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Seagrass-Watch

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

Economic value of seagrass

Local eyes Global wise

In this issue:

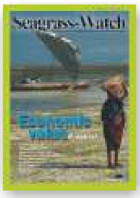
From the editors

In a world driven by economic growth, the need to attribute a dollar value to natural resources, such as seagrass ecosystems, has become a necessity to benefit conservation and realise the unforeseen "costs" of mismanagement. In this issue are several articles on the economic valuation of seagrass ecosystems, and how they benefit human well-being.

Included are also articles on how seagrass and marine habitats are being protected in the Gili Islands Matra MPA and the Verde Island Passage to sustain incomes to local communities generated from tourism and fishing.

As seagrasses provide habitat and food resources for endangered and threatened animals, this issue includes articles on the important Ramsar wetlands of Shoalwater Bay in Queensland and Roebuck Bay in Western Australia.

In this issue, you can also read about the impacts of the recent oil spill in Singapore and a survey of seagrasses in North-Eastern Madagascar. Catch up with the revived monitoring in the Pulai River estuary (Malaysia) and the ongoing monitoring at Suva (Fiji). You can even learn about hermit crabs.



COVER:
Chwaka Bay, Zanzibar, Tanzania.
Photographer Len McKenzie

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A Dollar value on seagrass

Article by Richard Unsworth and Leanne Cullen-Unsworth
Photography Len McKenzie, Stuart Campbell & Rudi Yoshida

Seagrass meadows are globally being lost at a rate of up to two football fields per hour; this loss is roughly equal to the current rates of loss of coral reefs or tropical rainforests. Although many factors intricately interact to contribute to these losses, scientists and conservationists commonly believe that ecosystem degradation largely stems from anthropogenic impacts that are often exacerbated by a lack of appreciation for the actual economic value of ecological systems.

Many would argue that ecological systems are 'priceless', however, by not valuing natural resources, when economic and resource management decisions are made, the value may be assumed to be zero.

Continued economic growth is the mantra of the majority of the world's governments. To achieve this growth decisions need to be made and these are often based upon a cost-benefit analysis. Decisions about investing in a new port terminal, developing new legislation to control polluters, or providing funds for the construction of a new sewage treatment works are all based on cost-benefit analyses (i.e. what will be the economic cost to build or implement, and what will be the resultant economic benefits). Such analyses require extensive information about impacts and the resources that will be affected.

'Cost-benefit' decisions, however, are not always solely based on financial terms. Decisions may be based upon 'voter' cost-benefit, or social cost-benefit, but these can often be linked to an actual financial value for the decision makers. If an environmental resource has no known financial value, and its value can only be seen through emotive terms such as being termed 'priceless' and 'invaluable', its actual financial value will often not be considered or be considered to be negligible. If a resource has no value on an asset register the loss of that resource may be perceived to be inconsequential.

Placing a direct economic value upon nature is always going to be controversial as some people will always believe that nature is 'priceless'. But nature provides goods and services just like a company does. The insight that nature provides goods and services to mankind is not a new one. The Cambridge Professor of Economics Partha Dasgupta recently described how in 360BC Plato remarked on the helpful role that forests play in preserving fertile soil; in their absence, he noted, "the land was turned into desert, like the bones of a wasted body". Valuation of ecological goods and services such as those provided by a forest is difficult. In that instance it may be possible to provide a cost or value for the rehabilitation of the land from desert, but this will not provide a value for the habitat the forest provided for insects critical to pollinating nearby crops.

Fish trap or "dema" (Chwaka Bay, Zanzibar, Tanzania)

Fish trap (Cyrene Reef, Singapore)

Placing a value upon the ecological goods and services provided by seagrass is equally difficult. Providing an economic value for a seagrass meadow can firstly be done through the consideration of its ecosystem services, defined as the "benefits human-kind obtains from a multitude of resources and processes that are supplied by natural ecosystems". Economists commonly refer to the ecosystem goods and services provided by these resources as 'direct' and 'in-direct' use values. The actual methods used to place financial values upon these goods and services are varied and often controversial but are well explained within a number of key textbooks (see further reading below).

The commonly observed goods and services that seagrass meadows provide include 'fisheries production' and 'fisheries nursery value', as well as 'biodiversity protection' (e.g. dugong, turtle, seahorses). Seagrasses also provide services that are a little less obvious such as 'nutrient cycling', 'coastal protection', 'water filtration (sediment trapping)', 'carbon cycling' and acting as a 'carbon sink' (while also producing oxygen). Other services that seagrass meadows provide include social, cultural and spiritual resources. Many indigenous peoples' have close cultural and spiritual links to seagrass meadows, including their use in cultural and religious ceremonies. In many locations seagrass meadows are also economically important for the habitat they create for cultivating seaweed.

