

# Seagrass-Watch

The official magazine of the Seagrass-Watch global assessment and monitoring program



## dugongs

Are dugongs fussy eaters?

Cape York seagrasses

Secret sirens of Singapore

Palawan dugongs

Dugong sanctuary

At the edge

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## From the editors

Dugongs are highly dependent on seagrass communities and this issue explains that contrary to perceived wisdom, dugongs eat virtually all seagrass species they encounter. Although only able to masticate relatively non-fibrous tissues effectively, dugongs are probably less dependent on pioneering seagrass species than previously suggested.

In this issue you can read more about the 2011 extreme weather events in Queensland and how dugongs responded to the loss of their seagrass habitats. Many animals died, others left the urban Great Barrier Reef region, presumably for the greener pastures further north where the vast seagrass meadows off Cape York escaped the ravages of cyclones and floods (as revealed by recent helicopter surveys). Further north again, the Torres Strait is not only the 'dugong capital of the world', but as recently discovered, boasts one of the largest seagrass meadows in Australia.

Dugongs are not wilderness animals and in this issue you can read how they still persist in the busy waters around Singapore, even though their feeding trails are often the only evidence that they inhabit this region. In Palawan, southern Philippines, dugongs are having a tough time as a result of the destruction of their seagrass habitats by terrestrial runoff associated with deforestation. Conserving dugongs and their seagrass habitats is especially challenging in developing countries, but in this issue we explain how the UNEP-CMS MOU is trying to make a difference using modern economic tools.

### COVER:

'Dennis' the dugong, Abu Dabab, near Marsa Alam in the Red Sea.  
Photographer Fergus Kennedy

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#### Editors:

Len McKenzie, Rudi Yoshida & Richard Unsworth  
Guest Editor: Helene Marsh  
Copy Editor: Rob Coles  
Proofreader: Louise Johns  
Layout & graphic design:  
Rudi Yoshida & Len McKenzie



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Seagrass-Watch acknowledges the Traditional Owners on whose sea country we monitor

Seagrass-Watch HQ,  
Northern Fisheries Centre  
PO Box 5396, Cairns. Qld. 4870 AUSTRALIA  
email: [hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)

This magazine can be downloaded as a pdf from  
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# are dugongs fussy eaters?

Article by **Helene Marsh**  
Photography by **Sebastian Gerhard** (SebastianGerhard.de)  
& **Len McKenzie**

*Many dugong researchers have asserted that dugongs are fussy eaters dependent on pioneer genera of seagrass, such as *Halodule* and *Halophila*. However, my analysis of the literature<sup>(1)</sup> indicates that they feed on at least eight of the nine seagrass genera and most of the approximately 26 species of seagrass that occur within their range<sup>(2)</sup>. Quantitative comparisons of dugong mouth and stomach contents indicate that the relative importance of seagrass genera differs among locations and changes with seagrass availability.*

Dugongs expand their diet opportunistically when seagrass meadows are seriously depleted by natural or human-induced seagrass loss. Tony Preen and I<sup>(3)</sup> found algae, dead seagrass rhizomes and anoxic sediment in the stomachs of dugongs that died in the Hervey Bay region in south-east Queensland after the loss of more than 1000 square kilometres of seagrass caused by two floods and a cyclone in 1992. Comparison of the diets of dugongs killed by indigenous hunters at Mabuiag Island in Torres Strait in 1977 (a time of seagrass dieback) and 1997- 98 (when the seagrass meadows were healthy) indicates that the dugongs ate relatively more of the fibrous species *Enhalus acoroides* when other seagrass was scarce<sup>(1)</sup>.

Dugongs may also change their diet on a seasonal basis especially when their access to some seagrass meadows is limited by water temperature.

Paul Anderson<sup>(4)</sup> observed dugongs feeding on *Halodule uninervis* in Shark Bay in summer, and inferred from their behaviour that they fed on *Amphibolis antarctica* and *Halophila spinulosa* in winter.

In some environments, dugongs apparently subsist largely on algae. Scott Whiting<sup>(5)</sup> documented dugongs closely associated for long periods with algal-covered, rocky reefs in the Northern Territory. Dugongs also deliberately eat invertebrates such as burrowing mussels, ascidians, chaetopterid worms and possibly sea pens in the at least in the winter in the sub-tropics, suggesting that they may be closet carnivores! As yet there is no scientific evidence that dugongs deliberately feed on invertebrates in the tropics, although dugongs certainly consume invertebrates incidentally when feeding on whole seagrass plants.

Diet selection may be defined as an animal's choice of food from an array of available food items. Individuals of many species of terrestrial herbivores can be kept in cages enabling the biomass and nutrient content of both the food offered and the food consumed to be measured with precision. It is much more difficult to confirm diet selection in the wild where diet selectivity is usually measured by comparing the relative abundance of food in an animal's diet with the relative abundance of the foods available. This approach has limited applicability for herbivores such as dugongs for which food quality is likely more important than food quantity and is further complicated when food availability changes with tide and season as for the dugong.

Some researchers who have analysed dugong digesta or studied dugong behaviour have inferred that dugongs selectively target pioneer, low biomass, genera of seagrasses, especially *Halodule* and *Halophila*, in preference to more fibrous climax genera, such as *Zostera*. Unfortunately, most of these claims are not supported by data on the biomass or nutrient concentrations of the available seagrasses<sup>(1)</sup>. In addition, observations of the signs of dugongs feeding are more obvious when they are feeding by excavating whole plants leaving a feeding trails in the sediment than when they are cropping seagrass leaves<sup>(1)</sup>. Nonetheless, there is some evidence that these claims are correct at certain locations. Tony Preen<sup>(6)</sup> ranked the dugong's preference for seagrasses in Moreton Bay, Queensland, in summer and autumn (when the abundance of seagrass is greatest) on the basis of: (1) frequency of encounter with feeding dugongs in different seagrass communities, (2) the relative abundance of different seagrasses in areas accessible to dugongs, and (3) the signs left by feeding dugongs. His ranking was: (1) *Halophila ovalis* (most preferred), (2) *Halodule uninervis* thin-leaf morph, (3) *Syringodium isoetifolium*, (4) *Halodule uninervis* broad-leaf morph, and (5) *Zostera capricorni* broad-leaf morph.

This hierarchy of seagrasses as preferred food for dugongs is not consistent across all locations or times. *Zostera capricorni* appeared to be the main seagrass eaten by dugongs in the inshore waters of a significant dugong habitat, Shoalwater Bay, Queensland, in 1975<sup>(7)</sup>, although there was some evidence that they avoided dense old stands. *Amphibolis antarctica* is almost certainly the seagrass



**Trang (Thailand):** Dugongs used to live along both sides of the south of Thailand but today they are found only on the Andaman side on the west. They are commonly found in the national reservation areas of Had Chao Mai and Libong Island in Trang, which is estimated to support no more than 70 dugongs. Today the numbers of the dugong have fallen rapidly to a critical condition because they have been hunted for food, caught in fishing nets and die as a result. In addition to the long reproduction cycle, dugong eat only sea grasses which are getting scarcer because of pollution, contributing to the loss of feeding areas.

Source: Thai Society for the Conservation of Wild Animals, tscwa.org



**Terumbu Pempang Laut (Singapore):** Dugongs feed by excavating or cropping, depending on seagrass morphology and the nature of the sediment. When feeding on structurally small seagrasses of the genera *Halophila*, *Halodule*, *Cymodocea*, *Syringodium* and *Zostera* dugongs excavate the plant as they swim forward, carving characteristic feeding trails in the sea bottom and creating clouds of sediment. These feeding trails are usually 10–25 cm wide (roughly the width of a dugong's facial disk), serpentine, between 30cm and several metres long and up to about 6cm deep<sup>(1)</sup>.

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eaten most often by dugongs in Shark Bay, the area that supports the second largest known dugong population in the world. Ian Johnstone<sup>(8)</sup>, Bernard Nietschmann<sup>(9)</sup> and Jessica André<sup>(10)</sup> and their co-authors have independently confirmed that *Thalassia hemprichii* is a very important food of dugongs in Torres Strait, the area which supports the world's largest dugong population<sup>(11)</sup>.

James Sheppard and his co-workers<sup>(11)</sup> conducted the most comprehensive study of factors influencing dugong diet selectivity in subtropical Hervey Bay, in winter. They tracked seven male dugongs at a fine spatial scale using GPS transmitters and compared the dugong's use of space with the seagrass community to quantify the patterns of association between dugongs and the four seagrass species present. Dugongs were associated with *Halodule uninervis* and *Halophila spinulosa* only on daytime low tides when the animals' habitat choices were limited by tides and possibly vessel traffic. The dugongs were associated with *Halophila*

*ovalis* only at intermediate tides at night. In general the dugongs tended to avoid areas with a high density of *Halophila spinulosa* and *Zostera capricorni*. These results are consistent with some of Tony Preen's findings from Moreton Bay<sup>(6)</sup> but demonstrate that the selection of seagrass by dugongs is influenced by many factors.

The dugong is thus probably less dependent on pioneer genera of seagrass such as *Halodule* and *Halophila* than claimed by some researchers. Dugong food choices are not restricted by Latin names! Nonetheless, as Janet Lanyon and Gordon Sanson<sup>(12)</sup> point out, dugongs, unlike manatees, seem only able to masticate relatively non-fibrous species of food plants effectively.

Within their relatively specialised habitats of intertidal and subtidal tropical and subtropical seagrass meadows, dugongs are clearly capable of exploiting a relatively wide diet including most of the seagrass species available, macro-invertebrates and algae. This capacity probably explains their large range.

Thus dugongs should probably be considered 'seagrass community specialists' rather than 'seagrass specialists' or 'rhizovores'. I conclude that their reputation as 'fussy eaters' is over-stated.

