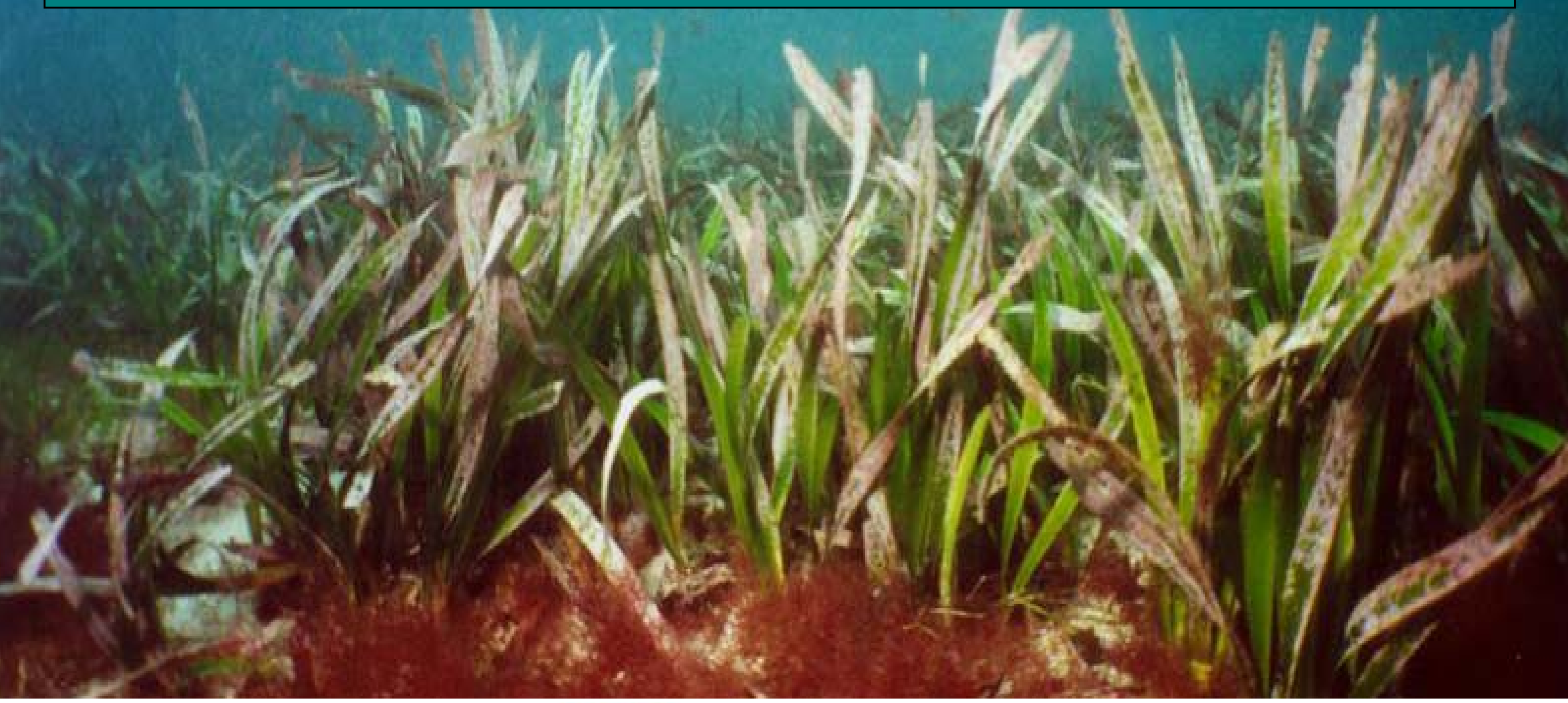
WATCHING THE SEAGRASS GROW

A guide for community seagrass monitoring in New South Wales

Reference Manual



Community Environment NETWORK

NSW Environmental TRUST

This Project has been funded by the NSW State Government through it's Environmental Trust Program

Disclaimer

This Manual contains information about seagrass species within NSW and provides information to support community seagrass monitoring and water quality data collection. As this is a dynamic science, it is necessary to determine regularly if any new information is available. Data collected via the methods outlined in this Manual should be used simply to identify changes to seagrass beds and provide information that may be used as a tool for management decisions. Accurately quantifying these impacts, and identifying the exact causes of these impacts, will usually require consultation with relevant experts and potentially further investigation.

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Contents

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2 Abstract

Seagrass beds provide unique ecosystems in coastal locations such as estuaries, lakes and lagoons, and are vital environmentally and economically for a number of reasons.

As a natural resource these areas are extremely productive increasing plant production and biomass to the ecosystem. Seagrass beds are also important nurseries and shelter areas for a variety of fauna including many wild species used in aquaculture providing huge economic gains and exports to Australia. The habitat component that seagrass beds provide also aids in commercial and recreational fishing and other aquaculture ventures, as the seagrass provides food and protection for juvenile species aiding nourishment and growth.

The presence of seagrass also improves water quality by decreasing sediment within the water column. With an extensive root system, seagrass beds cover the soft sediment in which they grow, laying a 'mat' covering otherwise unstable sediment. Seagrass plants also take in many nutrients and heavy metals, entering waterways through the catchment, storing and processing them for a number of uses. Seagrasses convert these nutrients and heavy metals into organic matter that can be utilised by other marine flora and faunal species.

Seagrass beds have declined dramatically in NSW as urbanisation increases in many catchment areas. Impacts from land clearing, urban development, agricultural activities as well as commercial activities and development have affected water quality and subsequently the health of seagrass. Contaminations from runoff into coastal waterways, and activities such as dredging and reclamation of seagrass beds have also taken their toll.

Currently the NSW government provides funding to expand knowledge and studies of seagrass through various grant schemes. As well as this, many local councils are looking into ways seagrasses can be monitored using 'high tech' devices such as Satellite Remote Sensing, and the NSW government is constantly formulating legislations and policies such as The Estuary Management Policy.

However there is presently no regionally coordinated approach to monitor seagrasses throughout NSW. As the environment is constantly changing from one place to the next, and from one day to the next, there is a great need to conduct repeated monitoring in local areas so that these changes can be detected. By using this manual as well as The Field Guide to conduct Community Seagrass Monitoring, we can "fill in" gaps that currently exit and use information collected as a tool for management decisions in the future.

3 Introduction

The aim of Community Seagrass Monitoring is to achieve a collaborated effort from community members and experts to monitor and preserve seagrass across NSW. The objective is that community groups across NSW be set up using this manual, to conduct monitoring events that will aid in the monitoring and preservation of seagrass. The goal of the program is to gather as much localised information across NSW that will aid in decision making based on seagrasses that will fill gaps in an attempt to preserve this natural resource.

The funding for the Community Seagrass project was developed in 2003 and was well received on the Central Coast, where it was initially trialled with the support of the Department of Sustainable Natural Resources, NSW Fisheries and Gosford Council. In 2004, the CCCEN received a grant from the NSW government through the Environmental Trust for a project "Coastal Communities Caring for Seagrass". The current project seeks to make this Manual available to coastal communities across NSW. CEN is proposing to take the lessons learnt from the development and trial phases of this Manual to encourage, train and support NSW coastal communities in seagrass monitoring.

Community seagrass monitoring across Australia has been implemented effectively particularly in Queensland with the Great Barrier Reef Marine Parks Authority where monitoring of seagrass has occurred over several years under a successful "Seagrass Watch Program". This program which involves community members and experts working together. It is hoped that through the use of this manual a regional community seagrass monitoring effort will be achieved, with the long-term goal of a national approach in the not to distant future.

Six-Spined Leatherjacket (*Meuschenia freycineti*) in *Halophila*
(Source: David Harasti, 2003)

(Source: Peter Adderley, 2003)

SEAGRASS IS WONDERFUL

4 Seagrass Is Wonderful

There are around 60 species of seagrass worldwide with over half of these species growing in Australian waters. South Australia is the center of seagrass diversity with one third of seagrass species worldwide with 14 species occurring nowhere else. In NSW there are eight species of seagrasses, five, which have a statewide distribution, and three that are distributed in the south of the state.

4.1 What is Seagrass?

Seagrasses are Rhizomatous Marine Angiosperms or flowering plants with true roots, adapted to live and reproduce submerged within a saltwater environment. Seagrasses grow in shallow, sheltered soft-bottomed coastal habitats such as coastlines, estuaries and lakes. They are closely related to terrestrial land plants such as lilies and gingers and fossil records date back to Gondwana, 70 million years ago. Individual seagrass plants have been dated at 1000 years, such as those found in the Baltic Sea.

Like land plants, seagrasses have leaves, veins and roots and reproduce by flowers and seeds. However, in the absence of birds and bees as pollinators, seagrass have evolved other strategies for transferring pollen. Most seagrass pollen is denser than water and will sink slowly after being released from the male flower. To increase dispersal some seagrass use currents or release pollen from floral spikes high above the sea floor such as *Posidonia* species.

There are many factors important in maintaining healthy seagrass. These include sediment quality and depth, water quality (temperature, salinity, turbidity), currents and hydrodynamic processes (water movement) as well as species interactions (epiphytes and grazers). Depth, turbidity (water clarity) and water movement determine where seagrass occur. Seagrass needs sunlight for photosynthesis, and depth and turbidity determine how much light is available to seagrasses. Some seagrass species are capable of surviving with little light (e.g. *Halophila australis*) while others are found only on shallow, sunlit sediments (e.g. *Posidonia australis*).

Posidonia australis (Source: Peter Adderley, 2003)

4.2 The Importance and Significance of Seagrass

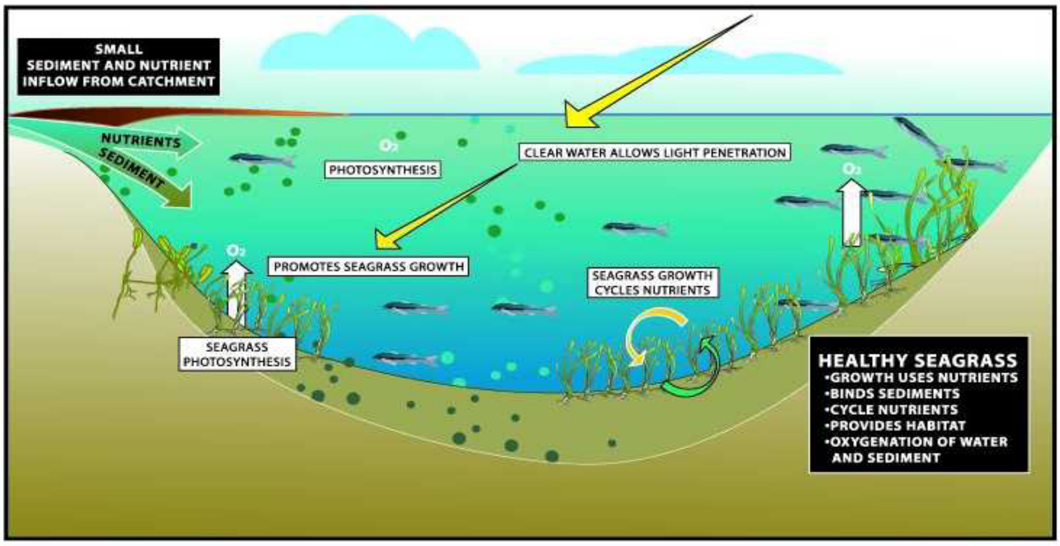
Seagrass beds are unique ecosystems vital environmentally and economically as a natural resource. They are extremely productive, increasing plant production and biomass to the ecosystem. Seagrass captures the sun's energy and converts it into organic matter that may be utilised by the whole food chain.

Seagrass beds are important nurseries and shelter areas for a variety of fauna such as dugongs and green turtles in the tropics, as well as many bird and fish species in cooler temperate waters such as swans, garfish and leatherjackets. Economically many wild caught species dependant on seagrass are used in aquaculture providing huge economic gains and exports to Australia. The habitat seagrass beds provide also aid in commercial and recreational fishing and other aquaculture ventures as the seagrass provides food and protection for juvenile species for nourishment and growth.

Seagrass blades provide a point of attachment for other plants and animals called **epiphytes**, which create an increasingly complex habitat. These epiphytes provide food and shelter for numerous small fish and invertebrates', which also seek protection from larger predators in the seagrass. Seagrass beds therefore provide important nursery areas and are a key in-shore habitat area, increasing the in-shore biodiversity.