In addition to these direct and in-direct ecosystem goods and services there are other non-use values that can be calculated, such as their 'existence' and 'bequest' values (knowledge that a resource exists and will continue to exist for future generations), and their 'intrinsic' value (value of biodiversity and

Components of seagrass meadows that contribute to their Total Economic Value (TEV)
(from Cullen 2007)

Use values				Non-use values	
Direct		Indirect	Other	Existence & Bequest	Intrinsic
Consumptive	Non-consumptive				
Fisheries Aquarium trade *(e.g. seahorses)* Curio trade *(e.g. shells)* Bio-prospecting *(e.g. sponges)* Construction materials	Tourism Research Education Recreation Culture Religion	Biological support *(e.g. fish nursery)* Coastal protection Global life support *(e.g. oxygen production)*	Option value *(e.g. maintenance of system for future use)*	Knowledge of system existence and continued existence for enjoyment by future generations	Biodiversity Species richness Existence with no human use

The commonly observed goods and services that seagrass meadows provide include things like 'fisheries production' and 'fisheries nursery value', as well as 'biodiversity protection' (e.g. dugong, turtle, seahorses)

ecosystems removed from any perceived human benefit). Bringing all these direct, indirect and non-use values together provides what is termed the Total Economic Value (TEV), and this can be a very useful tool for decision makers. Valuing seagrass meadows is highly complex, as what we observe in a productive intertidal meadow may well be different in a deepwater meadow or in a muddy estuary. One value may not fit all. And as we all see regularly in our Seagrass-Watch monitoring, the seagrass meadows can be highly variable, both annually and seasonally; and with these changes, the magnitude of the value of many ecosystem services can also change. Values for goods and services also change between locations, for example the US$ price of 1 kg of fish in Indonesia is very different to that in Australia.

Understanding the TEV of seagrass meadows also has to extend beyond seagrasses as stand-alone ecosystems. Seagrasses are part of the coastal seascape that includes many different components, in a tropical context this includes mangroves, algal beds, and coral reefs, and these components all interact and have varied levels of connectedness. Although it may be possible to calculate a value for the fish and invertebrate stocks of a seagrass meadow, the abundant fauna (particularly the molluscs, echinoderms and crustaceans) of seagrass meadows provides a huge feeding resource for fish assemblages of reef and deeper water ecosystems that migrate onto a seagrass meadow at night. Seagrass meadows are not just productive in their own right; they also support the productivity of other connected ecosystems such as coral reefs.

A range of values have been calculated for seagrass meadows throughout the world based upon a number of different goods or services. One of the most straight forward values to be placed upon a seagrass meadow is that of its exploitable (or exploited) fisheries. This has yielded results from a variety of locations with values ranging from US$47 to US$3500 $ha.yr^{-1}$. A widely quoted value for seagrasses is that of US$19,004 $ha.yr^{-1}$ calculated by Prof. Robert Costanza of Portland State University when he determined the goods and services provided by the global natural environment to be worth US$16-54 trillion per year, in 1997. This value importantly doesn't include many of the obvious values such as fisheries, but instead estimates the value seagrasses provide in cycling nutrients, effectively operating as coastal water filters. It is these less visible services that can often be the most valuable.

A range of cumulative values approaching TEV for seagrass meadows do exist, but the exact nature of these calculations is not always clear. One specific value that is calculated in Indonesia within East Bintan finds seagrasses to be worth over US$3.5 million to the local communities (or 2,287 $ha^{-1}.yr^{-1}$). Two-thirds of this value arose from tourism, but it did not include a calculation of any non-use values. At a location such as Green Island on the Great Barrier Reef, the value of the seagrass meadow could be equally high as a result of at least a small proportion of the estimated 300,000 annual tourists that visit the Island travelling to see the abundant green turtles feeding in the seagrass.

Economic value can also be determined by calculating the 'replacement cost' for rehabilitating or recreating a degraded or destroyed resource as in the example of Plato's forest. But as with the forest example, this is not an actual value that reflects the services the resource provided. In the U.S. many thousands of hectares of seagrass has been destroyed and only in the last decade have restoration techniques begun to be sufficient to embrace habitat rehabilitation. Seagrass value based upon replacement costs in the U.S. have been determined to range from US$1,200 to US$140,000 ha^{-1}, leading the authors to conclude that at such a high value why are seagrass meadows allowed

Catch:

The seagrass meadow at Ontoloe Island (Flores, Indonesia) provides a bounty of goods.

Fishermen collect their catch from a net set over the meadow.

A haul of Volutidae and Strombidae gastropods gleaned from the intertidal meadow.