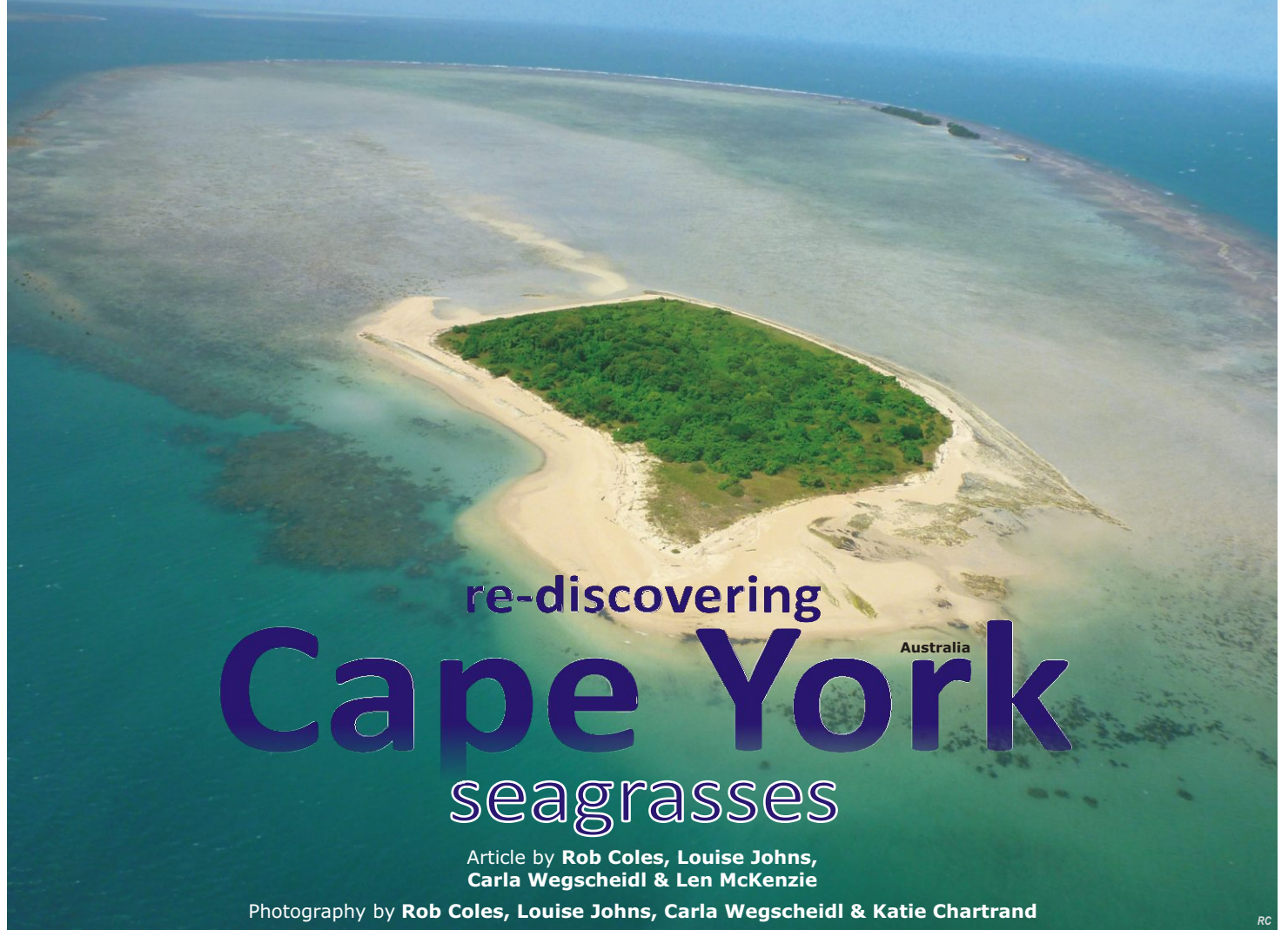
This is a highly edited extract from 'Ecology and conservation of the Sirenia: dugongs and manatees' by Helene Marsh, Tom O'Shea and John Reynolds published by Cambridge University Press in 2011.

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**Yule Point, Queensland (Australia):** Feeding scars in seagrass meadows indicate excavating (furrow grazing) by dugongs. Dugongs mostly use excavating when feeding on seagrasses with accessible rhizomes (such as *Halodule uninervis* and *Halophila ovalis* as found at Yule Point, north of Cairns), presumably because of the nutritional advantages in eating both the above- and below-ground parts of these plants. Because seagrasses are modular plants, even when a dugong feeds on both the above- and below-ground portions of a plant, the whole food organism is rarely killed<sup>(1)</sup>.



re-discovering  
**Cape York** Australia  
seagrasses

Article by **Rob Coles, Louise Johns,  
Carla Wegscheidl & Len McKenzie**

Photography by **Rob Coles, Louise Johns, Carla Wegscheidl & Katie Chartrand**

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*The east coast of Queensland, Australia has extensive inshore, coastal and deepwater (>15m depth) seagrass with an estimated area of 55,300 square kilometres<sup>(1,2)</sup>. This coast is globally important as it is within the Great Barrier Reef World Heritage Area and its conservation managed area; the Great Barrier Reef Marine Park (GBR).*

The GBR is recognised for its iconic coral species and coral reef, but by far the greatest area of the park is coastal and inter-reef lagoon. The health of these habitats is closely aligned to the health of the wider coral province<sup>(3)</sup>.

Healthy seagrass meadows in the GBR are important as the primary food for dugongs, green turtles, numerous commercially important species and as habitat for large number of invertebrates, fish and algal species. Much of the connectivity in reef ecosystems depends on intact and healthy non-reef habitats, such as seagrass meadows. As seagrasses are well recognised as integrators of environmental stressors, monitoring their status and trend provides insight into the status of the surrounding environment.

Ten years ago we would have not have been able to report on the health of GBR seagrass meadows and changes in the parameters (e.g. abundance, species diversity, nutrient levels) that define health. But the Seagrass-Watch program and the initiatives based on its methods, such as the GBR Reef Rescue Marine Monitoring Program (see issues 35 & 39) now give us that ability. Unfortunately much of the reporting focuses on the

urbanised coast of the GBR (south of Cooktown), as in the remote north (north of Cooktown) locations are not accessible all year round and logistics and costs in the past have made sampling in that region prohibitive.

That is changing. With funding provided through the Queensland Government's Reef Plan branch (Sustainable Agriculture) of the Department of Agriculture, Fisheries and Forestry, additional seagrass monitoring sites are being established in the Princess Charlotte Bay region and north of Lockhart River at Piper Reef and Shelburne Bay. The funding will support monitoring at these new sites for two years as well as the establishment of a new site in Bowling Green Bay near Townsville. These additional sites will improve the overall monitoring program occurring throughout the Reef catchments, to better understand sediment, nutrient and chemical runoff to the Reef.

However, prior to establishing sites, we needed to identify representative meadows in locations suitable for monitoring. To do this, we conducted a reconnaissance survey in the first week of March 2012 using a low level helicopter trip from Cairns to

**CAIRNS**



178 kms



**COOKTOWN**

97 kms



Thursday Island and back. This was a trip of near epic proportions covering over 950 kilometres of coastline. The low tides of early March and a break in the weather gave us three days of flying over an amazing coastline and a chance to revisit meadows not surveyed since the 1980s. And there was no shortage of seagrass. The far north coast has not had the impacts of Tropical Cyclone Yasi and the floods of 2011 and there were few places without some seagrass meadows. Flying at 100 feet with stops to check species is a very efficient (and sometimes exciting) way of covering large areas.

The result is good news. Unlike southern Queensland, seagrass meadows appeared to be in excellent condition and there were many meadows for us to choose from to monitor. We found extensive seagrass meadows, marked with abundant dugong feeding trails along most of the coast. We found a range of intertidal species commonly dominated by *Halodule uninervis* and *Halophila ovalis* on coastal meadows and by *Cymodocea rotundata*, *C. serrulata* and *Thalassia hemprichii* on reef platforms.

**STARKE  
RIVER**



330 kms



**PORT STEWART**





### Clack Reef, Flinders Island Group

Seagrasses are found on fringing reef flats throughout the Flinders Island Group. The meadows are dominated by *Halodule uninervis* with *Halophila ovalis*, *Cymodocea*, *Syringodium* and *Thalassia*.

The Flinders Group National Park is located adjacent to Princess Charlotte Bay, 25 km west of Cape Melville and 11 km north of Bathurst Heads. The Group comprises seven islands (Flinders, Stanley, Blackwood, Maclear, Denham, King and Clack). On the basis of the Yiithuwarra peoples' traditional affiliations, the Flinders Group has been successfully claimed under the Aboriginal Land Act (Qld) 1991<sup>(4)</sup> although the leaseback provisions have yet to come into effect. The islands also lie within the Great Barrier Reef World Heritage Area and the surrounding waters and reef are protected as part of the Great Barrier Reef Marine Park.

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There were as many as six seagrass species in some meadows, such as Yum Yum Beach in Weymouth Bay just south of the Pascoe River.

The final monitoring sites were selected based on access logistics. We worked with Traditional Owners and the Queensland Department of Environment and Heritage Protection to obtain permission to visit these sites on a regular basis and for assistance with sampling.

No trip of this extent can be successful without help. Cape York is home to many aboriginal traditional lands and we acknowledge the support of Traditional Owners while working in their country. In particular Greg Pascoe who came with us north of Lockhart River and to Piper Reef and Loddie Chippendale & Lucy Hobson who gave us advice on the best places to look around Shelburne Bay.

