Australian pastures of the sea

Many people think of seagrasses as green weeds in coastal waters that foul our favorite swimming areas or wash ashore only to smother beaches with smelly decaying remains. They make up one of Australia's most ecologically productive and economically valuable ecosystems, says researcher **Len McKenzie**. For example, the carbon stored in Australia's seagrasses has been valued at around $3.5 billion.

About 100 million years ago, from habitats in fresh water, flowering plants started colonising the sea. Although known as seagrasses – with common names like turtle grass, eelgrass, tape grass and spoon grass – they are actually more closely related to gingers and lilies than to true grasses, and have evolved independently along three or more separate pathways (they are a functional rather than taxonomic group of plants). Like their relations on land, seagrasses produce flowers with pollen and fruits containing seeds. They are not in any way related to seaweeds (algae).

Australia is richer in seagrasses than any other continent – hosting 40 of the world's 72 species, 22 of which are endemic (only found here). Their leaf size ranges from no bigger than a fingernail (*Halophila minor*) to having two metre long leaves (*Enhalus acoroides*).

Seagrasses grow in most of Australia's shallow coastal waters, occupying 95,000 square kilometres, which is at least one sixth and perhaps a third of the global extent of seagrass meadows. North-eastern Queensland and southern Western Australia have the most species, although those found in the north are shared with Asia. As the majority of Australia's endemic seagrasses are in the temperate south, they are likely to be Gondwanan relics, the long isolation and relatively stable conditions of this region having resulted in fewer extinctions than elsewhere. The richness of Australia's tropical species is probably due to the interchange of biota that occurred when the Australian continent drifted north and encountered the Asian continental plate.

In some regions, green turtles maintain grazing plots in seagrass meadows. Relative responses to grazing can shape the composition of seagrass communities. Some seagrasses compensate by increasing leaf output while others decline. This green turtle is feeding near Green Island in Queensland. *Photo: Len McKenzie*

As nurseries for fish and prawns, seagrass meadows attract predators, including this dusky flathead at Shelly Beach in New South Wales. *Halophila* seagrass is growing here with bubble algae (*Colpomenia sinuosa*). Unlike seagrass, algae (seaweeds) do not have veins in their leaves, nor do they possess roots and rhizomes to anchor them into the sediment, and they don't produce flowers or seeds. *Photo: Richard Ling*

Lurking! Starfish are one of many predators benefiting from highly productive seagrass habitats. *Photo: Len McKenzie*

Hunting for seagrass invertebrates such as worms, prawns and crabs, epaulette sharks can survive low oxygen conditions in tidal pools by switching off non-essential brain functions. *Photo: Rudi Yoshida*

The wealth of Australia's seagrasses is also in the ecosystem services they provide – nutrient cycling, sediment stabilisation, carbon sequestration, commercial and subsistence fisheries habitat, and food for dugongs and green turtles. Globally, these services have been valued at $2.1 trillion per year.

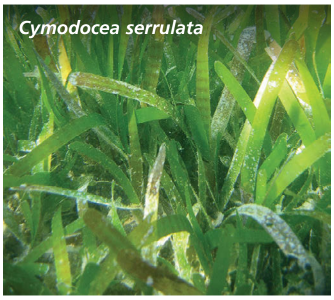
Life in salty water

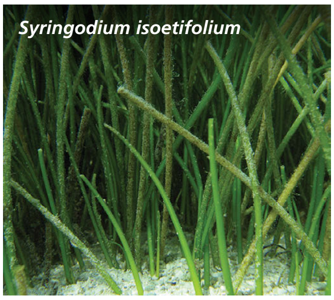
Like most plants, seagrasses rely on photosynthesis for growth. Their leaves have a thin cuticle (covering) to allow gas and nutrient exchange with the surrounding waters, and large air channels to provide buoyancy and promote gas exchange throughout the plant. They have roots and rhizomes to absorb nutrients from the sediment they grow in.

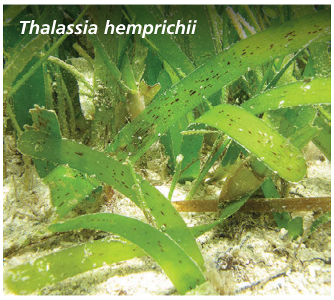
Seagrasses need to tolerate water movement and salt. Most species grow best in normal seawater salinities of 35 parts per thousand, but some can survive in a wide range of habitats from estuarine (with freshwater flows) to hypersaline (very salty). Seagrasses use special proteins to regulate the amount of salt and water in their cells – they quarantine excess sodium in cell vacuoles and lose water at the leaf surface when the surrounding water is salty and excrete salt if the water becomes less salty. In some species, the sheath around the base of leaves creates a low salt microenvironment that shields newly developing leaf cells from direct contact with sea water.

