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**International Salmon Research Aboard the R/V *Wakatake maru*
in the Central North Pacific Ocean and Bering Sea during the
Summer of 2007**

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International Salmon Research Aboard the R/V *Wakatake maru* in the Central North Pacific Ocean and Bering Sea during the Summer of 2007

Abstract

An annual high-seas salmonid research cruise was conducted in the central North Pacific Ocean and Bering Sea from June 6 to July 18, 2007 onboard the Japanese research vessel, *Wakatake maru*, to investigate salmon stock condition. Research cruise activities included collection of data on oceanography, primary production, zooplankton, salmonids, and other organisms. Average sea surface temperatures in the central North Pacific Ocean in 2007 were 0.5°C cooler than in 2006. The Subarctic Boundary was located between 40°N (St. 2) and 41°N (St. 3), which was similar to the location in previous years. In the central Bering Sea, sea surface temperatures in 2007 were 0.2°C warmer than in 2006. At 29 experimental fishing stations, a total of 14,265 salmonids was caught by longline and gillnet: 1,166 fish in the central North Pacific and 13,099 fish in the central Bering Sea. In the central North Pacific, chum salmon was the most abundant species (43.9% of the salmonid catch), followed by coho (41.3%), pink (9.8%), steelhead (3.1%), sockeye (1.3%), and chinook salmon (0.7%). In the Bering Sea, pink salmon was the most abundant species (75.3% of the salmonid catch), followed by chum (17.3%), sockeye (7.1%), chinook (0.3%), coho (0.02%), and steelhead (0.01%). Twelve snouts from adipose-fin clipped steelhead were collected for later potential retrieval of coded-wire tags. Four adipose-fin clipped steelhead were double-tagged with disk tags and released. A total of 1,053 disk tags were placed on salmonids during the survey, which included 9 sockeye, 142 chum, 19 pink, 30 coho, and 2 chinook salmon, and 4 steelhead released in the central North Pacific and 51 sockeye, 339 chum, 449 pink, and 8 chinook salmon released in the Bering Sea. Other sampling and salmonid research activities conducted by onboard researchers included collection of otoliths (chum salmon), stomach content analysis (all salmonids), lipid levels (chum and pink), genetics (steelhead, chinook), persistent organic pollutants (steelhead), stable isotopes (steelhead), zooplankton sampling, and seabird collection and observation.

Introduction

The main objective of this research cruise is to monitor the stock condition of salmon (*Oncorhynchus* spp.) in the central North Pacific Ocean and Bering Sea. A recent decrease in body size and increase in age of chum salmon (*O. keta*) at maturity has been reported (Kaeriyama 1989; Ishida et al. 1993; Helle and Hoffman 1995; Bigler et al. 1996). A scale pattern analysis showed that Japanese chum salmon suffered growth reduction after the second year of ocean life (Kaeriyama 1998). Urawa (2000) estimated that this reduction occurs in the Bering Sea, where chum salmon density increases in summer. To investigate these issues, a survey has been conducted annually in the central North Pacific Ocean and Bering Sea during summer. Routine observations have included collection of physical oceanographic data, estimates of primary production, and investigations into the relationships among zooplankton, salmonids, and higher trophic levels. This document summarizes the R/V *Wakatake maru* cruise conducted in these waters during June and July

2007.

Methods

Research Vessel and Survey Areas

The *Wakatake maru* (666 gross tons) began the cruise when she departed Kushiro on June 6, 2007 and completed it when she returned to Kushiro on July 18, 2007. There were 29 experimental fishing stations during the cruise (Fig. 1). Nineteen fishing stations were located in the vicinity of 180° longitude from 41°N to 58°30'N latitude. In addition, 10 fishing stations were located in international waters of the central Bering Sea. Oceanographic data were collected at each fishing station and between stations. Additional oceanographic data were collected enroute to and from the fishing area (Table 1).

Physical Oceanography

Seawater temperature and salinity data have been collected in the same manner since 1999 (Kawana et al. 1999, Urawa et al. 2000, Fukuwaka et al. 2001, Tanaka et al. 2002, Fukuwaka et al. 2003, Morita et al. 2004, Fukuwaka et al. 2005, Fukuwaka and Watanabe 2006). An expendable bathythermograph (XBT), which recorded data at 1-m increments from the surface to 780 m, was used at 1°-longitude intervals on the outbound, eastward transit at 40°N, and at 1°-longitude intervals on the return leg from the Bering Sea to Kushiro (n = 58). The conductivity, temperature, and depth sensor (CTD) was used at 5°-longitude intervals along the eastward transit and the return leg and at fishing stations (n = 41). The CTD records data in 1-m intervals from the surface to approximately 1000 m. In addition, an ARGO float, which collects temperature, salinity, and current data autonomously, was cast at four stations along 180° longitude at the request of the Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology.

Primary Production

Surface seawater was collected with a bucket to sample chlorophyll at fishing stations and at 5°-longitude intervals when transiting to and returning from the fishing area (n = 33; Table 1). Water (100 ml) was filtered through a glass fiber filter (Whatman GF/F) using a vacuum pump (100-150 mm Hg). Filters containing chlorophyll-a were soaked with 6 ml of N-dimethylformamide and stored in the freezer.

Zooplankton Collection

Macro-zooplankton were sampled with a remodeled NORPAC net (0.45 m ring diameter, 1.93 m net length, 0.33 mm mesh size) at 17 fishing stations and five transit stations located at intervals of 5° longitude from 150°E to 160°E. The net was towed vertically from 150 m to the surface. A calibrated flow meter was attached to the opening of the net in a slightly off-center position. Samples were fixed in 5% borax-buffered formalin in seawater. Samples collected by NORPAC net were collected at approximately midnight during fishing operations, or whenever the ship arrived on station for those locations enroute to and from the fishing transect (Fig. 1)

Large macro-zooplankton were collected at 17 fishing stations using an Ocean Research Institute (ORI) net (1.60 m diameter, 7.5 m in overall length, 0.67 mm mesh size) and a BONGO net (2 rings, 0.7 m diameter, 4.1 m in overall length, 0.335 mm mesh size). The ORI net was towed along side of the vessel at the surface at a speed of 1.5-2 knots for 10 min around 23:00 hrs. Immediately following the ORI net tow, the BONGO net was towed obliquely at the stern of the vessel from 100 m to the surface at a speed of

approximately 1.5-2 knots. After the ORI and BONGO net towing operations were completed, the the NORPAC net was towed, which completed the nightly zooplankton sampling.

Fishing Operations

A gillnet and longline were used for experimental fishing operations to collect salmonids and other pelagic fish. The gillnet was used at 8 stations in the central North Pacific Ocean and 14 stations in the central Bering Sea, outside of the U.S. EEZ (Fig. 1, Table 1). The gillnet was set at 16:00 in the afternoon (Local Mean Time [LMT], GMT + 12) and retrieved at 04:00 the following morning. The gillnet configuration consisted of a variable-mesh research gillnet (C-gear: 3 tans each of 48, 55, 63, 72, 82, 93, 106, 121, 138, and 157 mm mesh size, one tan is 50 m long) combined with panels of a commercial-mesh gillnet (A-gear: 19 tans of 115 mm mesh size, one tan is 50 m long). The longline was used at 29 fishing stations, where it was set 30 minutes before sunset and hauled 30 minutes after sunset (LMT). The longline comprised 30 hachi (overall length 3.32 km; 1 hachi is 110.68 m long with 49 hooks) and it was baited with salted Japanese anchovy (*Engraulis japonicus*).