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180 kms

LOCKHART  
RIVER



165 kms

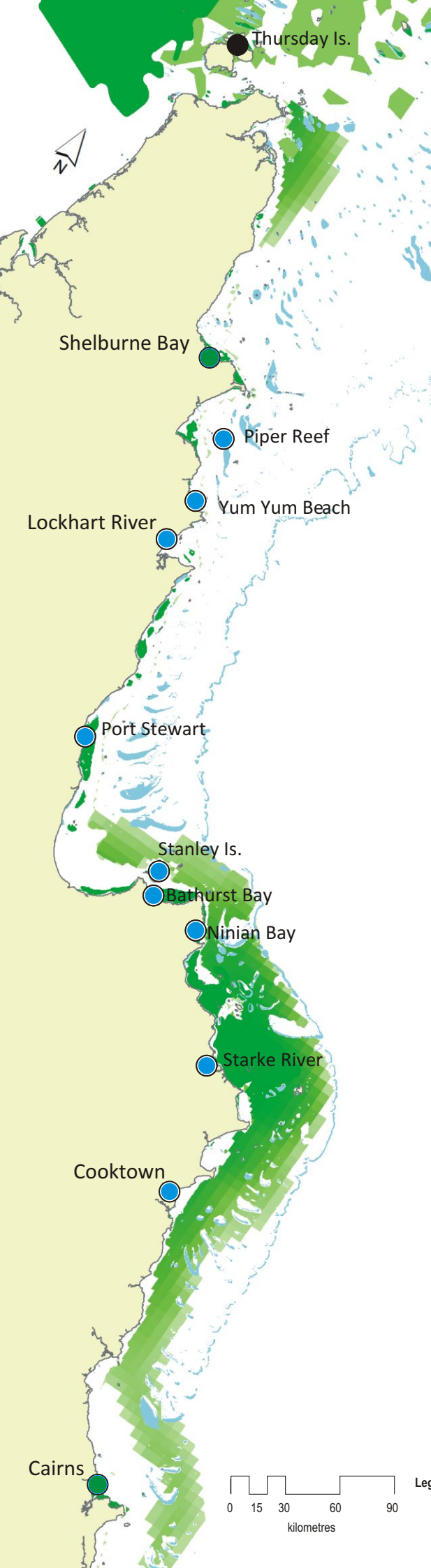




**“Yum Yum” Beach,  
Lockhart river region**

*Seagrasses are found on fringing reef flats along the shores of Weymouth Bay. The meadows are dominated by *Cymodocea* spp., *Thalassia*, and *Halodule* with some *Halophila ovalis* and *Enhalus*. Yum Yum Beach is located on the traditional lands of the Kuuku Ya'u, and is bounded by the rainforested low mountain ranges of the Iron Range National Park and the Great Barrier Reef Marine Park.*

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### Lockhart River to Shelburne Bay:



- There was little obvious seagrass in Lloyd Bay, patchy seagrass in Albatross Cove, extensive seagrass in the bay south of Portland Roads and along the coast to the Pascoe River (*H. uninervis*, *C. rotundata*, *C. serrulata*, *S. isoetifolium*, *T. hemprichii*, *E. acoroides* *H. ovalis* and *S. isoetifolium*).
- Seagrass was patchy in Temple Bay with extensive meadows in the south of the bay and patchy meadows north of the Olive River,
- There was a 20-30 percent cover of seagrass in an extensive meadow on Piper Reef (*T. hemprichii*, *H. ovalis* and *C. rotundata*)
- Patchy seagrass in west Margaret Bay and a very extensive seagrass meadow in west Shelburne

### Port Stewart to Lockhart River:



- Flown at high tide but several dugongs and turtles were sighted and there appeared to be patchy seagrass.
- In the mid 1980's, the intertidal flats were covered with either dense (30-100% cover) meadows of *Syringodium isoetifolium*/*Halodule uninervis* or sparse (1-10% cover) meadows of *Halophila ovalis*/*H. uninervis*. In the shallow subtidal waters, large *Halophila* meadows (*H. spinulosa* and *H. ovalis*) or isolated *Cymodocea* spp. patches occurred down to depths of approximately 10m.

### Starke River to Port Stewart:



- Extensive meadows from Murdoch Island north and patchy but extensive seagrass in Ninian Bay (*H. ovalis*, *H. uninervis* and *C. serrulata*). Several herds of dugongs were observed.
- Large meadows in the Bays of Bathurst and around into Princess Charlotte Bay (*H. ovalis*, *H. uninervis*, *C. serrulata* and *E. acoroides*). Extensive areas of dugong feeding trails.
- Clack Reef has a extensive but very low cover meadow of *H. uninervis*, *C. rotundata* and *T. hemprichii*
- Stanley Island fringing reef had *H. uninervis*, *C. rotundata*, *S. isoetifolium* and *T. hemprichii*
- Eden Reef had a low cover of *T. hemprichii*
- Cliff Islands to Port Stewart coast was mostly shifting sand banks with patchy seagrass and dugong feeding trails

### Cairns to Cooktown:



- Extensive seagrass meadows between Yule Point and Four mile Beach, immediately north of Port Douglas to Newell beach, and then patchy meadows in bays and on reef platforms through to Cooktown.
- All meadows had dugong feeding trails and some dugongs and turtles were seen

Legend: Seagrass maps are composite (all mapping surveys pooled).

Actual meadow boundary

50% - 100% Modelled meadow probabilities (pixel size of 2km<sup>2</sup> from all deepwater (>15m) survey points pooled).

Singapore  
secret  
sirens



Article by **Ria Tan, Loh Kok Sheng,  
Siti Maryam Yaakub &  
Lim Wei Ling**

Photography by **Ria Tan** (wild Singapore),  
**Loh Kok Sheng, Len McKenzie  
& Rudi Yoshida**

**W**HILE SIGHTINGS OF LIVE DUGONGS are rare in Singapore, dugong feeding trails are sometimes seen. In fact, TeamSeagrass saw feeding trails on the day we first started monitoring seagrass at Chek Jawa in 2007! Since then, dugong feeding trails continue to be seen throughout the region during our shore visits at low spring tides.

Chek Jawa lies on the eastern tip of Pulau Ubin, an offshore island at the mouth of the Johor River in the Johor Strait. On Chek Jawa, *Halophila ovalis* dominates, with large patches of *Cymodocea rotundata* and *H. spinulosa*. This one hectare seagrass meadow is ringed by a narrow strip of mangroves and natural coastal forest on the landward side. Dugong feeding trails are often seen in the dense meadows of *H. ovalis*, in particular near the northern sandbar. Several trails have also been seen near the southern sandbar well within sight of the visitor boardwalk! Thus, a lucky visitor might glimpse a dugong feeding at high tide from the boardwalk!

On mainland Singapore, the 3.5km stretch of Changi Beach facing Pulau Ubin has narrow patches of seagrass, about 15m x 5m and 20m x 10m. This shoreline has two major busy ferry terminals. Here, *Halophila ovalis* dominates with patches of *H. spinulosa*. Even on such tiny patches of seagrasses, dugong feeding trails have been seen. Sadly, we have also found fishing nets draped across the feeding trails.

Most excitingly, Loh Kok Sheng has spotted dugong feeding trails on Pulau Semakau, which lies south in the Singapore Strait. The 1.5km long seagrass meadow here is dominated by *Enhalus acoroides* with good representation of *Cymodocea serrulata*, *Thalassia hemprichii* and *Syringodium isoetifolium*. While *Halophila ovalis* can be found in the understory, there is a 10m x 10m patch dominated by *H. ovalis* on the southern tip of the island. It is here that Kok Sheng saw some dugong feeding trails! This area is





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edged by replanted and original mangroves, with reefs on the seaward side. Until recently, it was the first sighting of dugong feeding trails in the South.

In 2012, we have had several reports of dugong feeding trails from the south. In April, Siti Maryam Yaakub spotted dugong feeding trails at Cyrene Reef. A 1km long submerged reef, Cyrene has one of the best seagrass meadows in our Southern shores, with lush meadows of a wide variety of seagrass species including

*Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea serrulata*, *Syringodium isoetifolium*, *Halophila ovalis* and *Halodule uninervis*. A recent visit to Terumbu Pempang Laut (a submerged reef near the refineries on Pulau Bukom) in May, also revealed more feeding trails in the south (see page 5). These sightings were particularly surprising as Cyrene and Terumbu Pempang Laut lie in the middle of an 'industrial triangle' made up of the massive industries on Jurong Island, huge

### Singapore trails

Feeding trails spotted at Chek Jawa Pulau Ubin, January 2007 (left) and May 2012 (above). When dugong feeding trails at Pulau Semakau (below) were first spotted in May 2011, it was believed to be the first evidence of dugongs feeding in the south

Dugongs used to be sighted in the Johor Straits but were considered locally extinct by the 1980's.



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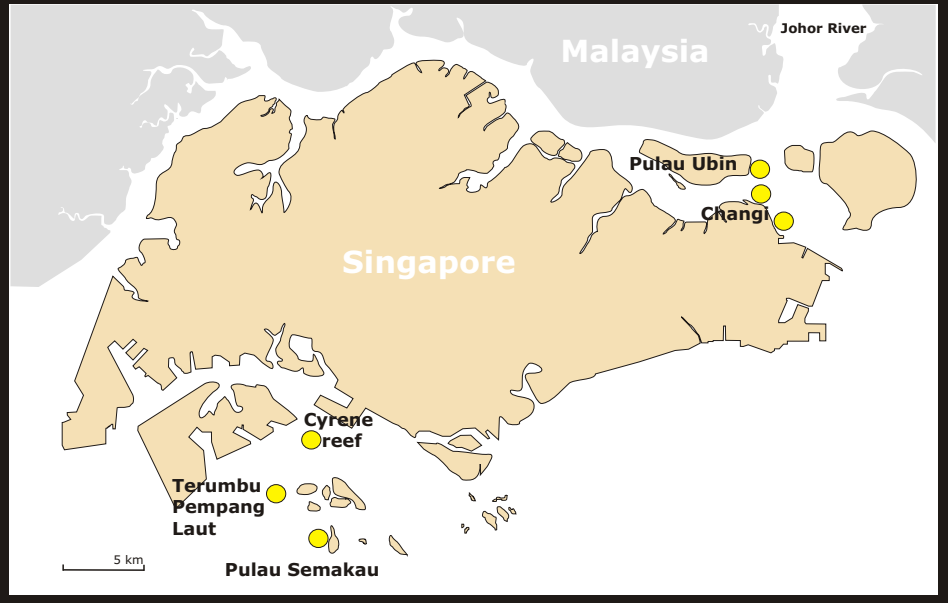
refineries on Pulau Bukom and the world-class container terminals at Pasir Panjang. Singapore is one of the world's busiest ports and the waters around these reefs are major shipping lanes with heavy traffic in small and large vessels including container ships.