The presence of seagrass also improves water quality by decreasing sediment within the water column. With an extensive root system, seagrass beds cover the soft sediment in which they grow, laying into a 'mat' covering otherwise unstable sediment. Seagrass plants also take in many nutrients and heavy metals entering

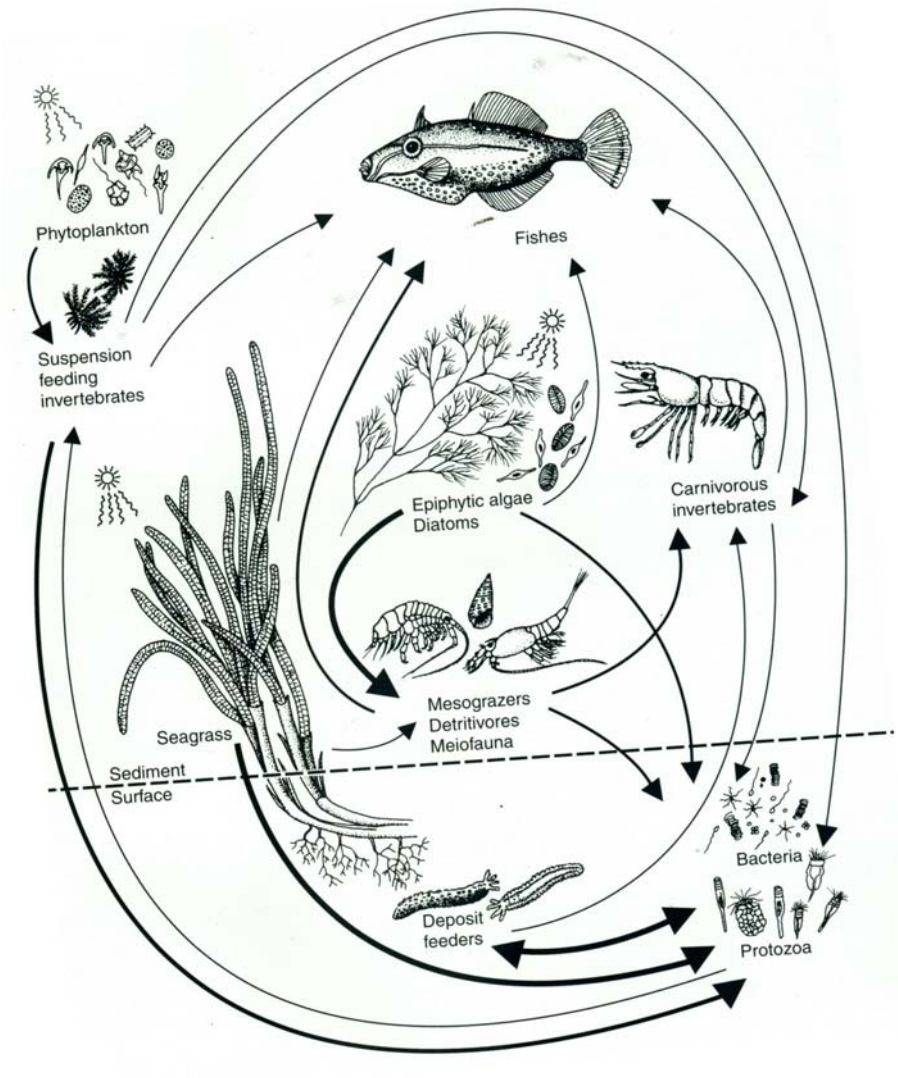
Figure 1: Healthy Seagrass Environment
(Reproduced from Laegdsgaard, 2001)



waterways through the catchment, storing and processing them for a number of uses. Seagrasses convert these nutrients and heavy metals into harmless organic matter that can be utalised by other marine flora and faunal species. Additionally, invertebrate filter feeders such as sponges, ascidians and hydroids, which also attach to seagrass blades, aid in the removal of particles from the water column.

Seagrass wrack (leaves detached from the original plant) also plays a vital role as a microhabitat both in the water and along the shoreline. Accumulation of decaying seagrass (or wrack) on the shoreline provides food and habitat, and is a source of nutrient cycling for inshore estuarine ecosystems. When seagrass dies and begins to breakdown microbes, such as bacteria, create fragments of decaying seagrass. This is then consumed microbes and all by prawns and other invertebrates'. Other animals, including shore birds and fish, will then eat these invertebrates, and so the cycle continues. Thus decaying seagrass or "wrack" also plays an important role in

Figure 2: Estuarine food web with seagrass as a marine primary producer. Wider arrows reflect increased importance of each linkage. (Reproduced from Edgar, 2001)



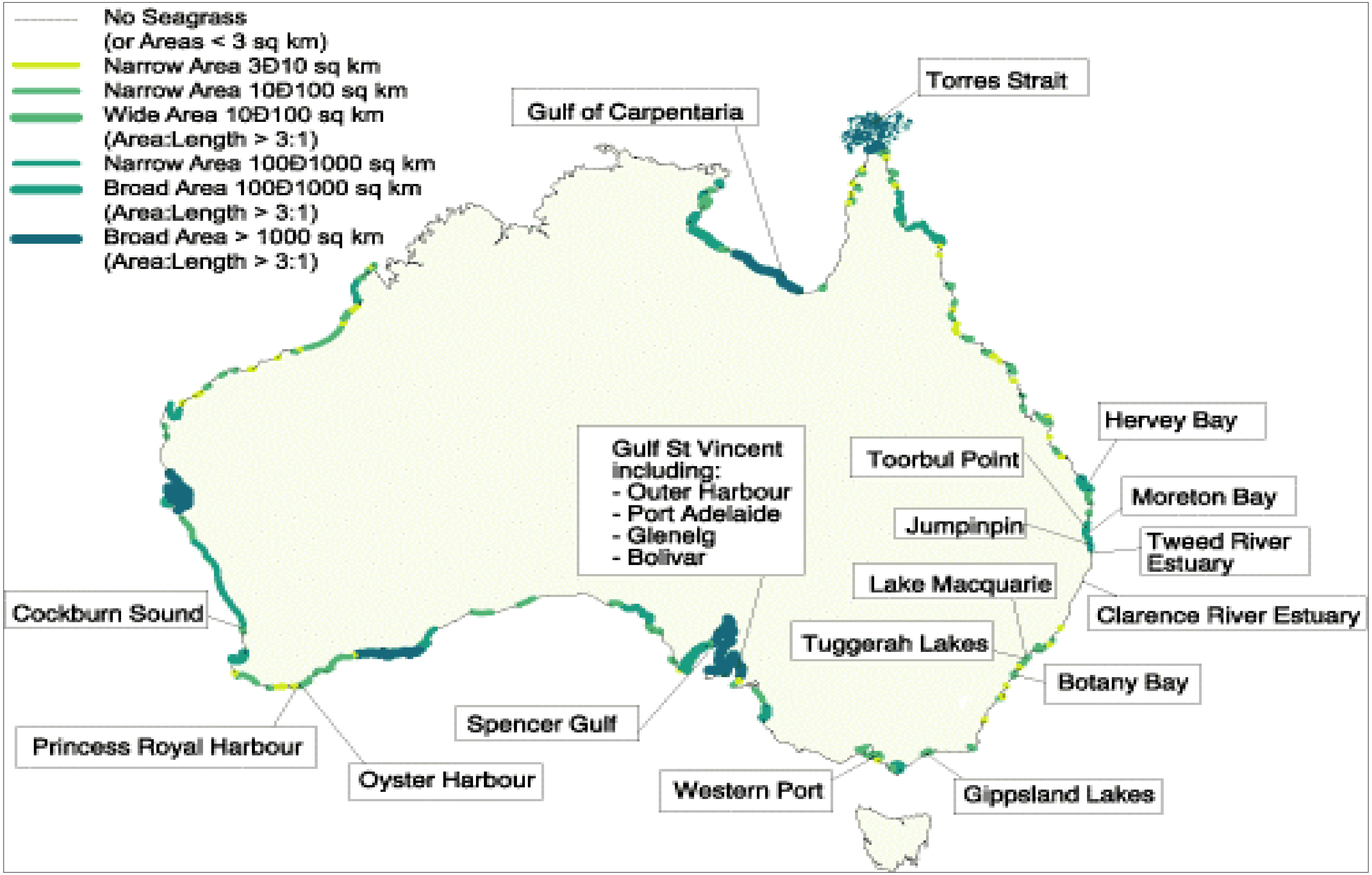
maintaining inshore marine ecosystems. Wrack has also been identified as a significant nutrient contributor to other associated estuarine ecosystems such as salt marsh. Wrack present on the foreshore maintains suitable conditions for saltmarsh growth by providing shade, trapping water and providing nutrients.

4.3 Seagrass Species Globally and Australia

There are there are about 12 major divisions of seagrass comprising sixty species of seagrass found globally. Seagrasses are found in a number of location throughout the world including the Sea of Japan, deep tropical waters of Brazil and vast underwater meadows of seagrass which skirt the coasts of Australia, Alaska, southern Europe, India, east Africa and the islands of the Caribbean.

Australia has thirty species of seagrass with fifteen species found in northeast Australia, twelve species found in northwest Australia, eleven species found in south east Australia, eighteen in southern Australia and nineteen species found in southwest Australian regions.

Figure 3: Seagrass distribution in Australian waters. Reproduced from Distribution data compiled from State and Commonwealth. Sources by Environment Australia (2000) and Kirkman (1997).



SEAGRASS SPECIES IN NSW

5 Seagrass Species in New South Wales

In New South Wales there are eight species of seagrasses with many species growing south of Wallis Lake.

Seagrasses in New South Wales are generally found in estuaries and sheltered bays where ocean currents and wave action are not as great. They are often found along with other seagrass species or species of marine algae.

The most common species of seagrass in New South Wales are *Zostera, Posidonia, Halophila* and *Ruppia* species.

5.1 Posidonia Species

*Posidonia s*pecies*,* commonly known as *Strapweed*, is one of the slowest growing seagrasses in the world. Studies on *Posidonia* species have indicated that beds damaged could take hundreds of years to recover.

5.1.1 Posidonia australis

Distributed south of Wallis Lake to the New South Wales / Victorian boarder in approximately twenty estuaries. *Posidonia* can form extensive beds in clear shallow sub tidal areas to a depth of about 15m, for example, on mid-north coast of New South Wales. *Posidonia* can tolerate extremes in salinity and temperature, however it is very sensitive to changes in water clarity.

Posidonia is physically characterized by its large strap-like leaves, which are thick and stiff with rounded tips. *Posidonia* generally grows to a maximum length of 45 cm and approximately 15-20 mm wide, with 14-20 longitudinal veins. The leaves are generally bright green in colour with approximately 3-5 leaves arising from the leaf bases at the rhizomes (which occur below the sediment surface).

Posidonia australis bed (left). Individual plant relative size and root structure (right)
(Source: Peter Adderley, 2003)

5.2 Zostera Species

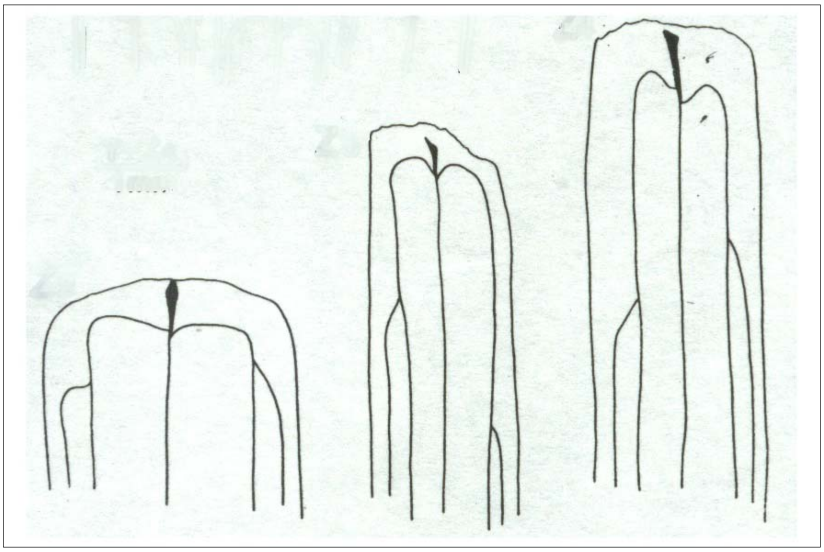
Zostera species, commonly known as *Eelgrass,* are closely related, and identification between species is difficult and often depends on microscopic analysis of the rhizome or root system.

5.2.1 Zostera capricorni

Distributed statewide and is an adaptable species. *Zostera capricorni* is tolerant of exposure and depending on light penetration, can be found in depths ranging from 0-7m.

The physical characteristics of *Zostera capricorni* are quite variable depending on environmental conditions. Leaves range from very short and narrow, to long and wide although the tip of each leaf is blunt. Leaves vary from 7-50 cm long and 2.5-5 mm wide, with 4-5 longitudinal veins. The leaves also vary in colour from bright green to brown and approximately 4-6 leaves arise from the leaf bases at the rhizomes (which occur below the sediment surface).