Sea cucumbers harvested from the Russell Islands (Solomon Islands): *Juvenile sea cucumbers settle into near-shore seagrass meadows where they remain until they mature and move offshore as adults.*

(despite the consequences) to be damaged so frequently in the first place. As we enter an age increasingly likely to be economically influenced by carbon it is important to recognise that seagrass can be an important store and sink for carbon and the value of this service is likely to increase.

To our knowledge the calculation of an economic value for seagrasses is mostly limited to the studies outlined here, and although theses are diverse they do not provide more than a broad insight into the total economic value of seagrass meadows around the world.

The lack of any usable values or formulae for seagrass meadows is a key difficulty in situations where coastal developments require seagrass to be destroyed and the impact economically 'offset'. This lack of information may also limit the attention paid to seagrass in the conservation agenda of many nations. As scientists and conservationists, reaching an estimate for the total economic value of seagrasses may help seagrasses to be more widely recognised as the critically important ecosystems that they are. To obtain a true estimate also requires a better understanding of the many interacting factors contributing to and utilising seagrass productivity.

Further reading:
Costanza et al. (1997) Nature. 387: 253-260
Cullen (2007) Natural Resource Dependence, Resource Use Patterns and Development of Economic Performance Criteria within a Small Island Community. University of Essex.
Edwards-Jones et al. (2000) Ecological Economics. Wiley-Blackwell.
Fortes (1990) ICLARM.
Unsworth et al. (2010) Ocean and Coastal Management 53: 218-224
Unsworth & Cullen LC (2010) Conservation Letters 3: 63-73 (online open access)
Watson et al. (1993) Marine & Freshwater Research 44: 211-220

Service	Study	Location	Value
Fisheries exploitation	Watson *et al.* 1993	Queensland, Australia	3,500 US$.ha^{-1}.yr^{-1}
Fisheries production	Author unknown	Indian River Lagoon, US	1,862 US$.ha^{-1}.yr^{-1}
Fisheries production	McArthur *et al.* 2006	South Australia	133 US$.ha^{-1}.yr^{-1}
Fisheries standing stock	Unsworth *et al.* 2010	Wakatobi, Indonesia	47 to 109 US$.ha^{-1}
Nutrient cycling	Costanza *et al*. 1997	Globally	19,004 US$.ha^{-1}.yr^{-1}
Restoration	Thorhaug 1990	US	1,236 US$.ha^{-1}
Restoration	Engeman *et al*. 2008	Florida US	140,752 US$.ha^{-1}
Use values	UNEP 1990	SE Asia	215,000 US$.ha^{-1}
Use values	Kuriandewa *et al.* 2008	South China Sea	80,226 US$.ha^{-1}.yr^{-1}
Carbon sink	Cebrian & Duarte 1996	Mediterranean	*Up to 27 US$.ha^{-1}.yr^{-1}
Carbon standing stock	Duarte & Chiscano 1999	Global	*Mean 28 US$.ha^{-1}
Total Economic Value	Dirhamsyar 2007	East Bintan, Indonesia	2,287 US$.ha^{-1}.yr^{-1}

*Based upon present authors extrapolation of ecological study to EU Climate Exchange variable C price of US$20/ton

For full citations, contact hq@seagrasswatch.org

Protecting the Gili islands

Indonesia

Article by Stuart Campbell, Irfan Yulianto & Tasrif Kartawijaya
Photography Irfan Yulianto & Department of Fisheries and Marine Affairs

LOCATED just off the northwest coast of Lombok (Indonesia), the three islands of Gili Air, Gili Meno and Gili Trawangan are rapidly becoming one of the most popular tourism destinations in Indonesia. The islands are easily accessible from Bali with many options for marine based tourism activities including scuba diving, snorkelling, surfing, fishing and kayaking. The Gili Islands are inhabited by 2,935 people spread over 552 families. Most people living in the Gili Islands are part of the Buginese community from southern Sulawsei, whereas the Sasak community are the dominant culture on nearby Lombok. Recently many people from Lombok, Sumbawa, Bali and Java have settled in the three islands.

In 1993, the Minister of Forestry declared the three small islands of the Gili's as a Marine Protected Area (MPA) under the management of the Department of Forestry. The Gili Islands Matra MPA, located in the Province of Nusa Tenggara Barat is 2,954 hectares, with 449 ha of seagrass and coral reef ecosystems and 665 ha of terrestrial environments (see map, page 8). More than 6,000 species of marine life have been recorded. In 1998, a management plan was developed for the islands and a few staff (*jagawana*) visited the islands on regular basis to conduct some limited management of marine ecosystems. However, this was inadequate and destructive fishing practices were widespread in the 1990's (blast fishing, *muro-ami*) and anchor damage from tourism boats was unregulated.

