waste.

The number of landfills in the United States is steadily decreasing—from 8,000 in 1988 to 1,858 in 2001. The capacity, however, has remained relatively constant. New landfills are much larger than in the past.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) was enacted by Congress in 1976 and amended in 1984. The act's primary goal is to protect human health and the environment from the potential hazards of waste disposal. In addition, RCRA calls for conservation of energy and natural resources, reduction in waste generated, and environmentally sound waste management practices.

Household Hazardous Waste

Households often discard many common items such as paint, cleaners, oils, batteries, and pesticides, that contain hazardous components. Leftover portions of these products are called household hazardous waste (HHW). These products, if mishandled, can be dangerous to your health and the environment.

Environmental Terms, Abbreviations, and Acronyms

EPA provides a glossary that defines in non-technical language commonly used environmental terms appearing in EPA publications and materials. It also explains abbreviations and acronyms used throughout EPA.

Recommended Sources for MSW Information

- *Background Press Information On Municipal Solid Waste Management*
  This series of documents has been organized to assist reporters covering municipal solid waste management issues. They provide background information on EPA's solid waste reduction and recycling goals.
- *Municipal Solid Waste in the United States: 2001 Facts and Figures:* Describes the national MSW stream based on data collected between 1960 and 2000. Includes information on MSW generation, recovery, and discard quantities; per capita generation and discard rates; residential and commercial portions of MSW generation; and the role of source reduction and other trends in MSW management.
- *Decision-Maker's Guide to Solid Waste Management, Volume II:* Contains technical and economic information to assist solid waste management practitioners in planning, managing, and operating MSW programs and facilities. Includes suggestions for best practices when planning or evaluating waste and recycling collection systems, source reduction and composting programs, public education, and landfill and combustion issues.

Additional MSW materials can be found at Publications.

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Endangered Species

Region 3

Freshwater Mussels
(threatened, endangered, proposed, and candidate)
Available Information

Freshwater Mussels of the Upper Mississippi River System

Clubshell *(Pleurobema clava)*
Fact sheet
Species Account
Final Rule: Determination of Endangered Status for the Northern Riffleshell Mussel (Epioblasma torulosa rangiana) and the Clubshell Mussel (Pleurobema clava) - January 22, 1993

Cracking pearlymussel *(Hemistena lata)*
Fact sheet
Recovery Plan

Curtis' pearlymussel *(Epioblasma florentina curtisi)*
Fact sheet
Species' Profile linked to National USFWS Endangered Species website
Best Management Practices for the Curtis' Pearlymussel (Missouri Department of Conservation)

Fanshell *(Cyprogenia stegaria)*
Fact sheet

Fat pocketbook *(Potamilus capax)*
Fact sheet

Higgins eye pearlymussel *(Lampsilis higginsii)*
Higgins eye pearlymussel recovery plan: first revision - PDF May 2004
News Release: Service Releases Final Recovery Plan for Higgins eye Pearlymussel July 15, 2004

Higgins' eye pearlymussel fact sheet
Species Profile linked to the National USFWS Endangered Species website
Fact Sheet - Saving the Higgins' eye Pearlymussel - Propagation at Genoa National Fish Hatchery (May 2001)
Upper Mississippi River Section 7 Consultation

Mussels
America's Mussels: Silent Sentinals
Mussels of the St. Croix River
Mussels of the Ohio River
The Zebra Mussel Threat

Neosho mucket *(Lampsilis rafinesqueana)*
Neosho Mucket Candidate Form (PDF)

Northern riffleshell *(Epioblasma torulosa rangiana)*
Fact sheet
Final Rule: Determination of Endangered Status for the Northern Riffleshell Mussel (Epioblasma torulosa rangiana) and the Clubshell Mussel (Pleurobema clava) - January 22, 1993

Orange-footed pearlymussel (=pimple back) *(Plethobasus cooperianus (p. striatus))*
Fact sheet

Pink mucket pearlymussel *(Lampsilis orbiculata (=l. abrupta))*
Fact sheet

Purple cat's paw pearlymussel *(Epioblasma (=l. dysnomia) obliquata obliquata)*
Fact sheet

Ring pink mussel (=golf stick pearly) *(Obovaria retusa)*
Fact sheet

Rough pigtoe *(Pleurobema plenum)*
Fact sheet

Scaleshell mussel (*Leptodea leptodon*)

Recovery Plan
News Release: Draft Plan Outlines Steps to Help Rare Freshwater Mussel August 6, 2004

Federal Register Notice of Availability of the Draft Recovery Plan for the Scaleshell Mussel for PUblic Review and Comment: August 6, 2004 (PDF)

Scaleshell Mussel Draft Recovery Plan (PDF)

General Information
Fact Sheet
Species Profile (links to our national endangered species website)

Status Assessment Summary
Status Assessment (.pdf file 173K)

click here for link to free Adobe software to read .pdf files

Tubercled-blossom pearlymussel *(Epioblasma torulosa torulosa)*
Fact sheet

White cat's paw pearlymussel *(Epioblasma obliquata perobliqua)*
Fact sheet

White wartyback pearlymussel *(Plethobasus cicatricosus)*
Fact sheet

Winged maple leaf mussel *(Quadrula fragosa)*
Fact sheet
Recovery Plan (pdf file; 359 pages)

Wisconsin Department of Natural Resources Fact Sheet
Mussels of the St. Croix River
Upper Mississippi River Section 7 Consultation

August 2004

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U.S. Fish and Wildlife Service
Division of Endangered Species
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Fort Snelling, Minnesota 55111-4056

U.S. Fish & Wildlife Service Great Lakes - Big Rivers

Endangered Species

Region 3

Indiana's Federally-Listed Threatened, Endangered, Proposed, and Candidate Species' County Distribution

PDF Version

for more information on Indiana's federally listed species, contact
U.S. Fish and Wildlife Service, 620 S. Walker St., Bloomington, Indiana 47403-2121
or phone (812)334-4261

Species are linked to fact sheets

Species	Status	Counties	Habitat
Mammals			
Gray bat (*Myotis grisescens*)	Endangered	Clark, Crawford, Floyd, Harrison, Perry, Spencer	Caves
Indiana bat (*Myotis sodalis*)	Endangered	Statewide CRITICAL HABITAT: Big Wyandotte Cave (Crawford County), Ray's Cave (Greene County)	Hibernacula = Caves and mines; Maternity and foraging habitat = small stream corridors with well developed riparian woods; upland forests
Birds			
Bald eagle (*Haliaeetus leucocephalus*)	Threatened	Statewide	
Least tern (*Sterna antillarum*)	Endangered	Gibson	
Piping plover (*Charadrius melodus*)	Critical Habitat Designated	Porter - 7.9 km of Lake Michigan shoreline (5 km are part of Indiana Dunes State Park and the remainng 2.9 km	

		are part of Indiana Dunes National Lakeshore) No recent records	
Reptiles			
Copperbelly water snake (*Nerodia erythrogaster neglecta*)	Threatened	Kosciusko, St. Joseph, Steuben	Wooded and permanently wet areas such as oxbows, sloughs, brushy ditches and floodplain woods
Eastern massasauga (*Sistrurus c. catenatus*)	Candidate	Allen, Carroll, Elkhart, Kosciuscko, Lagrange, LaPorte, Marshall, Noble, Porter, Pulaski, St. Joseph, Steuban, Tippecanoe	
Mussels			
Clubshell (*Pleurobema clava*)	Endangered	Carroll, Dekalb, Fulton, Kosciusko, Marshall, Pulaski, Tippecanoe, White	Rivers
Fanshell (*Cyprogenia stegaria*)	Endangered	Carroll, Daviess, Lawrence, Martin, Pike, Tippecanoe, Wabash, White	Rivers
Fat pocketbook (*Potamilus capax*)	Endangered	Gibson, Knox, and Posey	Rivers
Northern riffleshell (*Epioblasma torulosa rangiana*)	Endangered	Dekalb, Pulaski	Rivers
Rayed Bean (*Villosa fabalis*)	Candidate	Allen, Dekalb, Fulton, Kosciusko, Marshall, Parke	St. Joseph and Tippecanoe Rivers, Sugar Creek, Lake Maxinkuckee
Rough pigtoe (*Pleurobema plenum*)	Endangered	Martin	Rivers
Sheepnose (*Plethobasus cyphyus*)	Candidate	Carroll, Cass, Clark, Floyd, Fulton, Pulaski, Spencer, Tippecanoe, Vanderburgh, Warrick, White	Eel, Ohio, Tippecanoe, and Wabash Rivers

White cat's paw pearlymussel (*Epioblasma obliquata perobliqua*)	Endangered	Dekalb	Rivers
Insects			
Mitchell's satyr (*Neonympha mitchellii*)	Endangered	LaGrange, LaPorte	Fens
Karner blue butterfly (*Lycaeides melissa samuelis*)	Endangered	Lake, Porter	Pine barrens and oak savannas on sandy soils and containing wild lupines *(Lupinus perennis)*, the only known food plant of larvae.
Plants			
Eastern prairie fringed orchid (*Plantathera leucophaea*)	Threatened	White	Mesic to wet prairies and meadows
Mead's milkweed	Threatened	Lake	Prairies
Pitcher's thistle (*Cirsium pitcheri*)	Threatened	Lake, Porter	Lakeshores; stabilized dunes and blowout areas
Running buffalo clover (*Trifolium stoloniferum*)	Endangered	Dearborn, Ohio, Ripley, Switzerland	Disturbed bottomland meadows
Short's bladderpod (*Lesquerella globosa*)	Candidate	Posey	
Short's goldenrod (*Solidago shortii*)	Endangered	Harrison	

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U.S. Fish & Wildlife Service Great Lakes - Big Rivers

Endangered Species

Region 3

Michigan's Federally-Listed Threatened, Endangered, Proposed, and Candidate Species' County Distribution

PDF Version

For more information about threatened and endangered species in Michigan, contact the U.S. Fish & Wildlife Service office at 2651 Coolidge Road, East Lansing, Michigan 48823 (517/351-6274)

Species are linked to fact sheets

Mammals

Species: Gray wolf *(Canis lupus)*
Status: Threatened
Habitat: Northern forested areas
Current distribution: Alger, Baraga, Chippewa, Delta, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Luce, Mackinac, Marquette, Menominee, Ontonagon, Schoolcraft

Species: Indiana bat *(Myotis sodalis)*
Status: Endangered
Habitat: Summer habitat includes small to medium river and stream corridors with well developed riparian woods; woodlots within 1 to 3 miles of small to medium rivers and streams; and upland forests. Caves and mines as hibernacula.
Current distribution: Allegan, Barry, Berrien, Branch, Calhoun, Cass, Eaton, Ingham, Jackson, Hillsdale, Kalamazoo, Lenawee, Livingston, Macomb, Manistee, Monroe, Oakland, St. Joseph, Van Buren, and Washtenaw

Species: Canada lynx *(Lynx canadensis)*
Status: Threatened
Habitat: Northern forests
Current distribution: A Canada lynx was recently documented in the Upper Peninsula. The counties listed here have the highest potential for Lynx presence: Alger, Baraga, Chippewa, Delta, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Luce, Mackinac, Marquette, Menominee, Ontonagon, Schoolcraft.

Birds

Species: Bald eagle *(Haliaeetus leucocephalus)*
Status: Threatened
Habitat: Mature forest near water
Current distribution: Alcona, Alger, Allegan, Alpena, Antrim, Arenac, Baraga, Bay, Benzie, Charlevoix, Cheboygan, Chippewa, Clare, Crawford, Delta, Dickinson, Emmet, Gladwin, Gogebic, Grand Traverse, Gratiot, Houghton, Huron, Ionia, Iosco, Iron, Kalkaska, Keweenaw, Lake, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Mecosta,

Menominee, Midland, Missaukee, Monroe, Montmorency, Muskegon, Newaygo, Oceana, Ogenaw, Ontonagon, Osceola, Oscoda, Otsego, Ottawa, Presque Isle, Roscommon, Saginaw, Schoolcraft, St. Clair, Tuscola, Wayne, and Wexford

Species: Kirtland's warbler *(Dendroica kirtlandii)*
Status: Endangered
Habitat: Breeding in jack pine
Current distribution: Alcona, Baraga, Clare, Crawford, Delta, Iosco, Kalkaska, Marquette, Montmorency, Ogemaw, Oscoda, Otsego, Roscommon, Schoolcraft

Species: Piping plover *(Chradrius melodus)*
Status: Endangered
Habitat: Beaches along shorelines of the Great Lakes
Current distribution: Alger, Alpena, Benzie, Berrien, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Leelanau, Luce, Mackinac, Muskegon, Schoolcraft

Species: Piping plover *(Chradrius melodus)*
Status: Critical Habitat Designated
Habitat: Beaches along shorelines of the Great Lakes
Current distribution: Alger, Benzie, Charlevoix, Cheboygan, Chippewa, Emmet, Iosco, Leelanau, Luce, Mackinac, Mason, Muskegon, Presque Isle, Schoolcraft

Reptiles

Species: Copperbelly water snake *(Nerodia erythrogaster neglecta)*
Status: Threatened
Habitat: Wooded and permanently wet areas such as oxbows, sloughs, brushy ditches and floodplain woods
Current distribution: Branch, Calhoun, Eaton, Hillsdale, Oakland, St. Joseph

Species: Eastern massasauga *(Sistrurus catenatus catenatus)*
Status: Candidate
Current Distribution: Alcona, Allegan, Alpena, Antrim, Arenac, Barry, Berrien, Branch, Calhoun, Cass, Cheboygan, Clare, Clinton, Crawford, Eaton, Emmett, Genesee, Grand Traverse, Hillsdale, Huron, Ionia, Iosco, Jackson, Kalamazoo, Kalkaska, Kent, Lapeer, Lake, Lenawee, Livingston, Macomb, Manistee, Mason, Missaukee, Montcalm, Montmorency, Muskegon, Newaygo, Oakland, Oscoda, Presque Isle, Saginaw, St. Joseph, Shiawassee, Van Buren, Washtenaw, Wayne

Insects

Species: Hine's emerald dragonfly *(Somatochlora hineana)*
Status: Endangered
Habitat: Spring fed wetlands, wet meadows and marshes; calcareous streams & associated wetlands overlying dolomite bedrock
Current distribution: Alpena, Mackinac, Presque Isle Counties

Species: Hungerford's crawling water beetle *(Brychius hungerfordi)*
Status: Endangered
Cool riffles of clean, slightly alkaline streams; known to occur in only 3 isolated locations
Current distribution: Emmet, Montmorency

Species: Karner blue butterfly *(Lycaeides melissa samuelis)*
Status: Endangered
Habitat: Pine barrens and oak savannas on sandy soils and containing wild lupines *(Lupinus perennis)*, the only known food plant of larvae.

Current distribution: Allegan, Ionia, Kent, Lake, Mason, Mecosta, Monroe, Montcalm, Muskegon, Newaygo, Oceana

Species: Mitchell's satyr *(Neonympha mitchellii mitchellii)*
Status: Endangered
Habitat: Fens; wetlands characterized by calcareous soils which are fed by carbonate-rich water from seeps and springs
Current distribution: Barry, Berrien, Branch, Cass, Jackson, Kalamazoo, Lenawee, St. Joseph, Van Buren, Washtenaw

Mussels

Species: Clubshell *(Pleurobema clava)*
Status: Endangered
Habitat: Found in coarse sand and gravel areas of runs and riffles within streams and small rivers
Current distribution: Hillsdale

Species: Northern riffleshell *(Dysnomia torulosa rangiana)*
Status: Endangered
Habitat:Large streams and small rivers in firm sand of riffle areas; also occurs in Lake Erie
Current distribution: Monroe, Sanilac, Wayne

Species: Rayed Bean (*Villosa fabalis*)
Status: Candidate
Habitat: Belle, Black, Clinton, and Pine Rivers
Current distribution: Macomb, Oakland, St. Clair

Plants

Species: American hart's tongue fern *(Asplenium scolopendrium* var. *americanun = Phyllitis japonica* ssp. *a.)*
Status: Threatened
Habitat: Cool limestone sinkholes in mature hardwood forest
Current distribution: Chippewa, Mackinac

Species: Dwarf lake iris *(Iris lacustris)*
Status: Threatened
Habitat: Partially shaded sandy-gravelly soils on lakeshores
Current distribution: Alpena, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Mackinac, Menominee, Presque Isle, Schoolcraft

Species: Eastern prairie fringed orchid *(Plantathera leucophaea)*
Status: Threatened
Habitat: Mesic to wet prairies and meadows
Current distribution: Bay, Cheboygan, Clinton, Eaton, Genesee, Gratiot, Huron, Livingston, Monroe, Saginaw, St. Clair, St. Joseph, Tuscola, Washtenaw, Wayne

Species: Houghton's goldenrod *(Solidago houghtonii)*
Status: Threatened
Habitat: Sandy flats along Great Lakes shores
Current distribution: Charlevoix, Cheboygan, Chippewa, Crawford, Delta, Emmet, Kalkaska, Mackinac, Presque Isle, Schoolcraft

Species: Lakeside daisy *(Hymenoxy acaulis var. glabra)*

Status: Threatened
Habitat: Dry, rocky prairie grassland underlain by limestone
Current distribution: Mackinac

Species: Michigan monkey-flower *(Mimulus glabratus var. michiganesis)*
Status: Endangered
Habitat: Soils saturated with cold flowing spring water; found along seepages, streams and lakeshores
Current distribution: Benzie, Charlevoix, Cheboygan, Emmet, Leelanau, Mackinac

Species: Pitcher's thistle *(Cirsium pitcheri)*
Status: Threatened
Habitat: Stabilized dunes and blowout areas
Current distribution: Alcona, Alger, Allegan, Alpena, Antrim, Arenac, Benzie, Berrien, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Grand Traverse, Huron, Iosco, Leelanau, Mackinac, Manistee, Mason, Muskegon, Oceana, Ottawa, Presque Isle, Schoolcraft, Van Buren

Species: Small whorled pogonia *(Isotria medeoloides)*
Status: Threatened
Habitat: Dry woodland; upland sites in mixed forests (second or third growth stage)
Current distribution: Berrien

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Endangered Species

Region 3

Indiana's Federally-Listed
Threatened, Endangered, Proposed, and Candidate Species'
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Reptiles			
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Mussels			
Clubshell (*Pleurobema clava*)	Endangered	Carroll, Dekalb, Fulton, Kosciusko, Marshall, Pulaski, Tippecanoe, White	Rivers
Fanshell (*Cyprogenia stegaria*)	Endangered	Carroll, Daviess, Lawrence, Martin, Pike, Tippecanoe, Wabash, White	Rivers
Fat pocketbook (*Potamilus capax*)	Endangered	Gibson, Knox, and Posey	Rivers
Northern riffleshell (*Epioblasma torulosa rangiana*)	Endangered	Dekalb, Pulaski	Rivers
Rayed Bean (*Villosa fabalis*)	Candidate	Allen, Dekalb, Fulton, Kosciusko, Marshall, Parke	St. Joseph and Tippecanoe Rivers, Sugar Creek, Lake Maxinkuckee
Rough pigtoe (*Pleurobema plenum*)	Endangered	Martin	Rivers
Sheepnose (*Plethobasus cyphyus*)	Candidate	Carroll, Cass, Clark, Floyd, Fulton, Pulaski, Spencer, Tippecanoe, Vanderburgh, Warrick, White	Eel, Ohio, Tippecanoe, and Wabash Rivers

White cat's paw pearlymussel (*Epioblasma obliquata perobliqua*)	Endangered	Dekalb	Rivers
Insects			
Mitchell's satyr (*Neonympha mitchellii*)	Endangered	LaGrange, LaPorte	Fens
Karner blue butterfly (*Lycaeides melissa samuelis*)	Endangered	Lake, Porter	Pine barrens and oak savannas on sandy soils and containing wild lupines *(Lupinus perennis)*, the only known food plant of larvae.
Plants			
Eastern prairie fringed orchid (*Plantathera leucophaea*)	Threatened	White	Mesic to wet prairies and meadows
Mead's milkweed	Threatened	Lake	Prairies
Pitcher's thistle (*Cirsium pitcheri*)	Threatened	Lake, Porter	Lakeshores; stabilized dunes and blowout areas
Running buffalo clover (*Trifolium stoloniferum*)	Endangered	Dearborn, Ohio, Ripley, Switzerland	Disturbed bottomland meadows
Short's bladderpod (*Lesquerella globosa*)	Candidate	Posey	
Short's goldenrod (*Solidago shortii*)	Endangered	Harrison	

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NRC NEWS

U.S. NUCLEAR REGULATORY COMMISSION
Office of Public Affairs Telephone: 301/415-8200
Washington, DC 20555-0001 E-mail: opa@nrc.gov
www.nrc.gov

No. 01-035 March 30, 2001

NRC ORGANIZES FUTURE LICENSING PROJECT ORGANIZATION

NRC's Office of Nuclear Reactor Regulation intends to staff the organization in phases with the objective of having a fully functional Future Licensing Project Organization by the end of September.

Several utilities and organizations have contacted the NRC to initiate discussions associated with the possible construction of new nuclear power plants in the United States. These include Exelon's request for a pre-application review of a Pebble Bed Modular Reactor and Exelon's stated intention to submit an application to build the Pebble Bed Reactor.

Licensees have also indicated to the NRC that applications for early site permits could be submitted in the near future. These permits would allow pre-certification of sites for possible construction of nuclear power plants. An application for design certification of the Westinghouse AP 1000, an advanced light water reactor incorporating "passive" safety features, also is expected next year. While the schedules for these activities are not certain, NRC is gearing up to carry out its licensing responsibilities efficiently.

This first phase group will be responsible for establishing a project management function for future licensing tasks that include updating parts of NRC regulations, review of the AP 1000 reactor design, preparation for Pebble Bed reactor licensing review, coordination with NRC's Office of Nuclear Regulatory Research on Pebble Bed reactor pre-application issues, environmental and siting project management and other tasks, including interaction with interested stakeholders. The group will be formed initially through rotational assignment of staff experienced in regulatory programs, including the design certification process.

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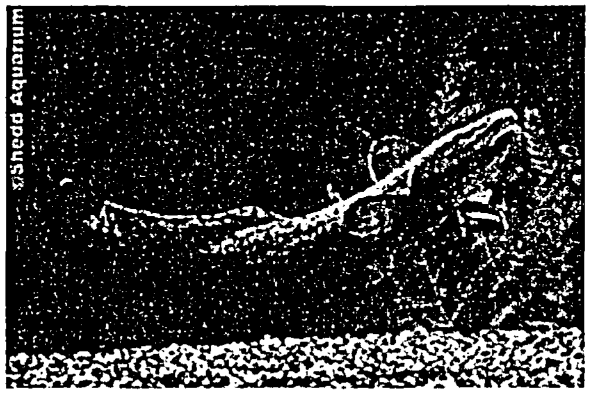
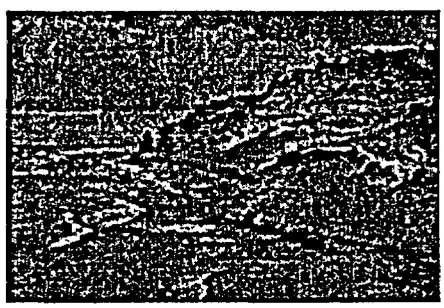


Fish of Lake Michigan

The lake's northern tier is in the colder, less developed upper Great Lakes region, while its more temperate southern basin contains the Milwaukee and Chicago metropolitan areas. Averaging 279 feet in depth, the lake reaches 925 feet at its deepest point. Almost 100 species of fish have been recorded in Lake Michigan.

You can also find lists of fish found in Lake Superior, Lake Huron, Lake Erie, Lake Ontario, non-native species, or the complete list. Note that not every species of fish found in the Great Lakes is included.



For current weather conditions, as reported by regional stations, see NOAA's Interactive Marine Observations site. For more weather and fishing information, see the Fishing page under Special Features on this site.

More information on Lake Michigan.