Fish Examination

Salmonids were processed soon after removal from the fishing gear. For each mesh size, the catch was sorted and counted by species. Biological data were collected using a two-tiered sampling scheme, namely a routine and an abbreviated scheme. The routine scheme consisted of determining fork length (FL, mm), body weight (BW, g), sex, and gonad weight (GW, g), and collecting scale samples. The routine sampling scheme was used on a maximum of 60 individuals per species per mesh size from the research gillnet and commercial gillnet (total number of meshes = 11) and from a maximum of 60 individuals per species from longline mortalities. One scale (pink salmon *O. gorbuscha*), two scales (sockeye *O. nerka*, chum, coho *O. kisutch*, chinook salmon *O. tshawytscha* and steelhead *O. mykiss*), and a scrape scale sample (chinook salmon and steelhead) were collected. Scales were collected from the INPFC-preferred (International North Pacific Fisheries Commission) area on the body for age determination (Davis et al. 1990). The presence of external injuries on salmon and visceral adhesions in sockeye salmon and other species were recorded (Nagasawa et al. 1997). An abbreviated sampling scheme was used for all other salmonids caught in the research gillnet (number of meshes = 10) over and above the 60 individuals by species sampled by the routine scheme just described. The abbreviated sampling scheme consisted of determining fork length, body weight, and sex. All salmonids were inspected for the presence of clipped fins. If the fish had a clipped adipose fin, the snout was removed, salted, and frozen for later potential recovery of the coded-wire tag (CWT) by researchers at NOAA NMFS, Auke Bay Laboratories (ABL).

All non-salmonid catches were identified and counted by mesh size. Body lengths were measured for non-salmonid fish, squid, and other organisms, and a few were frozen for taxonomic and ecological studies. Neon flying squid (*Ommastrephes bartramii*) were sent to the National Research Institute of Far Seas Fisheries, Yokohama, and birds were sent to the Graduate School of Fisheries Science, Hokkaido University, Hakodate (HU), for further examination.

Other Sampling and Research

Salmonid stomach samples were collected for two different studies. In one study, stomachs were examined for the purposes of examining interannual and interspecific differences in salmon diets. For this study, stomach samples were collected from all species of salmon and steelhead trout. These samples were collected from a maximum of 10 fish per species from longline mortalities and from each of five mesh sizes of the

research-mesh gillnet (48, 63, 82, 106, and 138 mm) and from the commercial-mesh gillnet (115 mm). Stomach samples were weighed to the nearest gram before and after removal of the contents, and the weight of the stomach contents obtained by subtraction. The stomach contents were examined on board using a binocular microscope and separated into several prey categories as described by Ueno et al. (1998). The percent volume in each prey category was estimated by eye. A second study of salmon stomach contents was conducted to examine the relationship between salmon and seabird diets, and the availability of prey in zooplankton samples. This study required stomach samples be collected from a maximum of eight sockeye, chum, and pink salmon caught in five mesh sizes of the research-mesh gillnet (55, 72, 93, 121, and 157 mm). Samples were fixed in 10% borax-buffered formalin in seawater and stored for later examination at HU.

Additional chum salmon scale samples were collected for stock identification using mitochondrial DNA and both sagittal otoliths were collected from chum salmon for identification of thermal marks. These scale and otolith samples were obtained from identical chum salmon sampled using the routine sampling scheme from the research mesh gillnet (maximum of 60 chum per mesh-size). The dried chum salmon scales and otoliths were sent to the National Salmon Resources Center (NASREC), Sapporo, for analysis.

Gutted chum and pink salmon were collected and frozen for determination of lipid levels. Five fish per species per sex were collected at each station from gillnet catches and sent to NASREC for analysis.

The axillary process was collected from steelhead and chinook salmon for genetic analysis, and muscle samples were collected from steelhead for determination of persistent organic pollutant (POP) levels. These samples were obtained from mortalities from all fishing gear. In addition, stable isotope samples obtained from muscle and stomach contents were collected from steelhead, coho, and chinook salmon to establish isotopic levels in these fish at locations where steelhead were caught. These samples were sent to the School of Aquatic and Fishery Sciences, University of Washington, Seattle (UW).

Disk Tags and Data Storage Tags

Live salmonids caught in a healthy condition were put into a recovery tank immediately after removal from the longline. Fish were tagged with two disk tags; one issued by the Fisheries Agency of Japan (FAJ) and one issued by the University of Washington (UW). Both disk tags were placed on one plastic cinch strap and applied to the fish anterior to the dorsal fin. The fork length was measured and two scales were collected before the fish was released to the sea.

Data storage tags (DST; Lotek model LTD 1100-500), which record temperature and depth data, were placed externally on chinook salmon and steelhead immediately anterior to the dorsal fin. Disk tags were also placed on a fish tagged with a DST because the disk tags acted as backing plates for the DST.

Results

Physical Oceanography

The position of oceanographic domains was identified along the 180° transect according to the seawater characteristics described by Dodimead et al. (1963) and Favorite et al. (1976; Figs. 2, 3). Stations 1 and 2 were located in the Transition Zone, an area characterized by relatively saline waters (> 34.0 psu) (Fig. 3). The vertical 34.0 psu isohaline, which characterizes the Subarctic Boundary and separates subtropical and subarctic waters, was located between 40°N (St. 2) and 41°N (St. 3). In 2007, the Subarctic Boundary was located approximately 3° latitude further south than during the 2006 research cruise (Fukuwaka and Watanabe 2006). Over a longer time scale, the

Boundary was located at the same latitude in 2007 that it was observed during cruises in 1997, 1998, 2000, and 2003-2005, and the Boundary was located 1° latitude south of its 2007 position in 1991-1996, 1999, and 2001-2002 (Davis et al. 1996, Nagasawa et al. 1997; Ueno et al. 1998, Kawana et al. 1999, Urawa et al. 2000, Fukuwaka et al. 2001; Tanaka et al. 2002, Fukuwaka et al. 2003, Morita et al. 2004, Fukuwaka et al. 2005). The southern limit of the Transition Domain is the Subarctic Boundary and the northern limit is delineated by cold water (< 4°C) below 100 m depth in the central North Pacific. The Transition Domain was located between 41°N and 47°30'N (between St. 3 and 10; Fig. 2). The Subarctic Current, an eastward-flowing surface current of cool, dilute waters can be identified by cold water (near 3.5°C) at approximately 125 m. This current was located between 47°30'N (St. 10) and 49°30'N (St. 12). Further to the north, the westward-flowing Alaska Current, identified by warm (> 4°C) and dilute (< 33.6 psu) freshwater run-off at depths less than 100 m, was located in the vicinity of 50°30'N (St. 13).