Zostera capricorni bed (left) Individual plant relative size and root structure (right) (Source: Peter Adderley, 2003)

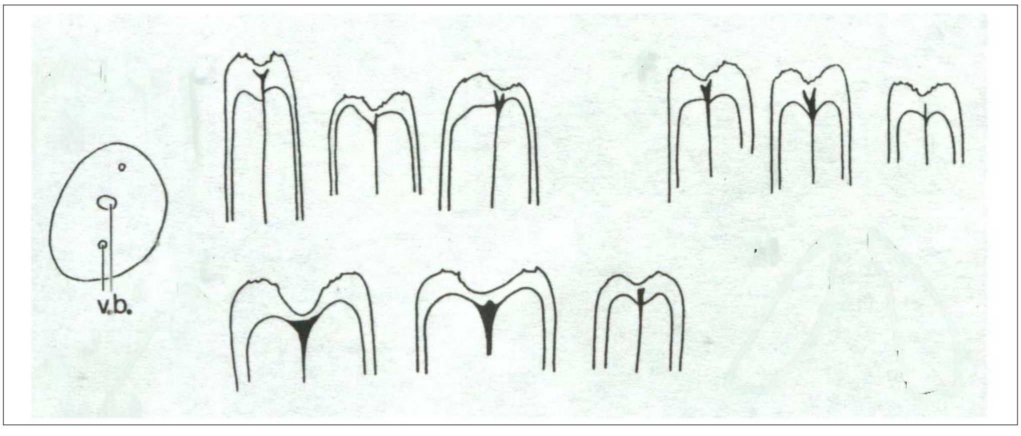


Leaf apices of *Zostera capricorni*. Rhizome vascular bundle is the same as *Zostera muelleri* (Reproduced from Womersley, 1984)

5.2.2 Zostera Muelleri

Distributed in southern New South Wales, from the New South Wales / Victorian boarder to Sussex Inlet. *Zostera muelleri* is found in inlets and estuaries, on mud or sand in the intertidal region on calm water coasts, in lagoons and other land-locked waters.

Physical characteristics of the species varies considerably, including leaf apex shape, length and breadth of leaf blade, the number of roots per node. Leaves vary from 5-10 cm long (to 60cm long when permanently submerged) and 1-3 mm wide. Leaves have 3 longitudinal veins (the two lateral ones very close to the margin so the leaf may appear to have one vein) and the apex is rounded with a shallow or deep notch and frequently small denticulations. Approximately 2-5 leaves arise from the leaf bases at the rhizomes (which occur below the sediment surface).

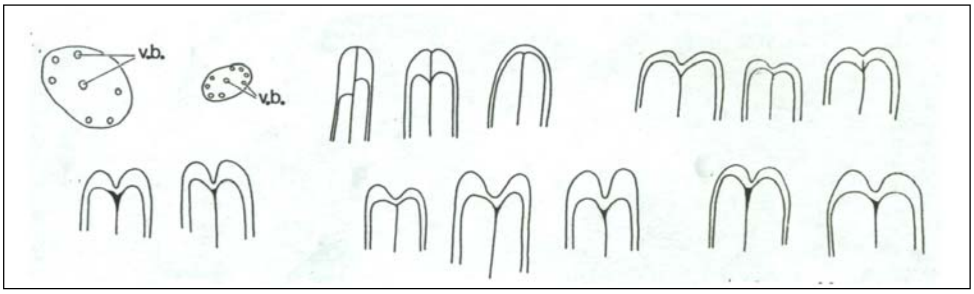


Rhizome vascular bundles (left) and leaf apices (right) of *Zostera muelleri* Reproduced from Womersley, 1984)

5.2.3 Heterozostera tasmanica

Distributed in southern New South Wales, from the New South Wales / Victorian boarder to Jervis Bay. *Heterozostera tasmanica* usually occurs in shallow coastal waters, from below low tide level to a depth of approximately 8m.

Physical characteristics of *Heterozostera* include leaf blades that are generally long and thin with a rounded apex or tip (usually deeply notched), sometimes with fine denticulations (teeth). Leaves are usually in bundles of 2-6 per shoot and are between 20-25 cm long, 1-2 mm wide, with 3 longitudinal veins.



Rhizome (far left) and stem (right) Vascular bundles and the leaf apices of variously aged *Heterozostera tasmanica* (Reproduced from Womersley, 1984)

Leaf shaft, stem and reproductive structures of *Heterozostera tasmanica* (Reproduced from Womersley, 1984)

5.3 Halophila Species

Halophila species commonly known as *Paddleweed* is one of the smallest seagrass species in the world. This species is a coloniser and recovers well after disturbance.

5.3.1 Halophila ovalis

Distributed statewide in tropical and warm temperate waters. This species can form extensive beds in shallow waters in clear or quite turbid waters. *Halophila* typically utilises the space between other seagrasses forming mixed beds, although it can form exclusive beds. This species prefers slightly more exposed conditions.

Physically characterized as a small seagrass with upright stems that have rounded leaves in pairs. Leaves are light green in colour and grow up to 4cm long and 2cm wide. Stems and leaves come off runners, which occur below the sediment surface and also bear the roots.

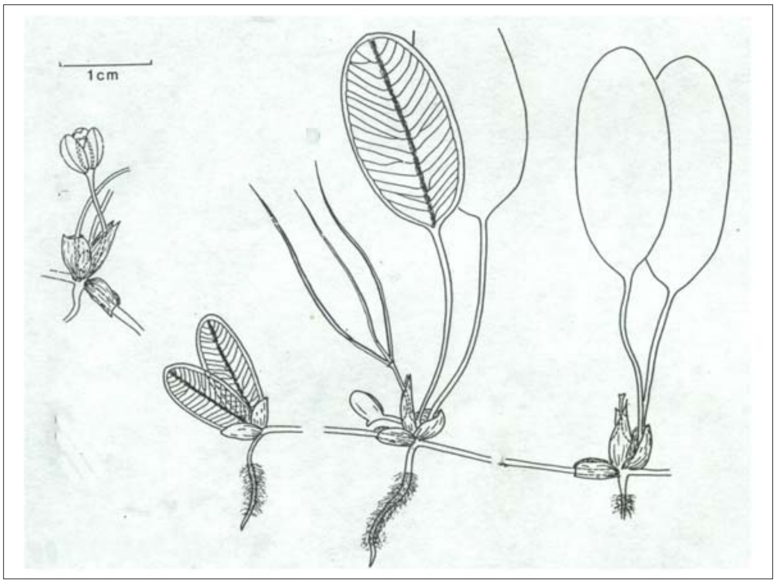


Diagram shows *Halophila ovalis* leaf structure, roots and runners.
(Reproduced from Womersley, 1984)

Halophila ovalis growing in sandy sediment (left). Individual plant relative size and root structure (right) (Source: Peter Adderley, 2003)

5.3.2 *Halophila australis*

Distributed in southern NSW from The Central Coast to the NSW/VIC boarder. *Halophila australis* is a temperate water species, occurring in both sand and mud, from low tide level to 23 m deep, usually in calm waters.

Physical characteristic include small upright, elongated oval (lanceolate) leaves in pairs. Leaves are usually between 5-6 cm long, 6-15mm wide and are narrowed towards the base. Stems and leaves come off runners (which occur below the sediment surface) and which also bear the roots.

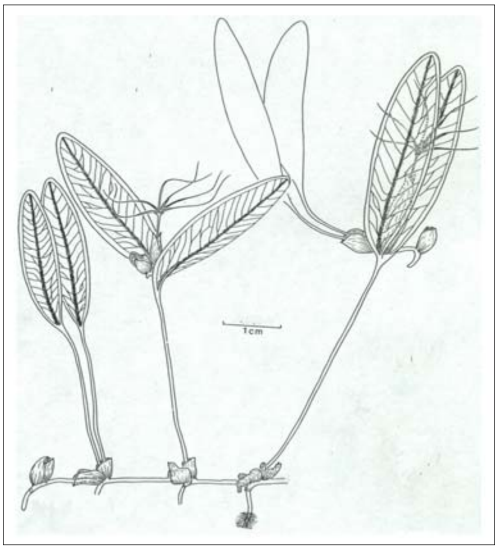


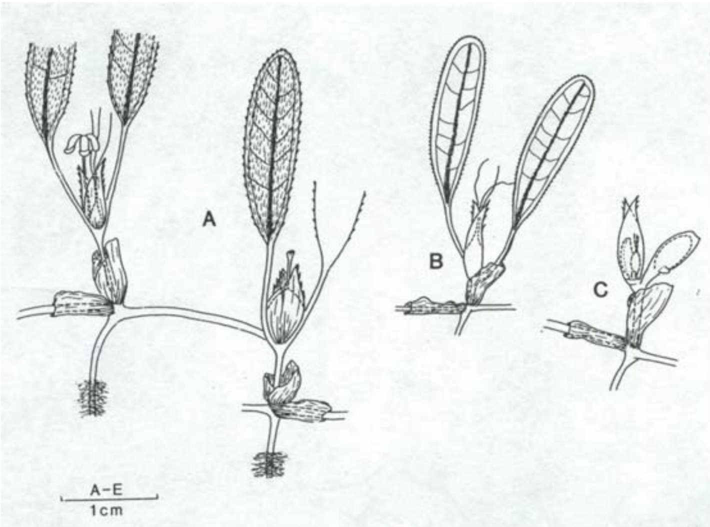
Diagram shows *Halophila australis* leaf structure, roots and runners (left). (Diagram reproduced from Womersley, 1984)

Leaves and stems of the elongated leaf of *Halophila australis* (right) (Source: EPA QLD, 2003)
An individual runner with attached stems and leaves (left) (Source Peter Adderley, 2003)

5.3.3 Halophila decipiens

Distributed statewide in tropical and warm temperate water species. *Halophila decipiens* occurs in sand and mud, usually from low tide level to 4 m deep.

Physically characterized as a small seagrass with delicate, bright green paired leaves, glabrous or with scattered unicellular hairs on one or both faces. Leaves are usually between 1-2.5 cm long, 2.5-6mm wide and are oblong-elliptical and rounded at the apex. It can be distinguished from the other species by the fine serrations on its leaf margin and its small size. Stems and leaves come off runners (which occur below the sediment surface) and which also bear the roots.



Reproductive structures and nodes of *Halophila decipiens*
(Reproduced from Womersley, 1984)

Above water view of *Halophila* in Central Coast waters in NSW (left) Leaf structure of *Halophila* (right) (Source: Peter Adderley, 2003)

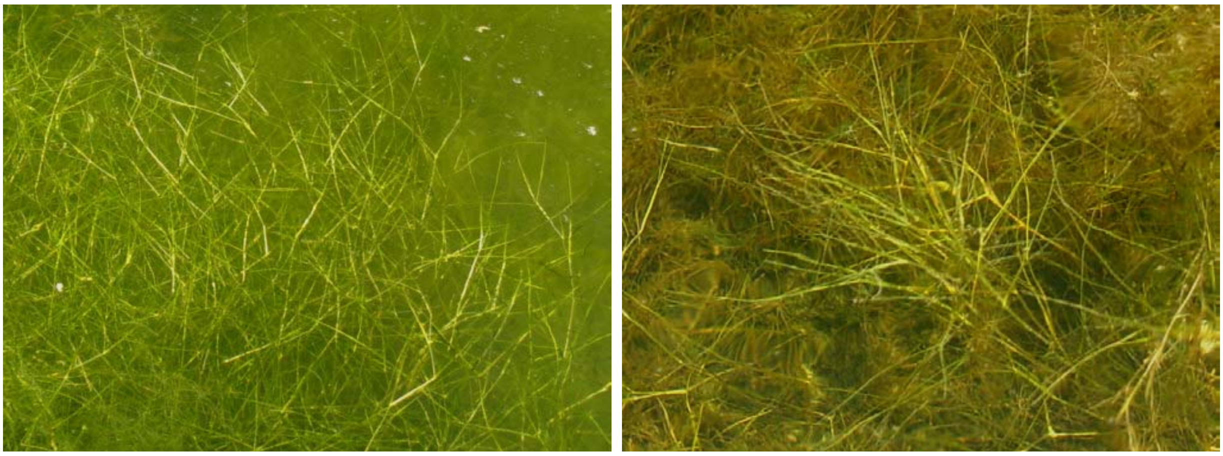
5.4 Ruppia Species

Ruppia species commonly known as Sea Tassel, is not a true seagrass as it releases spores into the air and not into the water like true seagrass. It also can tolerate a range of saline conditions including seawater to fresh water, and may be found close to salt-water sources such as the estuary mouth.

5.5 Ruppia megacarpa

Distributed state-wide, in estuaries and coastal lakes to approximately 2 m deep and can tolerate a range of conditions from highly saline to freshwater and from clear to turbid. *Ruppia* often occurs in mixed beds with *Zostera*.

Physical characteristics include long slender leaves with a narrow (0.5-2 mm), highly branched stem. Leaves are from 50-200 mm long, are generally dark green in colour and have an indented tip.



Ruppia Megacarpa leaves and stems as seen above water.
(Source: Peter Adderley, 2003)

Ruppia Megacarpa individual plant size
(Source: Peter Adderley, 2003)

SPECIES LIVING ON SEAGRASS

6 Species living on seagrass

Any plant or animal growing on the shoots or blades of seagrass that is not parasitic or gaining any nourishment from the seagrass is called 'epiphytic material'. More specifically, plant material growing on seagrass is an "epiphyte" and any animal growing on the seagrass is "epifauna".