According to the latest Singapore Red Data Book (2008), dugongs are recorded mainly from the north-eastern Johor Straits around the Johor River estuary. Strandings have occurred on Pulau Ubin, Pulau Tekong, Changi and East Coast Park. Individuals have been sighted off Changi, around Pulau Ubin, Pulau Tekong and Labrador.

According to the Singapore report in the UNEP status on dugongs <sup>(1)</sup> dugongs used to be sighted in the Johor Straits but were considered locally extinct by the 1980s.

### Scattered tracks

Map showing the location of feeding trails at Chek Jawa (Pulau Ubin), Changi, Pulau Semakau, Cyrene Reef and Terumbu Pempang Laut



### Recent discovery

A number of dugong feeding trails were discovered at Terumbu Pempang Laut (a submerged reef near the refineries on Pulau Bukom) revealing more feeding trails in Singapore's southern Islands!





## Cyrene evidence

The feeding trails discovered, on the reef, in April and again in May 2012, are particularly surprising as Cyrene lies in the middle of an 'industrial triangle' made up of the massive industries on Jurong Island, huge refineries on Pulau Bukom and the world-class container terminals at Pasir Panjang.

While in the late 1990s, there were increased encounters with dugongs in the Johor Straits, there were fewer sightings in the 2000's.

The most recent dugong encounter was in 2006 when a three-metre long female dugong washed up dead on Pulau Tekong<sup>(2)</sup>. According to N. Sivasothi, the dugong carcass was in surprisingly reasonable condition and was thus further dissected. There were no extraordinary signs of physical impact and she had a stomach full of seagrass. Cause of her death remains unknown.

Dugong carcasses have also been recorded washing up on the East Coast in 2001, near Pulau Ubin in 1999, and Changi in 1996. In 1998, a female calf was spotted swimming around her dead

mother which had drowned in a fishing net<sup>(3)</sup>. The calf was taken to Underwater World Singapore, an aquarium based in Sentosa, where she was named Gracie and remains to this day.

The Tropical Marine Science Institute has set up the Singapore Wild Mammal Survey (SWiMMS) to monitor wild dolphins, porpoises and dugongs in the sea around Singapore by establishing a volunteer network and reporting system<sup>(4)</sup>. So far, the program has yet to report any recent confirmed dugong sightings.

Threats facing dugongs in Singapore include high shipping traffic as Singapore remains one of the world's busiest ports. A large oil spill occurred in May 2010 affecting some parts of the shores in the Johor Strait, while another spill occurred

in January 2012 in the Singapore Strait near Pulau Semakau. Fishing nets continue to be used extensively on all shores and abandoned nets wash up in alarming quantities.

Hopefully, monitoring by TeamSeagrass will help us better understand and manage Singapore's precious seagrass meadows, which support these mysterious and fascinating dugongs.

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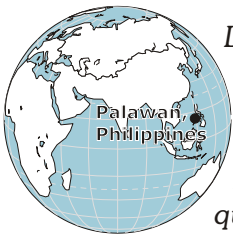
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# palawan Philippines dugongs

Article by **Leo Cayaban & Mariel Harrison**

Photography by **Community Centred Conservation (C3)**  
& **Len McKenzie**



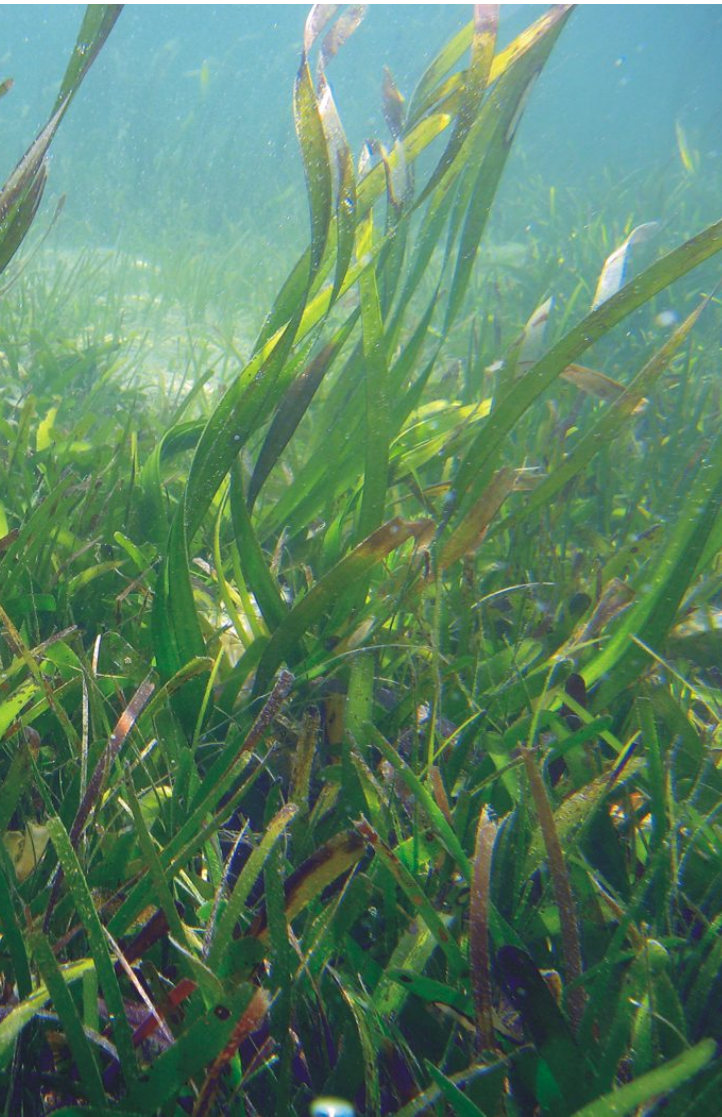
*Dugongs are the most endangered marine mammal in the Philippines, having been pushed almost to extinction by hunting and habitat destruction. Palawan province, an archipelago of 1,700 islands, is one of their last remaining strongholds in the country, and thus a conservation priority area. Community Centred Conservation (C3) is currently working in Busuanga, an island in the north of Palawan, to assess the status of the dugong population there; its size, distribution, the extent and quality of its seagrass habitat, and the threats both face*

Interviews with over 150 Key Informants from eight barangays (village districts) have confirmed that dugongs are still present. In some areas, they are seen almost daily by fishers at sea. However, over half of all interviewees believe that the dugong population is in decline, and most see them only rarely. Commonly cited threats are the cyanide and dynamite used illegally for fishing, entanglement in gill nets, and occasional hunting for consumption. If caught accidentally, dugongs are sometimes killed for food. As one Key Informant from barangay Buluang says, “*Before I always saw dugongs, but now I seldom see them. [...] A dugong was caught in a fish pen and they chopped it up for meat.*”

Interestingly, relatively few Key Informants mentioned perhaps the biggest threat to the dugong's survival in the Philippines; habitat destruction. Dugongs depend on seagrass meadows for their survival. An adult consumes about 25 kg of seagrass each day<sup>(1)</sup>. One of the major causes of seagrass meadow degradation in Busuanga is siltation caused by run-off from slash-and-burn agriculture. Over 30% of the Philippines' forest was lost in this way between 1990 and 2005, making it the country with the third highest rate of deforestation in the world for this period.

Mangroves, vital in protecting coastal habitats from sedimentation, are also being rapidly destroyed, mostly for shrimp and milkfish farming. Recent estimates suggest that 80 to 90% of the Philippines' mangroves have been lost, and continue to be deforested at a rate of 4,572 hectares per year. Without the mangroves to filter domestic waste and agricultural runoff, nutrient loading and sedimentation cause excessive epiphyte growth on seagrass, blocking sunlight and killing the plants. The expanding Filipino





**Images:**  
 Interviews with over 150 Key Informants (far left) from eight barangays (village districts) have confirmed that dugongs are still present .  
 One of the major causes of seagrass meadow (centre) degradation in Busuanga is siltation caused by run-off from slash-and-burn agriculture .  
 A senior fisherman (above), an excellent source of information on dugong populations on Busuanga .

population and ever increasing migrants to Palawan, who come seeking out the Philippines' last remaining natural resources, mean that the magnitude of threats from habitat destruction is growing at a worrying rate.

In order to assess the health of the seagrass meadows in Busuanga, we have conducted Seagrass-Watch surveys. Although eight of the 14 species known to exist in Palawan have been identified in total so far, most meadows are dominated by *Enhalus acoroides*, a hardy species, that may be tough for the dugong to process efficiently<sup>(1)</sup>. Furthermore, in some barangays there was little or no seagrass at all. As yet we are unsure whether this is the historical state of the habitats or if they are undergoing serious degradation. One Key Informant in Barangay Concepcion stated that “few food sources” and “less seagrass” were having a negative effect on dugongs, so habitat degradation is a possibility. Further Seagrass-Watch surveys are planned to monitor changes in the health of the seagrass meadows and determine the level of damage caused by destructive fishing gears and siltation.

In addition to seagrass surveys, we are developing methods for direct observation of the dugongs of Busuanga from both land and sea. We hope to create detailed maps of dugong and seagrass distribution. These maps will be presented to local stakeholders and relevant governmental authorities to prioritise areas for conservation action for this magnificent but threatened animal.

Thanks are due to the Municipal Government of Busuanga, the University of the Philippines, and all volunteers and local communities for their ongoing support of this work. For further information: Leo Cayaban, Programme Coordinator, C3 Philippines and Micronesia Programme, leo@c-3.org.uk, www.c-3.org.uk.