Station 14 was located in Amchitka Pass in the Aleutian Islands, one of several locations where North Pacific waters enter the Bering Sea. Stations north of 52°00'N (St. 15 through St. 31) were located in the central Bering Sea basin. The central Bering Sea is characterized by a cold, saline surface layer (depth to approximately 200 m), which is produced by cooling and mixing during the previous winter. This year, superficial warming of the sea surface during the summer produced a shallow seasonal thermocline at approximately 30 m (Fig. 2).

In 2007, average sea surface temperatures in the North Pacific were 0.5°C cooler than in 2006 (St. 3-13; 2007 mean = 9.1°C, 2006 mean = 9.6°C). In the Bering Sea, sea surface temperatures in 2007 (St. 14-31; mean = 7.0°C) were 0.2°C warmer than in 2006 (St. 14-26; mean = 6.8°C).

Salmonid Catches

A total of 14,265 salmonids was caught by longline and gillnet: 1,166 fish in the central North Pacific Ocean (St. 3-13) and 13,099 fish in the central Bering Sea (St. 14-31; Table 2). In the central North Pacific, chum salmon was the most abundant species (43.9% of the salmonid catch), followed by coho (41.3%), pink (9.8%), steelhead (3.1%), sockeye (1.3%), and chinook salmon (0.7%). In the Bering Sea, pink salmon was the most abundant species (75.3% of the salmonid catch), followed by chum (17.3%), sockeye (7.1%), chinook (0.3%), coho (0.02%), and steelhead (0.01%).

Non-Salmonid Catches

Pacific pomfret (*Brama japonica*: n = 562) was particularly abundant in the catch (Table 2). In addition, 96 boreal clubhook squid (*Onychoteuthis borealijaponicus*), 60 eight-armed squid (*Gonatopsis borealis*), 33 seabirds, 32 neon flying squid, 29 Pacific saury (*Cololabis saira*), 23 Atka mackerel (*Pleurogrammus monopterygius*), 14 spiny dogfish (*Squalus acanthias*), three square tail (*Tetragonurus cuvieri*), two salmon shark (*Lamna ditropis*), two Dall's porpoise (*Phocoenoides dalli*), one Pacific lamprey (*Entosphenus tridentatus*), and one daggertooth (*Anotopterus pharao*) were caught.

Trends in Mean Fish Size at Age

Preliminary data on mean length (FL, mm) at age for salmon caught in research mesh gillnet (C-gear) were plotted for the period 1991 to 2007 for the central North Pacific and Bering Sea to investigate trends in mean fish size. Size data for sockeye in the central North Pacific have been available from ocean age-1 and -2 fish regularly since 1998, which may indicate a shift in distribution of these ages of sockeye salmon to this area after 1997 (Fig. 4). In the Bering Sea, trends indicate the size of ocean age -1 sockeye and ocean age -1 chum salmon increased between 2001 and 2006, but decreased in 2007. The size of ocean age-3 sockeye and ocean age-3 and -4 chum salmon has been stable since 2004.

The size of pink salmon in both areas has increased since 1999 (Fig. 5). The size of maturing coho salmon in the central North Pacific has generally decreased since 2001. Size of ocean age-1, -2 and -3 chinook salmon in the Bering Sea decreased in 2007 since 2005 (Fig. 6). In the central North Pacific, the mean size of ocean age-2 and -3 steelhead has decreased since 2002.

Sampling

A total of 17 fin clipped salmonids (steelhead and chum salmon) was caught by longline and gillnet (Table 3). Only twelve snouts from adipose-fin clipped steelhead were collected for later retrieval of CWTs because four adipose-fin clipped steelhead were double-tagged with disk tags and released. The snout was not collected from the chum salmon because this fish was not adipose-fin clipped.

During the cruise, a total of 1,825 samples of stomach contents was collected. In this total, samples collected from 151 sockeye, 331 chum, 243 pink, 108 coho, and 32 chinook salmon, and 29 steelhead were examined on board the ship, and samples from 217 sockeye, 345 chum, 368 pink, and 1 coho salmon were fixed in 10% formalin for later examination.

A total of 1,362 scale samples was collected from chum salmon in the central North Pacific (n = 239) and Bering Sea (n = 1,123) for genetic stock identification. A total of 1,349 pairs of sagittal otoliths was collected from chum salmon in the central North Pacific (n = 234) and Bering Sea (n = 1,115) to detect the presence of thermal marks.

A total of 394 gutted fish was collected from 92 chum and 22 pink salmon in the central North Pacific and from 138 chum and 142 pink salmon in the Bering Sea for lipid content analysis.

Genetic samples were obtained from 33 steelhead and 32 chinook salmon. Eight steelhead were sampled for POP and 29 steelhead, 16 coho, and 4 chinook salmon were sampled for stable isotopes.

Disk and Data Storage Tags

A total of 1,053 salmonids were disk tagged during the survey. In the central North Pacific (St. 3-13), 206 disk tags were placed on fish, including 9 sockeye, 142 chum, 19 pink, 30 coho, and 2 chinook salmon, and 4 steelhead. In the Bering Sea (St. 14-26) a total of 847 disk tags were placed on salmon including 51 sockeye, 339 chum, 449 pink, and 8 chinook salmon. Four LTD tags were placed on steelhead trout in the North Pacific and two LTD tags were placed on chinook salmon in the Bering Sea.

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Table 1. Research activities conducted at each station during the *Wakatake maru* cruise in 2007.