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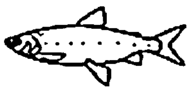
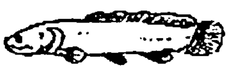
Last updated 05 February 2002 by Seaman

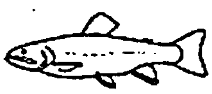
Alewife



Bloater

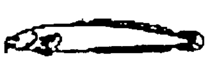


Bowfin



Brook Trout

Brown Trout



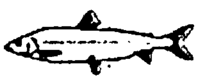
Burbot

Carp

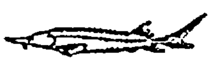
Chinook Salmon

Coho Salmon

Freshwater Drum

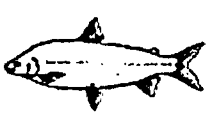


Lake Herring

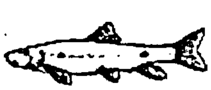


Lake Sturgeon

Lake Trout



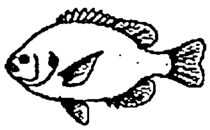
Lake Whitefish



Longnose Sucker

Muskellunge

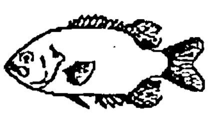
Northern Pike



Pumpkinseed

Rainbow Smelt

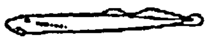
Rainbow Trout



Rock Bass

Round Goby

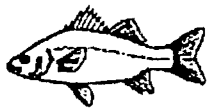
Round Whitefish



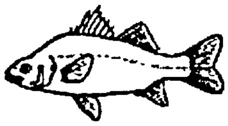
Sea Lamprey

Smallmouth Bass

Walleye

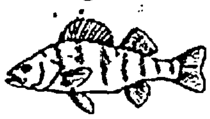


White Bass



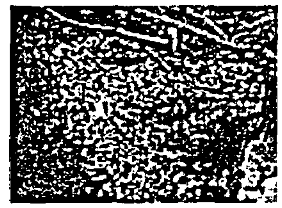
White Perch

White Sucker



Yellow Perch

Alewife Watch 2001

The satellite data is indicating surface water temperatures are above alewife spawning threshold at the monitored harbors. Aside from some concerns early in the season near Milwaukee, we did not experience an extensive alewife die off this year. I won't be updating the temperature graphs until we start again next year. Now we need to start watching for algae along the shoreline. Enjoy your summer.

Background

The alewife (*Alosa pseudoharengus*), native to the Atlantic Coast, entered the Great Lakes through the Welland Canal and made their way to Lake Michigan by 1949. Alewives are not well adapted to the osmotic stress associated with life in fresh water. In freshwater, the salt concentration in a fish's body is higher than the surrounding water. For this reason water tends to leak into the cells of the fish, a process called osmosis. Freshwater fish must constantly 'pump' water out of their bodies; fish that are well adapted to a freshwater environment have larger kidneys than their saltwater counterparts. Because of this physiological stress, alewives are rather sensitive to disturbances in their Great Lakes environment.

Alewives spend most of the year in the deeper waters of the open lake, but come into near shore waters in the summer when they are ready to spawn. Alewives begin to spawn when the water temperatures reach about 55-60o F. In their native habitat alewives are anadromous, swimming upstream to spawn in the spring. In the Great Lakes, the fish congregate near the outlets of rivers or streams or near harbors that occur at the outlet of a river. Generally, alewives begin reproducing at about two years of age. Alewives do not necessarily die after they spawn, but when the fish move from the deeper water to near shore areas they are exposed to fluctuating temperatures. A severe change in water temperature, such as can occur with upwelling, can cause the fish to die.

Underlying factors that relate to alewife mortality in the spring include: (1) their fragile condition due to the physiological stress of being in fresh water (2) a weakened condition due to lack of forage in the winter (3) stress related to spawning and (4) being exposed to rapid temperature changes when they enter nearshore waters to spawn. Whether we will see them die off in large numbers depends on population abundance, age of the fish, general physical condition, and the weather. Recall that last year there were one or two die offs with large numbers of the small silvery fish washing up along Lake Michigan shorelines. The fish were primarily comprised of the 1995 year class and the 1998 year class.

According to the Guy Fleischer of the US Geological Survey Great Lakes Science Center, the 1995 year class of alewives was very large, about three times the normal population. Since alewives live about six or seven years, these large, robust fish are nearing the end of their lifespan. During their life they have been able to produce several year classes of young fish. The 1998 year class was particularly abundant, but these fish were relatively weak. The 2000 year class was also robust so we may see some of these young fish along the beach as well this year.

AN UPWELLING

Based on the CoastWatch charts it looks as though there was an upwelling event near Algoma and Kewaunee on July 3rd. Morning water temperatures dropped to about 39 degrees F. from the high 40's for 50's the day before. Alewives have been clustering in harbor mouths in recent weeks. Watch the beaches to see if the temperature change results in additional alewife mortailities.

Water Temperature Graphs - NOAA Satellite data. The graphs illustrate the afternoon to evening water temperatures.

Algoma	Kewaunee	Manitowoc
Sheboygan	Port Washington	Milwaukee
Racine		

Water Temperature Graphs - CoastWatch data

Algoma	Kewaunee	Manitowoc
Sheboygan	Port Washington	Milwaukee
Racine		

June was quite cloudy so data are missing for several days in the month.

The temperatures plotted in the graphs are based on NOAA satellite information available at the Great Lakes Environmental Research Laboratory web site (http://coastwatch.glerl.noaa.gov/). Lake surface temperature readings are available at the CoastWatch web site when there is no cloud cover. The graphs will be updated as data are available.

Fish of the Great Lakes
Wisconsin Sea Grant

Why are the alewives dying?

There are several factors involved in the recent alewife die-off and the apparently large numbers that are washing up on the beaches. These factors are origin and life history of the fish, population abundance, and weather.

Origin

The alewife (*Alosa pseudoharengus*) is native to the Atlantic Coast; alewives entered the Great Lakes through the Welland Canal and made their way to Lake Michigan by 1949.

[x] alewife illustration

Alewives are not well adapted to the osmotic stress associated with life in fresh water. Freshwater fish must constantly 'pump' water out of their bodies; fish that are well adapted to a freshwater environment have larger kidneys than their saltwater counterparts. Because of this physiological stress, alewives are rather sensitive to disturbances in their Great Lakes environment.

Life History

Alewives spend most of the year in the deeper waters of the open lake, but come into near shore waters in the summer when they are ready to spawn. Alewives begin to spawn when the water temperatures reach about 55-60° F. In their native habitat alewives are anadromous, swimming upstream to spawn in the spring. In the Great Lakes, the fish congregate near the outlets of rivers or streams or near harbors that occur at the outlet of a river. Generally, alewives begin reproducing at about two years of age. Alewives do not necessarily die after they spawn, but when the fish move from the deeper water to near shore areas they are exposed to fluctuating temperatures. A severe change in water temperature, such as can occur with upwelling, can cause the fish to die.

So, we see there are two underlying factors that relate to alewife mortality in the spring: their fragile condition due to poor osmotic balance and being exposed to environmental changes when they enter near shore waters to spawn. This year, two other factors are involved: age and abundance.

Abundance

The spawning run of 1995 produced a strong year class of alewives. In addition to being abundant, these fish were robust, larger than fish produced in other years. These fish are now four years old, getting towards the end of their life. The spawn of 1998 produced a strong year class as well, however, these fish, though numerous, were not as robust. Though these were relatively strong year classes, the population is not considered to be 'over abundant' and the numbers of alewife in the lake are much lower than they were in the 1960's.

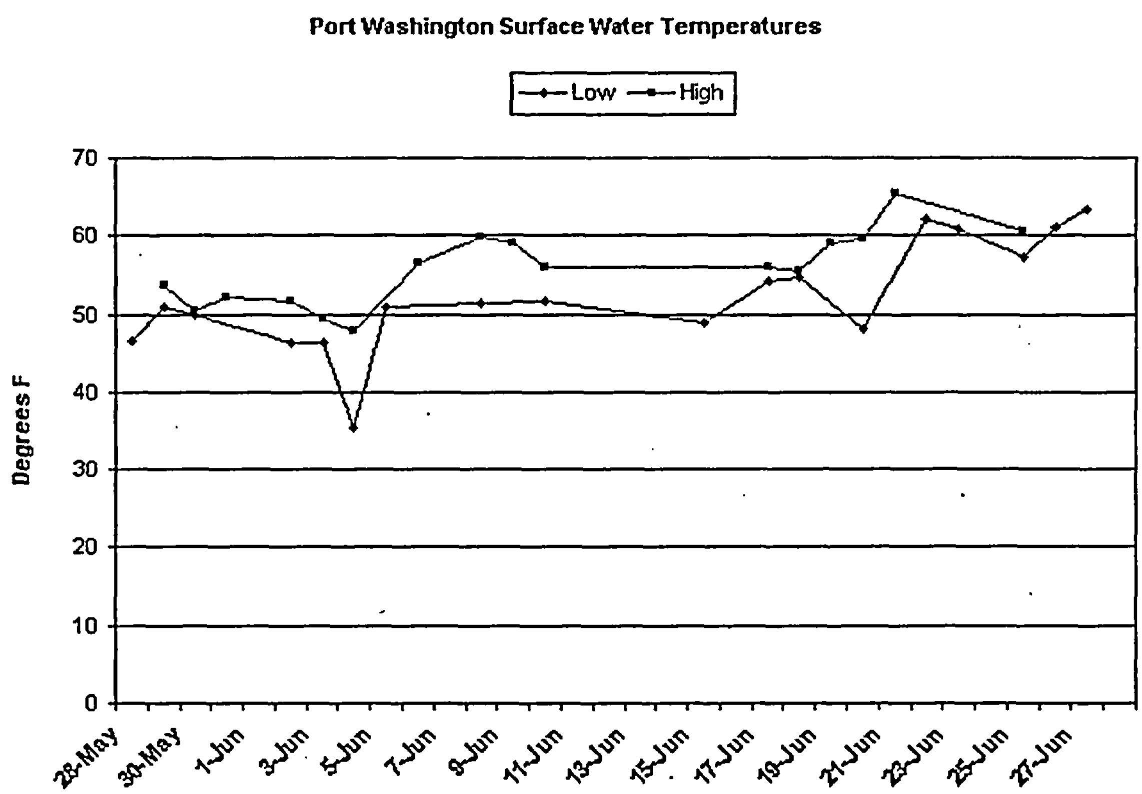
Weather

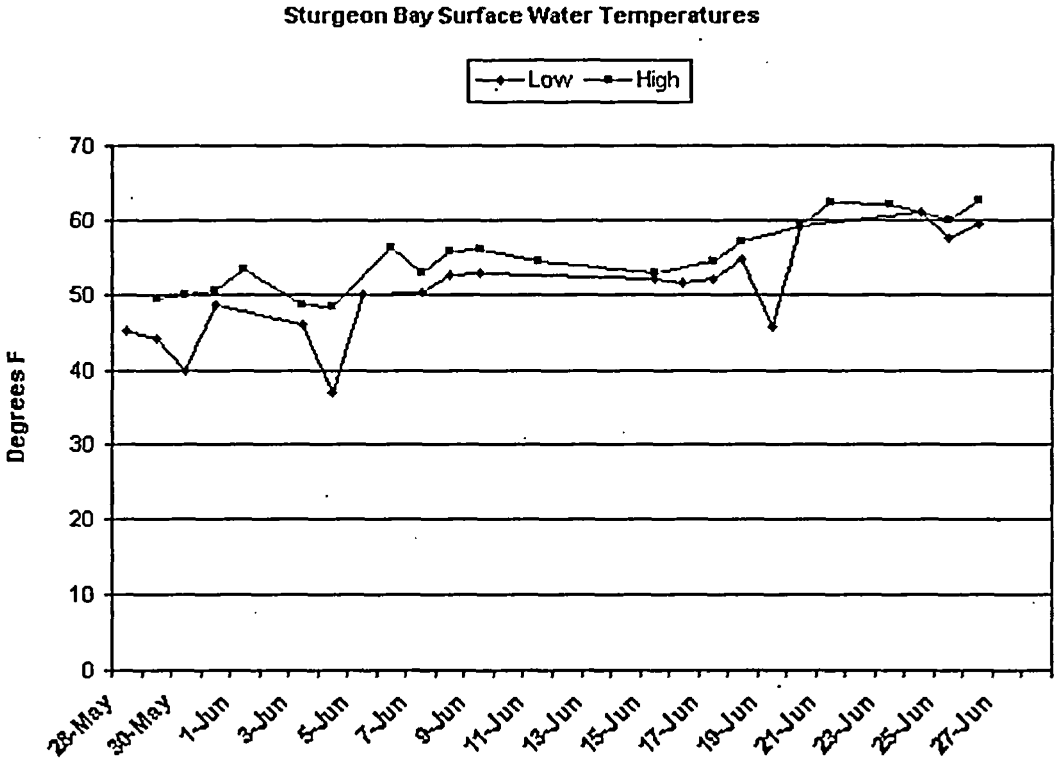
As these two strong year classes, and other smaller year classes moved from the deeper waters to near shore areas this spring, they were exposed to temperature fluctuations. These fluctuations probably contributed to the die off and the large numbers of dead fish that subsequently washed upon the beach. The graphs below (see end of story) illustrate the daily high and low Lake Michigan surface water temperatures from areas near Port Washington and Sturgeon Bay.

Notice that the water temperature generally increased through June, but that on at least two occasions, there was a sharp drop in temperature with a 24-hour period, probably related to upwelling events. The effect of this temperature change on the alewives would likely have been most profound in the latter part of the month, around the 19^{th} or 20^{th}. By this time, the water temperature had reached about 55^{O}F and the fish had probably begun to spawn. As indicated by the mid-lake buoy, wind direction in the two days preceding the temperature drop, was predominantly south, southwest. For about two days after the upwelling event, the wind was from as easterly direction. Fish that became weak or died during the rapid temperature change would have been blown into windrows close to shore or washed onto the beaches.

Thus, in addition to the normal, die-off of alewives, this year we had large two relatively abundant year classes, one of older fish and one with small, weaker fish near shore during an upwelling event. The upwelling of cold water occurring during the spawning season probably weakened or killed many of these fragile, saltwater-adapted fish. East winds following the upwelling event contributed to the large numbers of fish accumulating on the shoreline. The number of fish washing up on the beaches should begin to diminish as water temperatures rise, spawning ends, and the fish move out to deeper water.

--Philip Moy, UW Sea Grant Fisheries Specialist





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LAKE MICHIGAN

Man's Effects on Native Fish Stocks and Other Biota

Great Lakes Fishery Commission

TECHNICAL REPORT No. 20

The Great Lakes Fishery Commission was established by the Convention on Great Lakes Fisheries between Canada and the United States, ratified on October 11, 1955. It was organized in April, 1956 and assumed its duties as set forth in the Convention on July 1, 1956. The Commission has two major responsibilities: the first, to develop co-ordinated programs of research in the Great Lakes and, on the basis of the findings, recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; the second, to formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes. The Commission is also required to publish or authorize the publication of scientific or other information obtained in the performance of its duties.

LAKE MICHIGAN

Man's Effects on Native Fish Stocks and Other Biota

by

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Bureau of Sport Fisheries and Wildlife
Ann Arbor, Michigan 48107

and

ALBERTON L. McLAIN

Division of Fisheries Services
Bureau of Sport Fisheries and Wildlife
Twin Cities, Minnesota 55 111

TECHNICAL REPORT No. 20

GREAT LAKES FISHERY COMMISSION
1451 Green Road
P.O. Box 640
Ann Arbor, Michigan

January 1973

FOREWORD

This paper is one of seven lake case histories-Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, Lake Opeongo, and Lake Kootenay. Concise versions of these papers, together with other lake case histories developed for and by an international symposium on Salmonid Communities in Oligotrophic Lakes (SCOL) appeared in a special issue of the Journal of the Fisheries Research Board of Canada (Vol. 29, No. 6, June, 1972).

While this and each of the others in this series is complete in itself, it should be remembered that each formed a part of SCOL and is supplemented by the others. Because much detail of interest to fisheries workers in the Great Lakes area would not otherwise be available, this and the other case histories revised and refined in the light of events at the symposium are published here.

SCOL symposium was a major exercise in the synthesis of existing knowledge. The objective was to attempt to identify the separate and joint effects of three major stresses imposed by man: cultural eutrophication, exploitation, and species introduction on fish communities. Recently glaciated oligotrophic lakes were chosen as an "experimental set." Within the set were lakes which have been free of stresses, lakes which have been subjected to one stress, and lakes which have been subjected to various combinations of stresses. The case histories provide a summary of information available for each lake and describe the sequence of events through time in the fish community. Some of these events were inferred to be responses to the stresses imposed. Lakes Opeongo and Kootenay were included in this set somewhat arbitrarily, with the case histories of the Laurentian Great Lakes, to illustrate similarities and differences in the problems associated with other recently glaciated oligotrophic lakes.

We began organizing SCOL in 1968 and were later supported by a steering committee: W. L. Hartman of the U.S.A., L. Johnson of Canada, N.-A. Nilsson of Sweden, and W. Nümann of West Germany. After two years of preparation, a work party consisting of approximately 25 contributors and a similar number of interested ecologists convened for two weeks in July, 1971 at Geneva Park, Ontario, Canada.

Financial support was provided by the Great Lakes Fishery Commission, Ontario Ministry of Natural Resources, Fisheries Research Board of Canada, Canadian National Sportsman's Show, and University of Toronto.

Editorial assistance was provided by P. H. Eschmeyer, K. H. Loftus, and H. A. Regier.

K. H. Loftus
H. A. Regier

CONTENTS

LAKE MICHIGAN

Man's Effects on Native Fish Stocks and Other Biota[1]

by

LaRue Wells and Alberton L. McLain

ABSTRACT

Man's activities have caused great changes in Lake Michigan in the past 120 years. Although changes in water chemistry and lower biota have been generally modest (except locally), those in native fish stocks have been vast. Exploitation, exotic fish species, and eutrophication and other forms of pollution all have played a role in bringing about the changes (mostly declines in abundance) in fish populations.

Exploitation resulted in a noticeable reduction in abundance of certain native species (especially whitefish) soon after the establishment of the commercial fishery in the 1840's. By the 1930's the sturgeon and the two largest deepwater ciscoes (Coregonus *nigripinnis* and C. *johannae)* became severely depleted. Other species-whitefish *(Coregonus clupeaformis)*, lake trout *(Salvelinus namaycush)*, and lake herring (C. artedii)-remained important commercially, but at a lower level of production than originally; greatly increased fishing effort and efficiency were required to maintain even these decreased catches. The catch of intermediate-size ciscoes held relatively stable, but again only through sharply increased fishing effort and efficiency.

The earliest serious effects of exotic fish species on native fish stocks may have been during the *1930's*, when smelt *(Osmerus mordax)* first became abundant. Powerful influences by exotics were not obvious, however, until the 1940's, when the sea lamprey's *(Petromyzon marinus)* predation on several species, particularly the lake trout, became critical. In the 1950's the sea lamprey was joined by the alewife *(Alosa pseudoharengus)*, another exotic strongly deleterious to several native fish. The alewife apparently inhibited reproduction of deepwater ciscoes, yellow perch *(Perca flavescens)*, deepwater sculpins *(Myoxocephalus quadricornis)*, emerald shiners *(Notropis atherinoides)*, and perhaps others (through competing with young, or feeding on them). At the same time, however, the alewife as a prolific forage fish has made possible the highly successful introduction of several species of salmonines.

The effects of accelerated eutrophication and other pollution, although not always as easy to identify as the influences of other factors, were nevertheless clearly important as early as the mid-1800's. The first conspicuous contamination of Lake Michigan was by sawmill wastes, which covered spawning-grounds in streams and around stream mouths. This type of pollution was particularly destructive to whitefish. Other forms of stream degradation (e.g., dams, deforestation of watersheds) although not strictly "pollution," must also have been detrimental to stream spawners. Heavy pollution in southern Green Bay (a large area of the bottom of which is now covered with anoxic gray sludge) probably has resulted in reduction in abundance of several species, e.g., lake herring and walleye *(Stizostedion v. vitreum)*.

Exploitation was largely responsible for the changes in Lake Michigan fish stocks before the invasion of the smelt, and probably before the invasion of the sea lamprey.

1 Contribution 462, Great Lakes Fishery Laboratory, U.S. Fish and Wildlife Service, Ann Arbor, Michigan.

The lamprey and alewife, however, have exerted a greater impact than the fishery on native fish populations in recent decades. Accelerated eutrophication and other pollution, although important, have not equalled the other factors in causing changes in native fish populations.

INTRODUCTION

Lake Michigan, the world's sixth largest lake in both area and volume, is the only one of the Laurentian Great Lakes that lies entirely within the boundaries of the United States. It is divided among four political subdivisions-the states of Michigan, Wisconsin, Illinois, and Indiana-each with complete jurisdiction over the waters within its borders. By far the greatest shares belong to Michigan and Wisconsin.

The first rapid population growth around Lake Michigan began early in 1832, when termination of Indian hostility in Illinois encouraged settlement along the southwestern shore. In 1832 alone, the population of Chicago increased from 150 to an estimated 2,000 (Hatcher 1944). Settlements thereafter sprang up quickly at the major river mouths and harbors along shore.

The influx of settlers soon caused significant changes in the Lake Michigan environment, due largely to rapidly developing commercial fishing and lumbering operations. By 1850 fishing was a major industry. Changes in certain fish stocks, probably mostly due to heavy exploitation, were noticed by the late 1850's. By that time, however, pollution of rivers and their estuaries from sawmills and other sources, and other alteration of streams (e.g., deforestation, drainage, and construction of dams) had also begun to affect fish stocks. In the mid-1900's the introduction of several exotic fish species (indirectly as a result of man's activities) had devastating effects on the native fish stocks.

Changes in fish stocks have continued to the present. Other environmental changes may also have occurred more or less constantly since the early days of settlement, but data for making comparisons are almost non-existent. Limited comparative data for recent decades have shown changes in water chemistry and lower biota, but generally these changes have been much less obvious than those in the fish stocks.

Beeton (1969) reviewed changes in Lake Michigan, primarily with respect to eutrophication, and Smith (1968, 1970) described certain aspects of changes in the fish stocks and discussed reasons for these changes. The primary purpose of the present report is to describe further the changes brought about by exploitation, exotic fish species, and accelerated eutrophication and other forms of pollution on the environment of Lake Michigan, with particular reference to their effects on native fish stocks.