Many organisms can grow as epiphytes with algae the most dominant type as they are able to overgrow and smother other organisms and therefore more effective competitors. The dominant animal epifauna of seagrass are bryozoans and worms. All epiphytic organisms compete with each other for resources such as space and light.

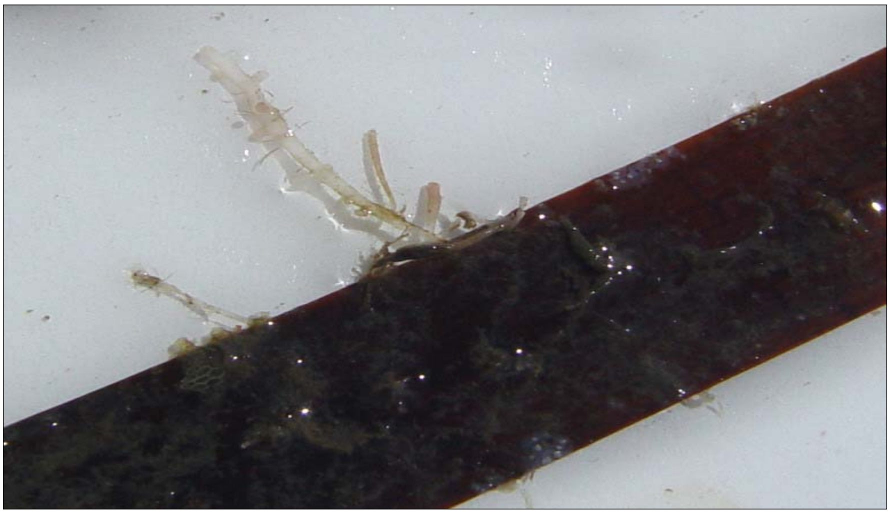
(Picture on Left) *Posidonia australis* leaf with epiphytic material (Green algae, white spiroid worms and pink bryozoans). (Source: Peter Alderley, 2003)

6.1 Epiphytes

Epiphytic algae provides habitat and food for snails (gastropods), crabs, shrimps, amphipods (shrimp-like crustaceans) and worms. Ephyphites are an important component of a productive estuarine ecosystems as they provide biomass and oxygen. As seagrass has roots and algae do not, a seagrass blade offers a point of attachment for algae not usually able to settle in sandy or muddy areas. In a healthy ecosystem, algae epiphytes are kept to a minimum by the continual shedding of leaves by seagrass, and by gastropods and crustaceans actively grazing the algae. Experiments have indicated that the presence of these grazers significantly increases seagrass growth by reducing the amount of epiphytic algae smothering the seagrass plant.

As seagrasses and epiphytic algae are competing for the same light and nutrients, seagrasses engage in partial chemical warfare with the algae. Seagrass plants release from their leaves dissolved compounds that interfere with epiphyte growth. Otherwise unchecked epiphytic algae absorb most of the light and nutrient before they reach the seagrass, reducing seagrass photosynthesis and hence growth.

There are many species of epiphytic algae that grow on seagrass. Some species include *Gracilaria, Laurencia intricate* and *Hypnea* species. *Gracilaria* is generally light green to yellowish in colour with many gelatinous branches, *Laurencia intricate* generally short and fleshy with easily recognisable green stems and pink tips and *Hypnea* sp. is generally orange to yellowish in colour with many slender branches, supporting many fine spine-like branchlets.



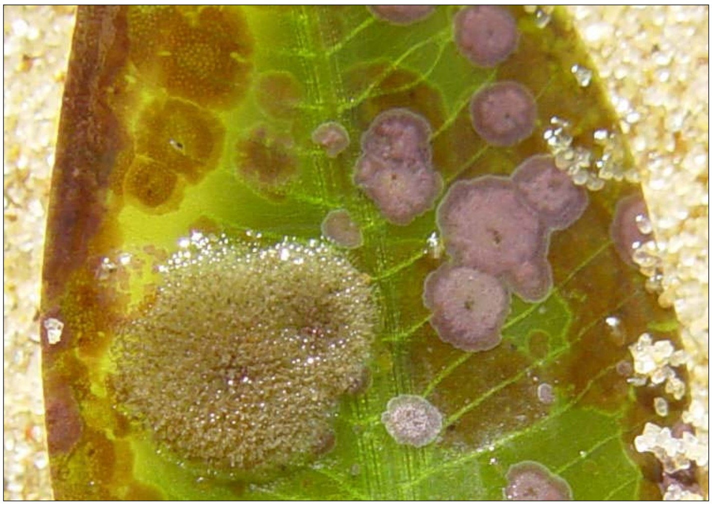
Posidonia australis with *Gracilaria* algal epiphyte (Source: Peter Adderley, 2003)

Posidonia australis with *Laurencia* algal epiphyte (Left). *Posidonia australis* with *Hypnea* algal epiphytes (Right). (Source: Peter Adderley, 2003)

6.2 Epifauna

6.2.1 Bryozoans (Lace Coral, Moss Animals)

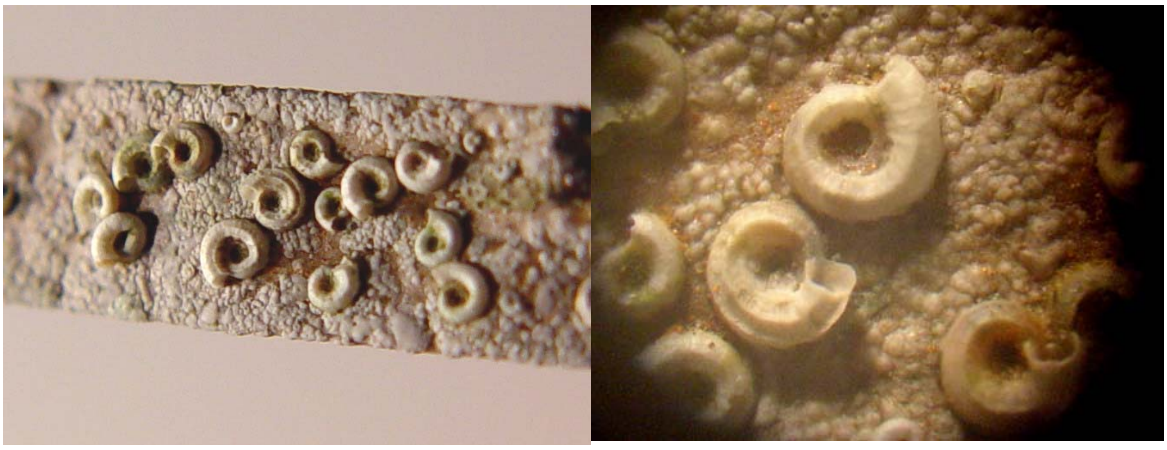
Bryozoans are small colonial animals enclosed by calcareous walls, with perforations to allow connection in a manner similar to corals. Colonies can exhibit a variety of shapes and colours however the ones that grow on seagrass leaves generally form flat, encrusting sheets that have a purplish colour.



Halophila australis with pink bryozoans (Source: Peter Adderley, 2003)

6.2.2 Worms (Spirorbid Polychaetes)

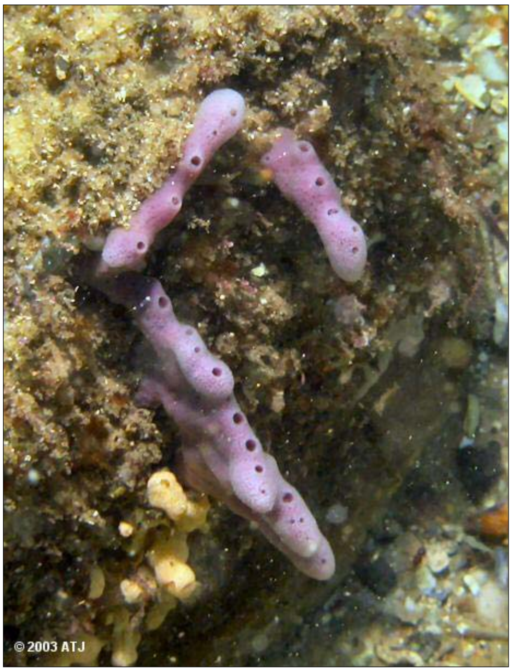
Spirorbid polychaetes are a distinctive group of worms, which live in a spirally coiled calcareous tube that is generally white and very small (1 mm diameter). They can occur in extremely high densities on seagrass leaves.



Posidonia australis leaf with Spirorbid polychaetes colony (left). Magnified view of Posidonia australis leaf with Spirorbid polychaetes (right). (Source: Peter Adderley, 2003)

6.2.3 Sponges

Sponges are a common, conspicuous and diverse group of multicellular animals, specially adapted for a stationary filter-feeding life. Sponges pump water at a high rate filtering their own volume of water in about 10 seconds. Small sponges are found attached to seagrass leaves.



Unidentified sponge
(Source: Andrew Trevor-Jones, 2003)

6.2.4 Ascidians

Ascidians are a diverse group of filter-feeding animals with very different adult and larval stages. The adult stage, being adapted for feeding and reproducing, is fixed in one spot, whereas the larval form wanders in the plankton. It is this adult stage that is found on seagrass.

Ascidians growing in marine waters on The Central Coast of NSW
(Source: Peter Adderley, 2003)

SPECIES ASSOCIATED WITH SEAGRASS

7 Species associated with seagrass

7.1 Invertebrates

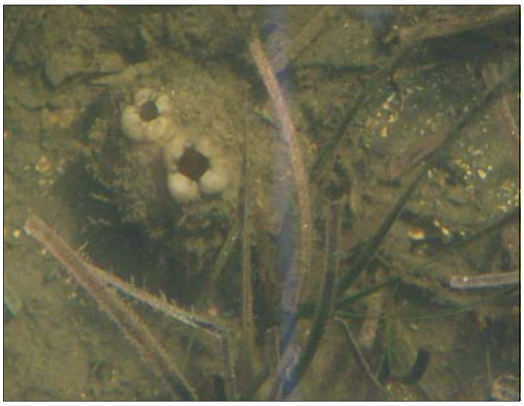
7.1.1 Mesograzers & Meiofauna

There are a number of small to very small invertebrate animals that graze on algal epiphytes and other small organisms living on seagrass. Invertebrates greater than 0.5mm are called 'mesograzers', and common species include amphipods, isopods and gastropods. Tiny invertebrate animals between 0.5mm and 0.063mm are called 'meiofauna', and this group eats microscopic organisms, such as bacteria and protozoa, are involved in the decay of seagrass. Examples of meiofauna associated with seagrass include gastropods and crustaceans.

An Isopod, an example of a mesigrazer (Source: Peter Adderley, 2003)

7.1.2 Filter Feeders

Filter feeders associated with seagrass, such as ascidians and sponges, feed on the plankton in the waters around seagrass.



Ascidian in amongst *Zostera capricorni* bed (Source: Peter Adderley, 2003)

7.2 Detritivores

Some animals feed on decomposing seagrass (and animal) particles that are richly covered in microbes such as bacteria and protozoa. Detritivores associated with seagrass include shrimp, prawns and crabs.

Prawn found among *Zostera* beds (Left). Hermit crab found in seagrass beds (*Pagurus sp.)* (Right) (Source: Peter Adderley, 2003)

7.2.1 Deposit feeders

There are a group of invertebrate animals that pass large quantities of sediment through their gut, extracting detrital and microalgal particles rich in microbes in the process. Deposit feeders associated with seagrass include peanut worms (sipunculans) and polychaetes.

Polychaete worm found in Seagrass Beds. (Source: Peter Adderley, 2003)

7.2.2 Carnivorous invertebrates

Carnivorous invertebrates are animals that feed on other animals, and many are found in or amongst seagrass beds. Some examples include many species of molluscs (e.g. pygmy squid, dumpling squid, blue-ringed octopus and welks) and crustaceans.

A striped Pyjama Squid (*Sepioloidea lineolata*) among seagrass beds in sandy sediment (Source: David Harasti, 2003)

7.2.3 Herbivorous invertebrates

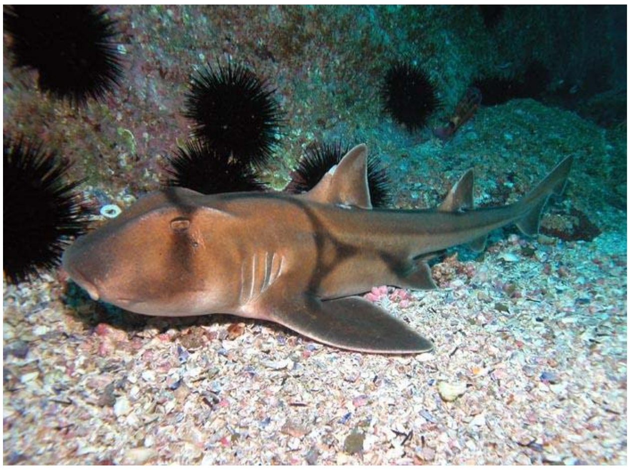
Herbivorous invertebrates feed on plants. Species associated with seagrass include many species of molluscs that eat algae and epiphytes in and amongst seagrass with their radular or tooth like tongue.