NO	ST	Date	Latitude	Longitude	XBT	CTD	Primary	NORPAC	ORI	BONGO	Gillnet	Longline	Remarks
1	T-1	2007 6 7 40 0	150 0	E	○	○	○	○					
2	T-2	2007 6 7 40 0	151 0	E	○								
3	T-3	2007 6 7 40 0	152 0	E	○								
4	T-4	2007 6 8 40 0	153 0	E	○								
5	T-5	2007 6 8 40 0	154 0	E	○								
6	T-6	2007 6 8 40 0	155 0	E	○	○	○	○					
7	T-7	2007 6 8 40 0	156 0	E	○								
8	T-8	2007 6 8 40 0	157 0	E	○								
9	T-9	2007 6 8 40 0	158 0	E	○								
10	T-10	2007 6 9 40 0	159 0	E	○								
11	T-11	2007 6 9 40 0	160 0	E	○	○	○	○					
12	T-12	2007 6 9 40 0	161 0	E	○								
13	T-13	2007 6 9 40 0	162 0	E	○								
14	T-14	2007 6 9 40 0	163 0	E	○								
15	T-15	2007 6 9 40 0	164 0	E	○								
16	T-16	2007 6 10 40 0	165 0	E	○	○	○						
17	T-17	2007 6 10 40 0	166 0	E	○								
18	T-18	2007 6 10 40 0	167 0	E	○								
19	T-19	2007 6 10 40 0	168 0	E	○								
20	T-20	2007 6 10 40 0	169 0	E	○								
21	T-21	2007 6 10 40 0	170 0	E	○	○	○						
22	T-22	2007 6 11 40 0	171 0	E	○								
23	T-23	2007 6 11 40 0	172 0	E	○								
24	T-24	2007 6 11 40 0	173 0	E	○								
25	T-25	2007 6 11 40 0	174 0	E	○								
26	T-26	2007 6 11 40 0	175 0	E	○	○	○						
27	T-27	2007 6 11 40 0	176 0	E	○								
28	T-28	2007 6 11 39 45	177 0	E	○								
29	T-29	2007 6 12 39 30	178 0	E	○								
30	T-30	2007 6 12 39 15	179 0	E	○								
31	ST-1	2007 6 12 39 0	180 0		○	○	○						ARGO Float cast
32	ST-2	2007 6 12 40 0	180 0			○	○						
33	ST-3	2007 6 13 41 0	180 0			○	○	○	○	○	○	○	ARGO Float cast
34	ST-4	2007 6 14 42 0	180 0			○	○	○	○	○	○	○	
35	ST-5	2007 6 15 43 0	180 0			○	○	○	○	○	○	○	ARGO Float cast
36	ST-6	2007 6 16 44 0	180 0			○	○	○	○	○	○	○	
37	ST-7	2007 6 17 45 0	180 0			○	○	○	○	○	○	○	ARGO Float cast
38	ST-8	2007 6 18 46 0	180 0			○	○	○	○	○	○	○	
39	ST-9	2007 6 19 47 0	180 0			○	○	○	○	○	○	○	
40	ST-10	2007 6 20 47 30	180 0			○	○	○	○	○	○	○	
41	ST-11	2007 6 21 48 30	180 0			○	○	○	○	○	○	○	
42	ST-12	2007 6 22 49 30	180 0			○	○	○	○	○	○	○	
43	ST-13	2007 6 23 50 30	180 0			○	○	○	○	○	○	○	
44	ST-14	2007 6 24 51 30	180 0			○	○	○	○	○	○	○	
45	ST-15	2007 6 25 52 30	180 0			○	○	○	○	○	○	○	
46	ST-16	2007 6 26 53 30	180 0			○	○	○	○	○	○	○	
47	ST-17	2007 6 27 54 30	180 0			○	○	○	○	○	○	○	
48	ST-18	2007 6 28 55 30	180 0			○	○	○	○	○	○	○	
49	ST-19	2007 6 29 56 30	180 0			○	○	○	○	○	○	○	
50	ST-20	2007 6 30 57 30	180 0			○	○	○	○	○	○	○	
51	ST-21	2007 7 1 58 30	180 0			○	○	○	○	○	○	○	
52	ST-22	2007 7 2 57 30	179 0	W		○	○	○	○	○	○	○	
53	ST-23	2007 7 3 57 30	178 0	W		○	○	○	○	○	○	○	
54	ST-24	2007 7 4 56 30	178 0	W		○	○	○	○	○	○	○	
55	ST-25	2007 7 5 56 30	179 0	W		○	○	○	○	○	○	○	
56	ST-26	2007 7 6 56 30	179 0	E		○	○	○	○	○	○	○	
57	ST-27	2007 7 7 56 30	178 0	E		○	○	○	○	○	○	○	
58	ST-28	2007 7 8 56 30	177 0	E		○	○	○	○	○	○	○	
59	ST-29	2007 7 9 57 30	177 0	E		○	○	○	○	○	○	○	
60	ST-30	2007 7 10 57 30	176 0	E		○	○	○	○	○	○	○	
61	ST-31	2007 7 11 56 30	176 0	E		○	○	○	○	○	○	○	
62	T-50	2007 7 12 56 0	176 0	E	○								
63	T-51	2007 7 12 55 30	175 0	E	○	○	○						
64	T-52	2007 7 12 55 0	174 0	E	○								
65	T-53	2007 7 12 54 30	173 0	E	○								
66	T-54	2007 7 12 54 0	172 0	E	○								
67	T-55	2007 7 13 53 30	171 0	E	○								
68	T-56	2007 7 13 53 0	170 0	E	○	○	○						
69	T-57	2007 7 13 52 20	169 0	E	○								
70	T-58	2006 7 13 51 40	168 0	E	○								

Table 1. (continued)

NO	ST	Date		Latitude		Longitude		XBT	CTD	Primary	NORPAC	ORI	BONGO	Gillnet	Longline	Remarks	
71	T-59	2007	7	13	51	10	167	0	E	○							
72	T-60	2007	7	13	50	40	166	0	E	○							
73	T-61	2007	7	14	50	0	165	0	E	○	○	○					
74	T-62	2007	7	14	49	20	164	0	E	○							
75	T-63	2007	7	14	48	40	163	0	E	○							
76	T-64	2007	7	14	48	0	162	0	E	○							
77	T-65	2007	7	14	47	30	161	0	E	○							
78	T-66	2007	7	14	46	50	160	0	E	○	○	○	○				
79	T-67	2007	7	15	46	10	159	0	E	○							
80	T-68	2007	7	15	45	30	158	0	E	○							
81	T-69	2007	7	15	44	50	157	0	E	○							
82	T-70	2007	7	15	44	10	156	0	E	○							
83	T-71	2007	7	15	43	30	155	0	E	○	○	○	○				
84	T-72	2007	7	16	42	50	154	0	E	○							
85	T-73	2007	7	16	42	10	153	0	E	○							
86	T-74	2007	7	16	41	20	152	0	E	○							
87	T-75	2007	7	16	40	40	151	0	E	○							
88	T-76	2007	7	17	40	0	150	0	E	○		○					CTD and NORPAC cancelled

Table 2. Salmonids, other fishes, and squid catches at each station with sea surface temperature (SST, °C) during the summer research cruise of the *Wakatake maru*, 2007. B-gear, surface longline; C-gear, salmon research gillnet (mesh sizes = 48, 55, 63, 72, 82, 93, 106, 121, 138 and 157 mm); A-gear, commercial gillnet (mesh size = 115 mm). The number of fish tagged with disk tags and released is listed for each station.