DESCRIPTION OF LAKE MICHIGAN

Lake Michigan is in the north central United States, and lies between 41°37′ and 46°06′ North Latitude, and between 84°45′ and 88°02′ West Longitude (Fig. 1). Its length is 307 miles (494 km), its maximum width 118

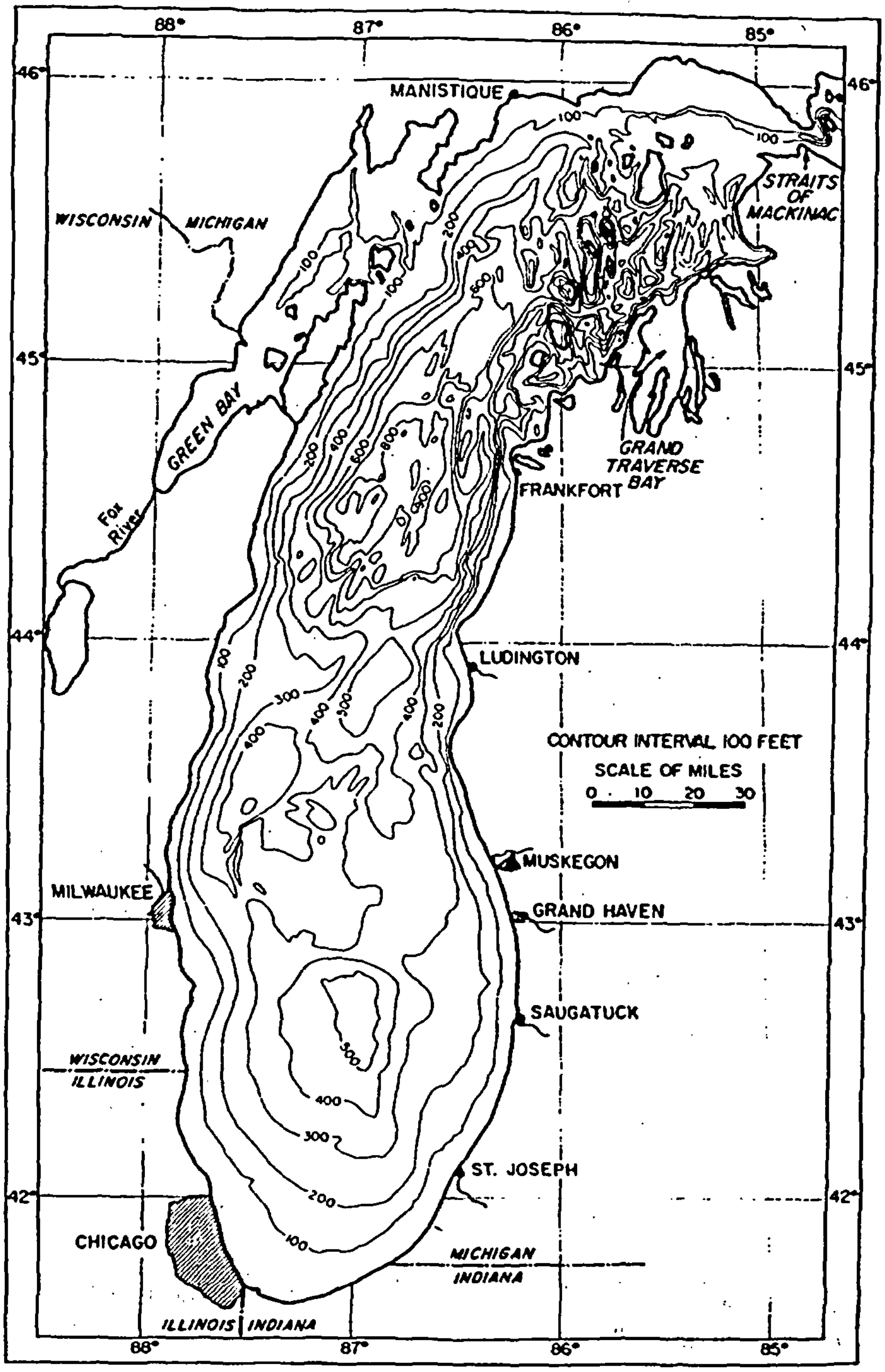

Figure 1. Lake Michigan (modified from Hough 1958). Grand Traverse Bay, which is not contoured, has a steeply sloping bottom and a maximum depth of about 600 feet.

miles (190 km), its shoreline length 1,661 miles (2,672 km), and its surface area 22,400 square miles (58,200 km^2). The mean depth is 276 feet (84 m) and volume of water 1,170 cubic miles (4,870 km^3). The drainage basin, including the lake, covers 67,860 square miles (175,760 km^2). No tributary stream has an average flow greater than 3,400 cfs (96 m^3/sec), and only eight have average discharges greater than 1,000 cfs (28 m^3/sec). The outlet is through the Straits of Mackinaw into Lake Huron; the mean discharge is 55,000 cfs (1,560 m^3/sec) (Powers and Ayers 1960). The lake's elevation above sea level averages about 579 feet (176.5 m).

Lake Michigan proper is divided into two rather distinct basins: the southern basin with a relatively smooth, gently sloping bottom and depths to 558 feet (170 m), and the northern basin with an irregular bottom and depth to 923 feet (281 m). The northern basin contains a number of islands. Almost the entire lake bottom is covered with glacial till or lake sediments (Hough 1958).

Much of the shore along the southern two-thirds of Lake Michigan is characterized by a smooth, unbroken shoreline, backed by gently rolling terrain; extensive dunes border the eastern and southern shores. The northern end of the lake has an irregular shoreline and in most places is bordered by hills. The southern part of the watershed is a mixture of farmland and urbanized areas, the central portion is primarily farmland, and the northern section is mostly forested. The largest city along the shoreline, Chicago, Illinois, is not considered to be in the watershed, because its drainage has been into the Mississippi River since the completion of the Chicago sanitary canal in 1900.

Green Bay, in northwestern Lake Michigan, is 118 miles (190 km) long and averages 23 miles (37 km) in width. It is generally more eutrophic and productive than the rest of the lake, and usually yields about half the lake's total annual catch of commercial fish.

Two small bays, Little Bay de Noc and Big Bay de Noc, are at the northern end of Green Bay. Grand Traverse Bay and Little Traverse Bay, the only other bays of consequence in Lake Michigan are in the northeast corner of the lake.

The average January temperatures at shore stations around Lake Michigan range from -4 to -9 C, and the average July temperatures from 20 to 23 C. Annual precipitation averages about 30 inches (76 cm); it is rather evenly distributed throughout the lake over the long term, but differs considerably in different areas of the lake in individual years. Winds are most often (at least 60%) from a westerly quadrant.

The following description of water temperatures in Lake Michigan is from J. F. Carr, J. W. Moffett, and J. E. Gannon (MS in preparation), and from unpublished data of the Great Lakes Fishery Laboratory.

The annual water temperature cycle consists of a 5-month warming period from middle or late March to middle or late August, and a 7-month cooling period. Thermal stratification does not develop until after mid-May, and is not stable until late June. Water temperatures are distinctly higher near shore than off shore through May but this difference is greatly reduced by late June, when the surface temperatures generally range from 15 to 20 C. The surface water is warmest in late July and early August, when temperatures of 20-25 C are common. At that time the epilimnion averages about 9-10 m in thickness, and the temperature gradient in the metalimnion is greater than 1 C/m. The epilimnion cools and thickens slowly in late August and early September, then rapidly from late September through November. By mid-November the surface temperature is about 10 C and the epilimnion is about 40 m thick. In mid-December the water temperature offshore decreases gradually from near 7 C at the surface to about 5 C at the bottom. In January-March the lake is vertically homothermous. Inshore temperatures are near 0.1 C. Offshore waters are warmer, but continue to cool throughout most of the period. In 1955, for example, temperatures at a station 15 miles (24 km) offshore were 4.2 C in January and 2.4 C in March. A large portion of Lake Michigan remains ice-free in winter, and large accumulations of ice are limited to shore zones, the extreme northern part of the lake proper, and Green Bay (which freezes over nearly every year).

Inshore temperatures are subject to frequent significant fluctuations in summer, particularly in August, due to the formation and dissipation of upwellings of various intensities. At a depth of 18 feet (5.5 m) off Saugatuck, Michigan, in August 1969, bottom water temperature changed as much as 10 C in 24 hours or less on three occasions, and as much as 3 C in 120 hours or less on 15 occasions.

Lake Michigan's waters are moderately hard. Total alkalinity (as $CaCo_3$) is 113 ppm; the concentrations of calcium, magnesium, and sodium are 31.5, 10.4, and 3.4 ppm, respectively; the phosphorus concentration is 0.9 ppb; and dissolved oxygen concentrations are near saturation at all depths (Beeton and Chandler 1963).

Lake Michigan's biota, except in southern Green Bay and areas around river mouths, is generally typical of that in North American oligotrophic lakes. Phytoplankton is dominated by diatoms; common oligotrophic diatom species are *Cyclotella comta, C. operculata,* and *C. ocellata* (Stoermer and Yang 1969). Invertebrate fauna is characterized by such oligotrophic forms as the amphipod *Pontoporeia affinis;* the mysid *Mysis relicta;* the copepods *Limnocalanus macrurus* and *Senecella calanoides;* and the oligochaetes *Stylodrilus heringianus, Peloscolex variegatus,* and *Limnodrilus profundicola.* AU of these invertebrates except *Senecella* are abundant. Many less highly oligotrophic benthic and planktonic forms also are common, however.

The original fish fauna of Lake Michigan included, among other species, 10 coregonines and 1 salmonine. The lake whitefish *(Coregonus clupeaformis),* the lake herring *(C. artedii),* and the lake trout *(Salvelinus namaycush)* were most abundant. Some of the coregonines have become rare or extinct, and several salmonines have been introduced. All common fish of Lake Michigan, past or present, are listed below. Excluded are a few species (characteristic of more eutrophic environments) that are occasionally common near river mouths or in certain areas of southern Green Bay.

Sea lamprey	*Petromyzon marinus*
Lake sturgeon	*Acipenser fulvescens*
Alewife	*Alosa pseudoharengus*
Lake whitefish	*Coregonus clupeaformis*
Blackfin cisco	*Coregonus nigripinnis*

. . . .	*Coregonus johannae*
Longjaw cisco	*Coregonus alpenae*
Shortjaw cisco	*Coregonus zenithicus*
Bloater	*Coregonus hoyi*
Kiyi	*Coregonus kiyi*
Shortnose cisco	*Coregonus reighardi*
Lake herring	*Coregonus artedii*
Round whitefish	*Prosopium cylindraceum*
Lake trout	*Salvelinus namaycush*
Brook trout	*Salvelinus fontinalis*
Rainbow trout (steelhead)	*Salmo gairdneri*
Brown trout	*Salmo trutta*
Coho salmon	*Oncorhynchus kisutch*
Chinook salmon	*Oncorhynchus tshawytscha*
Rainbow smelt	*Osmerus mordax*
Northern pike	*Esox lucius*
Carp	*Cyprinus carpio*
Emerald shiner	*Notropis atherinoides*
Spottail shiner	*Notropis hudsonius*
Longnose sucker	*Catostomus Catostomus*
White sucker	*Catostomus commersoni*
Channel catfish	*Ictalurus punctatus*
Bullheads	*Ictalurus* spp.
Trout-perch	*Percopsis omiscomaycus*
Burbot	*Lota lota*
Ninespine stickleback	*Pungitius pungitius*
Smallmouth bass	*Micropterus dolomieui*
Yellow perch	*Perca flavescens*
Walleye	*Stizostedion vitreum vitreum*
Freshwater drum	*Aplodinotus grunniens*
Slimy sculpin	*Cottus cognatus*
Spoonhead sculpin	*Cottus ricei*
Fourhorn sculpin	*Myoxocephalus quadricornis*

The common name of *Coregonus johannae* is sometimes listed as "deepwater cisco." In this report, however, the ciscoes as a group (except for the lake herring sometimes called "shallow-water cisco") are designated as "deepwater ciscoes"; to avoid confusion, we have not assigned a common name to *Coregonus johannae.* Of the species listed, northern pike, channel catfish, bullheads, and freshwater drum are restricted mostly to Green Bay, and smallmouth bass are confined mainly to certain shallow, rocky areas of northern Lake Michigan proper and northern Green Bay.

FACTORS THAT HAVE CAUSED CHANGES IN NATIVE FISH STOCKS AND OTHER BIOTA

General descriptions of the factors involved in changes in Lake Michigan are given here; their effects are discussed in later sections.

Exploitation

Exploitation of Lake Michigan's fish stocks has been almost altogether through commercial operations, but sport fisheries have at times been important, especially in recent years.

The commercial fishery

No attempt is made here to trace in detail the history of the commercial fishery; a summary of developments in the fishery (particularly in its earlier days), however, facilitates the later discussion of changes in the fish population. Most of these data, unless otherwise stated, are from Milner (1874), Smiley (1882), Smith and Snell (1891), and Baldwin and Saalfeld (1962 plus supplement 1970).

The date of first commercial fishing in Lake Michigan is not known, but it was at least as early as 1843. The fishery grew rapidly. In the beginning it was conducted mostly along shore with haul seines, but gill nets were introduced in 1846 or 1847 and pound nets about 10 years later. The use of gill nets and pound nets spread rapidly; they soon largely replaced haul seines and became, together with trap nets (introduced about 1885-Buettner 1965) the most important gears to the present time. Other gears, however, such as set lines, fyke nets, and trawls, have on occasion also been important.

The earliest fishery was primarily for whitefish, which were extremely abundant near shore. By 1860 certain grounds for this species already were becoming depleted and by the 1870's complaints about the scarcity of whitefish were common. Whitefish production, however, was still held at a high level-12 million pounds- in 1879 (the first year of record) by increased fishing effort, increased efficiency of gear (e.g., smaller meshes, finer twine in gill nets), and shifts to new fishing grounds. Total production for all species in that year (Fig. 2) was nearly twice the whitefish catch, because by that time lake trout, sturgeon, and lake herring had become important. Whitefish catches dropped abruptly soon thereafter but total production held rather stable until 1892 (average annual production 1879-92, 25.3 million pounds), due to increases in the catch of lake trout, lake herring, deepwater ciscoes, perch, suckers, and (to a smaller extent) walleyes. Total production jumped markedly to an average of 41.2 million pounds in 1893-1908, due mostly to increases in lake herring catches. The sturgeon ceased to be important during that period. Total production dropped abruptly between 1908 and 1911 (owing primarily to a decrease in the lake herring catches), but was rather stable at an average of 23.6 million pounds in 1911-42. During the latter period carp and smelt (both introduced) were added to the list of important species, and walleye production became rather low. Gallagher and Van Oosten (1943) listed the eight most important species, in order of yield and value, taken from Lake Michigan in 1939, as follows:

Order of yield	Order of value
Lake trout	Lake trout
Deepwater ciscoes	Deepwater ciscoes
Yellow perch	Yellow perch

Lake herring	Whitefish
Smelt	Lake herring
Suckers	Smelt
Carp	Suckers
Whitefish	Carp

Since 1942 the relative importance of the various species in the Lake Michigan commercial fishery has varied greatly. Important changes have been: a temporary drastic decrease in smelt production in the mid 1940's; the decline and elimination of the lake trout in the late 1940's and early 1950's; a great decrease in whitefish production in the middle and late 1950's, and some recovery in the 1960's; a substantially increased production of deep-water ciscoes beginning in the late 1940's; a brief, spectacular resurgence of walleye production from the late 1940's to the mid-1950's; and the appearance of the introduced alewife in the catches in the late 1950's and its extremely large production by the mid-1960's. In spite of these changes, total production did not vary markedly from the 1911-42 mean until 1966, when alewife catches became large. The average was 25.8 million pounds in 1943-65 and 50.5 million in 1966-70.

Throughout the history of the commercial fishery the efficiency of operation increased almost constantly. The changes in gill nets provide an example of these improvements. The earliest gill nets were constructed of coarse cotton webbing, with wooden-slat floats and stone weights. In the late 1800's cotton webbing gave way to finer linen twine, and wooden floats and stone sinkers to corks and leads. In the 1930's the linen webbing was replaced by more efficient flexible cotton, which in turn was replaced in the late 1940's and early 1950's by nylon. The earliest nylon nets were estimated to have been between two and three times as efficient in catching fish as the cotton nets they replaced (Hile and Buettner 1955). Improvements in nylon (e.g., monofilament construction) have been made in the past two decades. Over the history of the fishery, especially in the earlier years, there was a tendency toward smaller meshes and greater width in the gill nets. The range from home port was increased by a change from sailing vessels to power vessels (first steam tug in 1869) and the quantity of gill nets that could be set was increased by installation of power equipment for lifting the nets (beginning in the late 1800's).

At least as early as the 1870's many fishermen held the opinion that high production of certain species was being maintained only by increases in the efficiency and amount of gear fished. The same statement would apply to some extent throughout the history of the fishery, so that for some species the declines of abundance have been substantially greater than production figures indicate, including those figures based on catches per standard unit of fishing effort.

The sport fishery

Among the earliest references to sport fishing in Lake Michigan are statements by Smith and Snell (1891) that pleasure fishing was carried out by a great many people in the Chicago area in 1885. These anglers fished mostly from piers and wharves for yellow perch, using hand lines baited with

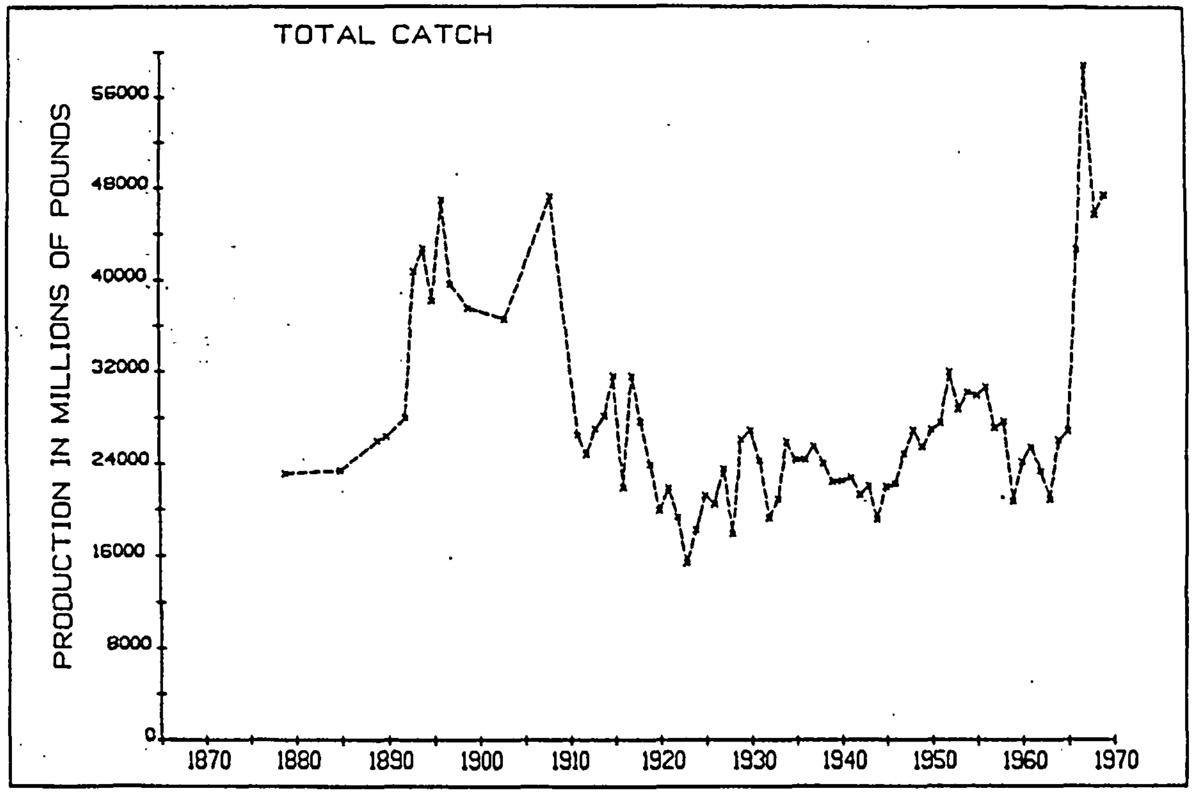

Figure 2. Total commercial production in Lake Michigan, 1879-1970.

minnows which also were taken from Lake Michigan. Although the history of the sport fishery is almost totally undocumented and few catch records have been kept until recently, it seems safe to assume that the yellow perch has been the most important species, considering the entire period. Until the past decade, most breakwalls around the lake were often lined with anglers fishing for yellow perch. The walleye also has been a favorite of sport fishermen. This species has been caught mostly in Green Bay, where it was taken in huge numbers in the 1950's. Smelt are caught throughout Lake Michigan (almost entirely in shallow areas or in streams during the spawning run), but mostly in the northern portion. The sport fishery for smelt was perhaps at its peak in 1942, when more than 5 million pounds were taken from Michigan waters of the lake alone-as compared with perhaps 200,000 pounds or less in 1970 (2.8 million fish; weight unknown). Trolling for lake trout was popular in Grand Traverse Bay before the collapse of this species in the late 1940's.

In recent years the intensive stocking of salmonids has led to the most spectacular sport fishery in Lake Michigan's history. The angling is for coho and chinook salmon and lake, steelhead, brown, and brook trout. An example of the magnitude of the sport fishery is given by these catches in 1970 in State of Michigan waters alone: 500,000 coho salmon, 275,000 steelhead trout, 229,000 lake trout, and 170,000 chinook salmon (unpublished records, Michigan Department of Natural Resources). Some brown trout and brook trout also were taken, but more of these are caught in Wisconsin waters, where they were stocked more heavily.

Smallmouth bass provide a lively sport fishery in certain shallow rocky areas of northern Lake Michigan. Also taken in limited numbers, mostly in Green Bay, are northern pike, rock bass *(Ambloplites rupestris),* and a few other warmwater species.

Introduced fish species

Exotic fish species have become extremely important in Lake Michigan. Their early histories and later fluctuations in abundance are described briefly here:

Carp

The time of the carp's first appearance in Lake Michigan is not known. Commercial production records started in 1893, with an entry of only 2,000 pounds, and by 1899 the catch had increased only to 25,000 pounds (Fig. 3). Production was nearly 0.5 million pounds in 1908 and passed 1 million pounds in 1934. The annual average was 1.5 million pounds in 1934-65 and 2.3 million in 1966-70. Although it may be assumed that the small catches before 1900 reflect the low abundance of carp soon after its introduction and that the great increase in catch soon after 1900 resulted from rapid increases in carp population, later changes in production have followed changes in market demand rather than abundance. A large proportion of the catch has been from southern Green Bay, although some carp are taken in nearly all shallow areas of the lake, particularly in the southeastern portion. Although the effects of carp (e.g., uprooted vegetation and muddied water) often

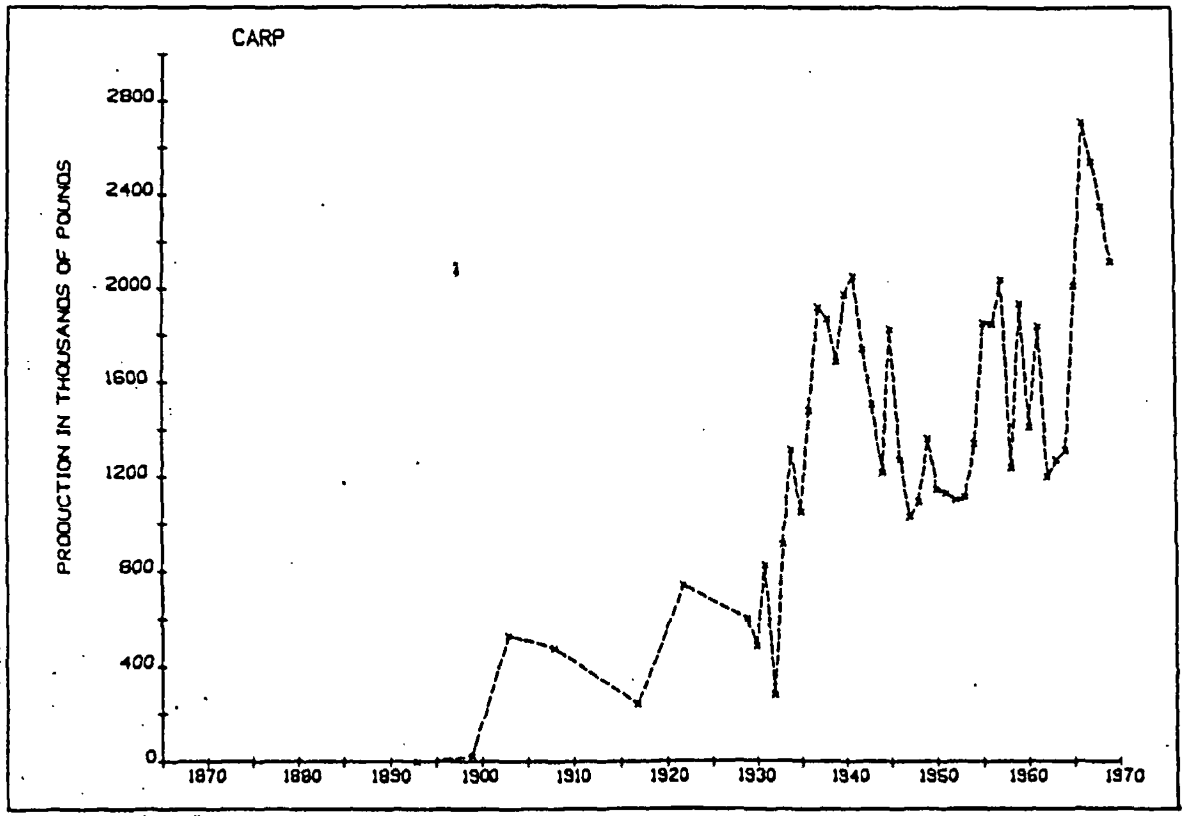

Figure 3. Commercial production of carp in Lake Michigan, 1893-1970.

reported in other bodies of water are not documented for Lake Michigan, it seems likely that the carp did cause certain changes injurious to native fauna in some areas of Lake Michigan, particularly Green Bay.

Smelt

The smelt in Lake Michigan originated from a planting in Crystal Lake, Michigan, in 1912 (Van Oosten 1937). The first smelt reported in Lake Michigan was caught in a commercial net in 1923 off Frankfort, Michigan, which is at the mouth of the stream through which Crystal Lake drains into Lake Michigan. By 1924 smelt had crossed Lake Michigan into Green Bay, and by 1936 they occupied the entire lake.