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Article by **Susan Sobotzick**  
Photography by **Susan Sobotzick & Rob Coles**

# Australia extreme weather & dugongs

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THE EXCEPTIONALLY HIGH RAINFALL and cyclones experienced in Queensland in early 2011 had significant effects on our coastal seagrass meadows (see issues 43 & 44) with flow-on effects to species that depend on this seagrass, including dugongs and turtles. Above average rainfall from wet seasons prior to 2011 had already depleted seagrass meadows in some areas, and this has led to increasing concerns about the status of local dugong and turtle populations.

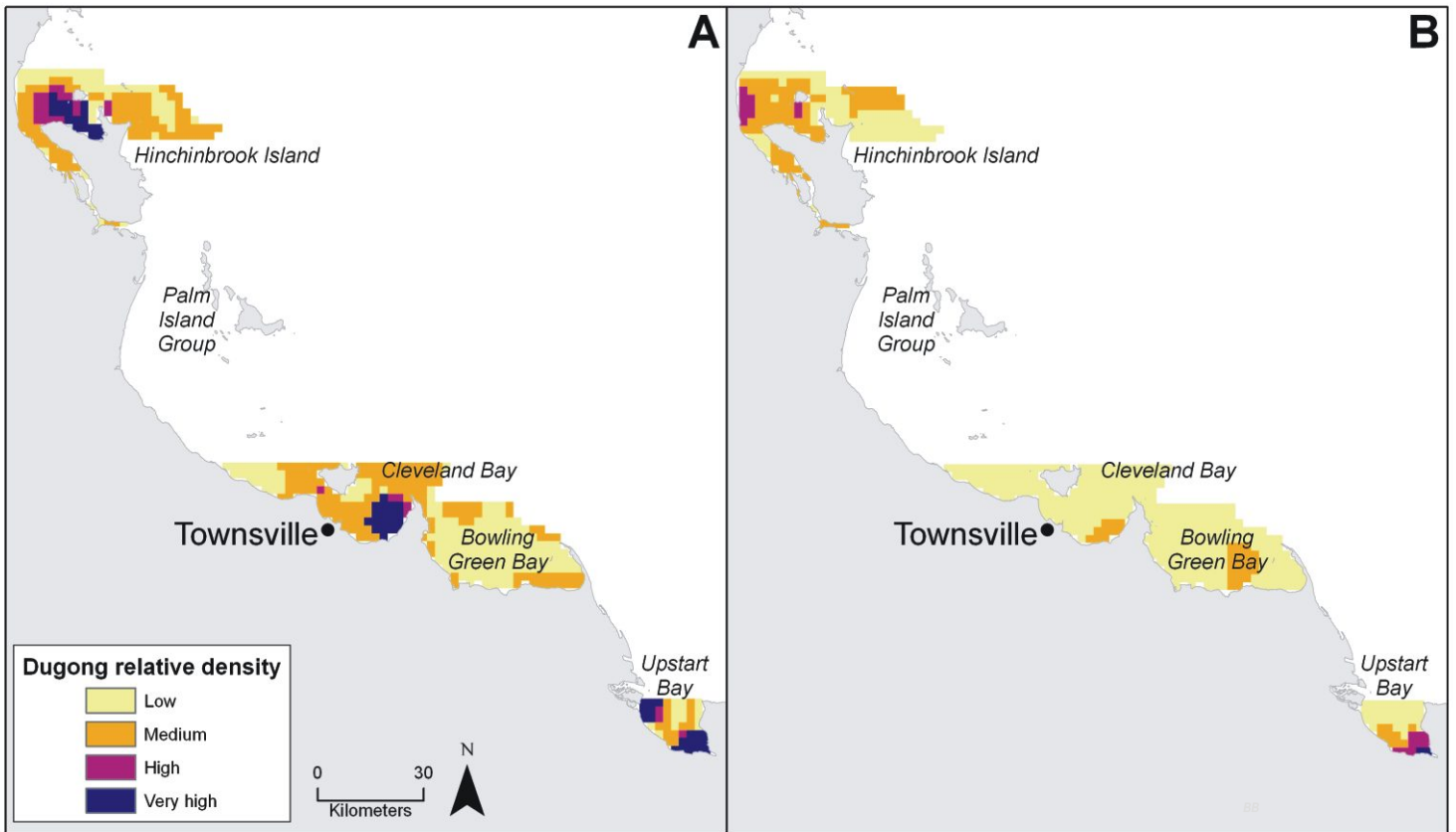
Funded by the Australian Marine Mammal Center (AMMC) and the National Environment Research Program (NERP), a research team led by Helene Marsh set out in November 2011 to document the impacts of the 2011 floods and cyclones on dugong distribution and abundance. Findings of this research are informing dugong management along the urban coast of Queensland (south of Cooktown) by continuing a long-term series of aerial surveys that have been conducted over the past 25 years. With the help of 15 participants, team leaders Rie Hagihara and Susan Sobotzick spent 4 weeks conducting aerial surveys, covering an area from just north of Port Douglas extending southwards to the New South Wales border. The two teams flew more than 440 individual transects, totalling nearly 10,000 km in length.

*Dugong feeding trails (above) criss cross through the meadow at Cackle Bay, Magnetic Island, Townsville, QLD (April 2012)*

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initial results show that dugong distribution and abundance for 2011 in some areas differs considerably from previous years

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**Dugong population density in Townsville region:** In 2011, far fewer dugongs were sighted in the Townsville area (B) compared with a similar survey in 2005 (A). Although some areas (e.g. Cleveland Bay) are mostly protected from fishing activities, such measures may not be enough to ensure local dugong populations can withstand pressure from extreme weather events especially when animals move as a result of seagrass loss. This figure was developed by Alana Grech. Map © Alana Grech

While data analyses are still ongoing, initial results show that dugong distribution and abundance for 2011 in some areas differs considerably from previous years. In Moreton Bay and Hervey Bay, both of which are significant dugong habitats, we were relieved to encounter several large herds and generally documented high numbers of dugongs. Other known dugong hotspots, in particular regions that were directly impacted by Tropical Cyclone Yasi such as Cleveland Bay off Townsville and the Hinchinbrook Island area, showed a major decrease in dugong sightings. Strandings of dead dugongs have increased significantly south of Cooktown in the last year with 193 strandings reported in 2011, compared with 88 strandings for 2010 and 67 for 2009<sup>(1)</sup>. Animals may have also left impacted habitats in search of new feeding areas.

The findings of the recent aerial survey show that while the establishment of Dugong Protection Areas in the mid 1990s and the re-zoning of the GBRMP in 2003 had contributed to stabilising dugong populations along the Queensland coast, these measures are not enough to ensure urban dugong populations can withstand pressure from extreme weather events. As the frequency and intensity of such events is predicted to increase with climate change, it is necessary to review current management strategies and consider whether we need to do more to protect dugong populations along the urban Queensland coastline.

**References**  
1. StrandNet data courtesy Department of Environment and Resource Management ([www.derm.qld.gov.au/strandnet/application](http://www.derm.qld.gov.au/strandnet/application)) [accessed 01 June 2012].



Dugong herd sighted in Moreton Bay in November 2011: dugongs feeding on whole seagrass plants generate clouds of sediment and feeding plumes, which are important signs of bottom feeding activity.

# Australia the dugong sanctuary

Article by **Helen Taylor**  
Photography by **Helen Taylor,  
Skye McKenna  
& Katie Chartrand**



THE TORRES STRAIT REGION of far north Queensland, Australia, comprises one of the most extensive seagrass communities in Australia and provides critical habitat for commercial and traditional fishery species. The seagrass meadows are regionally important habitat and food resources for threatened green turtle (*Chelonia mydas*) and dugong (*Dugong dugon*) populations.

Torres Strait comprises 247 islands, eighteen of which are permanently inhabited. Local island communities in the Torres Strait are deeply connected to their sea country through their culture, economy, spirituality and social way of life. The health of their marine resources has been, and continues to be, vital to Torres Strait Islander culture, subsistence, and commerce.