In 2009 the number of visitors to the Gili's exceeded 100,000, a sharp increase from around 40,000 in 2006. More than 560 local people are employed as tourism guides mostly in marine based activities , and 45 transportation companies (mainly dive and transport boats) exist. About 113 hotels or bungalows and 141 restaurants of varying sizes are located throughout the islands. This represents one of the most significant tourism precincts in Indonesia.

The increasing focus of tourism in the Gili's has heightened awareness of the importance of marine ecosystems to economic opportunities through employment and improvements in people's livelihoods. As a result local communities have become organized and with some assistance from dive companies and have begun to protect their coral reefs from blast fishing and muro-ami fishing (large set nets on the seabed) using local community management approaches. Using traditional customary laws called *awig-awig*, Environment

Conservation Groups (ECG) on each island have been established with responsibility for day to day management of natural resources and to the Kepala Dusun (Head of Sub-village). There are 12 people in each ECG, consisting of a leader, a secretary, a treasurer, conservation officers, cleaners and welfare officers.

The rapid pace of tourism development on the islands poses a threat to the health and resilience of marine ecosystems. Increased fishing pressure, damage to coral reefs caused by boat anchors and poor coastal development all put at risk the future health of the Gili Islands. The National Department of Fisheries and Marine Affairs, who in 2009 assumed management of the MPA from the Forestry Department, is currently re-designing the zoning and management of the MPA to promote greater community involvement in management of the Gili's natural marine assets.

“The increasing focus of tourism in the Gili’s has heightened awareness of the importance of marine ecosystems to economic opportunities through employment and improvements in people’s livelihoods”

A first step by the government has been to identify and map some of the important marine habitats including extensive seagrass meadows, and use this information for re-zoning the MPA. From April 27 to March 3, 2010, the Wildlife Conservation Society's Indonesia Marine Program assisted the National Department of Fisheries and Marine Affairs to survey coral reef and seagrass habitats of the Gili Matra MPA. Surveys of reef fish used visual census methods by divers exploring the reef and seagrass areas.

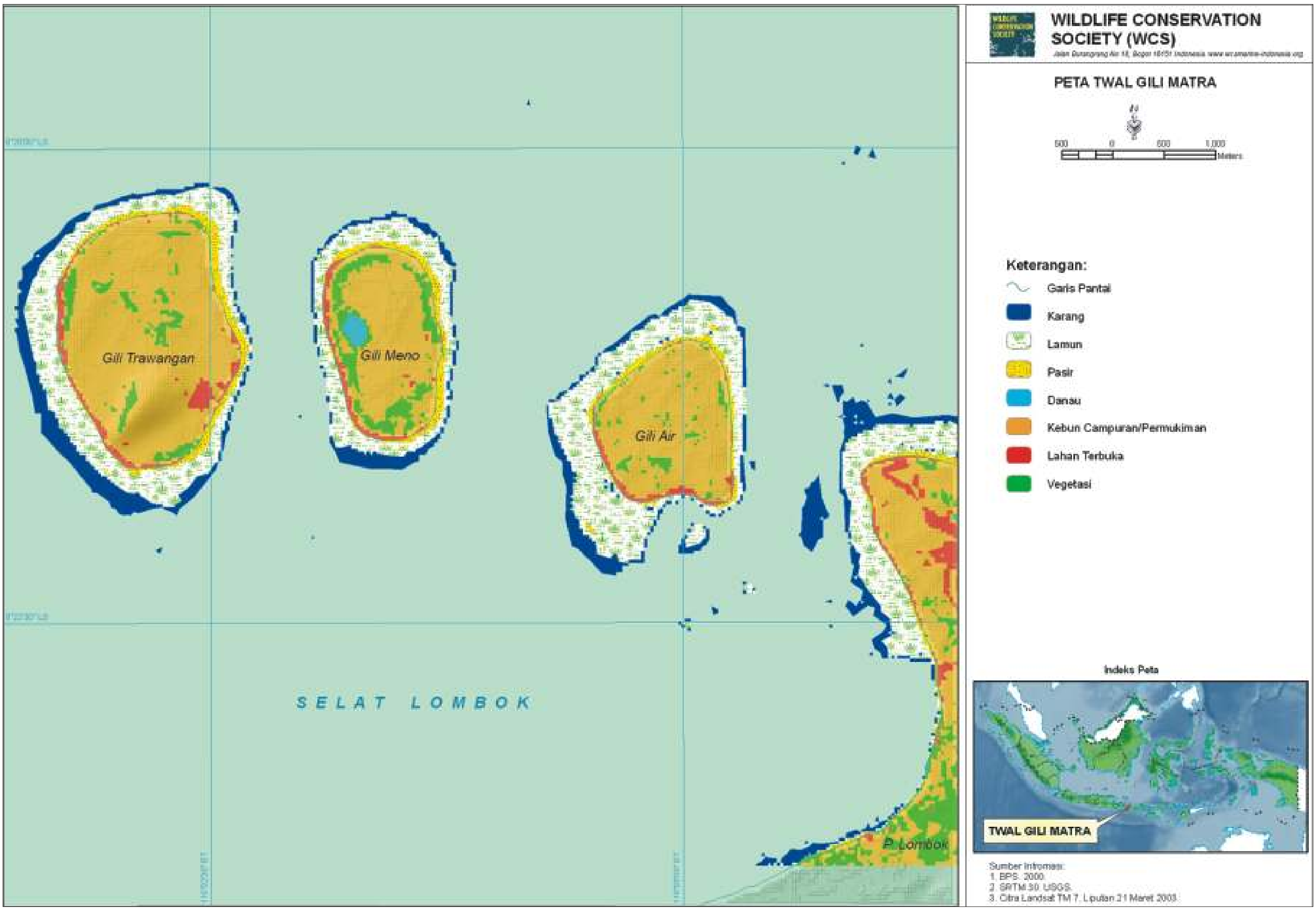
Clockwise from left:
Enhalus acoroides meadow
The dive team
Surveying subtidal seagrass along a transect