Commercial production of smelt increased from 86,000 pounds in 1931 (the first year of record) to 4.8 million pounds in 1941 (Fig. 4). The take then dropped abruptly to 2.2 million pounds in 1943 and 5,000 pounds in 1944 but recovered quickly to 1.1 million pounds in 1948 and reached a record 9.1 million pounds in 1958. Catches again dropped thereafter to 927,000 pounds in 1965 but increased steadily to 2.5 million pounds in 1969. Since 1953 (when the records first indicated the proportion of the catch from Green Bay), 72-98% of the annual commercial production has been in Green Bay.

The abrupt decline of smelt production in Lake Michigan in 1943 and 1944 was the result of a mass mortality (apparently caused by disease) in the winter of 1942-43 (Van Oosten 1947). The fairly substantial catch of 1943 was made in winter, before the dieoff had ended; by spring, few smelt remained in Lake Michigan. That the smelt population was enormous just before the dieoff is indicated by the dip net catch by sport fishermen in 1942, which was estimated at 5.5 million pounds in State of Michigan waters and was probably nearly that high in Wisconsin (Van Oosten 1947). It seems probable, therefore, that numbers of smelt were greater in the first peak production year of 1941 than in the record year of 1958, even though the 1941 commercial production was only about that of 1958.

Although the decline of smelt in 1959-65 probably was not as great as production figures indicate (reduced market demand influenced the catch), a substantial decline unquestionably occurred. Smith (1970) attributed the decrease to the alewife, although he believed (on the basis of information from other lakes) that alewives have less effect on smelt than on certain other species. Consequently, other important factors may also have been involved in the decline.

Effects of smelt on native stocks are not obvious, but it is difficult to imagine that an exotic which reached the abundance of smelt in Lake Michigan would not have exerted at least some influence. Evidence exists that smelt adversely affected lake herring (discussed later), and there is no question that smelt have provided valuable forage for lake trout (Wright 1968).

Sea lamprey

The sea lamprey almost certainly has had a greater influence than any other exotic on the native fish stocks of Lake Michigan. Its most conspicuous

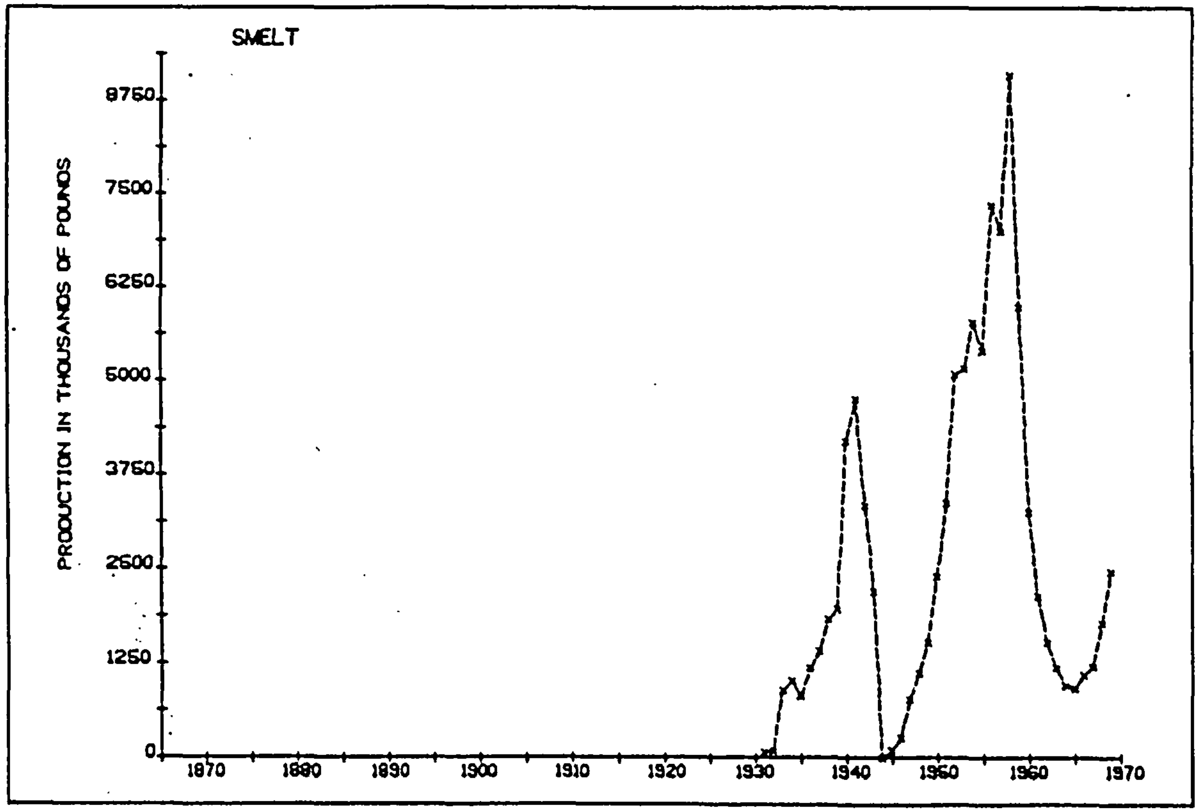

Figure 4. Commercial production of smelt in Lake Michigan, 1931-70.

effects have been in direct attacks on native species, but Smith (1970) believed that the destruction of predators by the lamprey allowed the invasion of another exotic, the alewife, which influenced native stocks still further. The first reports of this parasite in Lake Michigan were in 1936, when specimens were taken at several widely scattered localities (Applegate 1950). A decade later the sea lamprey was firmly established-spawning runs had been reported in many streams and commercial fishermen had for several years complained of high incidences of sea lamprey wounds on the fish in their catches (Shetter 1949).

Early reports indicated that the sea lamprey's primary victim was the lake trout, followed by whitefish, suckers, walleyes, yellow perch, and carp (Shetter 1949). Other species, particularly deepwater ciscoes and burbot, have also been severely attacked. Smith (1968) estimated that during its maximum abundance in Lake Michigan in the mid-1950's the sea lamprey destroyed 5 million pounds of fish per year, mostly deepwater ciscoes (by this time few lake trout remained).

Sea lamprey control efforts began in Lake Michigan in 1953 (several experimental control devices had been installed in 1952). By 1958, barriers (mostly electrical, a few mechanical) had been placed across 65 streams to block upstream migrations of sea lampreys. Barrier operations were discontinued in 1960 in favor of a much more effective method of lamprey control-the treatment of streams with a toxicant selective for lamprey larvae. All tributary streams known to harbor sea lamprey larvae had been treated by 1966, and many of the streams have since been treated a second time. The success of the treatment is shown by the sharp decline of spawning-run sea lampreys at three barriers which had been left in operation to provide yearly indices of abundance: 12,886 lampreys were caught in 1961 and 1,168 in 1966. Due to budgetary limitations the "index" barriers were removed after the 1966 spawning season; consequently, trends in lamprey abundance since that time are not easily ascertained. Reduced wounding rates for lake trout between 1969 and 1970, however, are encouraging.

Alewife

The first alewife recorded in Lake Michigan was taken in the northeastern portion in 1949 (near the source of introduction from Lake Huron); by 1953 the species was dispersed throughout most of the lake (Miller 1957). The population increased rapidly, first in the northern segment. Fairly large numbers of adults and several schools of young were seen in Green Bay in 1953 (Joeris and Karvelis MS 1962). By 1956 fishermen in Green Bay were taking large quantities in pound nets fished for other species. In September 1955 one of us (Wells) observed large numbers of young alewives in the Manistique River, a tributary along the north central shore of the lake. Although at that time alewives were fairly common throughout northern Lake Michigan (unpublished data, Great Lakes Fishery Laboratory), the greatest concentrations were almost certainly in Green Bay.

Alewives were scarce in southern Lake Michigan until about 1956; only two adults are known to have been caught in 1953 and several in 1954 (Miller 1957). The first young were received by the Chicago Natural History Museum in October 1956 (Woods 1960), and by the winter of 1956-57 commercial fishermen in southern Lake Michigan were complaining about large numbers of alewives fouling their gill nets set for chubs (Miller 1957).

In the late 1950's and early 1960's the population increase of alewives in Lake Michigan was explosive. Commercial production increased from 220,000 pounds in 1957 to 4.7 million pounds in 1962 and reached a peak of 41.9 million pounds in 1967 (Fig. 5). Commercial production of alewives is so strongly influenced by market demands that catch figures are not necessarily accurate indicators of abundance, but experimental catches by the U.S. Fish and Wildlife Service R/V *Cisco* in southern Lake Michigan show similar striking increases in 1962-66 (comparable data not available before 1962).

The nuisance aspects of the alewife in Lake Michigan have attracted wide public attention. When alewives are concentrated along shore in spring they often cause extreme difficulties by clogging intakes of steel mills, power plants, and municipal water filtration plants, and by dying in huge numbers and collecting in windrows on beaches. The first spring dieoff of alewives in Lake Michigan for which an account was published was in the Chicago area in 1957 (Woods 1960). The number of dead fish was small (Loren Woods, personal communication), and it seems likely that small unreported spring mortalities may have occurred in northern Lake Michigan before 1957. Spring mortality became increasingly severe in Lake Michigan in the early 1960's, and an enormous dieoff occurred in 1967 (Brown 1968). On the basis of aerial observation and counts along small segments of beaches in various areas, U.S. Fish and Wildlife Service biologists estimated that mortality at several billion fish.

Catches per unit of effort in commercial and experimental trawls (the latter by the Great Lakes Fishery Laboratory) in the falls of 1966 and 1967 suggested that about 70% of the alewives in Lake Michigan died during the 1967 dieoff. (E. H. Brown, MS in preparation). Production was high in 1967 because much fishing effort had been expended before the dieoff. Both experimental and commercial catches indicated a further decline in numbers in 1968 (commercial catches dropped to 27.2 million pounds), and modest increases in 1969 and 1970 (production 33.5 million pounds in 1970).

The alewife unquestionably has had detrimental effects on native fish stocks, probably mostly by competition with the young for planktonic food or by predation on the young. Wells (1970) showed that alewives have had a strong influence on zooplankton in Lake Michigan (discussed in a later section). On the other hand, the alewife, as a prolific forage fish, has made possible the outstandingly successful salmon stocking programs in Lake Michigan in recent years.

Salmonines

Although introductions of salmonines into Lake Michigan began about a century ago, their greatest importance by far has been in recent years. Earliest releases (nearly all fry) included several species of salmon and trout, and were for the purpose of establishing naturally spawning populations. Except for rainbow trout and perhaps brown trout, however, the attempts were unsuccessful. Plants in the past decade (all fingerlings or yearlings) have been

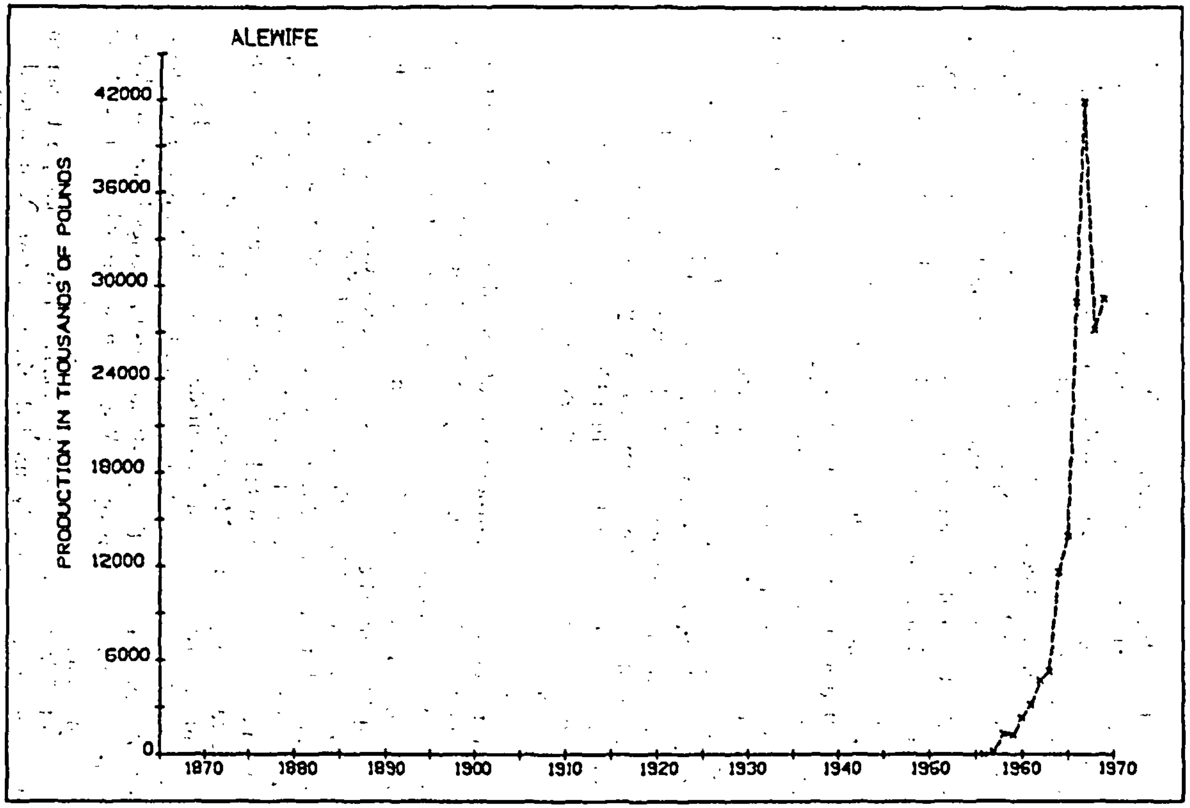

Figure 5. Commercial production of alewife in Lake Michigan, 1956-70.

designed mostly for a put-and-take sport fishery. The following statistics on salmonines have been taken from various reports of the U.S. Fishery Commission, the Michigan Department of Conservation (now the Department of Natural Resources), and the Great Lakes Fishery Commission, and from unpublished data of conservation agencies of the various states bordering Lake Michigan.

Early Pacific salmon introductions included 813 chinook salmon between 1873 and 1880, and 2,000 masu salmon (Oncorhynchus *masou)* in 1920. A large-scale program for the introduction of Pacific salmon into Lake Michigan began in 1966, when 660,000 coho salmon yearlings were released; a total of 10.3 million had been stocked through 1970. Extensive chinook salmon stocking began in 1967, and by the end of 1970, 4.1 million fingerlings had been released. The State of Michigan, which initiated the Pacific salmon program, released 94% of the coho salmon and 93% of the chinook salmon planted through 1970, but all the other states bordering Lake Michigan have participated in the stocking effort.

The success of the recent salmon program in Lake Michigan has been spectacular. In 1970 anglers in State of Michigan waters caught an estimated 500,000 coho and 170,000 chinook salmon, Of the coho salmon stocked in 1966, 1967, and 1968, the percentages ultimately either caught by fishermen or recovered at weirs on spawning streams were 32, 19, and 25, respectively. Equivalent figures cannot be given for chinook salmon because some of those from even the first planting presumably still had not spawned in 1970; 20% of the 1967 plant had been recovered by 1970, however. Growth of salmon has been excellent. Adult coho salmon weighed an average of 9.5 pounds in spawning runs of 1967, 1968, and 1969. In 1970 a world record coho salmon (33 pounds, 8 ounces) was taken. Twenty-pound chinook salmon were not uncommon in 1970, and a few caught by anglers weighed more than 30 pounds.

The first rainbow trout introduction of record into Lake Michigan tributaries was in 1880, but it is not clear whether these fish were from sea run "steelhead" stock or from nonmigratory strains. The first planting of fish specifically designated as "steelheads" was in 1896, when 10,000 yearlings were released in State of Michigan waters. Steelheads were stocked in most years thereafter until about 1915. From 1915 to 1960 few steelheads were planted, but since that time introductions have increased greatly. All states bordering Lake Michigan are now stocking rainbow trout. The program has been highly successful; an estimated 275,000 (many no doubt naturally spawned) were caught in State of Michigan waters alone in 1970.

A plant of 5,000 brown trout was made as early as 1883, and several hundred thousand brown and brook trout (mostly brown trout) have been stocked in Lake Michigan since the mid-1960's. Both species have provided a successful sports fishery, particularly in Wisconsin waters where most of the plants have been made.

Stocking of Atlantic salmon *(Salmo* salar) in Lake Michigan began in 1872 and continued intermittently until 1932, by which time a total of 645,000 had been released. The program was largely unsuccessful. None have been stocked in recent years.

The direct influence of the introduced salmonids on native fish stocks has probably been only negligible. It seems safe to assume, however, that in recent years they may have affected the abundance of alewives, their main item of diet, and in doing so may have affected some native species that have important interrelations with the alewife. Although alewives increased in 1969 and 1970, it seems at least possible that they would have increased considerably more in the absence of the heavy predation by the introduced salmonids.

Accelerated eutrophication and other forms of pollution

A noticeable deterioration of Lake Michigan's environment (in certain inshore areas) began at least as early as the mid-1800's, when sawdust and other refuse discharged from sawmills into tributary streams often floated out into the lake and sank (Milner 1874). By 1885 the Milwaukee River had become so polluted (probably by several contaminants) that few fish entered it (Smith and Snell 1891). Deforestation, drainage, and construction of dams, although not strictly "pollution," also must have affected Lake Michigan's fish stocks by blocking migration or by causing warming of the water in the streams and their estuaries. An expanding human population has discharged increasing amounts of domestic and industrial wastes and other pollutants into the lake. The most heavily polluted area is southern Green Bay, a large area of the bottom of which is covered with anoxic gray sludge (Edgington and Callender 1970).

Changes in certain chemical components of Lake Michigan are substantial enough to indicate that eutrophication has been accelerated to at least some extent by man. Beeton (1969), who analyzed all available records through 1966, showed that total dissolved solids increased by 30 ppm, sulfates by 13 ppm, and chloride by about 6 ppm during the preceding 90 years, and organic nitrogen increased and inorganic nitrogen decreased during the preceding 38 years; data were lacking for an analysis of changes in phosphorus. Oxygen levels have decreased greatly in southern Green Bay, and possibly also to some extent in the rest of the lake. Minimum oxygen concentrations in southern Green Bay declined from 2-3 ppm in 1938-39 to only 0.0-1.0 ppm in 1955-56 (Beeton 1969). Oxygen concentrations in the main body of Lake Michigan remain near saturation, although Ayers, Stoermer, and McWilliam (1967) believed that oxygen concentrations decreased somewhat in a part of northern Lake Michigan between 1955 and 1966. Records of the Great Lakes Fishery Laboratory do not indicate any change in the southern portion of the lake between 1954 and 1968. Schelske and Stoermer (1970) reported that silica has decreased in the southern part of Lake Michigan at an average rate of 0.1 ppm per year in the past 40 years. They attributed this decrease to an increase in the abundance of certain diatoms that are favored by eutrophication.

Toxic trace elements in Lake Michigan have received attention in several recent studies. Mercury concentrations in Lake Michigan fish have been generally low but values up to 0.82 ppm have been reported for deepwater sculpins in the open lake (Edgington, Thommes, Gassman, and Cutler 1970) and up to 0.75 ppm for unspecified species in Green Bay (Kleinert and Degurse 1971). Edgington and Callender (1970) reported mercury concentrations to be great enough (2.95 ppm) in anoxic sludge of southern Green Bay to suggest a high degree of mercury pollution in that area (levels are much lower in northern Green Bay). Methodology for mercury analysis, however, apparently has not progressed to the point that published figures can be considered absolutely reliable. Selenium, which falls into the lake in ash residues from burned fossil fuels, has been observed in rather high concentrations in zooplankton, especially in the southern part of the lake (Copeland 1970).

Lake Michigan has been subjected to considerable insecticide contamination. On the basis of concentrations in fish, insecticide levels in Lake Michigan are the highest in any of the Laurentian Great Lakes (Reinert 1970). Contamination, which is mostly by DDT and to a lesser extent dieldrin, is heaviest in the southern part of the lake. Insecticide levels fortunately do not appear to have increased further in Lake Michigan between 1967 and 1970 (unpublished data, Great Lakes Fishery Laboratory).

Thermal pollution in Lake Michigan, as in many other bodies of water, has become a subject of increasing public concern. Most of the heated effluents are from one nuclear and 23 fossil fuel power plants; seven additional plants (five nuclear and two fossil fuel) are scheduled for operation by 1974. Steel mills also contribute to the thermal input of Lake Michigan. The artificial heat input is now only a small portion of the total for Lake Michigan, but in the year 2000 it will be an estimated 11 times the level of 1968 (Acres 1970). Detrimental effects which are probably localized at present may therefore be expected to spread. Environmentalists are clamoring for legislation requiring closed cooling systems for all power plants put into service in the future (and for some of the largest now operating) on Lake Michigan.

CHANGES IN BENTHOS AND PLANKTON

Although limnological studies in Lake Michigan have proliferated in the past decade, a detailed assessment of changes in benthos and plankton is difficult due to a scarcity of earlier data with which to make comparisons. Enough data are available, however, to permit a limited evaluation of some of the more prominent changes.

Benthos

Some changes in Lake Michigan benthos in the past several decades have been documented; all have been attributed to accelerated eutrophication or other pollution.

Conspicuous changes in benthos have occurred in southern and central Green Bay (Beeton 1969 and Howmiller and Beeton 1970). Nymphs of the burrowing mayfly, *Hexagenia*, were common in 1939 but were rare in 1952 and absent by 1955. Oligochaetes and chironomids increased between 1939 and 1969, except for a decrease near the mouth of the Fox River (a large, grossly polluted tributary). Amphipods, leeches, snails, and fingernail clams were less abundant in 1969 than in 1952.

Changes in bottom fauna probably also have occurred in many shallow areas of the main body of Lake Michigan. Cook and Powers (1964) have shown differences between the benthos off the mouth of the St. Joseph River (which flows into Lake Michigan at St. Joseph) and an inshore area not near a major tributary, and attributed these differences to the greater inflow of suspended solids from the river. The benthos at the mouths of all major tributaries to Lake Michigan probably has changed, since the suspended solids of these rivers almost certainly have increased.

Robertson and Alley (1966) reported significantly larger numbers of oligochaetes and the amphipod *Pontoporeia affinis* in the southern two-thirds of Lake Michigan in 1964 than in 1931. Fingernail clams (Sphaeriidae) probably also were more abundant in 1964. The authors interpreted the increase in all three dominant benthos groups as a suggestion of a long-term trend, but believed that definitive conclusions were not possible on the basis of only 2 years' data because the abundance of benthic organisms may vary greatly from year to year, even in the absence of such trends.

In spite of the evidence of trends toward eutrophication, the presence of the oligochaete *Stylodrilus heringianus* and *Peloscoiex variegatus* (Hiltunen 1967) the midge *Heterotrissocladius subpilosus* (Henson 1966) and the fingernail clams *Pisidium coventus* and *Sphaerium nitidum* (Herrington 1962) indicate that the benthos of the open areas of Lake Michigan retain a strongly oligotrophic character.

Zooplankton

Zooplankton populations in Lake Michigan have changed strikingly in recent years, as indicated by collections made in 1954, 1966, and 1968 (Wells 1970). Sharp declines in abundance occurred between 1954 and 1966 in the three largest cladocerans, *Leptodora kindtii, Daphnia galeata,* and *D. retrocurva,* and the four largest common copepods, *Limnocalanus macrurus, Epischura lacustris, Diaptomus sicilis,* and *Mesocyclops edax. Daphnia galeata* and *Mesocyclops edax* were almost eliminated. At the same time most of the remaining zooplankton species increased in abundance. Between 1966 and 1968 the composition of zooplankton populations shifted generally back toward that of 1954. Wells attributed the changes to differences in the abundance of alewives as described earlier; this planktivore, which has been shown to select the larger species of zooplankton (Brooks 1968) increased phenomenally in abundance between 1954 and 1966, then declined drastically by 1968.

A conspicuous zooplankton change in Lake Michigan probably not related to the above events has been the recent invasion of the brackish water copepod, *Eurytemora affinis* (Robertson 1966).