Sea Hare *Aplysia dactylomela* feeding in Zostera seagrass beds (left). (Source: Peter Adderley, 2003). Little Sea Hare *Aplysia parvula*, in *Halophila* seagrass beds (right). (Source: David Harasti, 2003)

7.3 Vertebrates

Some vertebrates found in or around seagrass may be herbivorous or carnivorous. Some examples of vertebrates associated with seagrass include fish (such as leatherjackets, garfish, mullet), rays (such as cow tail rays and eagle rays), sharks (including juvenile Port Jackson sharks), birds (such as black swans and cormorates), reptiles (including sea snakes and green turtles) and mammals (such as dugongs).

Dugong and baby in Australian waters. (Source: David Kidd, 2005)



Port Jackson shark (left). A wondering shovel nosed ray (right). (Source: David Harstii, 2003)

SEAGRASS HEALTH

8 Seagrass Health

There has been a widespread decline in temperate and tropical seagrasses within NSW. Many major estuaries have lost as much as 85% of their seagrass beds in the past 30 to 40 years contributing to declines in abundance and diversity of many species including fish and invertebrates. In some estuaries and nearby coastal zones where seagrass has declined, animals on the seafloor studies have indicated species have been reduced.

Human based disturbances have had the largest impact to most waterways in NSW by degrading and altering estuaries and coastal locations. Dredging, reclamation works, construction of jetties, wharves, marinas, bridges, ramps, groynes, breakwaters and some aquacultural facilities physically remove or disturb seagrass. Some seagrass species may not recover or may take an exceptionally long time to recover from these impacts. For example, seismic testing at Jervis Bay in *Posidonia australis* beds in 1940's created large bare circles, which have still not re-grown. Other activities such as boating and recreation trample and cut through seagrass roots with propellers and moorings.

Removal of wrack from the foreshore interferes with the natural cycling of seagrass. Wrack has traditionally been collected for use on gardens and also to remove the "smell" as it begins to decompose. This smell is often the result of a highly altered foreshore ecosystem, frequently incorporating lawn, which does not allow the wrack to aerate, dry and slowly release its nutrients as it would in a more natural system. Recent experiments on the Central Coast of NSW have indicated the growth of salt marsh is directly enhanced by the breakdown of wrack (Roberts & Chapman, 2003). Other species, such as marine invertebrates and shore birds, utilise the wrack for shelter and food. The endangered Bush Stone-curlew (*Burhinus grallarius*) has been observed sheltering amongst wrack during the day, where their mottled plumage provides excellent camouflage. Wrack removal therefore removes a key component of inshore ecosystems. Machines used to clean up the floating seagrass debris and/or wrack currently being used over some seagrass beds in NSW may lead to decreased productivity of the whole ecosystem.

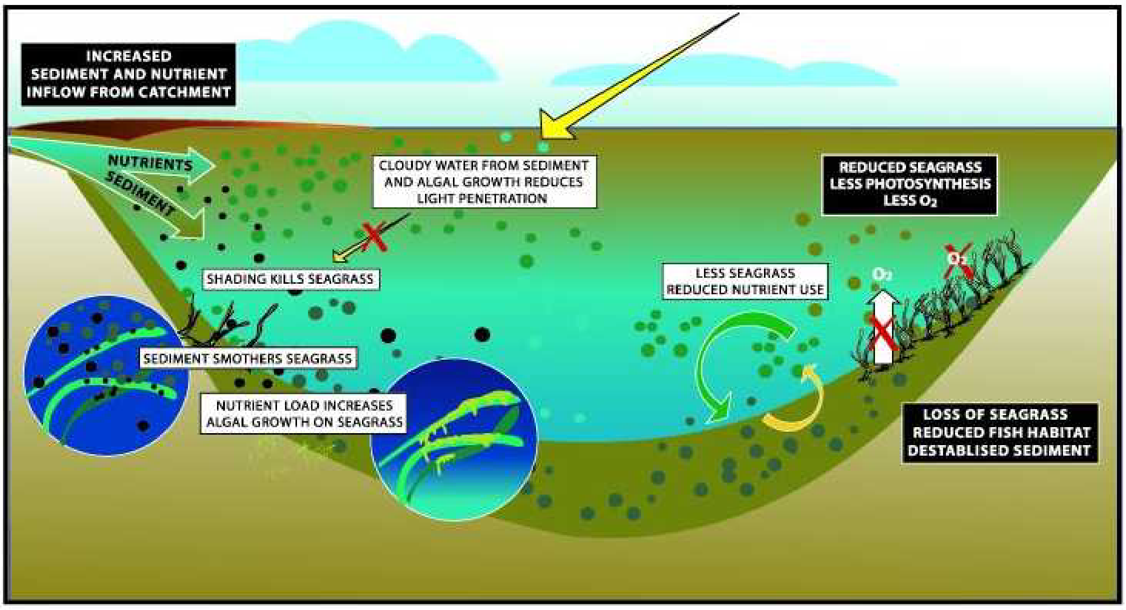
Wamberal Lagoon with major development in the catchment. (Source: Peter Adderley)

Development in land adjacent to water bodies may remove or significantly change the native vegetation fringing the waterway (riparian vegetation). This native vegetation, which often includes various combinations of native reeds (*Phragmites australis*, *Juncus* sp.), mangroves (*Avicennia marina*, *Aegiceras corniculatum*), salt marsh species (*Sarcocornia quinqueflora* and *Sporobolus virginicus*) and trees (*Casurina* sp., *Eucalyptus* sp.). These native plants act as a natural filter and buffer slowing water speed, and trapping sediment and nutrients from the runoff before it enters the water. Development in the land surrounding estuaries (the catchment) generally causes an increase in sediment loads entering the waterway through erosion, and an increase in nutrients in waterways through runoff. This in part is due to clearing these areas of natural buffers – flora.

An increase in sediment entering a waterway is called 'sedimentation', and can directly smother seagrass thus damaging or killing beds. Increased particles in the water column cause sunlight to scatter or may completely block the light available for seagrass photosynthesis, leading to degradation or dieback of seagrass also.

Increased nutrients in waterways, called 'eutrophication', may increase algal growth to 'bloom' levels, which may smother seagrass or block available light. Fertilizer, pesticides and faeces are major contributors to increased nutrients in waterways, as is run-off from soils exposed by land clearing which also causes nutrients to enter the waterways. This reduction in light can impact on the health and extent of seagrass beds and may ultimately result in seagrass death.

When seagrass beds are 'unhealthy' the ecosystem becomes less productive and less oxygen is produced for the whole ecosystem. Unhealthy seagrass environments means



"UNHEALTHY SEAGRASS ENVIRONMENT" (Reproduced from Laegdsgaard, 2001) a loss of food, shelter and nursery grounds for many species, as well as decreased 'nutrient cycling', increasing nutrients and trace elements such as heavy metals entering the ecosystem.

8.1 Disturbances, Impacts and Natural Variation

The environment is dynamic and constantly changes over time and space, meaning that seagrass health naturally changes within an area, between areas, and changes over time. Natural changes over time and space are called 'natural variation'.

Different species of seagrass react differently to natural changes and have varying recovery rates after disturbances. *Halophila* and *Zostera* are opportunistic seagrass species and, although frequently disturbed by wave action and floods, they recover quickly through rhizome growth and seed germination. A few seagrasses, such as *Posidonia*, resist wave action as they have deep, dense root mats within the sediment. Between 50 – 90% of the plant weight of *Posidonia* is buried underground in this mat. Posidonia rarely establishes beds from seeds on bare ground, needing several years of calm weather following good seed settlement for this to occur.

Estuary with Ruppia species showing many factors such as wind, sunlight and shading. (source: Peter Adderley, 2003)

Seagrass beds change seasonally, with changes developing due to many variables. For example *Zostera* and *Halophila* species are affected by water temperature changes each year, which stimulate a biological response from seagrasses to 'shed' leaves during winter. Seagrass "shedding" leads to beds contracting or thinning during colder periods, expanding and thickening during warmer months. However large-scale natural events may impact on seagrass beds, and also affect the health of the beds.

8.2 Natural impacts and disturbances

8.2.1 Storm and cyclone damage

Impacts from storm events are related to seagrass depth and storm intensity. If seagrasses grow in shallow waters they are more vulnerable to the impacts and disturbances of the storm. The more intense the storm is, the more likely that seagrasses in deeper waters will be affected. Storm damage to seagrass beds can be dramatic, with entire beds damaged or removed in a short period of time.

Changes due to the storm may affect a large or small area of seagrass beds, with impacts having a multiplication effect on living and non-living things in the ecosystem. Short-term disturbances from storm events may be a reduction in size of the beds, particularly in the shallower margins. Long-term disturbances may be one species displacing others.

Storm event over Brisbane water catchment area. (Source: Peter Adderley, 2003)

8.2.2 Flooding

Flooding from storm or rain events also has a major impact on seagrass health. Increased runoff from the catchment increases nutrients and sediment into the waterways where seagrasses grow, increasing turbidity. This decreased light may effect photosynthetic rates or smother seagrass beds completely.

8.2.3 Climatic Change over time

Climate change is a natural event, which increasingly is affecting world temperatures and currents. In 2002 seagrass burning occurred over a number of seagrass beds in Australia including the Whitsunday's in Queensland, leading to damage and loss of seagrass beds. Full recovery from severe bleaching events over seagrass beds may take years if viable seed banks are not present for the recruitment of seedlings to occur.

8.2.4 Disease, predation and pest species

Predation is a natural occurrence and is a vital link to the food web in the ecosystem. Species including Dugong and Green Turtles, as well as many fish and mollusk species feed directly on seagrass beds, affecting leaf density and health.

Posidonia australis with "bite" marks from predation. (Source: Peter Adderley, 2003)

Natural diseases such as bacteria and fungal growth, as well as parasites, also affect seagrass health often degrading organic matter and root structures.

Pest species also effect seagrass health and may affect other floral and faunal species. Direct predation of native species, competition for space and food, have resulted in competitive exclusion and extinction of native species in seagrass beds of sea star species (*Patiriella regularis)*. Changes in food web and habitat structure may occur, or pest species may, by accumulation of toxins, effect species higher in the food chain. Disruptions to aspects of nutrient cycling and benthic conditions by introduced species of fan worms for example may also effect where seagrasses an grow.

8.2.6 Abiotic factors

Abiotic factors are variables that are not living that may effect seagrass such as temperature, salinity, fresh water inputs, dissolved oxygen, turbidity and total dissolved solids. These alter over time and space naturally as a response to abiotic interactions in the ecosystem. For example, if the weather is hot and dry, water temperature may increase leading to an increase of salinity as water vapor is evaporated leaving more salts and total dissolved solids in the remaining water column. In contrast, if there are periods of cold weather with rain, then dissolved oxygen levels may increase, as will fresh water inputs leading to a decrease in salinity. These processes naturally affect seagrass health especially in terms of photosynthesis.

Another abiotic factor impacting seagrasses is hydraulic action or water movement such as tides and currents. In New South Wales each year during winter, hydrodynamic forces and wind force increase with southerly winds and stronger water currents naturally affecting seagrass stability. Such processes mean that the seagrass bed density decreases as “shedding” occurs and tides and currents cause increased rates of wrack (seagrass leaf) accumulation in water and on shore.

8.3 Human impacts and disturbances

Human impacts and disturbances may affect seagrass health and accelerate degradation of the ecosystem. The following are some human activities that affect seagrass health.

8.3.1 Boating – propellers, traffic, swing moorings and anchors

In areas of high boat traffic near seagrass, seagrass beds can suffer damage from propellers or hulls gouging into and up-rooting seagrass. When boat propellers hit seagrass they physically remove plants and cause damage to roots. As one seagrass plant often has extensive root structures connecting them, damage from propellers often means significant damage or death of seagrass in most cases.

Additionally, constant boat traffic may reduce various aspects of water quality such as increasing turbidity, particularly in muddy areas as fine mud or silt is constantly re-suspended in the water column, and/or increasing water pollutants such as oil and fishing line. In area where such impacts occur over time seagrass beds can become patchy or otherwise reduced in extent, density and condition.

Propeller damage by boats in seagrass.
(Source: Peter Adderley, 2003)

Where swing moorings are located in seagrass beds, the chain on the lower portion of the mooring has a tendency to plough up the seagrass bed in a neat circle around their point of attachment in the sediment. This area is commonly bare sand or mud with little or no seagrass growth.

'Setting anchor' in seagrass creates holes within beds reducing area density and increasing "patchiness" of seagrass distribution. With a loss of seagrass roots acting like a 'mat' to stabilize sediment, the area is more susceptible to erosion from wave and tide action. The unstable sediment may then be carried over seagrass beds further decreasing them.