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-Steel-nook head	Salmo- total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamp-ey	Salmon shark	Spiny dog-fish	Dagg tooth saury	Pacific pom-fret	Atka-macke-rel	Square tail	Dall's Sea-porpois birds				
3	6/14/07	4100	18000	11.7	B	30	0	12	0	2	0	0	14	0	0	0	0	0	0	0	113	0	0	0			
					C	30	0	20	0	1	0	0	21	13	3	33	0	1	0	0	6	124	0	0	0	0	
					A	19	0	0	0	4	0	0	4	19	0	2	0	0	0	0	0	0	136	0	0	0	0
					Total		0	32	0	7	0	0	39	32	3	35	0	1	0	0	6	373	0	0	0	0	
					Rel.		0	7	0	2	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	6/15/07	4200	18000	11.9	B	30	0	9	1	5	0	0	15	0	0	2	0	0	0	0	32	0	0	0			
					C	30	0	13	0	8	0	0	21	0	4	19	0	0	0	0	23	21	0	0	0	0	
					A	19	0	0	0	21	0	3	24	0	0	0	0	0	0	0	0	8	0	0	2	0	
					Total		0	22	1	34	0	3	60	0	4	21	0	0	0	0	23	61	0	0	2	0	
					Rel.		0	8	1	2	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	6/16/07	4300	18000	10.6	B	30	0	25	0	14	0	0	39	0	0	1	0	0	0	0	6	0	0	0			
					C	30	1	45	0	11	0	0	57	0	4	11	0	0	0	0	0	42	0	1	0	0	
					A	19	0	6	0	15	0	1	22	0	0	0	0	0	2	0	0	18	0	0	0	0	
					Total		1	76	0	40	0	1	118	0	4	12	0	0	2	0	0	66	0	1	0	0	
					Rel.		0	18	0	9	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	6/17/07	4400	18000	9.6	B	30	0	60	1	22	1	3	87	0	0	2	0	0	0	0	2	0	0	0			
					C	30	0	65	2	44	2	1	114	0	2	10	0	0	3	0	0	29	0	1	7	0	
					A	19	0	7	1	60	0	3	71	0	0	0	0	1	3	0	0	14	0	0	1	0	
					Total		0	132	4	126	3	7	272	0	2	12	0	1	6	0	0	45	0	1	8	0	
					Rel.		0	30	1	10	1	2	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	6/18/07	4500	18000	9.5	B	30	0	35	0	10	0	1	46	0	0	1	0	0	1	0	2	0	0	0			
					C	30	0	43	10	98	0	3	154	0	2	14	0	0	1	0	0	10	0	1	1	0	
					A	19	0	7	1	92	1	0	101	0	0	0	0	0	2	0	0	5	0	0	0	0	
					Total		0	85	11	200	1	4	301	0	2	15	0	0	4	0	0	17	0	1	1	0	
					Rel.		0	21	0	5	0	1	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	6/19/07	4600	18000	8.4	B	30	0	14	1	4	0	3	22	0	0	0	0	0	0	0	0	0	0	0			
					C	30	0	27	5	25	1	1	59	0	2	1	0	0	0	0	0	0	0	0	0	0	
					A	19	0	9	3	20	2	4	38	0	0	0	0	0	1	0	0	0	0	0	0	0	
					Total		0	50	9	49	3	8	119	0	2	1	0	0	1	0	0	0	0	0	0	0	
					Rel.		0	8	1	2	0	3	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. Sock-unit	eye	Chum	Pink Coho	Chi-Steel-nook head	Salmo-nid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamp-ey shark	Spiny Dagg dog-fish tooth	Dagg er Pacific saury	Pacific pommacke-fret	Atka rel	Square-tail	Sea-birds	Dall's porpoise					
9	6/20/07	4700	18000	8	B	30	0	3	3	0	1	7	0	0	0	0	0	0	0	0	0	0	0				
					C	30	1	9	14	2	0	4	30	0	3	0	0	0	0	0	0	0	0	0	0	1	
					A	19	0	2	5	10	0	5	22	0	0	0	0	0	0	0	0	0	0	0	0	0	1
					Total		1	14	22	12	0	10	59	0	3	0	0	0	0	0	0	0	0	0	0	0	2
					Rel.		0	2	2	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	6/21/07	4730	18000	8.1	B	30	1	11	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0				
					C	30	3	28	27	4	0	1	63	0	2	0	0	0	0	0	0	0	0	0	0		
					A	19	0	6	10	8	0	1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total		4	45	37	12	0	2	100	0	2	0	0	0	0	0	0	0	0	0	0	0	
					Rel.		1	8	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	
11	6/21/07	4830	18000	8.0	B	30	0	5	10	0	1	16	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		0	4	6	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0		
12	6/22/07	4930	18000	7.5	B	30	2	21	11	0	0	34	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		2	17	4	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0		
13	6/23/07	5030	18000	7.6	B	30	7	30	9	1	1	48	0	0	0	0	0	1	0	0	0	0	0				
					Rel.		6	20	4	0	1	0	31	0	0	0	0	0	0	0	0	0	0	0	0		
14	6/24/07	5130	18000	5.8	B	30	1	37	27	0	0	65	0	0	0	0	0	0	0	7	0	0	0				
					Rel.		1	22	21	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0	0		
15	6/25/07	5230	18000	5.4	B	30	4	18	14	0	1	37	0	0	0	0	0	0	0	9	0	0	0				
					Rel.		4	15	6	0	1	0	26	0	0	0	0	0	0	0	0	0	0	0	0		
16	6/26/07	5330	18000	6.2	B	30	3	33	15	0	1	52	0	0	0	0	0	0	0	2	0	0	0				
					Rel.		3	20	12	0	1	0	36	0	0	0	0	0	0	0	0	0	0	0	0		
17	6/27/07	5430	18000	7.2	B	30	1	57	16	0	0	74	0	0	0	0	0	0	0	0	0	0	0				
					Rel.		1	37	11	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	0		
18	6/29/07	5530	18000	6.2	B	30	0	6	2	0	0	8	0	0	0	0	0	0	0	0	0	0	0				
					C	30	15	125	153	0	0	0	293	0	0	0	0	0	0	0	0	0	0	0	0		
					A	19	32	76	276	0	0	0	384	0	0	0	0	0	0	0	0	0	0	2	0		
					Total		47	207	431	0	0	0	685	0	0	0	0	0	0	0	0	0	0	2	0		
					Rel.		0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0		