An accurate comparison of present zooplankton populations in Lake Michigan with those before 1954 is not possible. Although one major earlier study, based on samples collected in 1887-88 and 1926-27, was published (Eddy 1927), collection methods were much different from those used in later work. Eddy's samples were from the surface near shore (mostly from a Chicago breakwall), whereas later collections were from various strata offshore. Nevertheless, considerable attention has been given to the difference in abundance of *Bosmina coregoni* as reported for 1886-87 and 1926-27 (the most abundant cladoceran) and for 1954 (absent-Wells 1960). Beeton (1965) interpreted these differences as an indication of eutrophication; Brooks (1969) related them to a decrease in planktivorous fish, which permitted large zooplankton species to proliferate and completely exclude the smaller *B. coregoni.* The reappearance of *B. coregoni* in 1966 after intense alewife predation had decimated large zooplankters (Wells 1970), would seem to refute Beeton's argument and lend support to that of Brooks. Wells (1970) however, questioned whether there is a real basis for comparison, in light of the confusion in taxonomy of the genus.

Gannon (1970) showed marked differences in the species composition and abundance of crustacean zooplankton between southern Green Bay and the rest of Lake Michigan (including northern Green Bay), and suggested that the differences might be due in part to accelerated eutrophication, and consequent zooplankton changes, in southern Green Bay; proof is lacking, however, because no comparative data for earlier periods exist for southern Green Bay. Gannon's study also indicated that the effect of alewife predation on zooplankton populations has not been as pronounced in southern Green Bay (where, for example, *Mesocyclops edax* is still common) as elsewhere in the lake.

Phytoplankton

The phytoplankton of Lake Michigan has undergone some distinct changes since the 1800's, which have been attributed to accelerated eutrophication and other forms of pollution.

Stoermer and Yang (1969) studied changes in Lake Michigan diatoms (which have dominated the phytoplankton) by comparing data from several reports, dating back to 1872, with their own findings in extensive collections of 1964 and 1967; the following summary is from their review. The diatom flora of Lake Michigan is becoming more diverse. Certain taxonomic entities *(e.g., Stephanodiscus binderanus)* associated with moderate to high levels of pollution apparently were not present until about the 1930's; they are now abundant in certain inshore areas and are becoming increasingly common offshore. Members of the genera *Thalassiosira* and *Coscinodiscus,* indicators of extreme water quality degradation in the Great Lakes, came into Lake Michigan between 1947 and 1964; at the present time their distribution is highly restricted. On the basis of plankton diatom assemblages, the areas of greatest environmental disturbance in Lake Michigan are: the southern portion of Green Bay; the extreme southern crescent of the lake from Chicago, Illinois, to Benton Harbor, Michigan; the northeastern coast from Ludington to Frankfort, Michigan; and local areas near most major harbors. In the offshore areas certain strongly oligotrophic diatom species, such as *Cyclotella comta, C. operculata,* and *C. ocellata,* are still present, although their numbers are reduced-especially in the southern portion of the lake.

Although A. M. Beeton (MS in preparation) did not directly compare past and present data, he believed that the substantial differences in diatom species, abundance, and generation times (i.e., average doubling times for the populations) between offshore and inshore areas (particularly southern Green

Bay) of Lake Michigan (reported by Holland 1969), reflect changes in the inshore areas. Beeton implies that increased enrichment due to man's activities (which has the greatest effect in inshore areas) has made the inshore-offshore differences greater than in the past.

Schelske and Stoermer (1970) believed that, although a decrease in silicon in the past 40 years (mentioned in an earlier section) resulted from an increase in certain diatoms favored by eutrophication, some of the diatoms are not being replaced in the Lake Michigan phytoplankton assemblage by blue-green and green algae. The literature provides only limited further data for comparisons of present nondiatom phytoplankton with that of the past in Lake Michigan. Beeton (1969) reported the presence of the blue-green alga *Aphanizomenon* in 1938-1939 (blooms) and *Schizothrix* in 1952 and 1963-65 in Green Bay, and implied that these species were absent or less abundant formerly. The obnoxious green alga *Cladophora* unquestionably has increased, but it is found only in local areas of heavy pollution rather than widely as in Lakes Erie and Ontario (Beeton 1966).

CHANGES IN NATIVE FISH STOCKS

Lake Michigan's native fish stocks have changed vastly, and almost constantly in the last 120 years, far beyond what might be expected in normally fluctuating populations. Man's activities have been responsible, either directly by exploitation, or indirectly by eutrophication (and other pollution) or by causing conditions which led to the invasion of exotic fish species. Until the early 1920's when the smelt first entered Lake Michigan, only exploitation and pollution (and probably drainage, deforestation, and damming, which led to warming or blocking of spawning streams) were affecting fish stocks significantly. The species introduced before the smelt-salmonines (mostly unsuccessful) and carp-probably exerted little influence. Since the smelt's introduction, all three factors-exploitation, pollution, and exotic species-have been involved.

It is impossible, of course, to separate precisely the influence of the various factors on changes in Lake Michigan's native fish stocks. Opinions on the relative importance of the various factors, in fact, have varied over the years during which changes have been noted. Until about the mid-1940's, the prevalent opinion was that overexploitation was responsible for most of the changes, the most obvious of which were decreases in abundance of desired species. Most of the earliest commercial fishermen, observing marked declines in their favored species (particularly whitefish) were among the first to express this view, although they also recognized the adverse effects of pollution. Scientists investigating the early declines in commercial species agreed with these fishermen (see Milner 1874; Smith and Snell 1891). Some fishery scientists in the 1920's, 1930's, and early 1940's were vehement in their belief that declines in stocks of desired species in Lake Michigan and other Great Lakes were almost altogether a result of commercial overexploitation (see, e.g., Van Oosten 1938, 1939). Since that time a common, though by no means universal, opinion among fishery scientists has been that exploitation was overemphasized as a factor in the earlier declines, and that the fishery has had almost no effect on recent changes.

Following is a species-by-species discussion of changes in the abundance of common native fish of Lake Michigan. For the most part we have regarded total production figures (mostly from Baldwin and Saalfeld 1962, plus supplement 1970) as indices of abundance. The weaknesses in this procedure are obvious (e.g., changes in fishing intensity are not taken into account) but we believe that production has usually provided a reasonably accurate index of major changes in abundance.

Whitefish

The whitefish was the mainstay of the early fishery in Lake Michigan (data on the early fishery are from Milner 1874 and Smith and Snell 1891). It was easily taken in large quantities even in shore seines, and was considered to have the finest flavor-superior to lake trout-in the salted product which was commonly used at that time.

Early accounts clearly indicate a substantial decline in the abundance of whitefish well before commercial production figures were available; increased fishing intensity and more efficient nets were required to maintain the catch. The decrease began in some areas along the west shore as early as the 1850's. Milner estimated a drop in abundance along the west shore and in Green Bay of "all of 50 percent" in the 10 or 12 years just before 1872. Milner's estimate was for whitefish and lake trout combined, but a consideration of the priorities of the fishery at that time leaves little doubt that his assessment was influenced mostly by whitefish. By 188.5 abundance had been severely reduced in many areas, particularly in Green Bay.

The earliest figures related to the commercial production of whitefish in Lake Michigan are for 1879 and 1885, when the combined catches of whitefish, round whitefish, and the large deepwater ciscoes (Coregonus *nigripinnis* and *C. johannae)* were 12.0 and 8.7 million pounds, respectively (Fig. 6). Whitefish undoubtedly made up the bulk of these catches. Van Oosten, Hile, and Jobes (1946) reported that whitefish constituted about three-fourths of the total catch of the above species in 1890; statements by Smith and Snell (1891) regarding changes in the fishery suggest that the proportion of whitefish was at least as great in 1879 and 1885. Production figures for whitefish alone begin with 1889, when the take was 5.5 million pounds. In 1892 production had dropped to 2.8 million pounds, and the average for 1892-1908 was 2.4 million. In 32 of the 43 years from 1911 to 1953, production was between 1.0 and 2.6 million pounds. Periods of significantly higher production were in 1928-32 (peak, 5.4 million pounds in 1930) and 1947-49 (peak, 5.8 million pounds in 1947). Production continued to drop more or less steadily after 1949 (abruptly after 1952) to an average of only 40,000 pounds in 1956-59, and then began a somewhat erratic but substantial increase to 1.7 million pounds in 1970.

The conspicuous decline of whitefish abundance in the years before 1885 was attributed by early investigators and fishermen to overfishing and pollution from sawmills (Milner 1874; Smith and Snell 1891). Overfishing seems to have been judged the more important. Justification for this view was based on the rapid decrease of whitefish in successive areas of increased fishing intensity, on the appreciable decline in the average size of the fish in

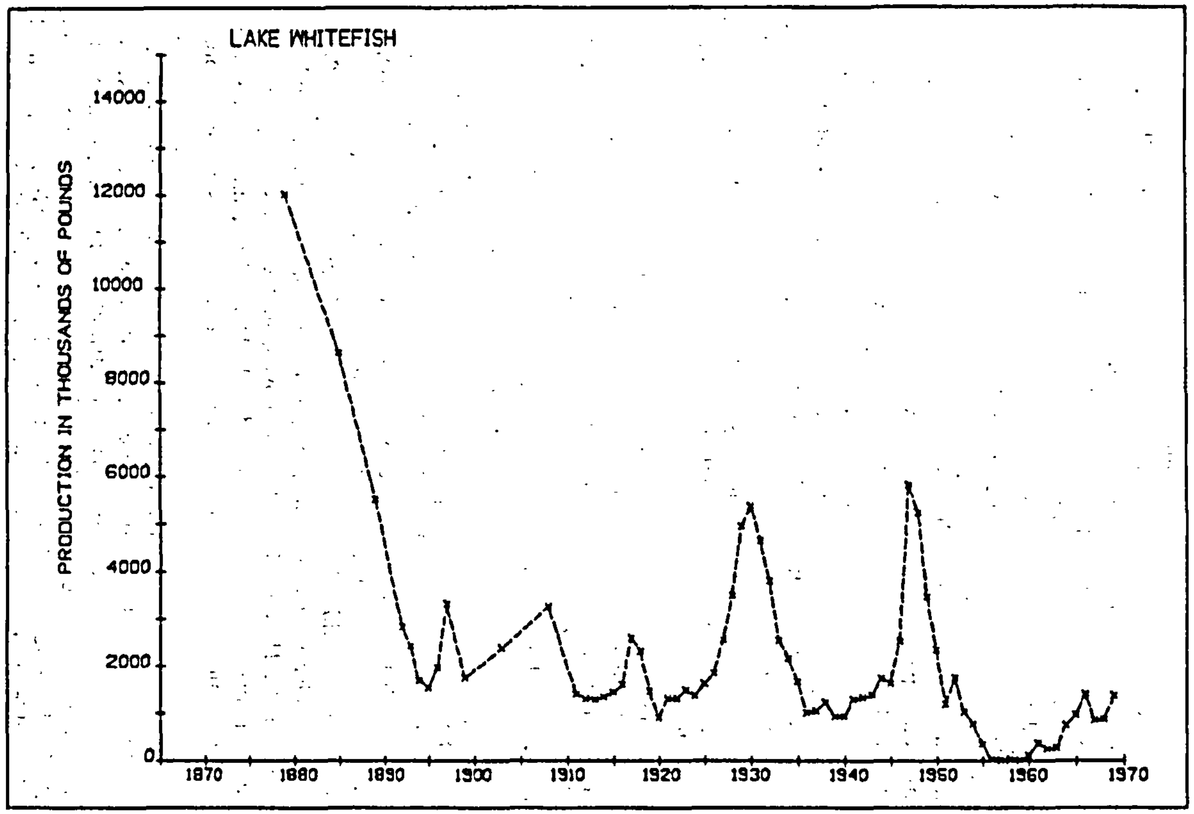

Figure 6. Commercial production of whitefish in Lake Michigan, 1879-1970.

the catch, and (by inference) on the wholesale slaughter of small whitefish. Koelz (1929), referring to the early exploitation of whitefish wrote, "At no season was the pursuit relented, and no fish were too small to be taken. The smallest, together with the herring and the sturgeon, often were carried out onto the beach (i.e., destroyed rather then released alive) because they were so numerous that they interfered with the capture of the larger whitefish. Though originally whitefish were found in incredible abundance all along the shore of the lake.. . they could not endure long such drains on their numbers." Regarding sawmill pollution Milner wrote "The refuse from the sawmills... is thrown into the streams in immense quantities to float out and sink in the lake. It is having a very injurious effect on the fisheries. The water-logged slabs... tear and carry away the nets. The sawdust covers the feeding and spawning grounds of the fish.. . ." Complaints about sawdust were common on both sides of the lake; many of the whitefish spawning areas in streams (some, particularly in Green Bay, were entered for spawning in the early days) and in the lake near river mouths must have been destroyed. Although not mentioned specifically by early investigators, other forms of stream degradation must also have been locally detrimental to whitefish.

The increased production of 1928-32 probably resulted from a single exceptionally strong year class and the high yields of 1947-49 are known to have been sustained mostly by a single year class-that of 1943 (Mraz 1964). It is not likely that the gain in abundance in either period was directly proportional to the increase in production, for-as Van Oosten, Hile, and Jobes (1946) pointed out-better fishing is apt to invite heavier fishing intensity. The reason for the unusual success of the year class (or classes) that supported the high 1928-32 yield is not apparent, but we are tempted to suggest that a contributing factor to the success of the 1943 year class was the phenomenal decline of smelt in the winter of 1942-43 (which would have left whitefish fry free of possible interference from smelt in 1943). Both periods of high abundance were short. Increased exploitation (including limited use of the allegedly destructive deep trap net) was implicated to some degree in the rapid decline in 1928-32 (Van Oosten, Hile, and Jobes 1946); and we suspect that the marked rise in fishing intensity in 1947-49 (Hile, Lunger, and Buettner 1953) also exacted its toll, and led to a considerably faster decline than would otherwise have occurred. Cucin and Regier (1966) estimated that, under intense fishing pressure in the early 1960's in southern Georgian Bay (Lake Huron), the fishery removed, in successive years, 68 and 61% of all whitefish between ages VI and VII. They also estimated that the natural mortality rate in the absence of fishing would have been only about 34%.

After the 1947-49 peak, abundance declined until extremely low levels of production of the late 1950's were reached. Possibly the substantial increase in the smelt population was a contributing factor; the alewife apparently was not, however, since the whitefish had become scarce before the alewife could have caused any effect. Sea lamprey predation assuredly contributed to this decrease, but perhaps not greatly in the beginning. The very high incidence of lamprey wounds on the lake trout in the 1940's, and its rapid extermination, leave little doubt that so long as the lake trout was available it was the favorite mark of the sea lamprey. Although whitefish was attacked by the lamprey soon after the predator's penetration into Lake Michigan (Shetter 1949), it probably did not suffer greatly until the lamprey had destroyed the lake trout populations and needed to turn elsewhere for prey. After the lake trout's collapse, however, whitefish may have been victimized extensively. Roelofs (1958) believed that a high (94%) mortality rate in whitefish of Big Bay de Noc (in northern Green Bay) between ages III and IV in the period 1951-54, may have been due to sea lamprey attacks, because local commercial fishermen reported that frequently large numbers of dead, commercial-sized whitefish, showing a high incidence of lamprey scarring, drifted into their nets. Spangler (1970) concluded that sea lamprey predation was an important component of natural mortality of whitefish in northern Lake Huron, because seasonal fluctuation in mortality of whitefish was positively correlated with seasonal changes in the incidence of lamprey scarring.

We attribute the increase of whitefish in the 1960's primarily to the lessened sea lamprey predation. Lower predation resulted mostly from sea lamprey control efforts, but probably also to some degree from the lake trout restocking program, which has restored to the predator its more favored victim. Recent work in northern Lake Huron has shown that the scarring rate on whitefish is influenced not only by the abundance of the sea lamprey, but also by the abundance of other prey species, e.g., the white sucker (Anonymous 1969).

Lake trout

The lake trout was the most valuable commercial species in Lake Michigan from 1890 until the mid-1940's. Production in Lake Michigan was usually the highest of any of the Great Lakes in that period.

Relatively few lake trout were caught in the earliest days of the fishery because they were not highly esteemed as long as whitefish were plentiful (Koelz 1926). In 1879, the first year for which records are available, production was a relatively low 2.6 million pounds; production then increased rapidly to 6.4 million pounds in 1885 (Fig. 7). Beginning in 1890 the fishery was characterized by exceptional stability for several decades, but some trends (mostly downward) were evident. A thorough treatment of these fluctuations by Hile, Eschmeyer, and Lunger (1951) is summarized briefly here. In 1890-1911 the catch was rather consistently high, averaging 8.2 million pounds. The average annual yield then dropped to 7.0 million pounds in 1912-26, and declined further to 5.3 million pounds in 1927-39. The trend was reversed in 1940-44 when the catch was above 6 million pounds in every year, and the average was 6.6 million. The year 1945 marked the beginning of a precipitous decline that led to a catch of only 342,000 pounds in 1949 and a mere 34 pounds in 1954. Lake trout were extremely rare in 1955 (Eschmeyer 1957) and the species probably became extinct in the lake in 1956.

Declines in lake trout stocks were observed in certain areas of Lake Michigan even before the 1880's, when production first became high (Milner 1874; Smith and Snell 1891). Since the declines were accompanied by appreciable decreases in average size, they probably were the result of

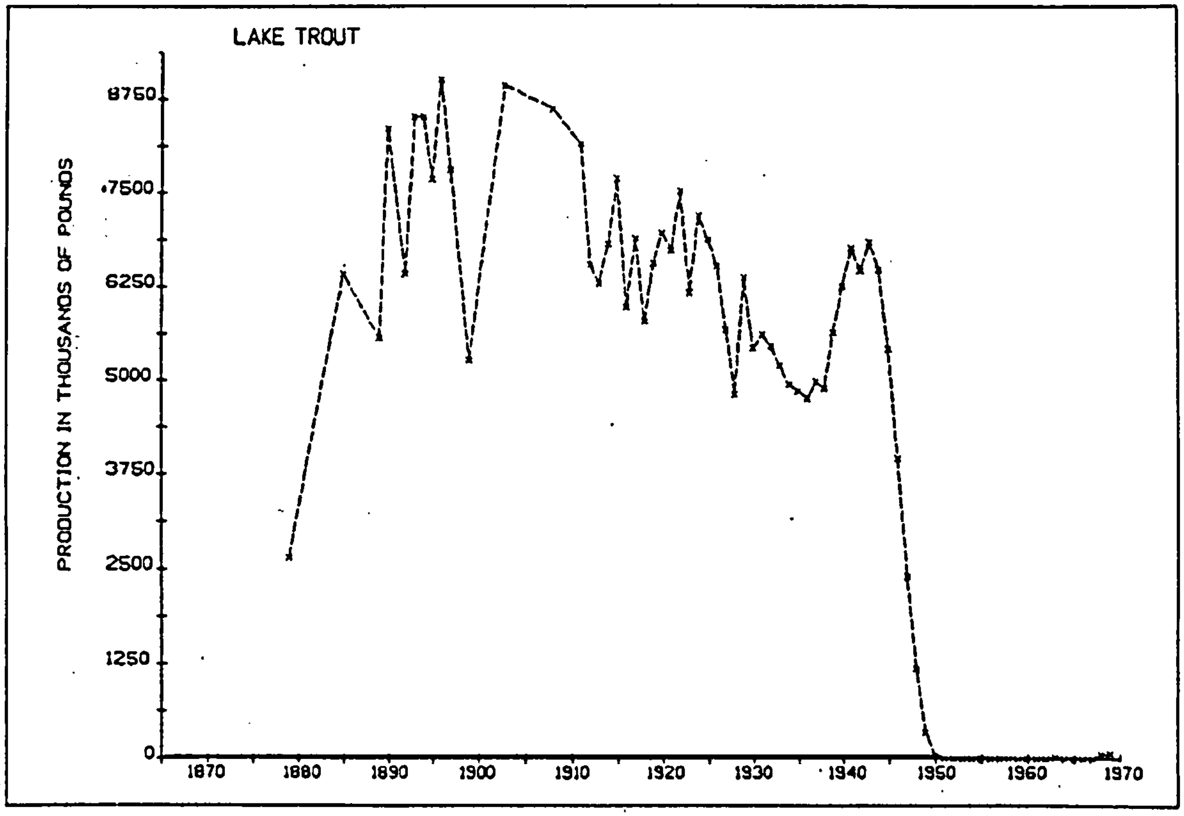

Figure 7. Commercial production of lake trout in Lake Michigan, 1879-1970.

exploitation. It is doubtful that this decline was lakewide, however, although a general decline in the stocks began shortly thereafter. Van Oosten (1949) noted that the gradual decrease in production during 1893-1938 occurred in the face of greatly increased fishing intensity. He believed that the decline was due to excessive exploitation, and we concur in that belief.

That the sea lamprey had a powerful influence on the phenomenal decline of the lake trout in Lake Michigan after 1944 is beyond question. Some authors held the sea lamprey totally responsible (Hile, Eschmeyer, and Lunger 1951; Eschmeyer 1957). Smith (1968) however, speculated that although sea lamprey predation hastened the decline once it had begun, the decline was initiated by markedly increased lake trout exploitation in Illinois waters in 1940-44. Although we agree with Smith that the increased lake trout yields of 1940-44 (275% above 1927-39 average) in Illinois were disproportionate to any likely increase in abundance, we question that an increase in production (and probably decrease in stocks) in so small an area in the southwest corner of Lake Michigan (Illinois waters are only 7% of total) could have exerted such an abrupt influence on stocks throughout the entire lake. Such an occurrence would have required extremely rapid dispersion of lake trout. The best evidence is that, although some lake trout in Lake Michigan travel widely, general dispersion is slow (Smith and Van Oosten 1940; Great Lakes Fishery Commission 1970). We believe that the disappearance of lake trout in Lake Michigan was a direct result of sea lamprey predation, although the lake trout was being somewhat overexploited before the parasite appeared. Whether a less exploited population could have better withstood the lamprey's assault is questionable, although that must be considered a possibility.

As a result of stocking, lake trout are once again abundant in Lake Michigan. Small experimental plants (36,000 to 94,000, mostly yearlings) were made each year in 1959-62 for a variety of studies relating to behavior of the stocked lake trout and their age before being subjected to heavy sea lamprey predation (Robert Saalfeld, personal communication). Rehabilitation was not an objective in these experimental plantings, since effective sea lamprey control had not yet begun. These trout apparently had disappeared by 1964.

The rehabilitation program, coordinated by the Great Lakes Fishery Commission, began in 1965. Since then an average of nearly 2 million yearling lake trout (average length about 6 inches) have been stocked each year. The program to date has been highly successful in producing fish to spawning size, in spite of continued troublesome sea lamprey predation. The trout have grown rapidly, attaining an average weight of about 4 pounds after only 3 years in the lake. Although spawning is known to have occurred in 1969 and 1970, no young have as yet been observed. Commercial fishing is prohibited, but a rapidly expanding sport fishery took more than 1 million pounds of lake trout in State of Michigan waters alone in 1970 (unpublished data, Michigan Department of Natural Resources).

Deepwater ciscoes

The deepwater ciscoes in Lake Michigan have supported a commercial fishery since at least 1869 (Koelz 1926). Reasonably complete commercial production records, however, have been kept only since 1926. Before then deepwater cisco catches were often either combined with other species (e.g., whitefish) in the statistics or not recorded at all (Hile and Buettner 1955). Even since 1926 the statistics for deepwater ciscoes have not been separated by species-all have been grouped as "chubs." The seven species originally represented (in order of decreasing size) were: *Coregonus nigripinnis, C johannae, C zenithicus, C. alpenae, C. reighardi, C kiyi,* and *C. hoyi.* In the following discussion most of these species are referred to by scientific name, since that is the usual practice. Exceptions are the blackfin *(C. nigripinnis)* and the bloater (C *hoyi),* which are well known by their common names.

Although the early records are not accurate, it may be inferred from the statistics that annual deepwater cisco production (Fig. 8) often amounted to several million pounds between the early 1890's and 1925 (Hile and Buettner 1955). The catches averaged 4.6 million pounds and were rather stable in 1926-39, dropped abruptly to 1.6 million pounds in 1940, remained near that figure through 1942, and then increased steadily to 9.3 million pounds by the end of the decade. The catch in the 1950's was nearly constant and averaged 10.2 million pounds. Peak annual production was in 1960-62 (12.0 million pounds). Landings dropped sharply to 7.5 million pounds in 1963 and 5.2 million pounds in 1964, but then began a steady increase to 10.1 million pounds in 1968 and were at 9.5 million pounds in 1970.