8.3.2 Reclamation and dredging

Reclamation of coastal areas over the last fifty years has meant significant loss of seagrass areas as estuaries and coastal waterways have been "filled in." Draining, infilling or clearing of land for urban or rural foreshore development, in many cases, completely destroys estuarine and coastal ecosystems. Reclamation may reduce the tidal range of an estuary or river leading to alteration of water inputs, and affecting water quantity through increased turbidity and complete removal of habitat.

Dredging works in areas where seagrass growth occurs is generally conducted in order to aid navigation, modify water flow, obtain supplies of natural materials such as sand and gravel or to lay pipes and cables. Dredging physically removes and destroys areas of seagrass beds, degrades and alters underlying sediment and decreases ecosystem quality by increasing turbidity and sedimentation. Seagrass beds have varying rates of recovery especially when seed banks within the sediment are disturbed, however some species may never recover.

8.3.3 Water movement changes, shading and physical damage by construction

Construction of structures such as groynes, breakwaters, break walls, jetties, wharves, bridges, ramps, pontoons, marinas and various aqua cultural facilities (e.g. fish farms) may alter the natural environment causing physical changes and shading of

Jetties in Brisbane Waters. (Source: Peter Adderley, 2003) the waterway affecting seagrass beds in the ecosystem. They can also affect water movement restricting the extent and health of seagrass beds. Construction of such structures within an estuary can dramatically change the water movement or hydrology of a water body. Changes to the waterways may include alteration of the entrance of the estuaries; dredging and dumping dredge spoil within estuaries, shading effects and changes in water circulation or currents.

As well as having a direct impact on the waterway during construction, these structures have long-term effects on the health of seagrass beds. These effects relate to water movement and impacts include changes in tidal exchange, water velocity and increased sedimentation. Water quality may be affected due to a reduction in water movement meaning less oxygen, and increased nutrients (causing eutrophication), algal bloom and seagrass degradation. On the other hand alteration of water movement may mean high velocity water movement, physically damaging seagrass beds by ripping out sediment and damaging root structures.

8.3.4 Seagrass Wrack Removal

Seagrass wrack (leaves detached from the original plant) plays a vital role as a microhabitat both in the water and along the shoreline. Its removal decreases food, shelter and nursery areas and alters food webs, as well as disturbing nutrient cycling within an estuary. Many animals attach eggs to seagrass wrack and removal of wrack kills these organisms. Seagrass wrack also plays an important role in maintaining inshore marine ecosystems, and removal can mean a change in abiotic conditions to the foreshore. Seagrass wrack on shore provides a cover retaining moisture and reducing the temperature of the substrate as well as being a significant nutrient contributor to foreshore communities. For example studies show that where seagrass wrack was removed from foreshore ecosystems, individual salt marsh numbers were reduced inn estuaries in NSW.

Seagrass wrack in water and on shore. (Source: Peter Adderley, 2003)

Removal of seagrass using tools or mechanical methods, such as a weed harvester, can disturb seagrass beds and impact on the extent and condition of the bed. Mechanical collection of wrack can disturb inshore areas by increasing turbidity as well as breaking and disturbing inshore seagrass beds. This results in inshore areas being more susceptible to destabilisation or erosion from wave and tide action. If growing seagrass is trimmed or wrack is removed by a weed harvester or any other mechanical method, the integrity of the seagrass bed can also be affected as mechanical weed harvesters are not always 100% selective for dead, floating seagrass and have been known to remove healthy seagrass plants. This can reduce the density of a seagrass bed and increase the "patchiness" of its distribution.

Seagrass harvester in Tuggerah Lakes. (Source: Peter Adderley, 2003)

8.3.5 Excess nutrients

Seagrass health is impacted upon greatly by excess nutrients and/ or increased sediment enters the waterway. This can occur as a result of a combination of human and natural impacts and disturbances. Increased nutrients and sediment entering the waterway through the catchment and alter natural quantities, often impacting on seagrass health and the water quality of the whole ecosystem.

The result of excess nutrients into the waterway often results in blooms of algae in the water. Small algae in the water column (phytoplankton) in or around seagrass beds can respond to an increase in nutrients by multiplying and growing faster than when there are normal nutrient conditions for that system. The result of growth and multiplication is a bloom covering the water surface and within the water column.

Under bloom conditions, large algae may out-compete seagrass for space while small algae reduce the light availability and therefore photosynthetic ability of seagrass. The result is often diminished health of seagrass with symptoms including colour changes from green to brown, and leaves are often slimy to touch.

Algal blooms affect water quality and therefore not only effect seagrass but also many other organisms in the ecosystem. As algae breaks down large amounts of dissolved oxygen is consumed by bacteria breaking down this algae. This effects the levels of oxygen in the ecosystem, in turn effecting photosynthetic rates of seagrass. It also makes respiration difficult for other species such as fish and invertebrates. A symptom often seen after algal blooms is large fish kills.

Another indicator of nutrients in the waterway is epiphytic algal growth on seagrasses. Excess growth provides important insights into nutrient availability in the waterway. When there is an excess nutrient present in the waterway there may be excess epiphytes covering seagrass, which may smother and restrict photosynthesis.


Algal bloom over *Ruppia* seagrass beds (left). Dense epiphytic algal growth on *Zostera capricorni* (right). (Source: Peter Adderley, 2003)

8.3.6 Excess sediment

Excess sediment in the waterway clouds the water and can settle on the blades of seagrass. This reduces the capacity for photosynthesis and over time will cause the loss of condition including colour changes from green to brown, and leaves, when scraped, have a fine sediment or mud layer on them. If light penetration through the water column is reduced due to changes in water quality, the depth at which seagrass can successfully grow is correspondingly reduced. Thus, reduced light results in seagrass beds becoming limited to shallower waters over time.

A significant reduction in light may also effect the health of seagrass by reducing the plants ability to photosynthesise. Reduced light through increased sedimentation may be a result of a variety of different disturbances, including water quality issues in the catchment and structural changes such as jetties, wharves, marinas, pontoons or significant foreshore development.

Recent research suggests a reduction in light can cause an increase in the length of seagrass leaves over time. The seagrass leaf responds to the lack of light by increasing its leaf length, to reach higher up into the water column towards the light. Growing longer to reach light requires high energy from seagrass plants, which may affect their respiration and photosynthetic rates. This reduces the density of seagrass beds as each plant reduces its production of leaves per shoot and also the number of shoots per bed are greatly reduced.

Sediment entering a waterway from a building site. (Source: Peter Adderley, 2003)

DIFFERENCE BETWEEN SEAGRASS & ALGAE

9 Difference between algae and seagrass

Marine algae's or 'seaweeds' are often confused with seagrass species, however the two are vastly different. The major difference between seagrasses and algae is that seagrasses have a true root system. Seagrasses are thus able to successfully colonise otherwise unstable surfaces, such as sand and mud, whereas most algae cannot. Algae instead pocess a structure known as a "holdfast", which generally grow from hard surfaces. Other differences can be seen in the table below.

Reproductive flower of *Zostera Capricorni*. (Source: David Harsitii, 2003)

TABLE 1. DIFFERENCES BETWEEN SEAGRASS AND ALGAE SPECIES

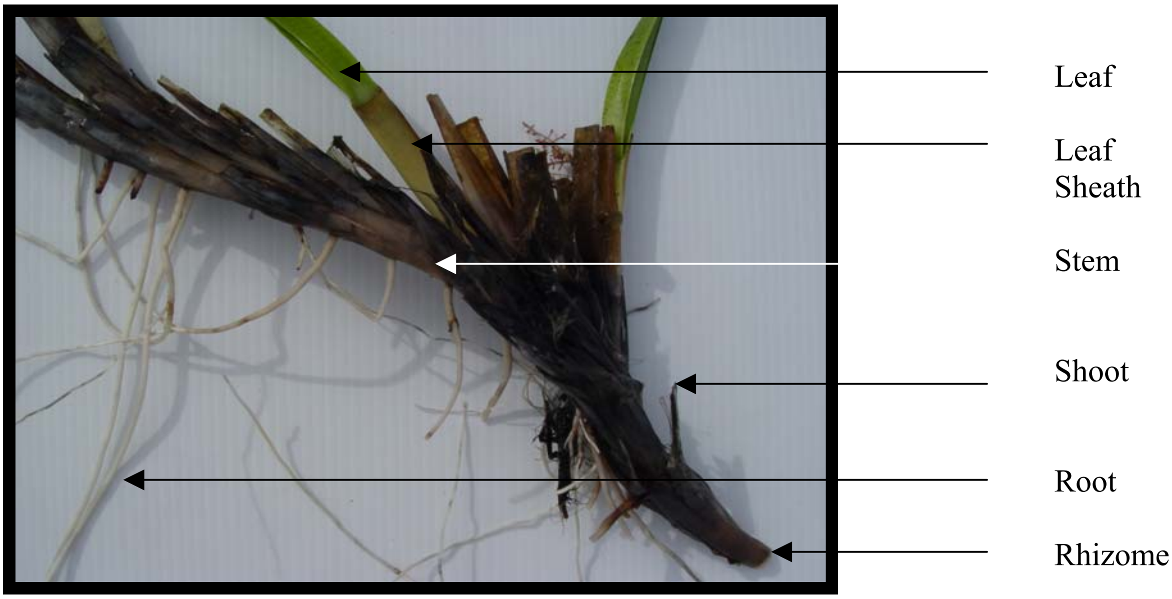
	SEAGRASS	**ALGAE**
Kingdom	Plantae – Plants with true roots, and leaves which photosynthesise	Protist - Not biologically a plant but it photosynthesizes
General description of structure	Angiosperm – True plant with roots, leaves and stems	Thallus – multicellular structure
Settling mechanism	Rhizomatous Roots	Holdfast
Nutrient Uptake	Through root system	By osmosis from water column into cells
Physiology	Complex Vascular plants	Simple few cell structure
Separate Male/ Female	Generally male and female individuals, but can have male and female elements together e.g. flowering structures.	Generally individuals not separate sex, however for some species male female individuals are separate
Reproductive Mechanism	Fruits, seeds, spores and asexual root branching and budding	Gametes, spores and asexual budding (splitting in half)
General Reproductive time in NSW waters	Winter early spring	Varies annually between species

9.1 Seagrass Structure

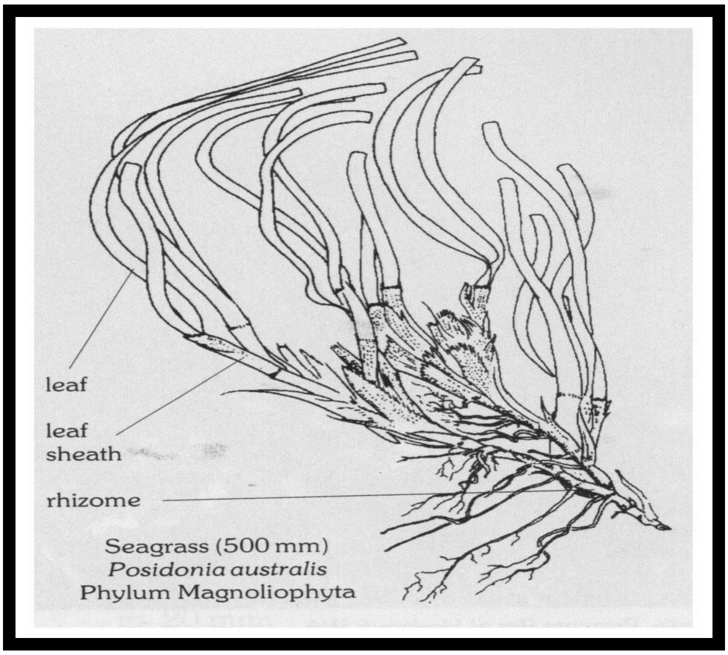
Seagrasses, like land plants, are structurally complex, possessing the structures shown in the table below

TABLE 2. SEAGRASS STRUCTURES AND FUNCTION

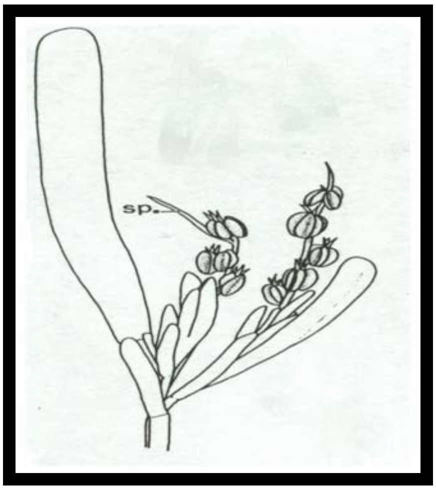
Seagrass Anatomy - Structure	Description / function
Root	For stability and nutrient uptake
Rhizome	A system of roots that extends both below and under the ground, connecting other plants in one entire living network.
Shoots	To expand and grow
Stems	For nutrient exchange within all structures of the plant and for strength
Leaves	The main area for photosynthetic processes to occur
Leaf sheath	Point at which the leaf is attached to the stem, gives leaf support
Flowers, fruits and seeds	For reproduction