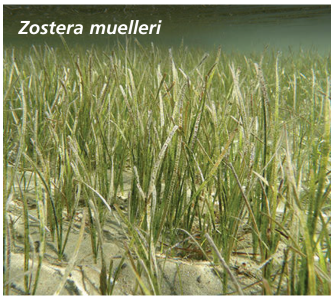
Light is typically the most limiting factor for growth of seagrasses. They have high light requirements in part because they have a proportionately limited leaf area for photosynthesis – up to 90 percent of a seagrass plant consists of roots and rhizomes, necessary for anchorage – and also because the sediments in which they grow are often devoid of oxygen. To offset this anoxia, oxygen from photosynthesis is transported to the below-ground parts and pumped into the surrounding sediment to facilitate nutrient uptake. On a sunny day, one square metre of seagrass can produce up to ten litres of oxygen.

Plants on land rely on wind and animals for pollination. Seagrasses rely on water currents – with pollen grains elongated or joined in chains to aid transportation – and animals. Recent research has shown that, like birds and bees on land, some crustaceans and polychaetes carry the pollen of seagrasses. About 70 percent of seagrasses have separate male and female plants, compared to only four percent of land plants. Most seagrass flowers are small, pale and at the base of leaf clusters. After fertilisation, the ovary of the female flower develops into a fruit with one to 30 seeds, depending on the species. The fruits of E*nhalus* seagrasses are collected by fishermen throughout Indonesia as a snack, and in the Philippines the seeds (up to two centimetres long) are dried, ground into flour and used to make biscuits.









Seagrasses vary both in their looks and geneology, having evolved from at least three different freshwater lineages, none of them related to grass, and encompassing six plant families, although not all taxonomists agree about this. Species with a paddle or fern shaped leaf are from the widespread genus *Halophila*. All but one member of the *Posidonia* genus and Posidoniaceae family are endemic to temperate Australia. While other genera are unique to Australia each of the five other families has representatives in many other parts of the world. *Photos: Rudi Yoshida (top), Len McKenzie (all others)*

As the tide falls, soldier crabs emerge from burrows and trek en masse down to freshly exposed sand that they scoop into their mouth to extract algae and other detritus and then eject in tiny pellets. Here they are moving through a seagrass bed of *Zostera muelleri* near Hervey Bay in Queensland. *Photo: Rudi Yoshida*

Seagrass virtues

Globally, seagrass meadows are rated the third most economically valuable ecosystem on a per hectare basis, preceded only by estuaries and wetlands. Because they influence the physical, chemical and biological environments they grow in, seagrasses are sometimes called ecosystem engineers. They create structural complexity, providing a multitude of habitat options and refuge for small animals from predators, harsh sunlight or fluctuating salinity and temperature. Seagrass meadows support about 40 times as many animals as bare sand.

One of the most important roles of seagrasses is providing a nursery and shelter for fish and prawns, many of which are valuable to fisheries. Juveniles of fish such as whiting, snapper, emperor and sweetlip all depend on seagrass meadows, as do commercial prawns such as red spot king, brown tiger, grooved tiger and endeavor.

Seagrass meadows are major foods for a number of big animals. An adult green turtle eats about two kilograms of seagrass a day and a dugong about 28 to 40 kilograms. Turtles crop the leaves, whereas dugongs prefer to dig up and consume the whole plant, roots and all. Water birds such as black swans eat 1.8 to 3.6 kilograms of seagrass a day. It's not just the living plants that provide food; decomposing seagrass feeds plankton and provides detritus which feeds crabs, prawns, sea cucumbers and even corals.

The rhizomes and roots of seagrasses bind sediments and stabilise the sea floor, and the leaves slow water flow, allowing suspended material to settle on the bottom. This increases the light reaching the seagrass meadow and creates a calm habitat for many animals. The plants also act as nutrient sinks, buffering or filtering nutrient and chemical inputs to the marine environment. A hectare of seagrass absorbs an estimated 1.2 kilograms of nutrients per year, equivalent to treating the effluent from 200 people.

The nutrient cycling services and the raw products provided by seagrasses have been valued at US$ 19,000 or more per hectare per year. More recently, they have been recognised for the role they play in carbon sequestration – removing carbon from the atmosphere and storing it in sediments. It has been estimated that Australia's coastal wetland ecosystems (seagrass, mangrove and saltmarsh) sequester and bury carbon at rates up to 66 times higher per hectare than land-based ecosystems, including forests, and they store five times more carbon in their sediments. The carbon stored in Australia's seagrasses has been valued at around $3.5 billion.