Trends in commercial production (even when based on catch per unit of effort) are not wholly satisfactory indicators of changes in abundance of deepwater ciscoes. Although the same is true to some extent for all the commercial species in Lake Michigan, the problem is much more acute for deepwater ciscoes for a variety of reasons, as described below:

Changes in fishing gear-particularly in mesh size-have been exceptionally great for deepwater ciscoes. The earliest gill nets for catching these species were of mesh sizes as large as 4½ inches, stretched measure (Smith and Snell 1891), but by 1950 the mesh size most commonly used had decreased to 2½ inches, and by the end of the decade 2-3/8-inch mesh was permitted in some areas (Smith 1964). The netting material changed, beginning about 1929, from linen to more efficient flexible cotton nets, and then changed again in 1946-52 to much more efficient nylon nets (Hile and Buettner 1955). A limited otter trawl fishery took great quantities of deepwater ciscoes (mostly small) in 1960-62. Differences over the years in the proportion of the catch sold by the fishermen have also influenced production without regard to abundance. Through most of the early history of the fishery small ciscoes usually were discarded (Moffett 1957), but in later years most were sold.

Perhaps the greatest shortcoming of the production records as indicators of changes in deepwater cisco populations has been a general lack of separation by species (except to some extent for the blackfin and *C johannae* in the early fishery). Periodic systematic experimental fishing, however, has provided a clear picture of changes in the last four decades. The first survey was in 1930-32, when the U.S. Bureau of Fisheries R/V *Fulmar* fished linen gill nets extensively in Lake Michigan. The U.S. Fish and Wildlife Service R/V cisco repeated much of *the Fulmar* sampling (identical gear, seasons, and locations) in 1954-55 and again in 1960-61 (for descriptions of the surveys, see Moffett 1957 and Smith 1964). Since 1961 the cisco has monitored Lake

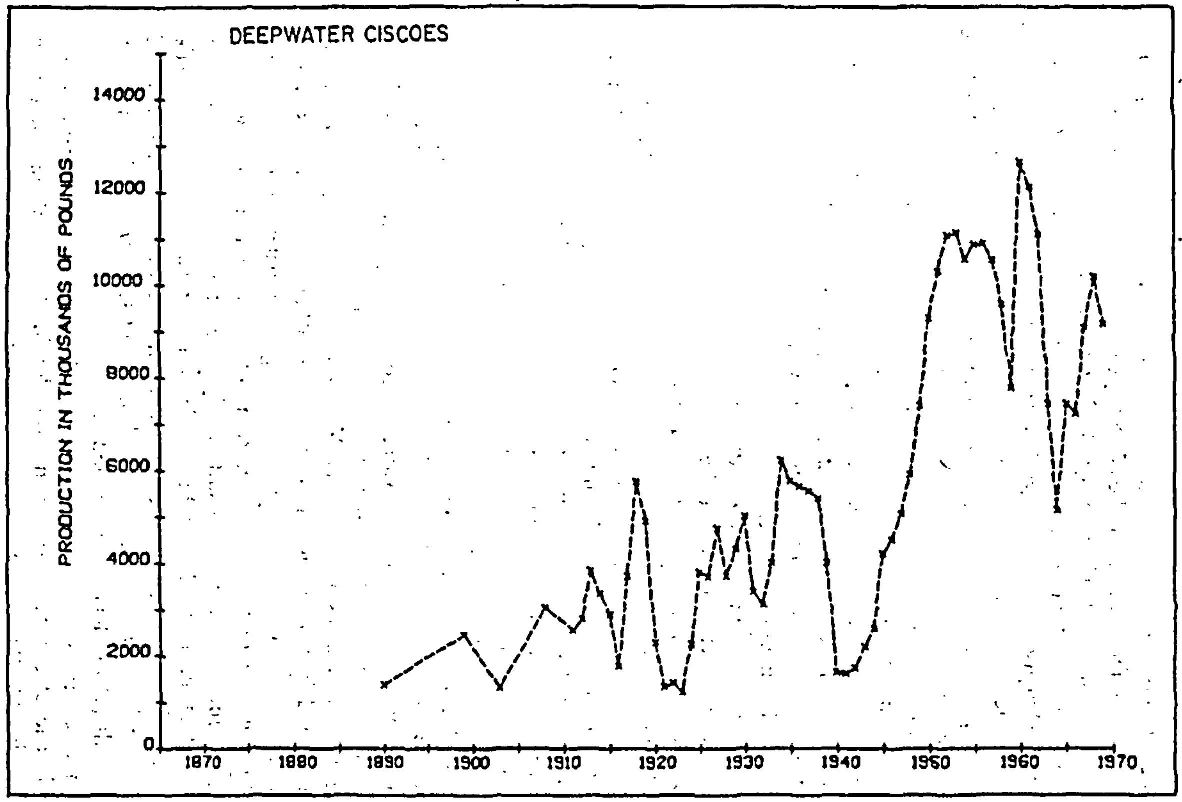

Figure 8. Commercial production of deepwater ciscoes in Lake Michigan, 1890-1970.

Michigan stocks of ciscoes (as well as other species) each year, particularly in the southern portion of the lake. Most of the recent sampling has been with trawls.

Changes in deepwater cisco stocks up to 1960-61, based mostly on the three surveys described above, were documented in considerable detail by Smith (1964). A brief summary of these changes is presented here. The largest species, the blackfin and *C johannae*, which supported the earliest fisheries (on the basis of inferences from the sketchy early records), made up only a small portion of the population in 1930-32; both apparently became extinct in the 1950's. Four others-C *zenithicus*, *C alpenae*, *C reighardi*, and C kiyi-declined sharply in abundance between 1930-32 and 1960-61. The numbers of bloaters, the smallest of the ciscoes, increased several-fold between 1930-32 and 1954-55; abundance changes between 1954-55 and 1960-61 are in doubt, since some areas showed increases, others decreases. The percentage of bloaters in experimental catches of deepwater ciscoes increased from 31 in 1930-32 to 76 in 1954-55 and almost 94 in 1960-61. Although the average size of each species decreased between 1930-32 and 1954-55, no further decrease was evident by 1960-61. Rather, the average length of bloaters in experiment trawl catches increased noticeably between 1954 and 1960 in southern Lake Michigan (Brown 1970).

The causes for the described changes (up to the early 1960's) in abundance of deepwater ciscoes in Lake Michigan are several. It seems almost certain that the large blackfin and *C johannae* were simply over-exploited in the early fishery, since they had become scarce before an effect on these deepwater species by any other factors would have been likely. Inferences from Koelz (1926) indicate that the intermediate-sized deepwater ciscoes were depleted to a considerable extent through overfishing by the 1920's. Reasons for changes in deepwater ciscoes in later years are more complex. Data in the following paragraph are from Smith (1968), and apply to changes from the early 1940's to the early 1960's.

Low production in the early 1940's was a result of reduced effort rather than low abundance. As the lake trout declined in the late 1940's and early 1950's, fishermen shifted to deepwater ciscoes and production increased greatly. During the same period predation on the deepwater ciscoes by sea lampreys became increasingly severe, as the lamprey's favored deepwater prey, the lake trout and burbot, disappeared. Both the fishermen and the lampreys selected the larger cisco species, thereby favoring the bloater. The bloater also benefited from the termination of predation by the lake trout, for which it had been a primary food. The result of these events was the previously described situation in the early 1960's: the largest deepwater ciscoes (blackfin and *C johannae)* apparently had been exterminated; the intermediate-sized species (C. *zenithicus*, *C alpenae*, *C reighardi*, and C *kiyi)* were uncommon; and the smallest (blaoter) was very abundant.

Rapid changes in deepwater cisco populations have continued since 1960-6 1. The bloater has become even more dominant; it made up more than 99% of the deepwater ciscoes taken in experimental trawls in 1964 (Wells 1966). By 1969 only a rare *C. reighardi* or C. *kiyi* was caught in experimental nets; even these few "non-bloaters" were not as distinct morphologically as formerly, their appearance suggesting hybridization with the bloater (see

Smith 1964 for a discussion of possible cisco hybridization in Lake Michigan). *C. alpenae* and *C zenithicus* apparently were extinct, or virtually so, in 1969, at least in the southern portion of Lake Michigan. Since the bloater dominated the deepwater cisco stocks so completely after 1960-61, further remarks here refer to that species only.

The abundance of bloaters decreased in Lake Michigan after 1960-61. Average catches per lo-minute trawl tow in identical series in southeastern Lake Michigan in late October or early November 1963-70 were 37, 33, 30, 16, 18, 25, 12, and 15 in the successive years. As abundance declined, size increased. Brown (1970), in fact, showed that, on the basis of experimental trawl catches, the average length of bloaters increased gradually throughout the period 1954-69, from 174 mm to 249 mm. Much of the increase to the early 1960's was due to faster growth, but in recent years the increase has been due mostly to a greater proportion of older fish in the population; the average age increased from 3.5 years in 1964 to 6.0 years in 1969 (Brown 1970). Poor recruitment and a lowered mortality rate among older fish appear to be responsible.

The decrease in numbers of bloaters in recent years probably has been at least to a large degree offset, in terms of biomass, by the significant increase in average weight of the fish (in Lake Michigan, bloaters nearly double in weight in growing from 213 to 249 mm, the average lengths in 1964 and 1968). This increase in weight, plus the greater vulnerability of large bloaters to commercial gill nets, was largely the reason for the increase in commercial production that began in 1965 (commercial trawling for ciscoes was unimportant by this time), in spite of a reduction in numbers of fish in the stocks. Also partly responsible for the gain was the increase in fishing intensity that followed a reduction in 1963-64. (The reduction had resulted from a marked decrease in demand after several persons who had eaten smoked ciscoes from Lake Michigan died of botulism poisoning.)

The increased growth rate of the bloater in Lake Michigan may have been a response to decreased intraspecific competition as numbers declined. The environmental factor or factors leading to poor recruitment, which was the main cause of this decline, are not clear. The alewife, however, is an obvious suspect. During its explosive increase in Lake Michigan from the 1950's to early 1967, it must have become increasingly competitive with the bloater. In the previously described alteration of zooplankton population by alewives between 1954 and 1966, large zooplankton species and zooplankton biomass were much reduced. Since young bloaters up to a length of several inches feed almost exclusively on zooplankton (Wells and Beeton 1963), the implications are obvious. Alewives also may be detrimental to bloaters by feeding on their eggs. Lake Michigan bloaters spawn in January-March, mostly at depths of 40-60 fathoms (73-110 m), at a time and place of great alewife concentrations (Wells 1966). Alewives are known to include fish eggs in their diet in Lake Michigan (Morsell and Norden 1968; unpublished data of Great Lakes Fishery Laboratory).

The apparent decrease of mortality among the older bloaters in recent years is probably due to lessened sea lamprey predation. Although sea lamprey control in Lake Michigan began in 1960 it was probably not until about 1966, when all lamprey producing tributary streams had been treated with lamprey larvicide, that the lamprey population had been reduced greatly. Intensive lake trout stocking, which began in 1965, also gave the sea lamprey an alternate, more favored victim, but perhaps not until about 1968, when substantial numbers of lake trout had grown to a size preferred by the lamprey.

The outcome of the recent rapid changes in bloater stocks is a subject of some concern. In addition to increased growth since the mid-1950's, and decline in numbers which began about that time (Brown 1970) or a few years later (Smith 1968) a marked shift in sex ratio also has occurred. The percentage of females in the population rose from 75 in 1954 to 97 in 1961, then changed little through 1967 (Brown 1970). Smith (1968) and Brown (1970) interpreted these changes as a response to environmental stress that probably will culminate in a disastrous decline in the stocks. Both authors based their views on similar changes which preceded sharp declines in other Coregonid populations (e.g., lake herring in Birch Lake, Michigan). Remarks by commercial fishermen have indicated that the average size of ciscoes also became very large just before their drastic reduction in the middle and late 1960's in Lake Huron.

In 1968, 1969, and especially in 1970, young-of-the-year and yearling bloaters appeared in experimental catches in far greater numbers than in any years of experimental fishing since 1955 (1960-71). The success of these young follows the severe reduction in alewife abundance after the spring of 1967 and the subsequent shift in zooplankton populations back toward 1954 levels (Wells 1970). It is of course too early to predict whether this recent success (and an accompanying increase in the proportion of males in the population) represents the beginning of a recovery of bloater stocks in Lake Michigan.

Lake herring

Lake herring production often was the highest of any species in the early fishery of Lake Michigan. In 1890, the first year for which figures were recorded, 6.1 million pounds were landed (Fig. 9). Production increased rapidly after 1890 and was very high in 1893-1908. Actual figures for this period are available for only 1899, 1903, and 1908, when 22.2, 15.4, and 24.2 million pounds, respectively, were recorded, but annual catches of 20.1-25.9 million pounds of lake herring and deepwater ciscoes combined in the other years were almost certainly mostly lake herring. Production dropped shortly thereafter, and has never returned to such high levels. The average annual catch was about 9.0 million pounds in 1911-18 and about 4.5 million pounds in 1919-38. Production dropped further to an average of only 1.6 million pounds in 1941-44, increased rather strikingly to 9.7 million pounds in 1952, and then declined to an average of only about 40,000 pounds per year in 1963-70. Green Bay has contributed about 87% of the lake herring catch of Lake Michigan since 1936 when, according to Smith (1956), reliable records of Green Bay's portion of the catch were first available.

Wide fluctuations in production of lake herring have been characteristic of all the Great Lakes. Although changing market demand for this generally low-value fish has influenced production, the primary reason for the great differences in catch unquestionably has been changes in abundance. The

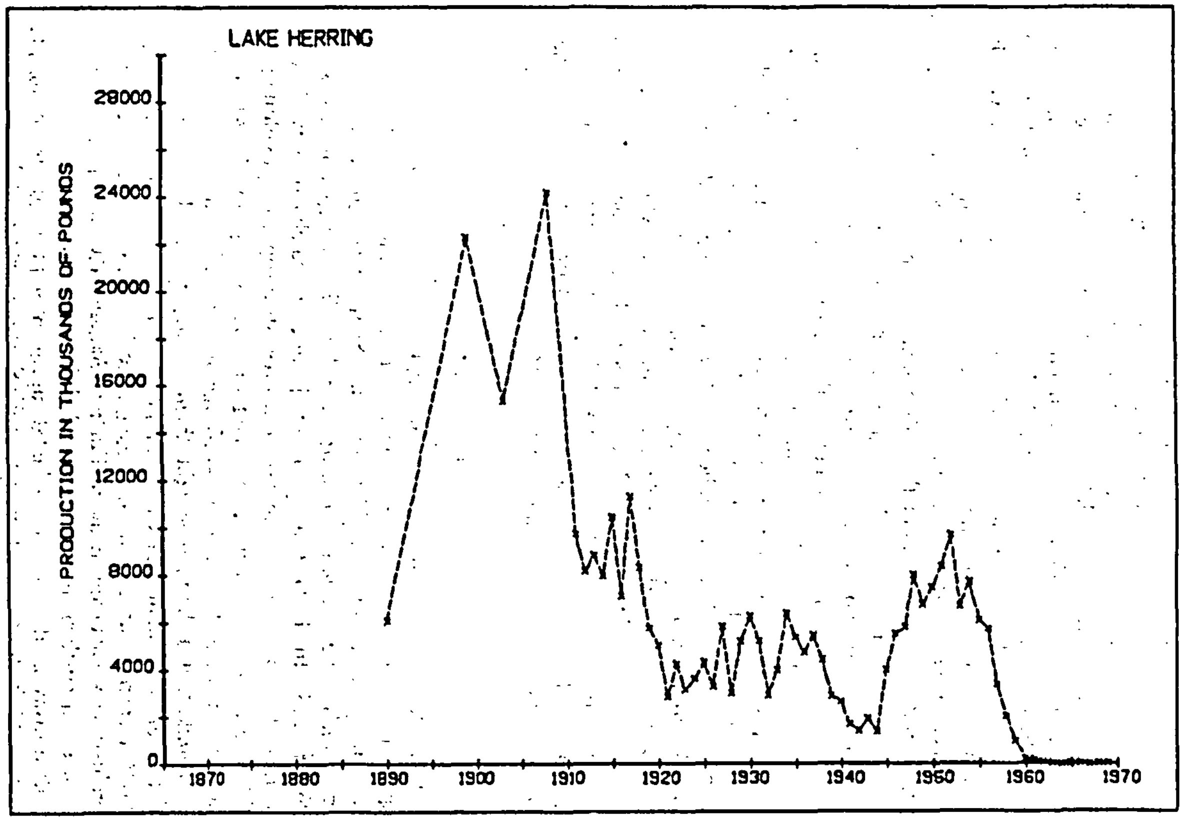

Figure 9. Commercial production of lake herring in Lake Michigan, 1890-1970.

general trend in production has been downward, although exceptionally strong year classes, e.g., the 1944 year class in Lake Erie (Scott 1951), occasionally have caused spectacular increases in the catch. Lake herring are far less abundant now than formerly in all the Great Lakes, The declines have been attributed to various causes: overfishing in Lake Erie (Van Oosten 1930); the influence of smelt and (to a smaller degree) bloaters in Lake Superior (Anderson 1969); and the effects of alewives in Lake Michigan (Smith 1970).

The early marked declines of lake herring in Lake Michigan were largely the result of heavy exploitation, although pollution must have been detrimental in southern Green Bay. The further decline (in the 1920's and 1930's) would seem also to relate to exploitation, but smelt probably were adversely affecting lake herring during the 1930's. The decrease of lake herring abundance which began in 1939 and resulted in an average production of only 1.6 million pounds in 1941-44, and the subsequent striking increase after the catastrophic smelt dieoff of 1942-43, suggest strong influence by the smelt. (Although over 2 million pounds of smelt were produced in Lake Michigan in 1943, nearly all were taken in winter before the dieoff had ended-only 5,000 pounds were caught in 1944.) The greatly reduced numbers of smelt in the spring of 1943 probably allowed a strong year class of lake herring to develop (through decreased competition for planktonic food with lake herring fry, or less predation on them, or both) as indicated by a much improved commercial catch in 1945. Production figures indicate that relatively strong year classes continued until the early 1950's, since the disastrous decline which has carried to the present did not begin until 1957. It seems likely that the resurgence of smelt to considerable abundance by the early 1950's, in combination with the explosive increase of alewives which began in the mid-1950's, has reduced the lake herring to its present insignificance in Lake Michigan.

Lake sturgeon

The lake sturgeon was reduced in abundance more abruptly than any other species in the early commercial fishery of Lake Michigan. Numbers had decreased in many areas before 1879 (Smith and Snell 1891), the year of first production records. The catch dropped from 3.8 million pounds in 1879 to only 96,000 pounds in 1899 (Fig. 10). A decline in catch to only 2,000 pounds in 1928 led to the complete protection of sturgeon from exploitation in Lake Michigan the following year. The closure was probably of little consequence, however. Sturgeon were so scarce for several years before 1929 that it is unlikely that fishermen sought them; nearly all catches must have been incidental. The incidental catch surely continued after the closure, and it is doubtful that many sturgeon thus caught were returned to the lake alive. Sturgeon fishing was legalized again in State of Michigan waters in 1951, but the annual catch since then has never exceeded 5,000 pounds.

The disastrous decline of the lake sturgeon was primarily a result of overfishing, although stream degradation probably was detrimental to spawning areas in rivers and near river mouths. Before about 1875 the commercial fishermen attempted purposely to exterminate the lake sturgeon because it damaged nets and otherwise interfered with fishing for other species, and because it had no commercial value. It was commonly removed from the nets

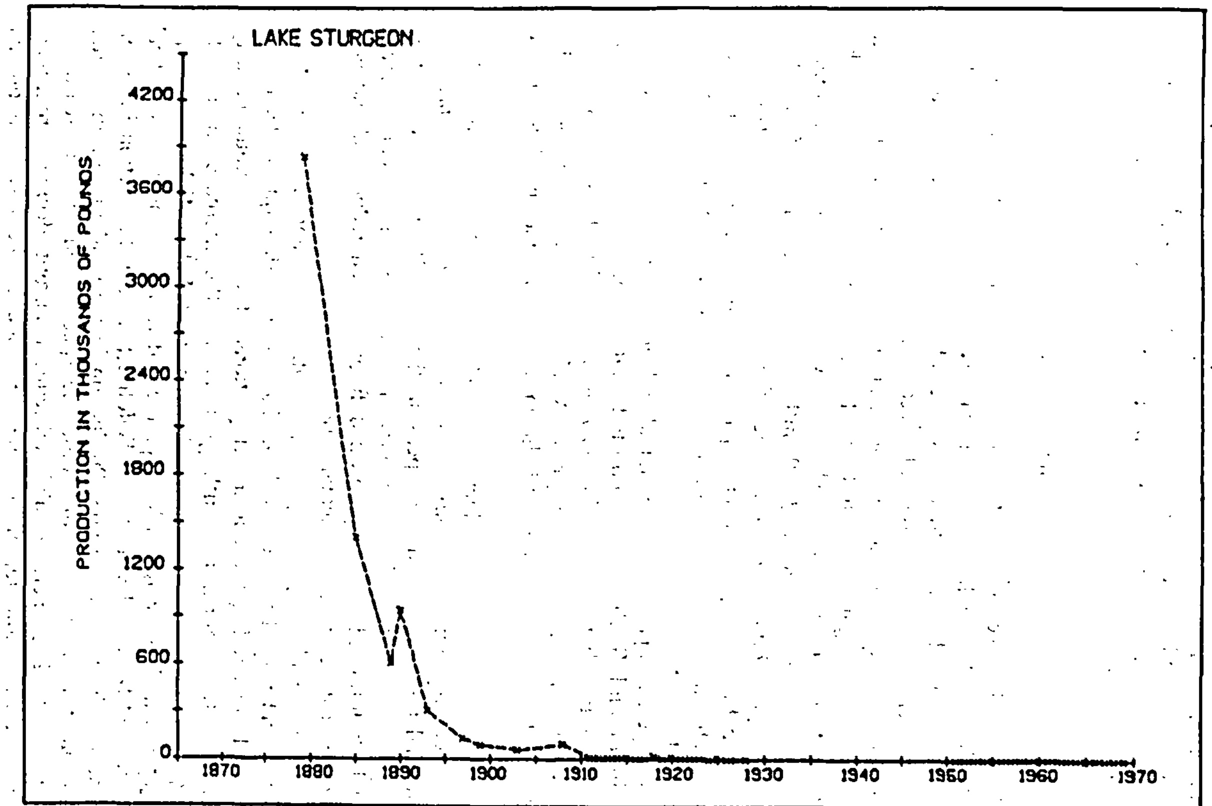

Figure 10. Commercial production of lake sturgeon in Lake Michigan, 1879-1970 (protected from commercial fishing 1929-1950).

in huge numbers and thrown into offal heaps on shore (Milner 1874), or fatally wounded and returned to the lake (Koelz 1926). Later, however, the lake sturgeon became valuable for its flesh, eggs (caviar), oil, and air bladder (for the manufacture of isinglass). The sturgeon's prolonged period of immaturity (about 22 years for females-Van Oosten 1956) reduced its chances of escaping nets long enough to reach spawning age and probably precluded any possibility that it could have maintained high populations in the face of the heavy fishing to which it was subjected, even if stream degradation had not occurred.

Yellow perch

Yellow perch have supported important sport and commercial fisheries in Lake Michigan. Although sport catch statistics are not available, the take must have been considerable until the last decade because breakwalls around the lake often were lined with dozens of successful anglers.

Commercial production has averaged 2.4 million pounds annually from 1889 (when records began) through 1970. Three notable deviations from this average have occurred: in 1894-96, when the average was 6.3 million pounds; in 1961-64, when the take averaged 4.9 million pounds; and in 196570, when production dropped abruptly to an average of only 890,000 pounds (Fig. 11). Southern Green Bay usually has been a particularly heavy producer of yellow perch, although all shallow areas of the lake have yielded this species in commercial quantities.

Yellow perch apparently were not abundant in the earliest days of the fishery. Smith and Snell (1891) reported that perch were uncommon in southern Green Bay before 1882, but increased spectacularly soon thereafter when whitefish and walleyes became rare. At about the same time perch also increased in extreme southern Lake Michigan, after a decline in whitefish and sturgeon.

The high yellow perch production of 1894-96 was probably related to high abundance and increased fishing effort as the species came into favor in the commercial trade. The production peak in the early 1960's was caused by increased fishing intensity and perhaps greater abundance; the sudden decrease in catch which followed obviously resulted from a much reduced abundance, as indicated by catches in experimental trawls.