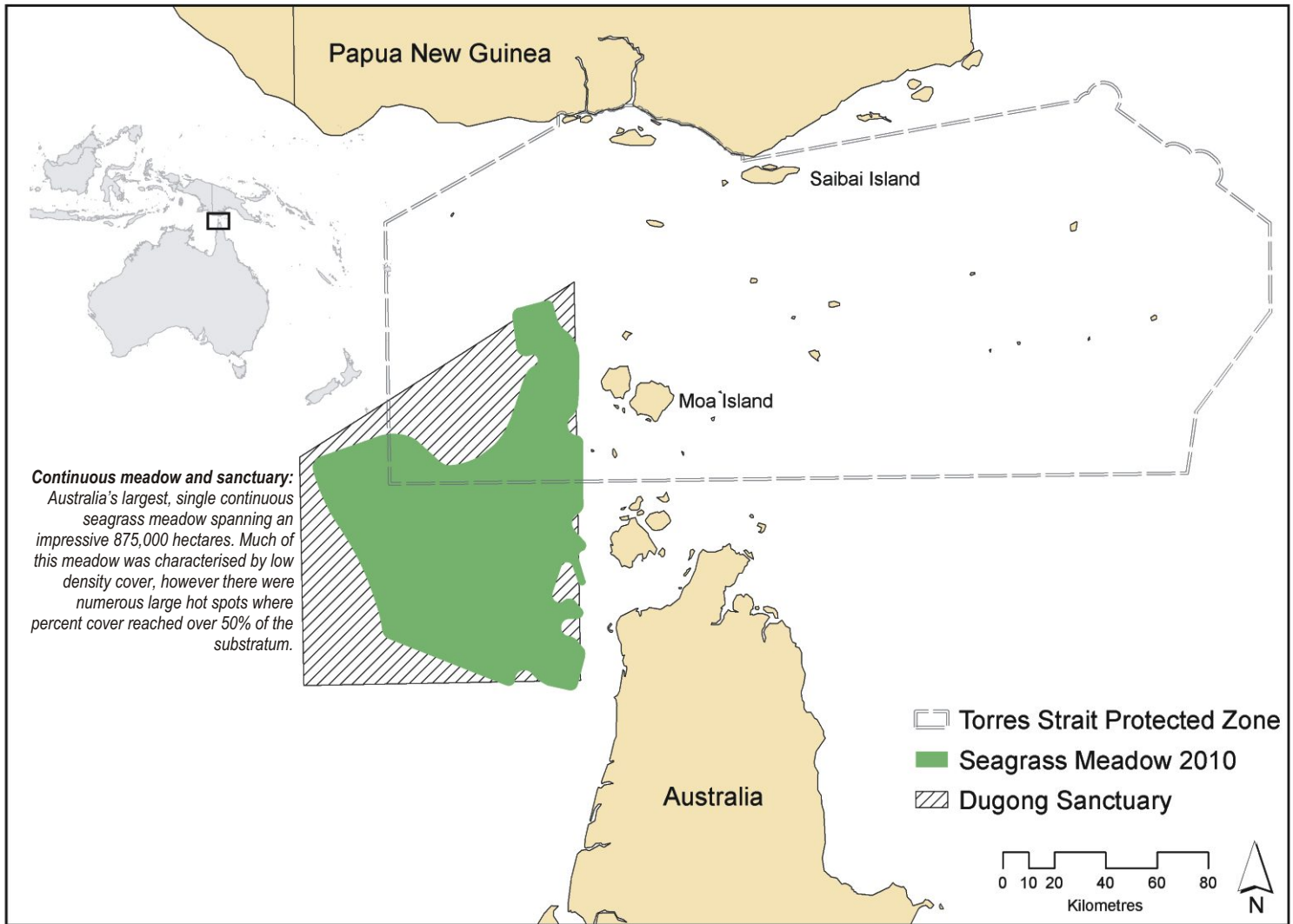
In 1985, Australia and Papua New Guinea ratified the Torres Strait Treaty to resolve the maritime boundaries in this region. The Treaty established the Torres Strait Protected Zone and provides a framework for the management, conservation and sharing of fisheries resources in the region. A segment of the Torres Strait Protected Zone and adjacent area was designated as a Dugong Sanctuary, in which all dugong hunting was banned. The Dugong Sanctuary covers an area in excess of 1.3 million hectares in the western Torres Strait region, from parallel to Latitude 11°10' South, and north to the Fisheries Jurisdiction line between Papua New Guinea and Australia in the north.

The largest population of dugongs in the world is in Torres Strait<sup>(1)</sup>, where the long-standing importance of dugongs for subsistence by Torres Strait Islanders has been traced in archaeological deposits dating back at least 7,000 years<sup>(2)</sup>. For the Indigenous people of Torres Strait, dugongs are the most significant and highest ranked marine food source in the traditional subsistence economy<sup>(3,4)</sup>.

Despite the value of seagrass habitats as a vital food source for dugongs, very little information was known on the distribution and abundance of subtidal seagrass habitat within and around the Dugong Sanctuary. Subtidal seagrasses had been studied at nearby Badu, Moa and Mabuiag Islands and the Orman Reefs where the extensive coverage of highly diverse seagrasses was identified as one of the most important areas of seagrass habitat in the Torres Strait and Queensland for dugongs<sup>(5)</sup>. A number of questions were raised about efficacy of the Dugong Sanctuary as a dugong refuge, including whether there was any seagrass in the Dugong Sanctuary and if present, was it suitable as a food source for dugongs?

In March 2010, we set out to find the answer to this question. A team of six from the Marine Ecology Group based in Cairns embarked on a 10 day journey to map the distribution, abundance and species composition of seagrass in the Dugong





The Dugong Sanctuary covers an area in excess of 1.3 million hectares in the western Torres Strait region, from parallel to latitude 11°10' South, and north to the Fisheries Jurisdiction line between Papua New Guinea and Australia in the north

Sanctuary. We used an underwater video camera that provided live feed to a video screen on the research vessel Gwendoline May. The camera was mounted to a sled and net system that collected a small sample of material as it moved across the substrate, allowing us to confirm our seagrass species identification.

What we found surprised us all; Australia's largest, single continuous seagrass meadow spanning an impressive 875,000 hectares (8750 km<sup>2</sup>, over 1% of the world's seagrass). Much of this meadow was characterized by low density cover, however there were numerous large hot spots where percent cover reached over 50% of the substratum. Six seagrass species were identified: *Halophila ovalis*, *H. decipiens*, *H. spinulosa*, *Cymodocea serrulata*, *Halodule uninervis* and *Syringodium isoetifolium*. The seagrass species identified are known to be important as a food source for turtles as well as dugongs and nursery grounds for commercial fisheries species. Helene Marsh and her co-workers surveyed this area in March 2011 and sighted large numbers of turtles as well as significant numbers of dugongs<sup>(6)</sup>. They suggested that it would be appropriate to make the region a 'Dugong and Turtle Sanctuary'.

Seagrasses in the tropics are well known to undergo seasonal shifts in distribution and abundance, sometimes up to 7-fold within a year. The next question we wanted to answer was

whether the seagrass was persistent throughout the year in the Dugong Sanctuary, providing a continual source of food for dugongs and green turtles. Eight months after the initial survey we set out to re-survey smaller representative areas as logistical and budgetary constraints prevented us from surveying the full 1.3 million hectare Sanctuary again. The second survey in November 2010 again identified healthy, productive seagrass within the representative areas. The study showed some changes to seagrass abundance and percent cover from March, however, these changes were not consistent between representative areas. Either way, our suspicions that seagrass is likely to be present year round in the Dugong Sanctuary were confirmed; great news for dugongs and turtle in the region. The vast area of seagrass mapped also provides a year round, important source of primary production supporting the region's marine ecosystem. Studies at the nearby Orman Reefs have shown seagrass meadows to be extremely productive, completely turning over their above-ground biomass every 9 to 25 days<sup>(5)</sup>.

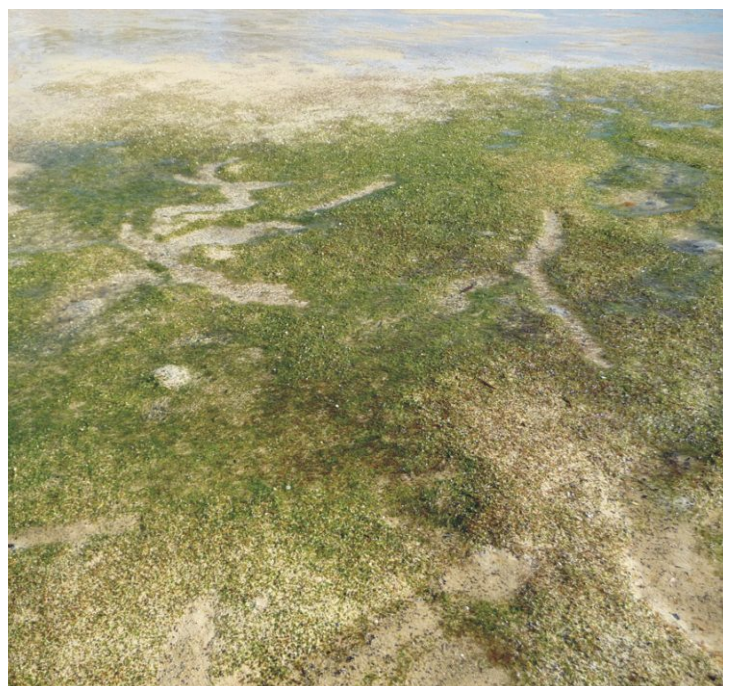
The fact that seagrasses in the Dugong Sanctuary are so important to the Torres Strait suggests that it would be beneficial to expand the protection afforded from just dugongs to include turtles and the habitat itself. Seagrass species vary in their sensitivity and resilience to impacts including those associated with shipping activities; a major activity in the Torres Strait. The



resilience of seagrass meadows is a result of a complex interaction of many factors including their carbohydrate reserves, ability of photosystems to recover, capacity for vegetative propagation, seed bank occurrence and disturbance regime. As the Dugong Sanctuary contains a wide range of species it follows that there would be a corresponding range of tolerances and capacity to recover from impacts. *Halophila* and *Halodule* species are able to rapidly colonise disturbed areas through high reproductive output and generation of large seed banks, however larger growing species (such as *Cymodocea serrulata*) are more dependent on recovery through extension of rhizomes meaning that they can take substantially longer to recover if lost. Preliminary results from a study on seed reserves in a subtidal seagrass meadow of similar seagrass composition at nearby Mabuiag Island found high densities of *Halophila decipiens* seeds, but the seeds of no other species<sup>(7)</sup>. This may be a particularly worrying sign for seagrasses in the Dugong Sanctuary and subsequently to dugongs and turtles; seagrass diebacks in the 1980's have been linked to declines in the dugong population.

The surveys that we have conducted indicate that seagrass communities within the Dugong Sanctuary appear to be in a healthy and productive state. They provide a good baseline of information against which changes to seagrass distribution and abundance could be measured in the future. The Marine Ecology Group and the TSRA Land and Sea Management Unit are developing a quarterly monitoring program to assess permanent sites within the sanctuary, to be conducted by Torres Strait Rangers and Dugong and Turtle Officers. This program will further develop our understanding of interannual and seasonal change in seagrass abundance and cover and its implications for dugongs, turtles and fisheries that depend on this habitat.

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**Images:**

Fisheries Biologist, Helen Taylor (far left) conducting productivity research on subtidal seagrasses, Mabuia Island.

One of the 247 islands (above, centre) that dot the Torres Strait region.

Principal Scientist Rob Coles and Fisheries Biologist Ross Thomas (top right) clear the sled net filled with *Halophila spinulosa* in the Dugong Sanctuary.