Seagrass losses

Despite their ecological importance and economic value, seagrasses are poorly protected and have been declining globally over the past few decades at a rate of 110 square kilometres a year, equivalent to two soccer fields an hour. Australian seagrass losses are just under 50 square kilometres a year – close to half the global total. These disturbing figures place seagrass meadows among the most threatened ecosystems on earth.

Multiple stressors are the cause of this decline. Some are natural due to storms, but most are the result of human activities. The most widespread and pervasive impact is reduced water quality and available light. Due to poor farming practices excess sediments and fertilisers are washing down creeks, and sewage and stormwater from urban developments are also elevating nutrients and reducing water clarity in coastal waters. These are recognised as the top human activities threatening seagrass, closely followed by coastal development, dredging, shipping and fishing. Climate change is likely to add to these pressures.

Seagrass-Watch

Collecting information on the status of seagrasses is critical for conservation. This is the important role played by the global seagrass monitoring program Seagrass-Watch. Developed in Queensland over 15 years ago, it focuses on long-term monitoring, awareness raising and capacity building, and provides early warning of coastal ecosystem decline. More than 25 countries participate in the program and monitoring occurs at over 350 sites. Program participants represent a diverse cross-section of the community, including tradespeople, engineers, indigenous communities, school teachers, fishers, divers, retirees, university students, biologists and ecologists.

The program has provided early alerts about coastal environmental problems before they became intractable. For example, during the dredging and reclamation stages of a coastal development in the Whitsundays, monitoring identified the onset of sedimentation on adjacent seagrass meadows and early intervention ensured they were not completely lost. The program has improved our understanding of seagrass ecosystem dynamics, including seagrass recovery after losses from flooding and other climatic events. The consequences of global climate change are being tracked. Findings from the program have contributed to Ramsar and World Heritage Area assessments, regional and local management plans and reports on the health of the Great Barrier Reef. Collaborations as exemplified by Seagrass-Watch are essential to protect Australia's valuable seagrass meadows. To register and make a difference, visit seagrasswatch.org. ■

LEN MCKENZIE is Principal Researcher and Seagrass-Watch Program Leader based at James Cook University in Cairns. Len's fascination with seagrass ecosystems stems from his youth, when he worked with his parents in their commercial fishing operation on Victoria's Gippsland Lakes. He has been researching seagrass ecology and resilience for over 25 years, contributing to seagrass management in Australia and internationally. Len developed the Seagrass-Watch program to provide a more coordinated monitoring approach that people from different cultures and backgrounds could contribute to.

Eyes on seagrass

THE EDITORS

Three times a year, volunteers coordinated by Wildlife Queensland spend three hours puddling about at low tide on mudflats in Moreton Bay, the large estuarine bay in southeast Queensland. Salty breezes, starfish, crabs, seahorses and other seagrass wildlife make for a pleasant outing. The citizen scientists return to land with data on the extent and species composition of seagrass cover over a 50 by 50 metre site, and other information such as whether *Lyngbya* (a cyanobacteria toxic to humans and wildlife) was present.

The volunteers have each undergone several hours of training, and to ensure quality control, photographs of the quadrats they sample are later also scored by a professional scientist. This has shown that the data collected by volunteers is of high quality with good consistency between the two sources.

Wildlife Queensland has been monitoring seagrass in Moreton Bay since 2001. Last year, 35 citizen scientists spent 280 hours monitoring 15 sites. The organisation also assists Quandamooka Yoolooburrabee Aboriginal Corporation to monitor sites and coordinates seagrass monitoring on the Gold Coast. Moreton Bay has about 25,000 hectares of seagrass with seven species, and is one of the largest Australian regions monitored using the Seagrass-Watch method. The sites monitored by volunteers have retained most of their seagrass cover over the dozen years of monitoring. But the overall extent and health of seagrass meadows in the bay has declined, particularly in the central and western bay near major urban development and where rivers and drains deliver sediments that shade and smother seagrasses. Floods in 2011 dumped immense volumes of soil into the bay and water scientist Jon Olley has warned that if nothing changes, Moreton Bay's seagrass habitats could become algal habitats within 20 years.

If sediments and pollutants are controlled, seagrass meadows can recover. In December 2013, Simon Baltais, manager of the Moreton Bay community monitoring program, found tiny patches of seagrass in Bramble Bay, where no seagrass had been seen since the 1974 Brisbane floods. 'It's very exciting to see what might be the start of seagrass recovery there,' he says.

The Moreton Bay program is supported by the Brisbane Airport Corporation, the Queensland Government, the Ecosystem Health Monitoring Program, Tangalooma Resort, SEQ Catchments, and Wildlife Queensland. ■

Wildlife Queensland volunteers at work monitoring seagrass near Moreton Island. *Photo: Debra Henry*