A total of 110 manta tows - *where people survey the reef on snorkel while being towed by a boat at 1-2 knots* - were used to map the reefs around all islands in the Gili Matra MPA. The condition of coral reefs varied from very bad to good, and some areas exhibited the effects of bleaching which has coincided with elevated seawater temperatures from April to June. Coral cover was highest in Gili Air compared with Gili Meno and Gili Trawangan. 214 species of coral reef fish from 34 families were recorded. Seagrass habitats were examined using Seagrass-Watch methods (50 x 50 m site). A single site at each island was surveyed to get an initial idea of the species composition of seagrass meadows of the three islands. Further surveys are planned to more accurately characterise the seagrass habitats.

Seagrass, macroalgae and sand cover at each of the three Gili Islands, Indonesia.

The work here is important for the protection of marine habitats and for sustaining incomes to local communities generated from tourism and fishing. Seagrass meadows in the Indo-Pacific play a major role as fish nursery and feeding grounds. Damaging fishing practices within seagrass habitats may severely impact upon adjacent coral reef fish assemblages and people's incomes and livelihoods. Future management and development of marine protected areas requires knowledge of coral-seagrass habitats to successfully enhance fish populations and conserve marine ecosystems.

Map of Gili Matra MPA – Legend: Garis Pantai = Coastline, Karang = Coral Reef, Lamun = Seagrass, Pasir = Beach, Danau = Lake, Kebun Campuran/Permukiman = Crops, Gardens/Settlements, Lahan Terbuka = Cleared Lands, Vegetasi = Vegetation.



Malaysia

Pulai estuary monitoring

Article by
Choo Chee Kuang

Photography
Ria Tan
(www.wildsingapore.com)

After approximately two quiescent years, the community-based seagrass monitoring program at the Pulai River Estuary, Malaysia has been revived under the funding from the UNEP-GEF Small Grants Program.

Led by the Malaysian Society of Marine Science seagrass coordinator, Faridah bt Mohd Saman and assisted by Jessie Tang, Tyng Tyng and Fang Meng, three meadows were successfully monitored with local participation from February to April 2010.

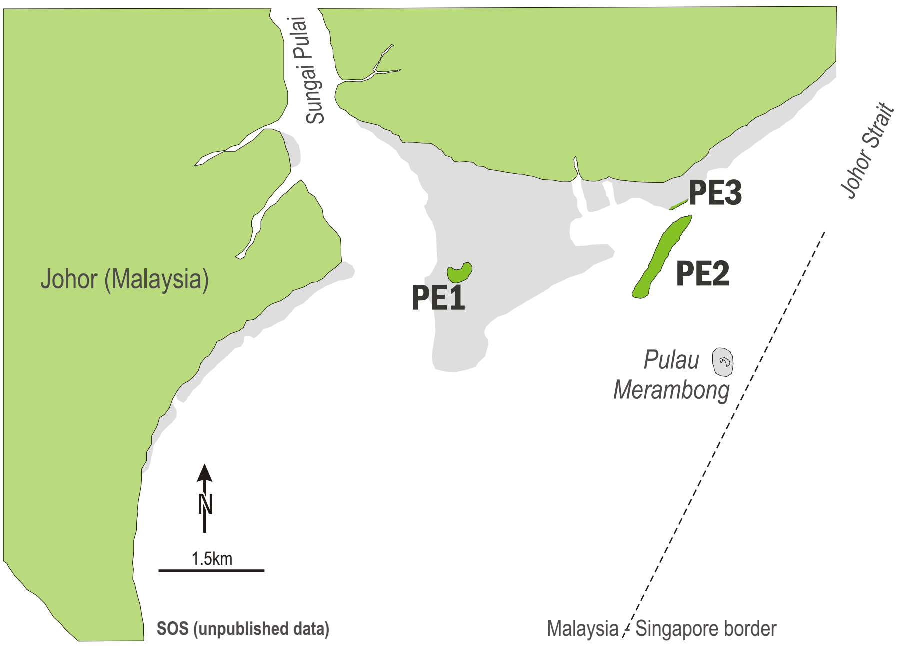
Since our team were eager to learn about the differences in terms of species composition across sites, some statistical analyses were conducted and the findings are presented here.