Torres Strait Rangers Frank Nona and David Baragud (bottom right) assist with seagrass sorting in the lab.

Teams members from the Marine Ecology Group (below) work hard to beat the fading light at Mabuia Island.

Dugong feeding trails (opposite), through a seagrass meadow on Badu Island.





*Dense seagrass meadows blanket the tops of intertidal reefs between Badu and Moa Islands, adjacent to the Dugong Sanctuary*





# Dugongs

at the  
edge

Article by **Katherine Hunt, Jenny Renell & Donna Kwan**  
Photography by **Mandy Etpison**



**D**UGONGS ARE GLOBALLY classed as “Vulnerable to Extinction” by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, but it is recognised that data are often insufficient for making an accurate status assessment across much of the dugong's range. The largest populations are found in Australia, followed by the United Arab Emirates (UAE), but the range stretches across some 40 countries in tropical and sub-tropical zones where seagrass is abundant.

The close association between dugongs and seagrass is likely to have contributed to their status as an endangered species in some parts of the world. As dugongs must often come near to the shore to graze, they are left vulnerable to unfavourable human interactions, including death or injury from vessel strikes. In developed countries, the key threat is often

degradation and loss of habitat through coastal development with its associated dredging and pollution, as well as incidental catch by gill net fisheries and damage to seagrass from fishing by trawling.

The situation differs in developing nations: in some areas, dugong hunting still takes place, even when it is illegal, and a dugong can represent a valuable catch to be sold or to provide protein for communities struggling with insufficient food resources. Incidental catch in artisanal fisheries is another negative impact. Dugongs are often viewed to be worth more dead than alive, and accidentally catching a dugong in a net can represent a windfall of meat (and money) for a fisher and their family. As the majority of dugong range states are developing nations, effective conservation measures need to take this into account and consider the needs of the local population to achieve results.

**“ in some areas dugong hunting still takes place, even when it is illegal, & a dugong can represent a valuable catch to be sold or to provide protein for communities struggling with insufficient food resources. Incidental catch in artisanal fisheries is another negative impact....”**



ME

Due to the particular life history of the dugong - long-lived with slow maturity and low reproductive rate - even a minor level of human-caused adult mortality in a localised population of dugongs can cause the population to decline. The impact of climate change on dugong populations is another cause for concern even though its impact is uncertain. An increase in temperature and sea level might result in an extension of the range of seagrass growth, providing more habitat for dugongs. However, other likely outcomes of climate change such as more extreme storms may have a detrimental impact on essential seagrass habitats, for example, water quality is reduced after increased land run-off following storms. Severe storms are also known to cause dugong mortality through strandings. The continuing rise in human populations and the subsequent requirement for increased

#### worlds most isolated in Palau:

Palau's dugong population is considered to be the most isolated in the world and is unlikely to be supplemented by recruitment from any other area. Using IUCN parameters, Marsh (2010) estimated that the dugong population in Palau can be classified as critically endangered. It is also known that dugong hunters in Palau seem to prefer the meat of female and juvenile dugongs to that of adult males. If this preference is reflected in the catch, it will put added pressure on the stock. 40 animals were recorded in October, 2010. The same year, 11 dugongs were recorded killed, most by illegal poaching. Local fishermen estimate 5-15 dugongs are still killed each year.

Source: Dugongs - respect and protect : dugong profile for range states in the Pacific Islands. Apia, Samoa : SPREP, 2011.

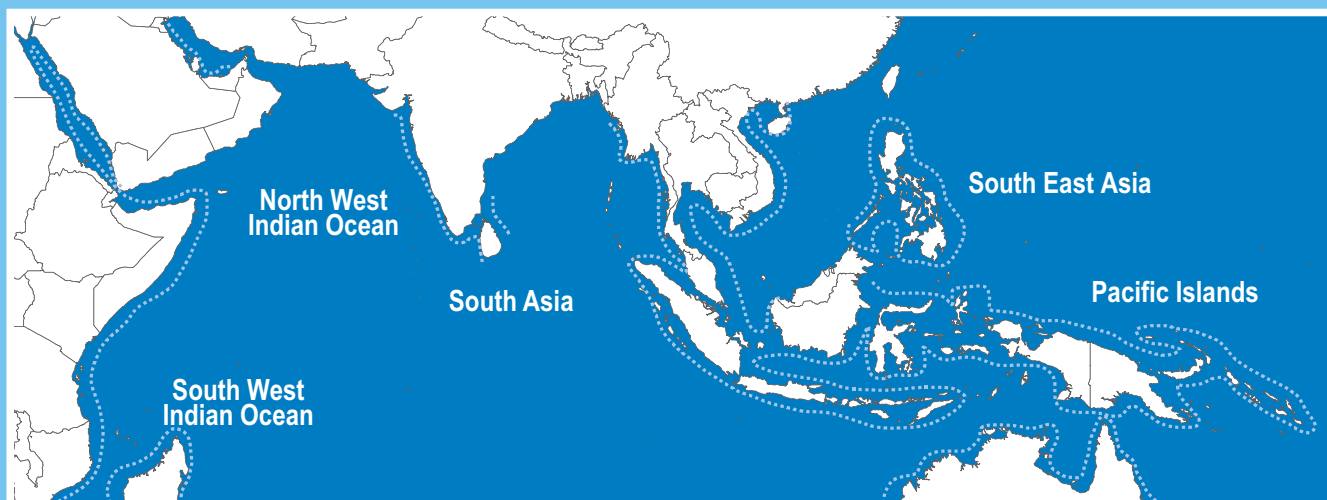
protein sources, particularly in developing countries where dugongs are found, may further exacerbate the problem<sup>(1)</sup>.

#### CMS & the Dugong MOU

The Convention on Migratory Species (CMS) is an intergovernmental treaty under the aegis of the United Nations Environment Programme (UNEP), which aims to conserve terrestrial, aquatic and avian migratory species of wild animals

throughout their range. CMS is the only global convention specializing in the conservation of migratory species, their habitats and migration routes. The Convention is a framework which works through various types of agreements such as Memoranda of Understanding (MOUs). A country may become a signatory to any agreement without first becoming a Party to CMS. The Convention is supported by a Secretariat based in Bonn, Germany and two satellite offices in Bangkok, Thailand and in Abu Dhabi, UAE.

## THERE ARE 21 CURRENT SIGNATORIES TO THE DUGONG MOU



**DUGONG MOU SIGNATORIES:** AUSTRALIA, BAHRAIN, COMOROS, ERITREA, FRANCE (MAYOTTE, NEW CALEDONIA), INDIA, KENYA, MADAGASCAR, MOZAMBIQUE, MYANMAR, PALAU, PAPUA NEW GUINEA, PHILIPPINES, SEYCHELLES, SOLOMON ISLANDS, SRI LANKA, THAILAND, UNITED ARAB EMIRATES, UNITED REPUBLIC OF TANZANIA, VANUATU AND YEMEN.

### 21 signatory states:

The Dugong MOU covers conservation and management of dugongs and their habitats, and it currently has 21 Signatory states. Encouraging support from and co-operation between range states is an important goal of the Dugong MOU. A regular meeting of all range states brings nations together to share reports on progress, highlight priority needs and discuss ways to move forward.

The Abu Dhabi office looks after two MOUs: one on the conservation of African-Eurasian migratory birds of prey and one on dugongs. The Dugong MOU covers conservation and management of dugongs and their habitats, and it currently has 21 Signatory States. Encouraging support from and co-operation between range states is an important goal of the Dugong MOU. Signatory State meetings are organised regularly and they bring nations together to share reports on progress, highlight priority needs and discuss ways to move forward.

### What is the UNEP/CMS Dugong MOU doing to protect dugongs?

The UNEP/CMS Dugong MOU provides a means for the exchange of information and shared activities and objectives in conserving dugongs and their habitats. It also helps to locate avenues for project funding as well as direct funding of small projects, and sponsorship for eligible participants to attend relevant workshops and meetings.

In addition to these ongoing activities, the MOU has recently been working on a larger programme, the Dugongs, Seagrass

and Coastal Communities Initiative. The Initiative was launched at “S.O.S.” event (‘Save Our Sirenians: Dugongs and West African Manatees’) held in Abu Dhabi in February 2012, which featured presentations from noted dugong expert Professor Helene Marsh, and two short films, one on West-African manatees and the other on dugongs.

Through the initiative, tailored conservation solutions will be trialed using innovative tools which will increase protection for dugongs and seagrass ecosystems at the same time as providing sustainable development for rural coastal communities. These trials will include a variety of alternative livelihood possibilities and incentives to move people away from hazardous fishing methods, as well as improving the management of protected areas and in some cases helping to create new protected areas or upgrade their status. One novel approach which could help to provide a sustainable funding stream for coastal communities is through ‘Blue Carbon’, a means of recognising the carbon sequestration value of coastal ecosystems like seagrass and mangrove forests.

Under the aegis of the UNEP/CMS Dugong MOU, pilot projects are already underway in Papua New Guinea, Mozambique and Gulf of Mannar (India-Sri Lanka transboundary project), and more are planned, subject to funding. The progress of these pilot projects, together with results currently being collated from standardised dugong catch surveys undertaken locally in several range states, will help to inform the broader national and regional direction of the programme.