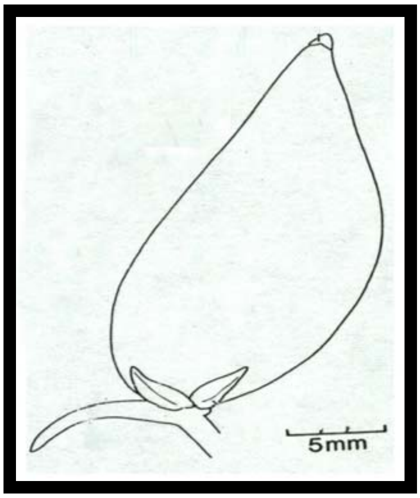


Seagrass Structures using photo of *Posidonia australis* species
(Source: Peter Adderley, 2003)



General seagrass structure, *Posidonia australis*
(Source: Reproduced from Edgar, 2001)





Flower (left) and fruit (right) of *Posidonia australis* - (Reproduced from Womersley, 1984)

Seeds and reproductive structures of *Ruppia megacarpa* (Source: Peter Adderley, 2003)

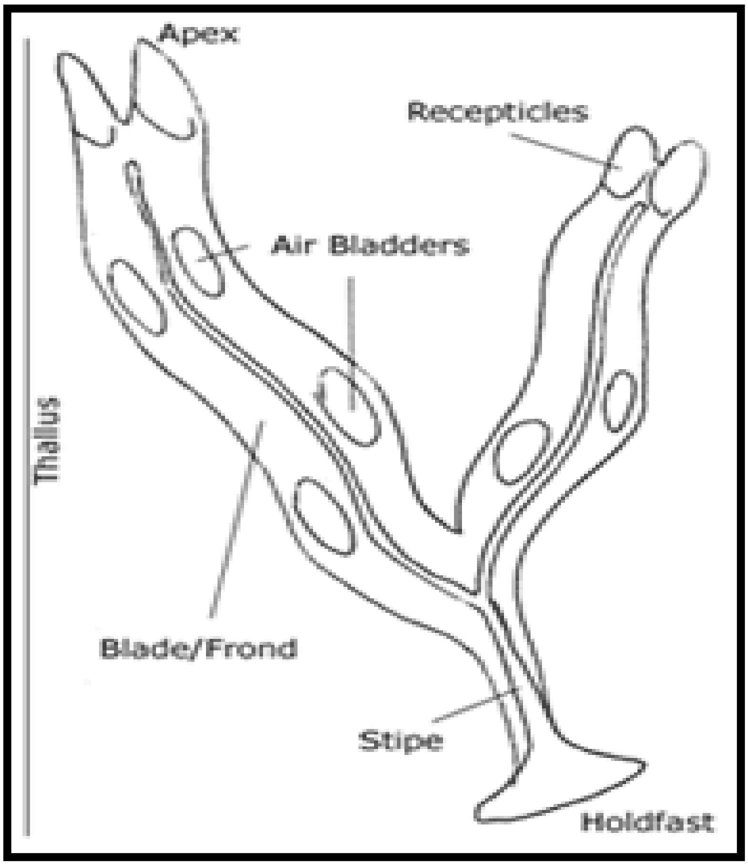
9.2 Marine Algae Structure

Algae have a simple structure and are not part of the plant kingdom as they do not have true roots, stems and leaves but structures known as foliose or leathery. Foliose algae are sheets of tissue attached to substrate by a small holdfast where as leathery algae are large with a complex structure, comprising of many adaptations to its environment such as bladders and the large claw holdfasts.

TABLE 2. MARINE ALGAE STRUCTURES AND FUNCTION

Marine Algae Anatomy - Structure	Description / function
Holdfast	For attachment to substrate usually rock
Thallus	Plant Body is called this; it is a body of cells
Supportive structures	Air bladders or pockets of air that hold the thallus upright in water for photosynthetic activity
Stipe	Stem like portion of Thallus
Blades or Fonds	Like leaves, are the main area for photosynthetic processes to occur
Cell walls (outside of algae)	The cell wall or outside of the algae; is generally slippery. This is Alginic Acid a source of *Alginate* which has the function of water-holding and stabilising, especially important when algae is exposed at low tide
Recepticules	The reproductive organs consisting of concepticles and receptacles.
Flagella	Whip or tail like structures on the outside of cells that beat to produce water currents, usually during reproduction.

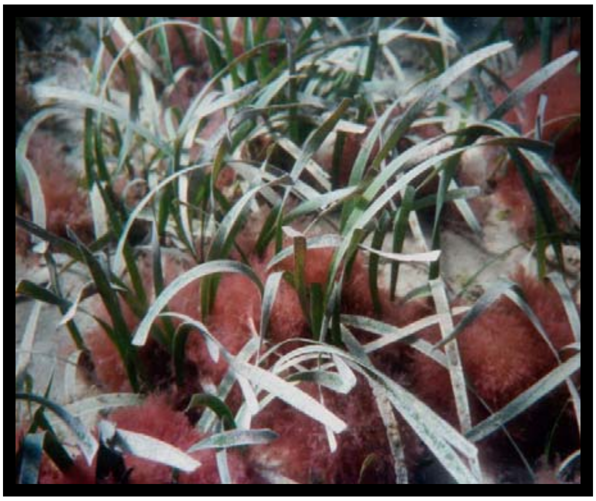
Marine Algae anatomy using photo of *Codium fragile* species (Source: Peter Adderly, 2003)



Structure of Marine Algae (Source: Reproduced from Davis, A. 2002)

9.3 Marine Algaes

There are many types of marine algae globally, both large and small. Algae that are large and easily seen with the naked eye called “macro” alga, and small film type alga are called “micro” alga. Marine macro algae are often called ‘seaweed’, however they are not weeds at all but important marine species. Human uses of seaweed extracts include uses as a stabilizer, emulsifier, in agar, and as carrageenans. Like seagrass, macroalgaes are important sources of food, shelter and nursery grounds for a number of species including fish and invertebrates. A dead macro alga, which drifts in the water, is important as a microhabitat onshore and in the water. Drifting marine macroalgaes are important as a point for egg attachment for recruits, as well as food and shelter for many species such as abalone.



Picture Left: Mixed bed of *Posidonia australis* and filamentous red algae
(Source: David Harasti, 2001)

Mixed bed of seagrass (*Zostera capricorni*) surrounding and brown macroalgae (*Cystoseira trinodis*)
(Source: Peter Adderley, 2003)

9.4 Species of marine algaes

There are three main divisions of marine macroalgaes worldwide including red algae's of which there are 6000 species (scientific name Rhodophyceae), brown algae's of which there are 2000 species (scientific name Phaeophyceae), and green algae's of which there are 1200 species (scientific name Chlorophyta). Marine macroalgaes in New South Wales are often found along seagrass species or species of other marine algae's. The most common species of seagrass in NSW include species of brown, green and red algae's.

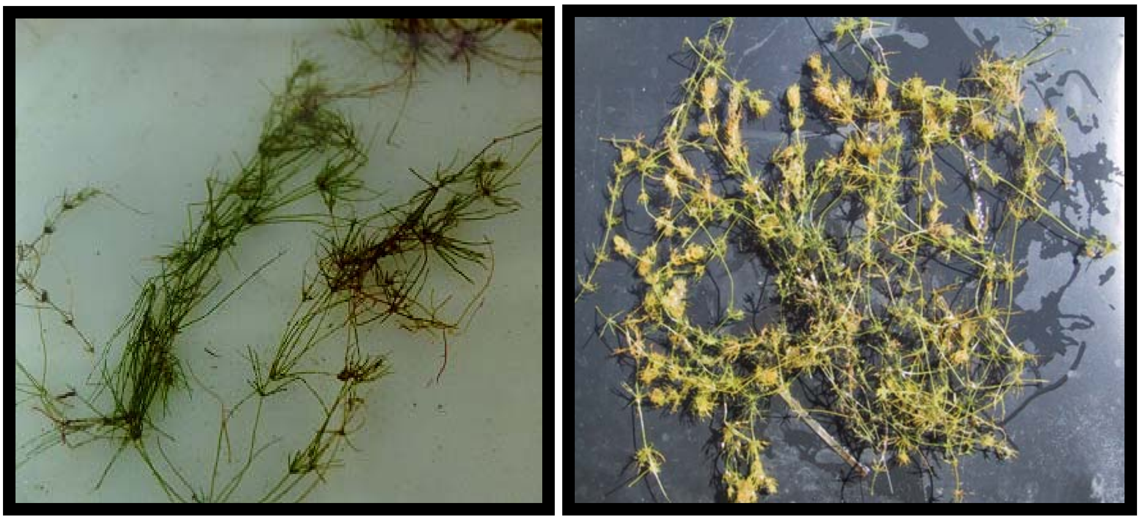
9.4.1 Green Algae

Green alga have no pigments to mask chlorophyll contained within their cells, and therefore appear green. Green alga all photosynthesise and contain chlorophyll a and b. Green algae species reproduce sexually and also do not have specialized supportive cells. Common species of green algae in NSW waters are below.

Chara species

With a common name of *stonewort*, this alga is distributed statewide, preferring to grow in slow moving to stationary waterways. *Chara* prefers to grow in waters with abundant concentrations of calcium contained in the water body.

Physically characterized by distinctive whirls of small spikes, located at approximately 2 cm intervals along the strand, which are slightly coarse and prickly due to calcification. *Chara* can form extensive exclusive beds up to 4 m deep. *Chara* varies from a bright green to a dark grey-green depending on location, growing to 1 m in length.



Chara species
(Source: Pia Laegdsgaard, 2001)

Chaetomorpha Species

Chaetomorpha is distributed statewide in sheltered locations often in close proximity to seagrass. If nutrients are plentiful, *Chaetomorpha* can form large dense beds which fill the water column.

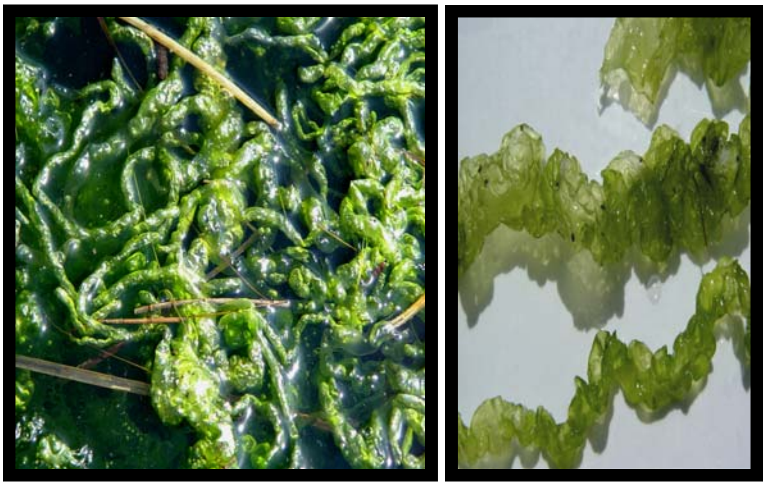
Physically characterized as a filamentous algae which forms a tangled masses of thin bright green filaments, that appear pale if bleached by the sun.

Chaetomorpha species
(Source: Peter Adderley, 2003)

Enteromorpha species

With a common name of *Green Guts*, this alga is distributed statewide, in shallow water, often floating over seagrass. If nutrients are plentiful, particularly after flooding events, *Enteromorpha* will bloom.

Physically characteriesed by its bright green colour and tangled masses, Enteromorpha appears ribbon-like. This species structure is a branched tube with very thin walls.

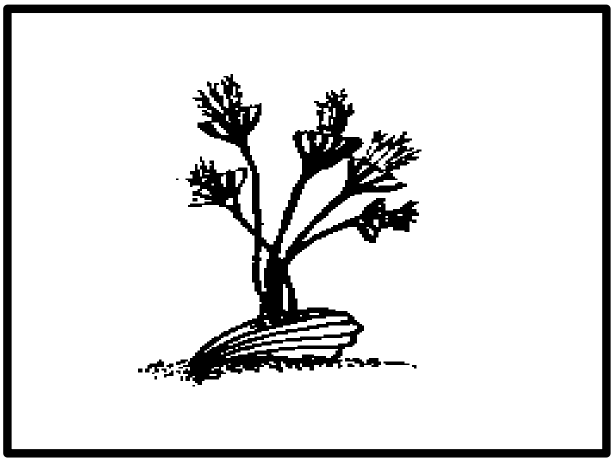


Entomorpha Species
(Source: Peter Adderley, 2003)

Acetabularia calyculus

Commonly known as *Mermaids Wineglass*, this species is distributed statewide in shallow water and in the absence of any other vegetation. *Acetabularia* only grows on hard substrates and abundantly on rocks or dead shells buried in the substrate.

Physical characteristics include small, delicate algae, approximately 5-10 cm long, with a cup at the apex (top) of a central stalk. It is slightly calcified and light green.