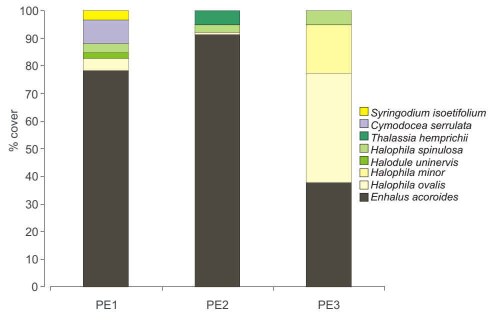
In summary, there were more seagrass species at PE1 (a total of six species) compared to the other two sites. PE1 harboured the densest seagrass but also the highest epiphyte abundance. On the other hand, macroalgae (predominantly *Ulva*) were more abundant at PE2.

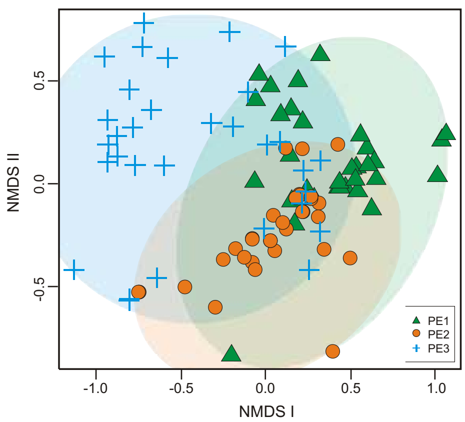
To further explore the differences in the patterns of seagrass and macroalgae composition across the three study sites, we employed multivariate analyses using non-metric dimensional scaling. It appears that the species compositions at PE1 and PE2 exhibit considerable similarities, with their ordination patterns being closer to each other, and at some points overlapped. PE3, having relatively abundant *Halophila ovalis* and *H. minor* in contrast to the other two sites, forms a more isolated group.

We hypothesized that the sediment characteristics play an important role in explaining the differences in terms of seagrass species and macroalgae assemblages at the study sites. PE3 is a shore-fringing meadow on muddy sediments, whereas both PE1 and PE2 sediments consist of sand, mud and shells as they are located on the shoals.

It would be interesting to take a further step of the study to explore seagrass species-sediment dependence mechanisms at this estuary. Meanwhile, we look forward to another set of monitoring from July - September 2010.







Both PE1 and PE2 overlap in seagrass species and algae composition. PE3, on the other hand, shows substantial isolation (ordination using NMDS).

Shoalwater Bay

Australia

a natural wonder

Article by Richard Unsworth & Naomi Smith
Photography Richard Unsworth

ONE of the many reasons that seagrasses are considered valuable is related to their importance in providing habitat and food resources for endangered and threatened animals, such as seahorses, dugongs and green turtles. In turn this provides feeding resources for other not so friendly but equally important fauna such as sharks and estuarine crocodiles. Witnessing a seagrass meadow that contains all of these components is unfortunately a rarity as in many areas of the Indo-Pacific and Caribbean the large herbivorous and predatory animals have all but disappeared, mostly as a result of hunting and overfishing.

It has therefore been a privilege to visit Shoalwater Bay, a remote area located 50km north of Rockhampton, over the last few years to monitor the seagrass as part of the Reef Rescue Marine Monitoring Program. The land surrounding Shoalwater Bay is owned by the Australian Defence Force and since the mid 1960's has been used as a military training exercise area therefore making it a restricted area to public usage. This bay is full of extensive networks of creeks and rivers that drain into the area which supports shallow seagrass meadows and lush mangrove communities. This area supports a wide diversity of fish species and is visited by many threatened species of turtles (Green, Loggerhead, Hawksbill and Flatback) and is home to the threatened dugongs. This area is part of the Great Barrier Reef Marine Park and a Ramsar Wetland.