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-Steel-nook	head	Salmo-nid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamprey	Salmon shark	Spiny dogfish	Dagg tooth saury	Pacific pommacke-fret	Atka rel	Square-tail	Sea-birds	Dall's porpoise				
19	6/30/07	5630	18000	6.7	B	30	2	23	67	0	0	0	92	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	32	41	274	1	1	0	349	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	
					A	19	14	49	410	0	0	0	473	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total		48	113	751	1	1	0	914	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Rel.		2	18	54	0	0	0	74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	7/01/07	5730	18000	6.8	B	30	3	8	21	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	29	40	313	0	1	0	383	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					A	19	13	54	553	0	1	0	621	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total		45	102	887	0	2	0	1036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Rel.		3	4	15	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	7/02/07	5830	18000	7.3	B	30	4	10	115	0	4	0	133	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	63	18	199	0	6	0	286	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	
					A	19	33	49	531	0	0	0	613	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	
					Total		100	77	845	0	10	0	1032	0	1	0	0	0	0	0	0	0	0	0	0	0	0	6	0
					Rel.		4	7	85	0	4	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	7/03/07	5730	17900W	7.3	B	30	7	16	60	0	0	0	83	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	61	30	559	0	0	0	650	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
					A	19	33	32	624	0	0	0	689	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
					Total		101	78	1243	0	0	0	1422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
					Rel.		7	15	44	0	0	0	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	7/04/07	5730	17800W	7.3	B	30	9	27	128	0	1	0	165	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	49	47	501	0	0	0	597	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					A	19	34	50	668	0	1	0	753	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total		92	124	1297	0	2	0	1515	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Rel.		9	19	90	0	1	0	119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	7/05/07	5630	17800W	6.8	B	30	2	55	13	0	0	0	70	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	42	130	429	0	1	1	603	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	
					A	19	29	96	634	0	1	0	760	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
					Total		73	281	1076	0	2	1	1433	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
					Rel.		2	44	11	0	0	0	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink Coho	Chi-Steel-nook head	Salmo-nid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamprey	Salmon shark	Spiny dogfish	Dagger Pacific saury	Pacific pommacke-fret	Atka rel	Square-tail	Sea-birds	Dall's porpoise					
25	7/06/07	5630	17900W	6.6	B	30	0	26	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	23	70	291	0	1	0	385	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
					A	19	13	23	423	0	1	0	460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					Total		36	119	734	0	2	0	891	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
					Rel.		0	15	14	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	7/07/07	5630	17900E	6.9	B	30	5	25	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	44	79	128	0	0	0	251	0	3	0	0	0	0	0	0	0	1	0	1	0		
					A	19	12	13	248	0	2	0	275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
					Total		61	117	404	0	2	0	584	0	3	0	0	0	0	0	0	0	0	1	0	1	0	
					Rel.		3	16	19	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	7/08/07	5630	17800E	7.1	B	30	2	6	27	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0				
					C	30	21	36	136	0	0	0	193	0	1	0	0	0	0	0	0	0	2	0	0	0		
					A	19	13	20	207	0	0	0	240	0	0	0	0	0	0	0	0	0	0	0	1	0		
					Total		36	62	370	0	0	0	468	0	1	0	0	0	0	0	0	0	0	3	0	1	0	
					Rel.		1	5	16	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
28	7/09/07	5630	17700E	7.8	B	30	3	47	24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	56	181	212	0	1	0	450	0	9	0	1	0	0	0	0	0	1	0	0	0		
					A	19	25	28	326	1	1	0	381	0	1	0	0	0	0	0	0	0	0	0	1	0		
					Total		84	256	562	1	3	0	906	0	10	0	1	0	0	0	0	0	0	1	0	1	0	
					Rel.		2	31	14	0	1	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
29	7/10/07	5730	17700E	8.2	B	30	2	24	27	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	36	32	169	0	4	0	241	0	1	0	0	0	0	0	0	0	0	0	0	0		
					A	19	9	32	244	0	0	0	285	0	0	0	0	0	1	0	0	0	0	0	0	0		
					Total		47	88	440	0	6	0	581	0	1	0	0	0	1	0	0	0	0	0	0	0	0	
					Rel.		2	18	22	0	2	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
30	7/11/07	5730	17600E	8.3	B	30	2	53	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
					C	30	63	183	123	0	2	0	371	0	5	0	0	0	0	0	0	0	0	0	2	0		
					A	19	24	46	307	0	1	0	378	0	0	0	0	0	0	0	0	0	0	0	1	0		
					Total		89	282	446	0	3	0	820	0	5	0	0	0	0	0	0	0	0	0	0	3	0	
					Rel.		2	35	11	0	0	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 2. (continued)

St	Date	Lat	Long	SST	Gear	No. unit	Sock-eye	Chum	Pink	Coho	Chi-Steel-nook	Steel-head	Salmo-nid total	Neon flying squid	Eight-armed squid	Hook-armed squid	Pacific lamp-ey	Salmon shark	Spiny dog-fish	Dagger tooth	Pacific saury	Pacific pommacke-fret	Atka rel	Square-tail	Sea-birds	Dall's porpoise
31	7/12/07	5630	17600E	8.2	B	30	7	18	5	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0
					C	30	31	163	119	0	0	0	313	0	12	0	0	0	0	0	0	0	0	0	1	0
					A	19	22	31	187	0	1	0	241	0	0	0	0	0	0	0	0	0	0	0	1	0
					Total		60	212	311	0	1	0	584	0	12	0	0	0	0	0	0	0	0	2	0	
					Rel.		5	13	4	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	
Total					B	870	67	714	661	58	12	9	1521	0	0	6	0	0	1	1	0	155	19	0	0	0
					C	660	570	1425	3664	194	20	11	5884	13	59	88	1	1	4	0	29	226	4	3	20	1
					A	418	306	636	5658	231	12	17	6860	19	1	2	0	1	9	0	0	181	0	0	13	1
					Total	1948	943	2775	9983	483	44	37	14265	32	60	96	1	2	14	1	29	562	23	3	33	2
					Rel.	870	60	482	468	30	12	8	1060	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Salmonids missing fins in the catch of the *Wakatake maru*, summer, 2007. Gear: A = commercial-mesh gillnet; C = research-mesh gillnet followed by mesh size (mm); and B = surface longline. Clipped fin: Ad = adipose fin, RP = right pectoral fin, LP = left pectoral fin, RV = right ventral fin, LV = left ventral fin, D = dorsal fin. – no data.

Date	Location		Gear	Species	Fork length (mm)	Body weight (g)	Sex	Gonad weight		Clipped fin	Sample /Tag Number
	Lat.	Long.						(g)	Age		
6/15/07	42°00'N	180°00'	A115	steelhead	580	2050	F	3	1.1	Ad	13-22
6/15/07	42°00'N	180°00'	A115	steelhead	596	1870	F	3	1.1	Ad	13-23
6/16/07	43°00'N	180°00'	A115	steelhead	569	1800	M	3	x.1	Ad	23-7
6/16/07	44°00'N	179°58'E	B	steelhead	753	4200	M	7	x.2	Ad	25-13
6/17/07	44°00'N	180°00'	A115	steelhead	593	2040	M	1	x.1	Ad	39-1
6/17/07	44°00'N	180°00'	A115	steelhead	539	1800	F	5	x.1	Ad	39-2
6/17/07	44°00'N	180°00'	A115	steelhead	540	1780	F	2	x.1	Ad, RP, LP	39-3
6/18/07	45°00'N	180°00'	C121	steelhead	590	2030	M	1	1.1	Ad	51-20
6/19/07	46°00'N	180°00'	C106	steelhead	590	2030	M	6	1.1	Ad, RV	63-17
6/19/07	46°00'N	180°00'	A115	steelhead	615	3730	M	2	1.2	Ad	64-6
6/20/07	47°00'N	180°00'	A115	steelhead	572	1900	M	7	x.1	Ad	72-20
6/20/07	47°00'N	180°00'	A115	steelhead	647	2900	F	16	x.2	Ad, D	72-21
7/01/07	57°30'N	180°00'	C82	chum	593	2830	M	130	0.4	LV	-
6/16/07	44°00'N	179°58'E	B	steelhead	722	-	-	-	1.2	Ad	LL5068, LL6868
6/18/07	46°02'N	179°58'W	B	steelhead	760	-	-	-	1.2	Ad, D	LL5123, LL8682
6/18/07	46°02'N	179°58'W	B	steelhead	628	-	-	-	x.1	Ad	LL5131, LL8690
6/21/07	48°30'N	180°00'	B	steelhead	474	-	-	-	x.1	Ad	LL5150, NN0875