For further information visit <http://www.cms.int/species/dugong/index.htm>

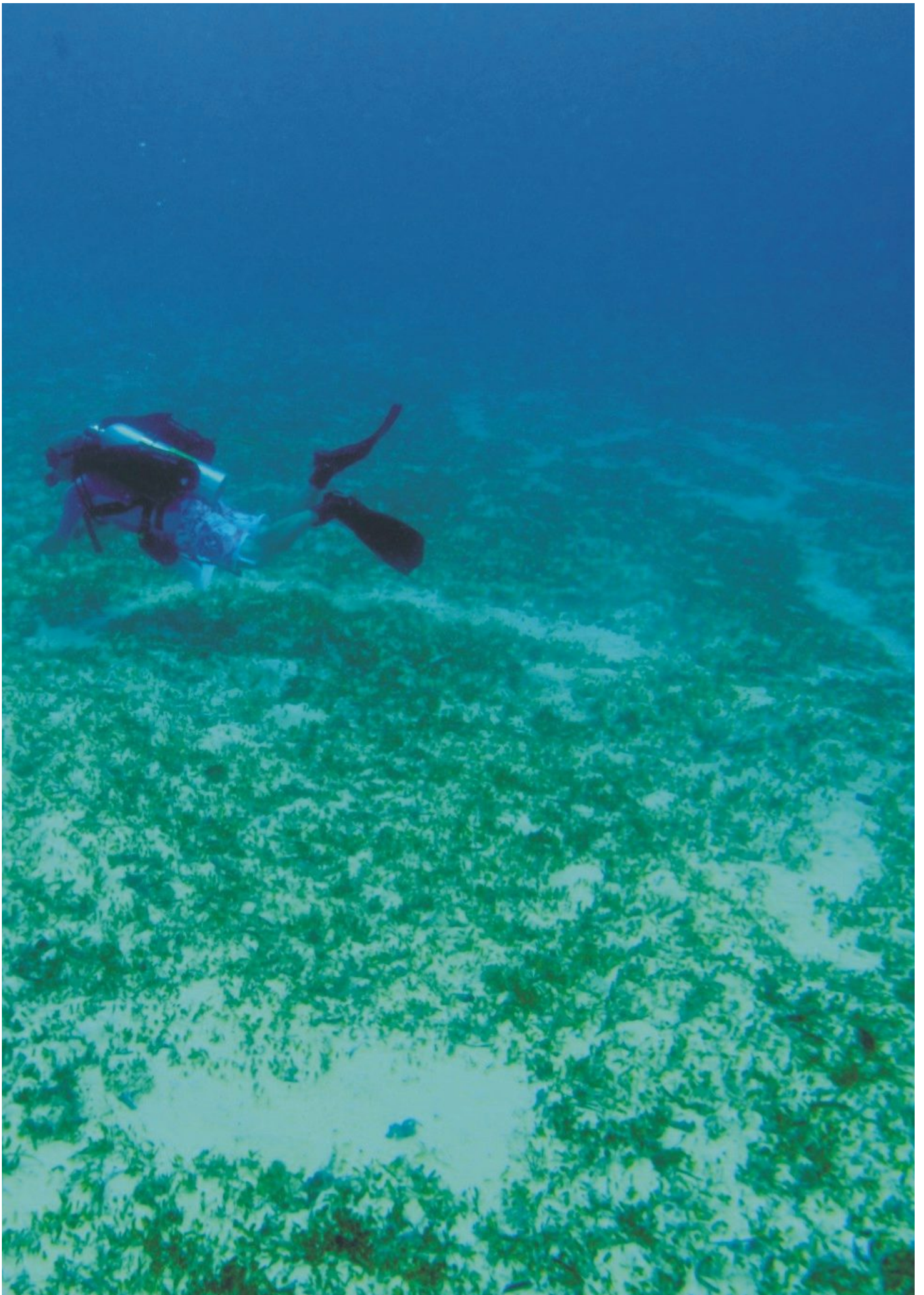
### Images:

Pg (25) Dead dugong found floating in Koror Harbour (Palau). The cause of death was unknown.

Pg (29) Dugong feeding trails, around the Ngederrak reef conservation area in Koror (Palau).

### References

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# Sirenia

## How similar are they?

Dugongs and manatees are the only large fully aquatic herbivorous mammals, justifying their common name: sea cows. Throughout history, sirenians have inspired cultural responses, provided people with meat, hides and oils, and stimulated myths and stories. Today they are increasingly being used as 'flagship species' to represent larger environmental causes.

Dugongs and manatees have a long evolutionary history extending back more than 50 million years, but their ancestors diverged some 25 - 40 million years ago. The sirenians possess a suite of morphological, ecological and physiological adaptations to a life of swimming, diving and eating aquatic flowering plants. Although dugongs and manatees look remarkably alike, there are a number of features and characteristics which separate them.

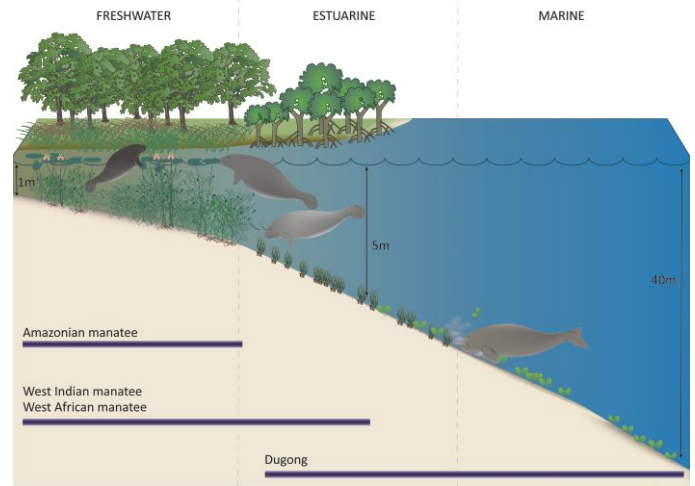


Diagram illustrating the habitats and food plants of the four extant species of Sirenians. By Catherine Collier, from Marsh *et al* (2011).

	Manatee	Dugong
<b>Species</b>	West Indian manatee ( <i>Trichechus manatus</i> ), Florida manatee ( <i>T. manatus latirostris</i> ), Amazonian manatee ( <i>T. inunguis</i> ) West African manatee ( <i>T. senegalensis</i> )	<i>Dugong dugon</i>
<b>Distribution</b>		
<b>Adult body length</b>	up to 3.5m	up to 3.3m
<b>Adult body mass</b>	up to 1,620 kg (Amazonian up to 450 kg)	up to 430 kg
<b>Body shape</b>	stout, tapered body ending in a flat, rounded tail	tapered body that ends in a deeply notched tail, or fluke
<b>Body colour</b>	dull grey, blackish, or brown	grey-brown
<b>Forelimbs</b>	<ul style="list-style-type: none"> <li>flippers with nails in <i>T. manatus</i> and <i>T. Senegalensis</i></li> <li>used for sculling, turning, bottom walking, and manipulating food</li> </ul>	<ul style="list-style-type: none"> <li>rounded flippers lacking nails</li> <li>used for balance</li> </ul>
<b>Head features</b>	low rostral deflected snouts (15-52°) to facilitate surface feeding or feeding on natant and emergent vegetation	<ul style="list-style-type: none"> <li>high rostral deflected snouts (~70°) to enable benthic foraging</li> <li>males have tusklike incisors</li> </ul>
<b>Social behaviour</b>	primarily solitary but form temporary aggregations of up to 20 at feeding areas, or during breeding	usually observed singly or as pairs. Herds of 12-300 are sometimes seen, with 670 being the maximum recorded
<b>Diving</b>	breathe every 1 - 8 mins, can remain submerged for up to 24 min	breathe every 1 - 6 mins, can remain submerged for up to 11 min
<b>Communication</b>	<ul style="list-style-type: none"> <li>faint chirps, squeaks, and grunts</li> <li>tactile contact by sensory hairs over body with sensitive facial vibrissae</li> </ul>	<ul style="list-style-type: none"> <li>whistle-like songs by mature males</li> <li>tactile contact by sensory hairs over body with sensitive facial vibrissae</li> </ul>
<b>Reproduction</b>	one calf every 2 to 3 years	one calf every 3 to 7 years
<b>Sexual maturity</b>	about 5 years, but as young as 3 years of age	about 10 years of age
<b>Lifespan</b>	up to 59 years	up to 73 years

Photography Mark Evans, Mandy Etpison & Patrick M. Rose (savethemanatee.org)





# Ecology and Conservation of the Sirenia: Dugongs and Manatees

Helene Marsh, Thomas J. O'Shea, John E. Reynolds

Available in Hardback, Paperback and e-book

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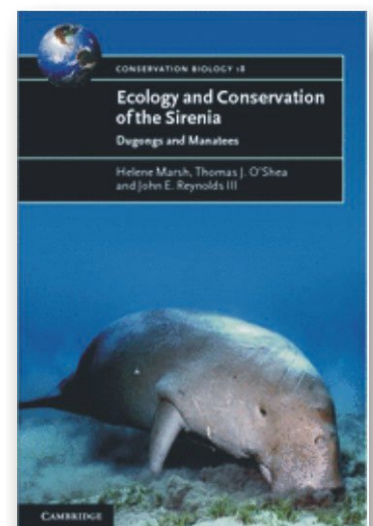
Dugongs and manatees, the only fully aquatic herbivorous mammals, live in the coastal waters, rivers and lakes of more than 80 subtropical and tropical countries and territories. Symbols of fierce conservation battles, Sirenian populations are threatened by multiple global problems. Providing comparative information on all four surviving species, this book synthesises the ecological and related knowledge pertinent to understanding the biology and conservation of the Sirenia. It presents detailed scientific summaries, covering Sirenian feeding biology; reproduction and population dynamics; behavioural ecology; habitat requirements and threats to their continued existence. Outlining the current conservation status of the Sirenian taxa, this unique study will equip researchers and professionals with the scientific knowledge required to develop proactive, precautionary and achievable strategies to conserve dugongs and manatees.

## Features

- A synopsis of the status and conservation needs of Sirenia in more than 80 countries, offering detailed material for each species and status information for each country or region
- Addresses human values, food security, poverty and other topics to equip researchers and professionals with the tools to develop successful strategies for conserving wildlife and habitat, in both developing and developed countries
- Summarises the ecological breadth and diversity of extinct Sirenians and their likely origins, providing readers with a greater appreciation of the evolutionary uniqueness of the Sirenia

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Image: Dennis the dugong (above). Photography by Fergus Kennedy





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