Twice a year a team from Fisheries Queensland visit two sites (RC1 and WH1) within Shoalwater Bay to conduct Seagrass-Watch and other tests to assess water quality and habitat resilience. These assessments have overwhelmingly confirmed previous reports from Central Queensland University that found seagrass in Shoalwater to be in a healthy condition. Compared to some other locations in the southern Great Barrier Reef, the waters are less turbid, nutrient levels are much lower and the habitats are full of life. But what is striking, is not the seagrass meadows themselves but the fish, the reptiles and the mammals that are found here.

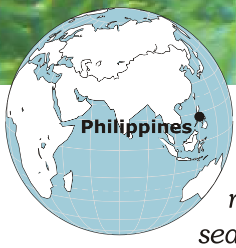
Seagrass meadows at Shoalwater Bay are the complete ecosystem. They are something out of an Attenborough documentary, truly a wonder to be seen. At low tide the meadows are exposed for as far as the eye can see (hundreds of metres!) to reveal not just the odd turtle or occasional dugong feeding trail, but tens of Green Turtles in excess of 1m in length lying in the seagrass warming themselves in the sun. The seagrass is weaved with hundreds of dugong feeding trails, and a quick glance towards the sea reveal herds of dugong coming to the surface for air. A wander along the muddy mangrove fringe also exposes an abundance of large mud crabs. People lucky enough to visit Shoalwater Bay and use the small fishing area quickly discover that a lifetime of poor fishing technique comes to an abrupt halt as a large Grass emperor jumps on your hook.

Shoalwater Bay is a natural wonder, arguably preserved from over fishing, poor water quality and coastal development by its isolation, and its continued preservation as a remote Australian army training base. Many scientists and conservationists talk about pristine and undisturbed ecosystems, but unfortunately these rarely still exist, even in the remotest of locations. Shoalwater Bay however is one of those places.

Philippines

centre of the centre

Article & Photography Len McKenzie



Located between the Philippine islands of Mindoro and Luzon, the Verde Island Passage has been described as a global epicentre of marine shorefish biodiversity[1]. This is primarily a consequence of the region supporting some of the most globally diverse marine ecosystems, including mangrove, coral and seagrass.

The Verde Island Passage forms the northern boundary of the Sulu Sea and is borded by the provinces of Batangas and Oriental and Occidental Mindoro. The Passage is about 100 kilometres long and only about 20 kilometres across at its narrowest point. Apart from being one of the busiest sea lanes in the Philippines, the Verde Island Passage is also one of the richest fishing grounds and top tourist destinations in the Philippines; providing natural resources and ecosystem services for the benefit of about 7 million people.

Unfortunately, the waters of the Verde Island Passage are plied daily by oil and chemical carriers, while on the shores of Batangas province there are shipyards, chemical and petrochemical plants and oil refineries. Not surprising, this globally unique region requires special conservation and management measures to protect marine and coastal habitats in the Passage from current and future threats.

Marine protected areas (MPAs) have been established throughout the Verde Island Passage Marine Biodiversity Corridor, including the Looc-Lubang MPAs with the Passage's largest "no take zone" at 1,150 hectares, while the remaining 13,335 hectares are designated as "fishery reserve areas" (only certain fishing methods and gears are allowed).

MPAs are established in order to protect the marine habitat and enhance fisheries resources. Unfortunately, the design of most MPAs is focussed on the protection and management of coral reefs and often overlooks the protection of linked marine ecosystems such as seagrass meadows and mangroves. Much of the connectivity (how one ecosystem is connected or depended upon another ecosystem) in coastal tropical ecosystems depends on intact and healthy non-coral habitats, such as seagrass meadows. These non-coral habitats are particularly important to the maintenance and regeneration of fish populations.

In late May 2010, as part of Conservation International's Sulu-Sulawesi Seascapes and Climate Change programs, seagrass ecosystem training was conducted in Puerto Galera by Conservation International, in partnership with the Marine Science Institute (University of the Philippines), the municipalities of the Verde Island Passage and Seagrass-Watch HQ.

The workshops aimed to increase awareness of seagrass and the services they provide and to ensure the sustainable management of seagrass resources. The training was tailored for managers of MPAs in the Sulu-Sulawesi Seascape to provide tools for monitoring, adaptive management, and conservation of seagrass meadows.

The first of the two 3-day workshops was attended by sixteen local participants including Bantay Dagat's (sea patrol volunteers) and Local Government Unit (LGU) officials from Batangas. Eighteen participants attended the second workshop, including LGU managers and officers from several municipalities within the provinces of Oriental and Occidental Mindoro.