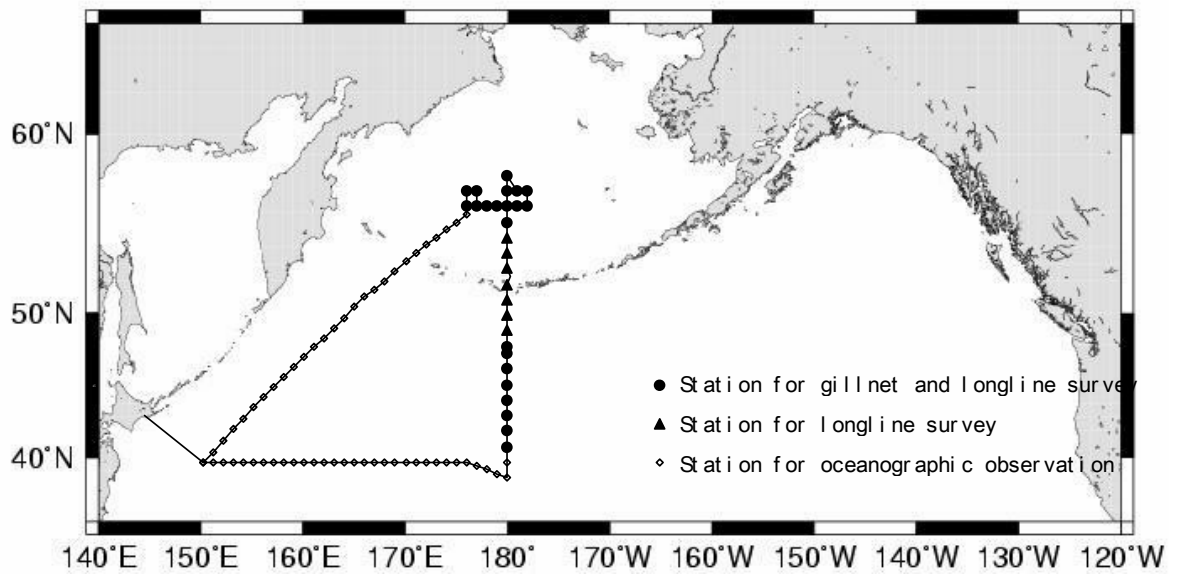


Fig. 1. Survey area of the R/V *Wakatake maru* salmon research cruise, summer 2007.

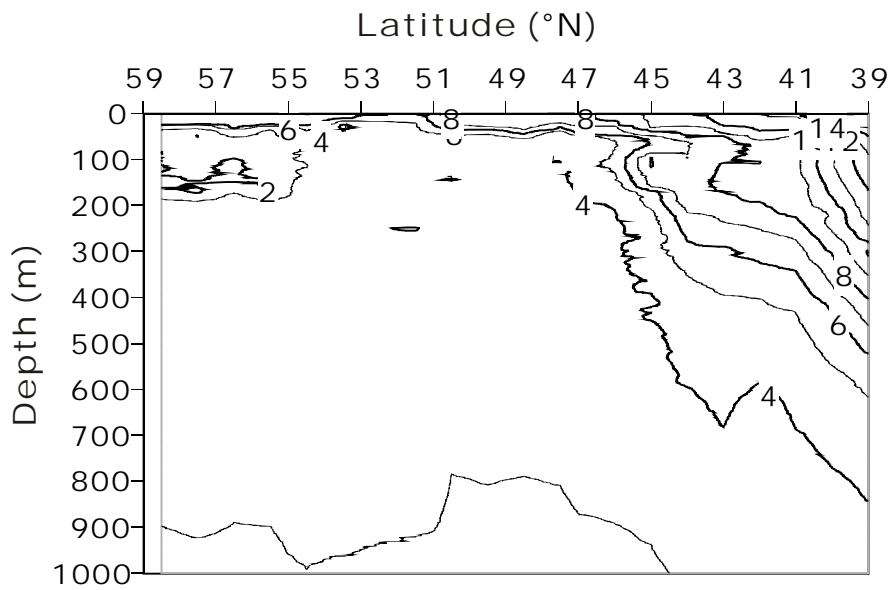


Fig. 2. Vertical section of water temperature (°C) along the 180° transect of the *Wakatake maru* cruise, 2007.

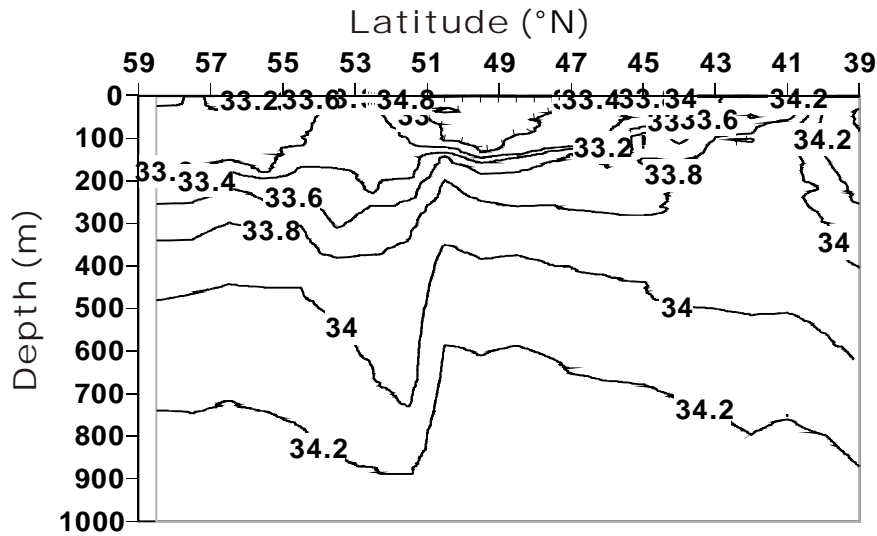


Fig. 3. Vertical section of salinity (psu) along the 180° transect of the *Wakatake maru* cruise, 2007.