Acetabularia calyculus or Mermaid wineglass
(Pia Laegdsgaard, 2001)

Codium

Codium fragile is one of a number of temperate *Codium* species with a statewide-distributed species, preferring sheltered or moderately exposed reef up to 2 m deep. *C. fragilis* can form abundantly in shallow water and will attach and grow on hard materials such as bivalve shells as well as reef surfaces.

Physically characterized by its dark green-branched fork structure, *Codium* grows to a maximum length of 30 cm. The forked branches have a furry appearance due to a profuse covering of hairs.

Codium fragile or dead mans fingers
(Source: Peter Adderley, 2003)

9.4.2 Brown Algae

Brown algae appear brown due to carotenoid pigment (fucoxanthin), which reflects yellow light. Brown algae photosynthesis and contain chlorophyll a and c, and store the products of photosynthesis in the cytoplasm in the form of granules of laminarin. Brown alga contain four membranes or layers around chloroplasts, the structures for photosynthesis. There are no supportive cells around gametes when sexually reproducing, and reproductive cells are motile (move) with two different arm like structures called flagella

Cystoseira trinodis

Also known as *Cockleweed*, this alga is distributed statewide in intertidal and subtidal sheltered and semi-exposed shores. Often found growing attached to shells or rocks within the sediment and can occur as large beds or mixed with seagrass species.

Cystoseira trinodis commonly known as *Cockleweed* (Source: Peter Adderley, 2003)

Physical characteristics of this species include its large size, growing to a length of 1.5-2 m, with several main radially branched axes (branches). The main branches have small spiny projections with small leaf-like structures often present. Small swellings may be present, usually in a chain of up to four.

Sargassum Species

A statewide distributed common algae, which is found in a variety of locations including amongst seagrass beds and floating on the surface of coastal lakes.

Physically characterized as a large brown algae with several species from 1-2 m long, generally with unbranched leaf-like lateral branches and large spherical flotation vesicles.

Sargassum species (Source: Peter Adderley, 2003)

Padina species

With a common name of *Funnel Weed*, this alga is distributed statewide. *Padina* is often found attached to hard structures such as rocks, pylons and oyster racks.

Physically characterized by its small to medium size, this alga grows in a flattened flower-like form in a slightly calcified state. The outer margins of the algae are in-rolled and concentric rings bearing the reproductive structures, can be seen on the algae surface.

Padina or Funnel weed
(Source: Peter Adderley, 2003)

Hormosira banksii

Also known as *Neptune's Necklace* or *Sea Grapes*, is found in New South Wales from Port Macquarie to the New South Wales / Victorian border. *Hormosira banksii* usually occurs in shallow coastal waters, from mid-tide level to low tide level.

Physically characterized as a distinctive dark brown or green algae made up of strings of hollow, water-filled, round or oval-shaped beads/ vesicles that are 15 mm in diameter. Beads are joined together by a short stalk called "fronds," which may be between 10 - 30 cm long, covering the outside surface of each bead.

Hormosira banksii species
(Source: Peter Adderley, 2003)

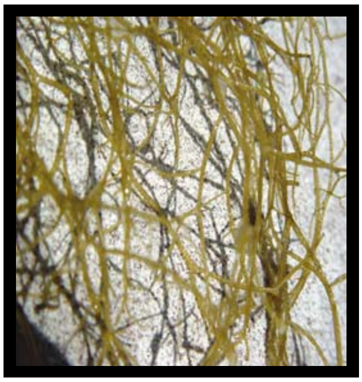
9.4.3 Red Algae

Red algaes appear red due to phycobiliprotein, a pigment that make these plants look red or pink. These species photosynthesise and contain chlorophyll a, as well as Floridean starch to store energy material in the cells. This group has no flagellated cells.

Red algaes have a greater number of marine species than the green and brown combined. This in part, is due to the ability to grow in deep waters depths compared to greens and brown algaes, which are generally restricted to around 50-60 metres. This is due to the red pigmentation contained in the cells of red algaes, and some species have been recorded as deep as 200 metres.

Gaillardia species

This diverse species has a statewide distribution, preferring in intertidal and subtidal regions. Gracilaria may occur alone or mixed with seagrass species such as *Zostera*.



Gracilaria species
(Source: Peter Adderley, 2003)

Physical characteristics vary between species, often forming tangled masses with firm fleshy body. All species have a central axis from which branches arise and vary in colour from yellow to bright red.

Laurencia species

A diverse group, distributed statewide, preferring sheltered areas among seagrass or in moderately exposed reef up to 10 m deep. Approximately 20 species of *Laurencia* occur in southern Australian waters.

Physical characteristics vary between species, but all are firm and fleshy. Species found in southern Australian waters possess an indentation in the tip of the branches.

Laurencia species (Source: Peter Adderley, 2003) taxifolia

Introduced Species - *Caulerpa taxifolia*

10 Introduced Species – *Caulerpa taxifolia*

There are a few species of algaes that are often confused as seagrass species. One such species is *Caulerpa taxifolia* a fast growing species that has a large tolerance range to many variables including pH, temperature and salinity. Species of *Caulerpa* are toxic to herbivores and therefore not kept to a minimum by grazers, like many native species.

As well as having a high tolerance range to environmental variables, *Caulerpa taxifolia* is able to reproduce asexually by growing from plant sections from sections from parent plant as small as 2mm. These pieces of *C. taxifolia* break off often starting whole new plants, spreading further in the estuary. As a result of their rapid growth and high tolerance ranges, invasive alga can overrun, smother and fundamentally alter seagrass beds and other marine habitat.

Caulerpa taxifolia

This species has the potential to alter all waterways in Australia, due to its ability to spread rapidly, tolerate environmental extremes and reproduce rapidly from small amounts of tissue. Recreational and economic activities such as boating and aquaculture should be minimised around this species as it may disturb and spread this species further.

If this species is observed in any water body in NSW please contact NSW Fisheries immediately!

Caulerpa taxifolia
(Source: Alan Millar, Royal Botanic Gardens)

Caulerpa taxifolia is a bright green algae, with a characteristic “creeping” stem (stolon), which can measure over 1 m in length and is fixed to the bottom by small 'roots' called rhizoids. The stolon bears feathery 'leaves' or fronds, which can be 5 to 65 cm in length.

There are naturally occurring species of *Caulerpa* in Australia, with three well known variants. One being the Queensland (Morton Bay) variety another the NSW variation, and the third being an invasive variety from the Mediterranean. *Calerpa* species from the Mediterranean were genetically modified for the aquarium industry to be a hardy ornamental plant that cannot be eaten. It has now over-run many marine and freshwater habitats in the Mediterranean and has the potential to do the same in Australian waterways.

The Mediterranean variety appears to have been derived from the Queensland variety, however this is being examined. The Meditarianian variety for the aquarium trade was acclimatized to be tolerant of cold water. *Caulerpa taxifolia* is native to Queensland but a cold-tolerant strain is invasive in NSW and may threaten coastal ecosystems. In NSW, the Department of Primary Industries (Fisheries) jhas identified *Caulerpa taxifolia* has been identified and listed as noxious marine vegetation, with a control plan in place.

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13 Glossary of Terms

Amphipod	small animals of the class Crustacea with two pairs of antennae and five pairs of walking legs; including sea lice/fleas, sand hoppers and their relatives.
Aquatic	something that lives in water.
Axes	the central column of a plant's growth.
Bacteria	single-celled microscopic organism.
Benthic	plants or animals living on or at the floor of a water body.
Biodiversity	includes all plants, animals and microorganism on earth, their genes and the habitats and ecosystems in which they live.
Biomass	the total quantity or weight of organisms in a given area or volume.
Biota	all living plants and animals.
Brackish	water that contains dissolved salts in the range 500 – 30 000 parts per million, which is less than in sea water (35 000 parts per million).
Carnivore	animal that feeds on other animals.
Catchment	a natural drainage basin where all runoff water flows to a low point.
Coloniser	initial organism to become established in an area.
Crustacean	an arthropod of the class Crustacea, having a hard shell and typically aquatic by nature.
Data (plural: datum)	numerical value or facts of any kind.
Decomposition	the breakdown of organic materials by micro-organisms.
Detritus	small pieces of dead and decomposing plants and animals.
Density	The thickness or concentration in a space.
Denticulations	teeth-like projections.
Dissolved Oxygen	the amount of oxygen that is dissolved in water.
Ecosystem	a community of organisms interacting with one another plus the environment in which they live. Processes occurring within an ecosystem are the flow of energy by food webs and nutrient cycling.
Epiphyte	a non-parasitic plant that grows on another plant.
Erosion	the movement of rock and soil materials by running water, wind, moving ice or gravity.
Estuary	a coastal body of water, typically at the mouth of a river, which is open to the sea and allows fresh water from inland to mix with sea water (creating brackish water).
Eutrophication	the enrichment of a water body by inorganic plant nutrients (e.g. nitrate and phosphate).
Fauna	the animal life inhabiting a particular area or environment.
Fertiliser	any substance, natural or manufacture, which is added to the soil to provide essential nutrients for plant growth.

Filamentous	structure of some types of algae, made up of a thread-like row of cells.
Filter Feeder	any marine or freshwater animal that feeds on microscopic organisms by using a complex system of filtering mechanisms to trap particles from the water.
Flora	the plant life inhabiting a particular area or environment.
Foliage	the leaves of a plant.
Gastropod	any mollusc of the class Gastropoda, that moves along by means of a large, muscular foot.
Genus (plural: genera)	taxonomic group of closely related species.
Glabrous	not hairy.
GIS	Global Information System; computerised information system which layers various information about an area on maps (e.g. population, vegetation, soils, etc).
GPS	Global Positioning System; type of navigational system.
Grazer	animal that consumes algae and other materials off the surface of submerged rocks and plants.
Habitat	a place that provides suitable shelter and food for an organism.
Herbivore	an animal that feeds solely on plant matter.
Hydrodynamic	forces acting on fluids
In situ	in position; without disturbing.
Invertebrate	an animal without a backbone.
Ions	an electrically charged atom or molecule formed by the loss or gain of one or more electrons.
Isopod	small animals of the class Crustacea with the first and often second body segment fused with the head.
Lateral	a side shoot or branch.
Macro invertebrate	an animal, which lacks a backbone and is large enough to be seen by the unaided eye.
Macrophyte	a large aquatic plant that can be seen with the unaided eye.
Mangroves	a swamp forest in tidal saline or brackish waters, which grows along the shores of estuaries.
Micro-organism	a single-celled organism that is invisible, or barely visible, to the naked eye (e.g. bacteria, fungi, viruses).
Nutrient	a substance used or required by an organism for food.
Organism	any living animal or plant.
Parasite	an organism living in or on another organism from which it obtains food.
pH	describes the hydrogen ion activity in a system. A solution with a pH between 0 and 7 is acidic, a pH of 7 is neutral, and a pH between 7 and 14 is alkaline.
Phosphorus (P)	an element that is essential for all living organisms. It is a common ingredient in fertilizers and washing detergents.

Photosynthesis a process by which plants (including algae) use solar energy , water and carbon dioxide to produce their own food, resulting in plants producing oxygen.

Phytoplankton small plants that drift in open waters.

Plankton small animals and plants, which drift in a water body.

Polychaete any aquatic annelid worms of the class Polychaeta, having numerous bristles on the fleshy lobes of each body segment.

Pristine an environment that remains untouched or undeveloped.

Protozoa minute, single-celled organisms.

Quadrat a small area marked out for study.

Radial divergences from the centre, usually at a 90˚ angle.

Reference Site a site, which most closely approximates pristine conditions.

Rhizome a creeping horizontal stem growing at or below ground level.

Riparian situated on, or associated with, a bank of a river or estuary.

Salinity the total quantity of dissolved salts in water, measured by weight in parts per million.

Salts compounds that dissolve and dissociate in water to yield positively and negatively charged ions.

Scavenger refers to animals that feed mainly on other dead animals, or that feed mainly on the products of other larger animals.

Sedimentation the movement and deposition of sediments, usually by water.

Silt a fine deposit of mud or clay in a water body.

Sipunculans unsegmented, leech-like animals commonly called 'peanut worms'; of the phyla Sipuncula.

Stolon a horizontal stem or branch, that takes root at points along its length forming new plants.

Substratum the surface or material on which any particular organism grows.

Taxonomy the scientific classification of organisms.

Terrestrial living on land.

Thallus leaf-like structure.

Total Dissolved Solids dissolved salts in water.

Transect scientific linear survey method that usually intersects (the shore, in the case of seagrass monitoring) at a right angle.

Turbidity the cloudy or muddy appearance of water, which is an indication of fine solids, suspended in the water.

Vegetation the plant cover of an area.

Vertebrate an animal with a backbone.

Vesicle a small bladder, bubble or hollow structure.

Watercourse a channel having defined beds and banks where water flows on a permanent or semi-permanent basis (e.g. river, stream).

Wetland a general term applied to open water habitats and seasonally or permanently waterlogged land areas.