The recent trends in yellow perch populations undoubtedly were related to alewife abundance. The increased production and subsequent decline of perch in the 1960's did not occur in all portions of the lake simultaneously but progressed from north to south, just as did the increase in alewife abundance. Peak production in the northern part of Lake Michigan (except Green Bay) was in 1960 (unpublished commercial fishery records by statistical districts compiled by the U.S. Fish and Wildlife Service). Production in Green Bay held at a high level in 1960-63. Production in the southern portion of the lake was highest in 1963-64; by that time the species had become scarce in the northern part. The increase and subsequent abrupt decline progressed southward somewhat more rapidly on the west side of the lake than on the east side. Abundance in Green Bay and the extreme southeastern portion of the lake never reached levels as low as those in other parts.

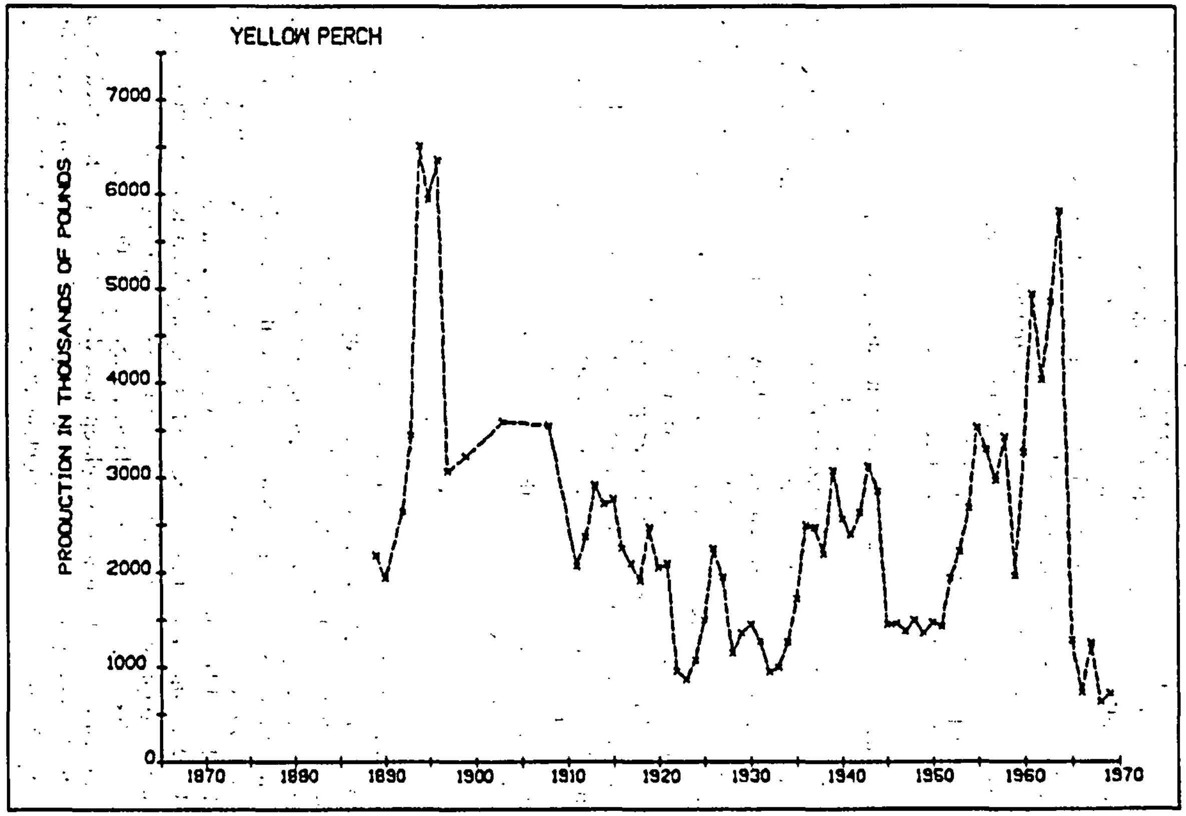

Figure 11. Commercial production of yellow perch in Lake Michigan, 1889-1970.

The alewife's primary damage to yellow perch seems to be in inhibiting reproduction. Lack of recruitment in the early and middle 1960's (a period when young perch were seldom taken in experimental catches of the R/V Cisco) led to the drastic decline (which no doubt was hastened by heavy exploitation). Evidence that the alewife may have been responsible for the poor hatches is provided by the exceptionally strong year class that developed in southeastern Lake Michigan in 1969, after the decline of alewives in 1967 and 1968. Perch in Lake Michigan spawn in shallow areas in spring when alewives also are concentrated inshore. No perch eggs have been found, however, in stomachs of alewives taken on several occasions from among spawning perch in southeastern Lake Michigan (unpublished records of Great Lakes Fishery Laboratory). Perhaps the gelatinous matrix in which perch eggs are embedded provides protection against predation by alewives. If so, it then seems likely that alewives adversely affect reproduction of perch by competing with, or feeding on, the fry.

The reason for the increased production (and catches per unit of effort) immediately before the drastic decline of the 1960's is not certain. Unfortunately the perch in the commercial catch were not examined, and systematic experimental fishing for perch was not conducted before peak production. Commercial fishermen indicate, however, that perch in the catches during peak production in southern Lake Michigan were larger than formerly, suggesting that the poorer reproduction of perch may have resulted in faster growth of those which survived-as occurred among deepwater ciscoes in the early 1960's (Brown 1970). The higher perch production per unit of effort may therefore have been a result of the capture of larger fish, rather than greater numbers. On the other hand, perhaps there was an increase in numbers of market-sized fish before alewives became extremely abundant, as asserted by Smith (1970) who attributed the increase to a greater supply of food provided by young alewives.

Walleye

The walleye has not generally been of great importance in Lake Michigan, having usually been taken incidentally with other species in the commercial catch. In one period (late 1940's to mid-1950's), however, it was vigorously sought by commercial fishermen and at the same time attracted great numbers of sport fishermen. Commercial production was 7 12,000 pounds in 1893, the only year before 1899 in which walleyes were recorded separately (Fig. 12). The average catch of 623,000 pounds in other years before 1899 included northern pike and saugers (Stizostedion canadense) although most probably were walleyes. From 1899 to 1946 production ranged between 31,000 and 345,000 pounds (average 128,000 pounds). A pronounced increase after 1946 to 1.3 million pounds in 1950 was followed by a decrease to 301,000 pounds in 1952 and another peak of 976,000 pounds in 1955. A steady decline after 1955 brought production to only 12,000 pounds in 1970.

The Lake Michigan walleye fishery is centered in Green Bay, which produced an average of 96% of the total annual catch in 1947-70. Production usually has been concentrated in the northern portion of the bay since 1930,

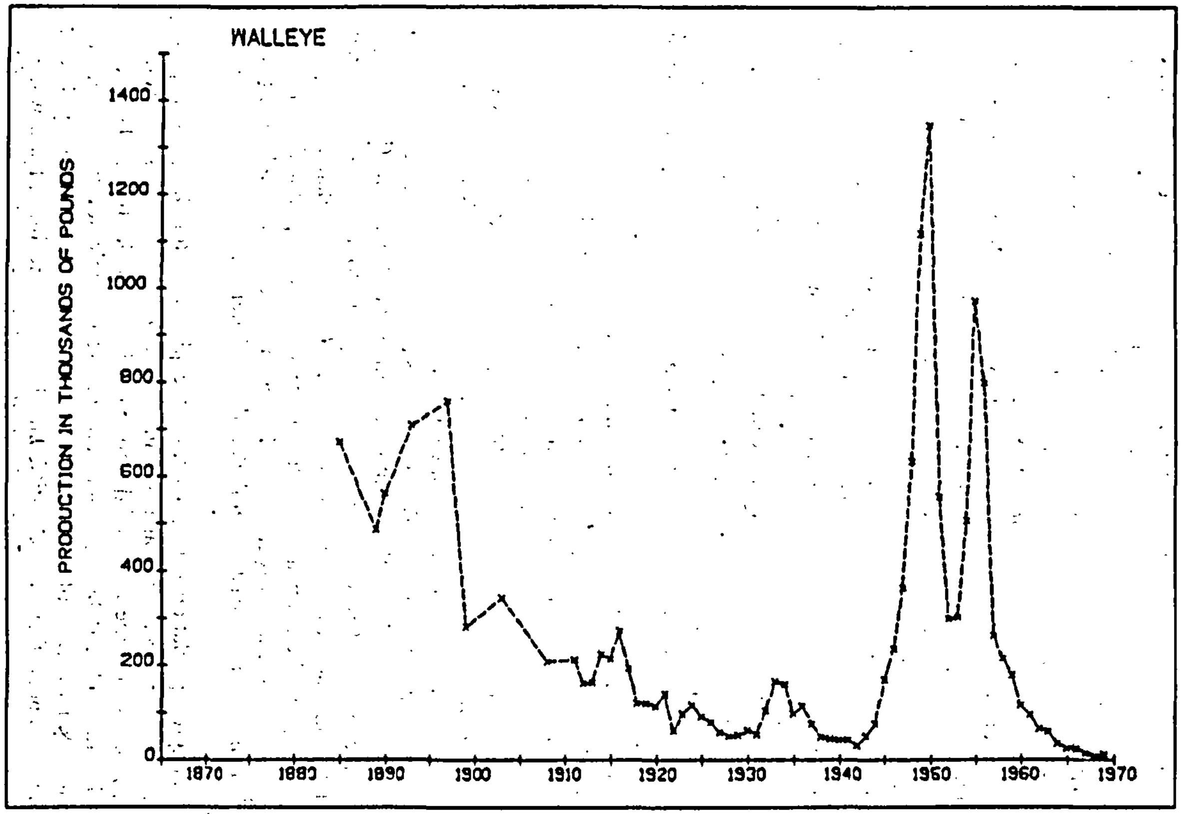

Figure 12. Commercial production of walleye in Lake Michigan, 1893-1970.

but was often greatest in the southern part before that time. Walleyes caught in the main body of Lake Michigan have come mainly from the east shore between Frankfort, Michigan, and the Michigan-Indiana border.

Although trends in abundance have not always been indicated by records of walleye production (Hile, Lunger, and Buettner 1953; Pycha 1961), certain broad changes are clearly apparent: Abundance declined substantially in southern Green Bay early in the fishery and has been generally low there since 1930; it reached peaks in northern Green Bay in 1949-50 and again in 1955-56 (Pycha 1961); and it has declined so greatly since 1956 that the species is not now common in any part of the lake.

Reasons for the early decline in walleye abundance in southern Green Bay are not clear. The severe decrease of walleyes which occurred there (coincidentally with a decrease in whitefish) before 1882 (Smith and Snell, 1891) probably was the combined result of heavy fishing and deteriorating environment; the generally low abundance since 1930 might logically be blamed on the unsuitable habitat in that heavily polluted area. The abundance peak in northern Green Bay in 1949-50 resulted from an extremely strong 1943 year class, which made up 57% of the catch even as late as 1952 (Pycha 1961). The high abundance in 1955-56 was the result of strong year classes in 1950, 1951, and 1952, the strengths of which approached or exceeded that of 1943 (Pycha 1961). These large year classes never carried commercial production as high as did the single 1943 year class, however, because, according to Pycha (1961), an intensive sport fishery cropped a large portion of the fish at a relatively small size.

The decline in walleyes since the mid-1950's seems too persistent to involve simply a chance succession of poor year classes. The eastern Lake Michigan stocks as well as those of Green Bay are now at extremely low levels. The reasons are not at all obvious. Fishing pressure, at least in eastern Lake Michigan, has decreased considerably in the past decade in the shallow areas inhabited by walleyes. Pollution in some streams is possibly inhibiting reproduction, but some of the best spawning streams-e.g., the Whitefish River which flows into northern Green Bay (Crowe, Karvelis, and Joeris 1963) and the Muskegon River which flows into eastern Lake Michigan (Eschmeyer 1950; Eschmeyer and Crowe 1955) - do not appear to be unduly polluted now. Some larger streams along the east shore (e.g., the Kalamazoo River, which enters Lake Michigan at Saugatuck) are now badly polluted, but none of the east shore streams except the Muskegon River have had significant walleye spawning for at least several decades (Walter Crowe, personal communication).

Sea lamprey predation offers a possible explanation for the present poor state of the walleye stocks in Lake Michigan, but the relation is certainly not as conspicuous as in some cases of destruction of fish stocks by sea lampreys. Hile and Buettner (1959) held the sea lamprey responsible for the decline of walleyes in Saginaw Bay of Lake Huron, but as was pointed out by Pycha (1961), the sequence of events was different there: The decline of the walleye was coincident with, or only slight behind, the reduction of the lake trout by lampreys, whereas in Lake Michigan walleyes were still abundant when the lake trout was finally exterminated. Lake trout (and perhaps other species) were, of course, preferred by sea lampreys, and perhaps the lamprey did not turn seriously to walleyes in Lake Michigan until the lake trout had become eliminated-but it is not clear why the same lag in predation effects would not have occurred in Lake Huron. It might be pertinent to mention that scarring rates on walleyes in Lake Michigan have always been low (Walter Crowe, personal communication) but probably this species, like the deepwater ciscoes, is almost always killed by a lamprey attack. (Deepwater ciscoes with a fresh lamprey wound and the lamprey which made the wound have occasionally been taken in trawls by the R/V *Cisco*, but no ciscoes bearing healed wounds have been caught.)

Alewives might have had an influence on walleye reproduction, but the relation is not obvious. If the walleye's decline has been a result of a long succession of year-class failures, the earliest failures would have to have occurred before 1955, on the basis of production records. Interference by the alewife at that early date is extremely unlikely. It is not too far-fetched to suppose, however, that the earliest year class failures were due to natural causes (e.g., weather conditions) and that by the late 1950's alewives were abundant enough to prevent any further possibility of a good hatch.

Suckers

Suckers have provided a moderately important commercial fishery in Lake Michigan. White suckers make up most of the catch, but longnose suckers and a few redhorse suckers (Moxostoma spp.) also are taken. Green Bay has been the center of production, but the northern portion of the main body of the lake yielded substantial catches several decades ago.

Commercial production of suckers in Lake Michigan ranged from 1.5 to 4.0 million pounds and averaged 2.1 million pounds in 1889-1949 (only 252,000 pounds were produced in 1885, the first year of record, and the only year recorded before 1889); no long-term trends developed in this period (Fig. 13). After 1949, production decreased, averaging only 766,000 pounds in 1950-60, and 337,000 pounds in 1961-68. An increase thereafter brought production to nearly a million pounds in 1970.

The production of suckers has been so strongly dependent on market demand that the catch figures are generally not useful as indices of abundance. It appears likely, however, that the severe drop in production which began in 1950 was at least partly due to decreased abundance resulting from sea lamprey predation. The sea lamprey has been shown to attack large suckers heavily in Lake Huron (Hall and Elliott 1954; Coble 1967), although it may not do so if more highly favored prey such as lake trout are abundant. The increase of sucker production in 1969-70 is perhaps related to decreased sea lamprey predation resulting from lamprey control and an increase in lake trout.

The abundance of suckers might have declined to some extent over the years, particularly in Green Bay, due to degradation of spawning streams.

Round whitefish

The round whitefish probably has never been abundant in Lake Michigan, except locally. Abundance is greater, however, than production figures

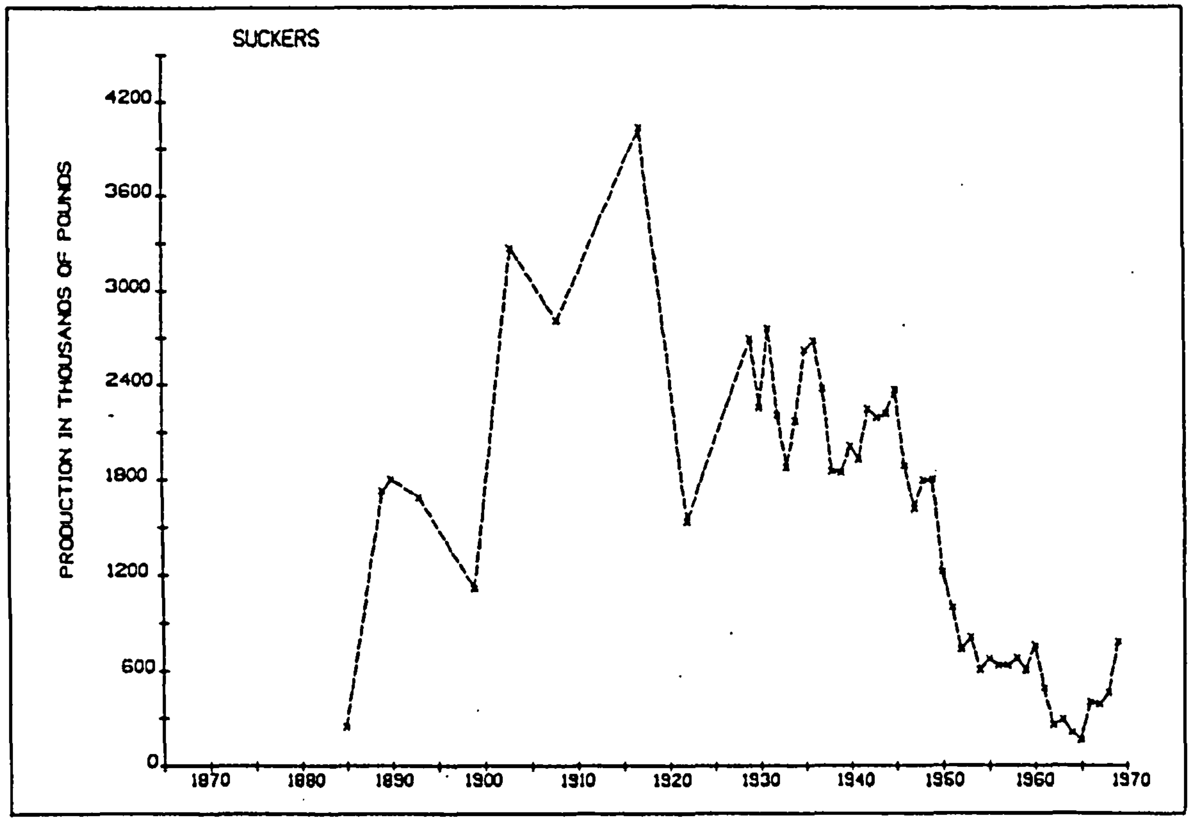

Figure 13. Commercial production of suckers in Lake Michigan, 1885-1970.

indicate because the round whitefish is usually sought only when the price is well above normal, or when fishing for more desirable species is poor. At other times much of the production is from incidental catches in nets fished for other species (e.g., lake whitefish).

Production of round whitefish was highest in the earliest years of record-423,000 pounds in 1893 and 519,000 pounds in 1899 (Fig. 14). The annual catch averaged 174,000 pounds in 1903-35, 57,000 in 1936-42, 126,000 in 1943-52, and only 19,000 in 1953-68. Production then jumped to 144,000 pounds in 1969 and 164,000 in 1970.

Although changes in production of round whitefish in Lake Michigan may not indicate abundance trends accurately (e.g., the substantially increased production in 1969 and 1970 was due mostly to increased effort by a few fishermen in response to improved prices), it is perhaps safe to speculate that the stocks have declined somewhat. Production in the late 1800's was considerably higher than that after 1900, and included (about 1885) catches of round whitefish "weighing 4 to 6 pounds each" (Smith and Snell 1891). Few approach that size today. Most commercial fishermen in the early 1940's thought that the round whitefish formerly had been more abundant (Gallagher and Van Oosten 1943). In the Muskegon-Grand Haven area of southeastern Lake Michigan, where production was 13,000 pounds in 1929 (the first year for which the catch was recorded by statistical districts), the species has rarely been seen since the late 1940's. The reasons for the apparent decrease are obscure.

Burbot

The burbot has never been of great commercial importance in Lake Michigan, owing to its low market demand. Even in the very early fishery burbot were discarded, except for a few sent to local markets (Milner 1874). Commercial production averaged 128,000 pounds annually for the 5 years of record in 1893-1917. The catch averaged 54,000 pounds in 1922-48 (no records for 1918-21) but dropped to only 13,000 in 1949-66. Production climbed to 61,000 pounds in 1967-70.

Since burbot have always been caught incidentally to other species and have been sold only as the small market demanded, production figures do not provide indices of abundance. From other sources (discussions with commercial fishermen and catches of the R/V *Fulmar* in 1930-32) it is evident that the burbot was once considerably more abundant than catch figures indicate. The three seasons of fishing with small-mesh nets by the *Fulmar*, for example, yielded about 6,000 burbot-or nearly one-half the total number of small lake trout caught (Van Oosten and Eschmeyer 1956). The burbot began declining at about the same time as the lake trout, however, and was reduced to rarity by the early 1960's; an increase, especially in Green Bay, reportedly began in the late 1960's.

The chronology of the changes in abundance of burbot in Lake Michigan in the past few decades strongly suggests that the sea lamprey was responsible for the decline, and that sea lamprey control led to the recent upswing in numbers.

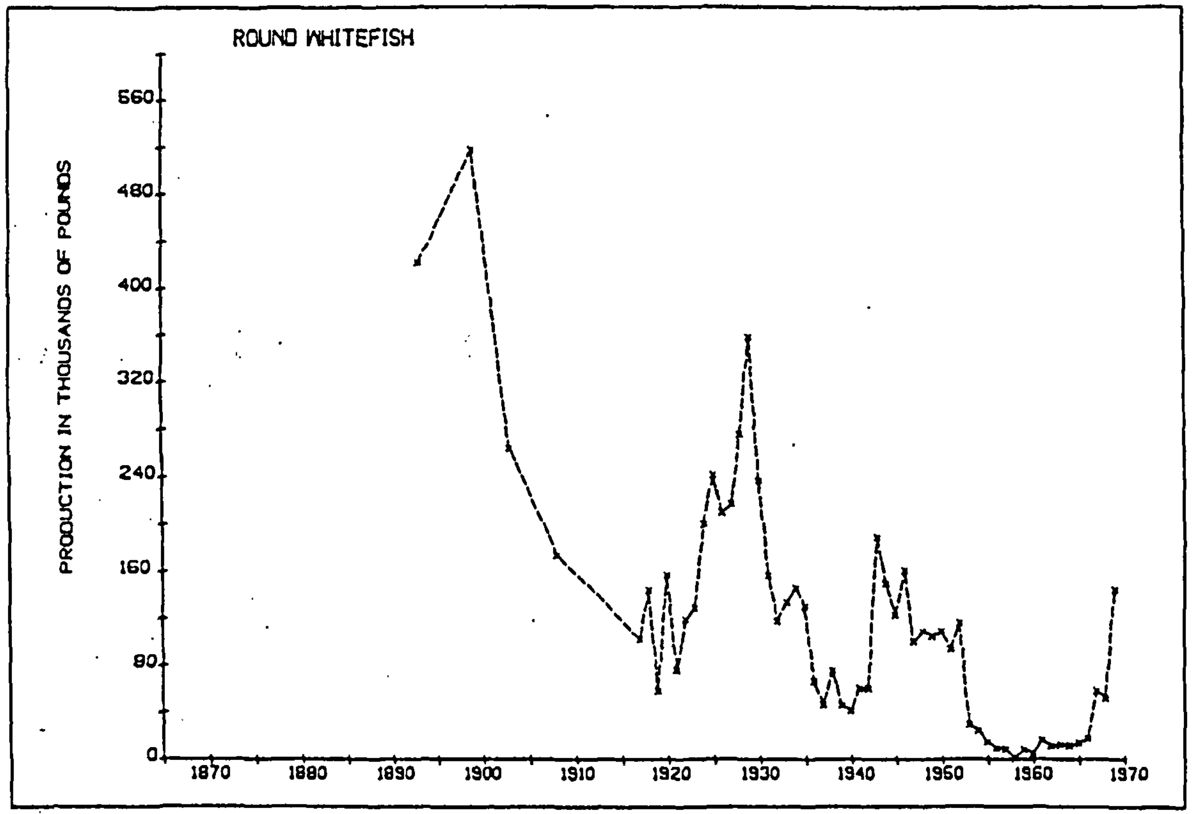

Figure 14. Commercial production of round whitefish in Lake Michigan, 1893-1970.