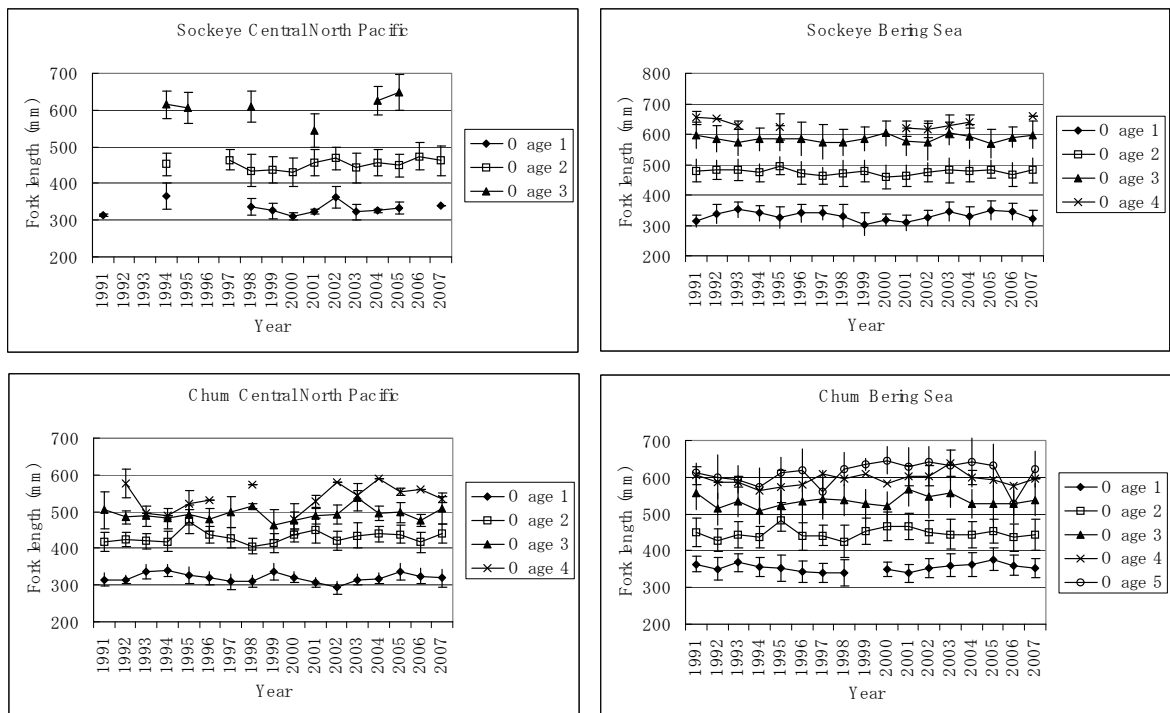


Fig. 4. Mean fork length (+/- one standard deviation) at ocean age by year for sockeye and chum salmon caught in the research-mesh gillnet (C-gear), 1991-2007. Fish were caught in the central North Pacific (CNP) and Bering Sea (BS).

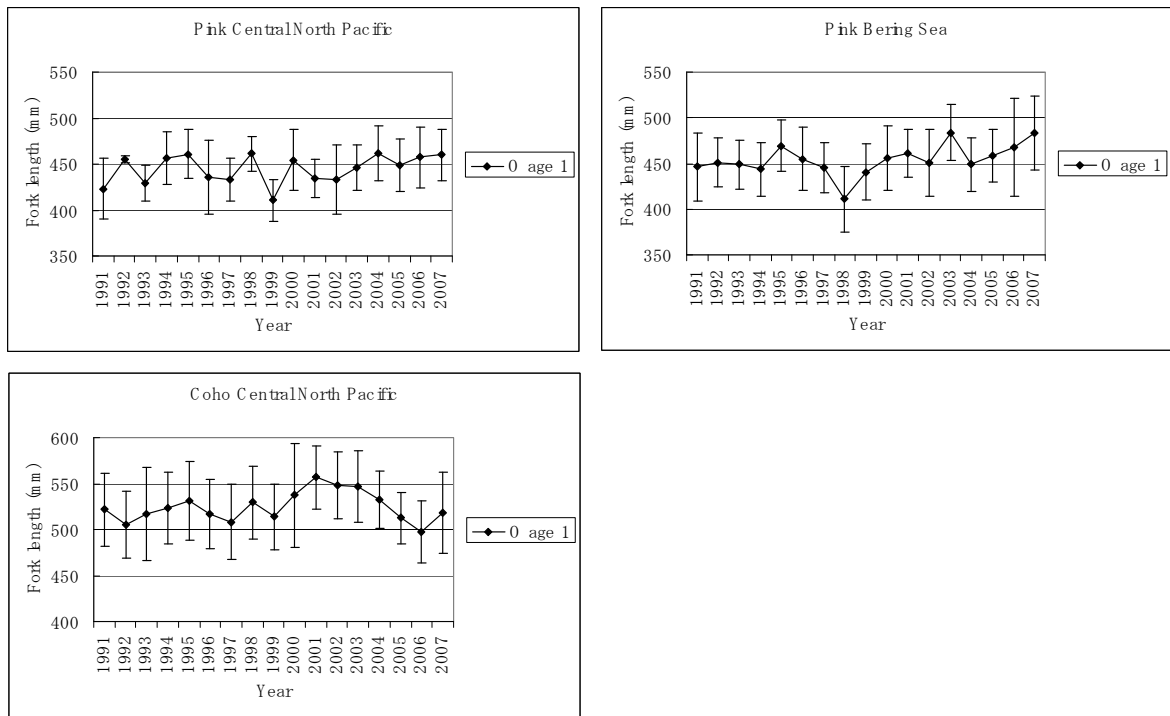


Fig. 5. Mean fork length (+/- one standard deviation) at ocean age by year for pink and coho salmon caught in the research-mesh gillnet (C-gear), 1991-2007. Fish were caught in the central North Pacific (CNP) and Bering Sea (BS).

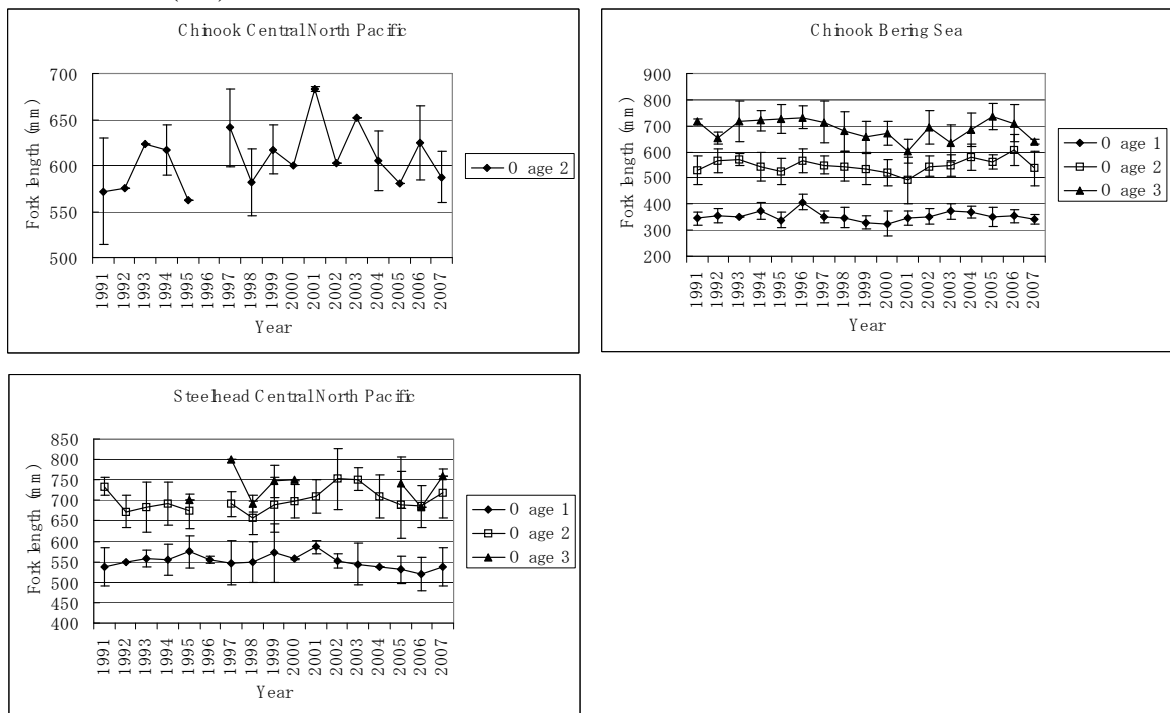


Fig. 6. Mean fork length (+/- one standard deviation) at ocean age by year for chinook salmon and steelhead caught in the research-mesh gillnet (C-gear), 1991-2007. Fish were caught in the central North Pacific (CNP) and Bering Sea (BS).