Emerald shiner

The emerald shiner has undergone perhaps the most extraordinary change in abundance of any species in Lake Michigan. Until about 1960, it was so abundant that it was regarded as a nuisance when it congregated in harbors in spring and fall. It occasionally clogged cooling water intake screens of power plants (Flittner 1964) and vessel engines (e.g., that of the *Cisco)*. Statements by residents around Lake Michigan indicate that the emerald shiner once provided a substantial commercial fishery for the fish-bait market; no production records were kept, however.

The emerald shiner disappeared from Lake Michigan in the early 1960's, even though it had been abundant enough to cause a problem at a power plant in Milwaukee at least as late as November 1956 (Flittner 1964) and was still highly conspicuous in the harbor at Grand Haven, Michigan, in 1960 (personal observation of senior author). The last specimens taken by the R/V *Cisco* were off Saugatuck in 1962. A few were caught in the Kalamazoo River about 2 miles from its mouth in 1963 (Edsall 1964) suggesting that small resident populations (possibly geographical races) may remain in some tributary streams.

The extremely rapid disappearance of the emerald shiner concident with the population increase of the alewife leaves little doubt, as indicated by Smith (1970) that the two occurrences were related. The emerald shiner population certainly could not have been greatly affected by the existing levels of exploitation, and the almost simultaneous deterioration of its habitat over the entire lake is highly unlikely.

Information on the life history of emerald shiners in Lake Michigan is lacking, but inferences from studies in Lake Erie (Flittner 1964) indicate that the species fed mostly on zooplankton, so that it could have been destroyed due to an inability to compete for food with the alewife. The young emerald shiners, particularly, may have suffered in this respect. On the basis of studies in Lake Erie, emerald shiner eggs hatch in late spring and early summer (Flittner 1964) and the young remain inshore until midsummer (Gordon 1968) by which time they would have been sharing this habitat with huge numbers of young alewives and many adults.

Deepwater sculpin

The deepwater sculpin declined markedly in abundance in Lake Michigan after 1960, on the basis of experimental sampling in the southeastern portion. (This species has not been used commercially except for small quantities taken in trawls in the early 1960's for the animal-food market.) Identical trawls fished off Grand Haven, Michigan, at the same depths on nearly the same dates took an average of more than four times as many deepwater sculpins in 1960 as in 1970. In standardized trawl series off Saugatuck, Michigan, in mid-April of each year 1964-71, the total numbers of deepwater sculpins caught in the successive years were 835, 409, 251, 179, 157, 76, 104, and 105. The somewhat larger numbers in 1970 and 1971 were due mostly to an influx of small individuals. No individual measurements were made, but the average weight (in grams) of deepwater sculpins in the catches climbed from 21 in 1960 to 24-25 in 1964-68, then dropped to 19 in 1969 and (off both Grand Haven and Saugatuck) 11 in 1970, and increased slightly to 12 in 1971. The increase in average size from 1960 to 1964-68 was due to a decreasing level of reproduction; few very small individuals were in the catches of 1964-68. The appreciably smaller average size in 1970-71 reflected a noticeable improvement in reproduction.

The decline in abundance of deepwater sculpins in the mid-1960's (and probably in the early 1960's) was a result of the above-described deficiency in recruitment. The alewife probably was responsible for the poor reproduction, because the decline in reproduction and subsequent improvement occurred during the buildup and decrease, respectively, of the alewife populations. Alewives in Lake Michigan are concentrated in deep water in winter when the deepwater sculpin spawns (as indicated by gonad condition at various times of the year-unpublished data, Great Lakes Fishery Laboratory). As mentioned previously, alewives are known to feed on fish eggs in Lake Michigan and might well include the eggs of deepwater sculpins in their diet. Alewives might also compete with larval sculpins for plankton food or prey upon them; although adult alewives are in shallow water when eggs of deepwater sculpins hatch in spring (unpublished data, Great Lakes Fishery Laboratory) many immature alewives probably remain in the deeper areas at that time. But even aside from this possibility, alewives had so decimated the populations of large species of zooplankton in Lake Michigan by the mid-1960's (Wells 1970) that the actual presence of alewives among deepwater sculpin fry may not have been necessary to exert an adverse effect on them.

The future of deepwater sculpins in Lake Michigan is uncertain. The increase in reproduction in the late 1960's, which was probably related to the decrease of alewives, may be reversed if the alewife's recent (1969-70) recovery continues. Deepwater sculpins are scarce or lacking in Lake Ontario, where they were once abundant (Wells 1969); Smith (1970) implied that the alewife was primarily responsible. Deepwater sculpins continue to be abundant in Lake Huron (unpublished data, Great Lakes Fishery Laboratory), in spite of the large numbers of alewives present (Smith 1970) (unfortunately, however, no data are available on their abundance before the invasion of the alewife). Perhaps this abundance is due to the more oligotrophic nature of Lake Huron (as compared with Lakes Ontario and Michigan), which may favor the deepwater sculpin and permit it to withstand better the influences of the alewife.

Spoonhead sculpin

The Spoonhead sculpin, which once was common lakewide in Lake Michigan (Deason 1939) has decreased progressively in numbers and is now rare or absent in the southern portion. Several specimens were observed in trawl catches made by the Great Lakes Fishery Laboratory in that area in 1954, but none in extensive trawling in 1960 and 1964-71. Although an occasional specimen might have been overlooked among slimy sculpins, it is doubtful that many would have gone undetected. The present status of the Spoonhead sculpin in northern Lake Michigan is not known; one was caught by trawl from the *Cisco* off Ludington in 1971. Wright (1968) observed several in 1966 in stomachs of Lake Michigan lake trout which were presumably taken from the northern part. No causes are suggested for the apparent disappearance of the Spoonhead sculpin in southern Lake Michigan.

Ninespine stickleback

Ninespine sticklebacks have increased in abundance in southern and east central Lake Michigan in the past few years, but data are lacking for the northern part of the lake, where the species is most common. Catches in standard trawl series off Saugatuck, Michigan, in mid-April 1964-71 were 0, 0, 1, 0, 0, 1, 13, and 60 in the successive years; in standard trawl series off Ludington in late October-early November 1967-70 the figures were 0, 41, 102, and 634. The increase might be related to the decrease in abundance of alewives but unfortunately no data for pre-alewife abundance of ninespine sticklebacks are available. Future surveillance of population changes of both species should establish whether or not such a relation exists.

Other species

Data for the other common fish species of Lake Michigan either are not adequate to evaluate trends in abundance, or do not indicate definite trends. Several of these species confined mostly to Green Bay have been of minor commercial importance. Production of northern pike averaged 46,000 pounds in 1899-1970 (highest 255,000 pounds in 1908). Catches of freshwater drum averaged 29,000 pounds in 1899-1962 (highest 139,000 pounds in 1944); the catch since 1962 has been negligible, due to poor market demand. Production of catfish (including channel catfish and bullheads) averaged 89,000 pounds in 1889-1970 (highest 387,000 pounds in 1945).

Several other species have not been taken commercially, but limited data on their abundance have come from experimental catches or other sources. Slimy sculpins were almost four times as abundant in 1970 as in 1960 in similar trawl tows (same depths, dates, gear) off Grand Haven. Identical trawl series off Saugatuck in mid-April of each year 196471 also showed a large population in 1970, but did not indicate a steady increase; total catches in the series during the successive years were 724, 490, 410, 825, 1,138, 582, 2,788, and 1,540. These changes may simply reflect normal fluctuations in abundance. Trout-perch and spottail shiners, on the basis of the mid-April sampling off Saugatuck, have shown no steady trends in abundance.

CONCLUSIONS

The far-reaching effects of man's activities on Lake Michigan's ecosystem have included changes in water chemistry, benthos, plankton, and native fish populations. Although the changes in water chemistry and lower biota have been generally modest (except locally), those in fish stocks have been vast. The changes in native fish stocks (mostly decreases in abundance) are primarily attributable to exploitation, the introduction of exotic fish species, and accelerated eutrophication and other forms of pollution.

Exploitation was easily the major factor causing changes in Lake Michigan's fish stocks until the smelt became abundant in the 1930's, and probably until the sea lamprey became well established in the 1940's and the alewife in the 1950's. The commercial fishery continued to influence native fish populations after the invasion of the exotics into Lake Michigan, but since their entry the impact of at least the sea lamprey and alewife has been much stronger than that of the fishery. Accelerated eutrophication and other pollution, although certainly important, have been less decisive than the other factors in bringing about changes in the native fish stocks of Lake Michigan.

LITERATURE CITED

ACRES, H. G., Ltd.

1970. Thermal inputs to the Great Lakes 19682000 Inland Water Branch, Dep. Energy, Mines, and Reservoirs. Canada Centre for Inland Waters. Niagara Falls, Ontario. 93 p.

ANDERSON, E. D.

1969. Factors affecting abundance of lake herring, Coregonus *artedii* LeSueur. Ph.D. thesis, Univ. Minn. 316 p.

ANONYMOUS

1969. Lake Huron Unit. In Res. Rev. 69, Res. Br. Ontario Dep. Lands and Forests, p. 18-35.

APPLEGATE, V. C.

1950. Natural history of the sea lamprey *(Petromyzon marinus)* in Michigan. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. No. 55: 237 p.

AYERS, J. C., E. F. STOERMER, and P. McWILLIAM

1967. Recently noticed changes in the biology-chemistry of Lake Michigan, p. 95-111. In J. C. Ayers and D. C. Chandler [ed.], Studies on the Environment and Eutrophication of Lake Michgian. Univ. Mich. Great Lakes Res. Div. Spec. Rep. 30.

BALDWIN, N. S., and R. W. SAALFELD

1962 (plus supplement 1970). Commercial fish production in the Great Lakes 1867-1960 [Supplement 1961-68]. Great Lakes Fish. Comm. Tech. Rep. No. 3: 166 p.

BEETON, A. M.

1965. Eutrophication of the St. Lawrence Great Lakes. Limnol. Oceanogr. 10: 240-254.

1966. Indices of Great Lakes eutrophication. Univ. Mich. Great Lakes Res. Div. Publ. 15: 1-7.

1969. Changes in the environment and biota of the Great Lakes, p. 150-187. *In* Eutrophication: causes, consequences, correctives. Nat. Acad. Sci. Publ. 1700.

BEETON, A. M., and D. C. CHANDLER.

1963. The St. Lawrence Great Lakes, p. 535-588. In D. G. Frey [ed.] Limnology in North America, Univ. Wis. Press, Madison.

BROOKS, J. L.

1968. The effects of prey size selection by lake planktivores. Syst. Zool. 17: 273-291.

1969. Eutrophication and changes in the composition of the zooplankton, p. 236-255. In Eutrophication: causes, consequences, correctives. Nat. Acad. Sci. Publ. 1700.

BROWN, E. H.

1968. Population characteristics and physical condition of alewives, *Alosa pseudoharengus*, in a massive dieoff in Lake Michigan, 1967. Great Lakes Fish. Comm. Tech. Rep. 13: 20 p.

1970. Extreme female predominance in the bloater *(Coregonus hoyi)* of Lake Michigan in the 1960's, p. 501-514. In C. C. Lindsey and C. S. Woods [ed.] , Biology of Coregonid Fishes, Univ. Manitoba Press, Winnipeg.

BUETTNER, H. J.

1965. Commercial fisheries of the Great Lakes, 1879-1963, p. 444466. *In* Fishery Statistics of the United States 1963, U.S. Fish Wildl. Serv. Statist. Dig. No. *57: 522* p.

COBLE, D. W.

1967. The white sucker population of South Bay, Lake Huron, and effects of the sea lamprey on it. J. Fish. Res. Bd. Canada 24: 2117-2136.

COOK, G. W., and R. E. POWERS

1964. The benthic fauna of Lake Michigan as affected by the St. Joseph River. Univ. Mich. Great Lakes Res. Div. Publ. No. 11: 68-76.

COPELAND, R.

1970. Selenium: the unknown pollutant. Limnos 3(4):7-9.

CROWE, W. R., E. KARVELIS, and L. S. JOERIS

1963. The movement, heterogeneity, and rate of exploitation of walleyes in northern Green Bay, Lake Michigan, as determined by tagging. Rep. Int. Comm. NW Atlantic Fish., Spec. Publ. 4: 38-41.

CUCIN, D., and H. A. REGIER

1966. Dynamics and exploitation of lake whitefish in southern Georgian Bay. J. Fish. Res. Bd. Canada 23: 221-274.

DEASON, H. J.

1939. The distribution of cottid fishes in Lake Michigan. Pap. Mich. Acad. Sci. Arts Lett. 24(2): 105-115.

EDDY, S.

1927. The plankton of Lake Michigan. Ill. Nat. Hist. Surv. Bull. 17: 203-232.

EDGINGTON, D. N., and E. CALLENDER

1970. Minor element geochemistry of Lake Michigan ferromanganese nodules. Argonne Nat. Lab. Radiol. Phys. Div. Annu. Rep. July 1969-December 1970. Part III ANL 7760: 39-44.

EDGINGTON, D. N., M. M. THOMMES, A. F. GASSMAN, and R. M. CUTLER

1970. The concentration of mercury in fish taken from Lakes Erie, Michigan, and Superior. Argonne Nat. Lab. Radiol. Phys. Div. Annu. Rep. July 1969-December 1970. Part III ANL 7760: 30-38.

EDSALL, T. A.

1964. Feeding by three species of fishes on the eggs of spawning alewives. Copeia 1964: 226-227.

ESCHMEYER, P. H.

1950. The life history of the walleye *Stizostedion vitreum vitreum* (Mitchill) in Michigan. Mich. Dep. Cons. Inst. Fish. Res. Bull. 3: 99 p.

1957. The near extinction of the lake trout in Lake Michigan. Trans. Amer. Fish. Soc. 85: 102-119.

ESCHMEYER, P. H., and W. R. CROWE

1955. The movement and recovery of tagged walleyes in Michigan, 1929-1953. Mich. Dep. Cons. Inst. Fish. Res. Misc. Publ. 8: 32 p.

FLITTNER, G. A.

1964. Morphometry and life history of the emerald shiner, *Notropis atherinoides* Rafinesque. Ph.D. thesis, Univ. Mich., 213 p.

GALLAGHER, H. R., and J. VAN OOSTEN

1943. Supplemental report of the United States members of the International Board of Inquiry for the Great Lakes Fisheries. Int. Bd. Inq. Great Lakes Fish. Rep. Suppl.: 25-213.

GANNON, J. E.

1970. A comparison of zooplankton Crustacea populations in Lake Michigan and Green Bay. (Abstract) 13th Conference on Great Lakes Res. Int. Ass. Great Lakes Res., p. 61.

GORDON, W. G.

1968. The bait minnow industry of the Great Lakes. U.S. Fish Wildl. Serv. Fish. Leafl. 608: 6 p.

GREAT LAKES FISHERY COMMISSION

1970. Annual Report for the year 1969. 58 p.

HALL, A. E., and O. R. ELLIOTT

1954. Relationship of length of fish to incidence of sea lamprey scars on white suckers, *Catostomus commersoni*, in Lake Huron. Copeia 1954: 73-74.

HATCHER, H.

1944. The Great Lakes. Oxford Univ. Press, New York, 384 p.

HERRINGTON, H. B.

1962. A revision of the Sphaeriidae of North America (Mollusca: Pelecypoda). Univ. Mich. Mus. Zool., Misc. Pub. No. 118, 74 p.

HENSON, E. G.

1966. A review of Great Lakes benthos research. Univ. Mich. Great Lakes Res. Div. Publ. 14: 37-54.

HILE, R., and H. J. BUETTNER

1955. Commercial fishery for chubs (ciscoes) in Lake Michigan through 1953. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. No. 163: 49 p.

1959. Fluctuations in the commercial fisheries of Saginaw Bay, 1885-1956. U.S. Fish Wildl. Serv. Res. Rep. 51: 38 p.

HILE, R., P. H. ESCHMEYER, and G. F. LUNGER

1951. Decline of the lake trout fishery in Lake Michigan. U.S. Fish Wildl. Serv. Fish. Bull. 52: 77-95.

HILE, R., G. F. LUNGER, and H. J. BUETTNER

1953. Fluctuations in the fisheries of State of Michigan waters of Green Bay. U.S. Fish Wild. Serv. Fish. Bull. 54: 1-34.

HILTUNEN, J. K.

1967. Some oligochaetes from Lake Michigan. Trans. Amer. Microsc. Soc. 86: 433-454.

HOLLAND, R. E.

1969. Seasonal fluctuations of Lake Michigan diatoms. Limnol. Oceanogr. 14: 423-436.

HOUGH, J. L.

1958. Geology of the Great Lakes. Univ. Ill Press, Urbana, 313 p.

HOWMILLER, R. P., and A. M. BEETON

1970. Some changes in the bottom fauna of Green Bay, Lake Michigan, from 1952 to 1969. Abstr. Pap. 33rd Amm. Meet., Amer. Soc. Limnol. Oceanogr. (unpaged).

JOERIS, L. S., and E. G. KARVELIS

MS 1962. The present status of our knowledge of the biology of the alewife in northwestern Lake Michigan and Green Bay. U.S. Fish Wildl. Serv., Great Lakes Fish. Lab., 9 p.

KLEINERT, S. J., and P. E. DEGURSE

1971. Mercury levels in fish from selected Wisconsin waters (a preliminary report). Wis. Dep. Natur. Resour. Res. Rep. 73, 16 p.

KOELZ, W.

1926. Fishing industry of the Great Lakes. Rep. U.S. Comm Fish. 1925. p. 553-617.

1929. Coregonid fishes of the Great Lakes. Bull. U.S. Bur. Fish. 43(1927), part 2: 297-643.

MILLER, R. R.

1957. Origin and dispersal of the alewife, *Alosa pseudoharengus*, and the gizzard shad, *Dorosoma cepedianum*, in the Great Lakes. Trans. Amer. Fish. Soc. 86: 97-111.

MILNER, J. W.

1874. Report of the fisheries of the Great Lakes; the result of inquiries prosecuted in 1871 and 1872. Rep. U.S. Comm. Fish and Fisheries for 1872 and 1873, p. 1-78.

MOFFETT, J. W.

1957. Recent changes in the deep-water fish populations of Lake Michigan. Trans. Amer. Fish. Soc. 86: 393-408.

MORSELL, J. W., and C. R. NORDEN

1968. Food habits of the alewife, *Alosa pseudoharengus* (Wilson), in Lake Michigan. Proc. 11th Conf. Great Lakes Res. 1968: 96-102.

MRAZ, D.

1964. Age, growth, sex ratio, and maturity of the whitefish in central Green Bay and adjacent waters of Lake Michigan. U.S. Fish Wildl. Serv. Fish. Bull. 63: 619-634.

POWERS, C. F., and J. C. AYERS

1960. Water transport studies in the Straits of Mackinac region of Lake Huron. Limnol. Oceanogr. 5: 81-85.

PYCHA, R. L.

1961. Recent changes in the walleye fishery of northern Green Bay and history of the 1943 year class. Trans. Amer. Fish. Soc. 90: 475-488.

REINERT, R. E.

1970. Pesticide concentrations in Great Lakes fish. Pestic. Monit. J. 3: 233-240.

ROBERTSON, A.

1966. The distribution of calanoid copepods in the Great Lakes. Univ. Mich. Great Lakes Div. Publ. 15: 129-139.

ROBERTSON, A., and W. P. ALLEY

1966. A comparative study of Lake Michigan macrobenthos. Limnol. Oceanogr. 11: 576-583.

ROELOFS, E. W.

1958. Age and growth of whitefish, *Coregonus clupeaformis* (Mitchill), in Big Bay de Noc and northern Lake Michigan. Trans. Amer. Fish. Soc. 87: 190-199.

SCHELSKE, C. L., and E. F. STOERMER

1970. Depletion of silicon and accelerated eutrophication in Lake Michigan. Abstr. Pap. 33rd Annu. Meet. Amer. Soc. Limnol. Oceanogr. (unpaged).

SCOTT, W. B.

1951. Fluctuations in abundance of the Lake Erie cisco (*Leucichthys artedi*) population. Contrib. Roy. Ontario Mus. Zool. No. 32: 41 p.

SHETTER, D. S.

1949. A brief history of the sea lamprey problem in Michigan waters. Trans. Amer. Fish. Soc. 76: 160-176.

SMILEY, C. W.

1882. Changes in the fisheries of the Great Lakes during the decade 1870-1880. Trans. Amer. Fish-Cult. Ass. [Trans. Amer. Fish. Soc.] 11: 28-37.

SMITH, H. M., and M. SNELL

1891. Review of the fisheries of the Great Lakes in 1885, with introduction and description of fishing vessels and boats by J. W. Collins. Rep. U.S. Comm. Fish and Fisheries for 1887; 1-333.

SMITH, O. H., and J. VAN OOSTEN

1940. Tagging experiments with lake trout, whitefish, and other species of fish from Lake Michigan. Trans. Amer. Fish. Soc. 69: 63-84.

SMITH, S. H.

1956. Life history of lake herring of Green Bay, Lake Michigan. U.S. Fish Wildl. Serv., Fish. Bull. 57: 87-138.

1964. Status of the deepwater cisco populations of Lake Michigan. Trans. Amer. Fish. Soc. 93: 155-163.

1968. Species succession and fishery exploitation in the Great Lakes. J. Fish. Res. Bd. Canada 25: 667-693.

1970. Species interactions of the alewife in the Great Lakes. Trans. Amer. Fish. Soc. 99: 754-765.

SPANGLER, G. R.

1970. Factors of mortality in an exploited population of whitefish, *Coregonus clupeaformis*, in northern Lake Huron, p. 515-529. In C. C. Lindsey and C. S. Woods [ed.], Biology of Coregonid Fishes, Univ. Manitoba Press, Winnipeg.

STOERMER, E. F., and J. J. YANG

1969. Plankton diatom assemblages in Lake Michigan. Spec. Rep. 47, Great Lakes Res. Div., Univ. Mich. 268 p.

VAN OOSTEN, J.

1930. The disappearance of the Lake Erie cisco-a preliminary report. Trans. Amer. Fish. Soc. 60: 204-214.

1937. The dispersal of smelt, Osmerus *mordax* (Mitchill), in the Great Lakes Region. Trans. Amer. Fish. Soc. 66: 160-171.

1938. The extent of the depletion of the Great Lakes Fisheries. Great Lakes Fish. Conf., Feb. 25-26, 1938, p. 10-17.

1939. Can the Great Lakes Fisheries be saved? Amer. Wildl. 28: 129-135.

1947. Mortality of smelt, *Osmerus mordax* (Mitchill), in Lakes Huron and Michigan during the fall and winter of 1942-1943. Trans. Amer. Fish. *Soc.* 74: 310-337.

1949. A definition of depletion of fish stocks. Trans. Amer. Fish. *Soc.* 76: 283-289.

1956. The lake sturgeon, p. 9-10. *In* Our Endangered Wildlife, Nat. Wildl. Fed., Washington, D.C.

VAN OOSTEN, J., and P. H. ESCHMEYER

1956. Biology of young lake trout *(Salvelinus namaycush)*, in Lake Michigan. U.S. Fish Wildl Serv., Res. Rep. 42, 88 p.

VAN OOSTEN, J., R. HILE, and F. W. JOBES

1946. The whitefish fishery of Lakes Huron and Michigan with special reference to the deep trap net fishery. U.S. Fish Wildl. Serv. Fish. Bull 50: 297-394.

WELLS, L.

1960. Seasonal abundance and vertical movements of planktonic crustacea in Lake Michigan. U.S. Fish Wildl. Serv. Fish. Bull. 60: 343-369.

1966. Seasonal and depth distribution of larval bloaters *(Coregonus hoyi)* in southeastern Lake Michigan. Trans. Amer. Fish. Soc. 95: 388-396.

1969. Fishery survey of U.S. Waters of Lake Ontario, p. 51-57. *In* Limnological survey of Lake Ontario, 1964. Great Lakes Fish. Comm Tech. Rep. 14.

1970. Effects of alewife predation on zooplankton populations in Lake Michigan. Limnol. Oceanogr. 15: 556-565.

WELLS, L., and A. M. BEETON

1963 Food of the bloater, *Coregonus hoyi*, in Lake Michigan. Trans. Amer. Fish. Soc. 92: 245-255.

WOODS, L. P.

1960. The alewife. Bull. Chicago Nat. Hist. Mus. 31(11): 6-8.

WRIGHT, K. J.

1968. Feeding habits of immature lake trout *(Salvelinus namaycush)* in the Michigan waters of Lake Michigan. M.S. thesis, Mich. State Univ., 42 p.

GREAT LAKES FISHERY COMMISSION

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