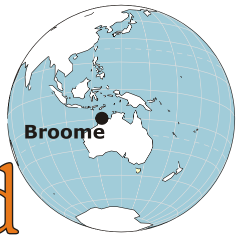
The comprehensive workshop curriculum gave the participants a thorough understanding of seagrass ecosystems and improved their capacity to monitor their seagrass resources. Participants shared their knowledge of seagrass resources in the Verde Island Passage and identified current and future threats (including climate change). The field component was conducted on the fringing reef meadow at San Antonio Island, where 6 of the 8 species reported from the Verde Island Passage grow (including *Halodule uninervis/Thalassia hemprichii* with *Enhalus acoroides/Cymodocea rotundata/Halophila ovalis/Syringodium isoetifolium*).

The training not only increased awareness among managers and local government officials, it also built capacity and empowered them to ensure the protection of seagrass ecosystems is specifically addressed within MPA management plans. The workshops also complemented recent training where LGUs had focussed on coral reefs and mangroves, and will hopefully allow resources managers in the Verde Island Passage to undertake a more comprehensive approach to the management of coastal marine resources in the future.

1. Kent E. Carpenter and Victor G. Springer (2005) The center of the center of marine shore fish biodiversity: the Philippine Islands. Environmental Biology of Fishes 72(4):467-480

The waters of the Verde Island Passage are plied daily by oil and chemical carriers, while on the shores of Batangas province there are shipyards, chemical and petrochemical plants and oil refineries.

Roebuck's Ramsar Wetland



Article by Fiona Bishop **Photography** Fiona Bishop, Kandy Curran, Len McKenzie & Tanya Vernes

IN THE NORTH WEST of Australia, magnificent seagrass meadows adorn one of the most important wetlands in the world - Roebuck Bay. This bay is the country of Yawuru people, the Traditional Owners, and lies next to the tropical town of Broome. The bay was listed as a "Ramsar Wetland" twenty years ago, under the International Convention on Wetlands of International Importance, because of its role in preserving biological diversity and because it is a representative and rare wetland type. Under this global treaty, Australia is obligated to protect the 34,000 hectares that comprise Roebuck Bay's Ramsar Wetland. The seagrass meadows within this Ramsar site are highly valued by the community. To understand the breadth of their worth, and the value of the Ramsar site they support, the "triple bottom line" can be a useful frame of reference. The triple bottom line includes social and cultural value, ecological value and economic value in other words, people, planet and profit.

For Yawuru people, Roebuck Bay and its Ramsar site is socially, culturally and spiritually important, with dozens of heritage sites and places of significance found along the beaches, cliffs, creeks and deeper waters. It is here that traditional activities such as fishing and hunting, gathering food and medicines, passing on stories, and practising law and culture, take place. The seagrass resource plays a vital role, supporting the large variety of traditional foods available in the bay, and the whole ecosystems[1,2]. The Roebuck Bay Ramsar site also enhances the social health of the wider community, as a place of great beauty with light-drenched vistas and brilliant colours, where friends and families come together to rest and relax in the fresh air, and enjoy recreational activities such as boating, fishing, swimming, picnicking, beach walking and exploring. The seagrass meadows are a particularly fascinating area to explore, as weird and wonderful creatures can be found, and they are highly valued for their support of fish stocks.

Roebuck Bay and its Ramsar site is a world renowned ecological treasure. Fringed by red pindan cliffs, dunes and shelly beaches, and lapped rhythmically by giant nine metre tides, the bay is a tapestry of interdependent ecosystems including mangroves, wide deep mudflats, terraces of reef, salt flats, marshes, estuaries, tidal creeks, pindan woodlands and, of course, seagrass meadows. The seagrass resource sustains many of the bay's larger animals. It provides a vital nursery and habitat for fish, prawns, stingrays and sea snakes. It is the main food of turtles and dugongs; dugongs can consume dozens of kilograms per day. Other animals benefit via the food chain, including dolphins and more than 100,000 shorebirds, some which migrate annually from around the globe. The seagrass meadows also support an incredible density of macrobenthic animals including crabs, starfish, anemones, shells, worms, snails, jellies, corals and sponges. Many species in the bay have been given priority listing by the Western Australian government, such as the Australian snubfin dolphin *Orcaella heinsohni*, which is extremely rare and became known to science only five years ago. Roebuck Bay has been recognised as a hotspot for concentrations of this species, which is Australia's only endemic dolphin species. Other marine species, such as dugong, are specially protected by the state, while still others, such as turtles, are listed by the state as "rare or likely to become extinct" and are included in the EPBC Act as endangered.

Economically, the Ramsar site delivers in diverse ways to Yawuru people and to the wider community. The bay is one of the reasons hundreds of thousands of tourists flock to the seaside town each year. Whether their draw card is the fishing, the scenery, the nature, or the warm balmy weather, they come from around Australia and the world, and collectively, they spend millions on accommodation, food, entertainment, souvenirs and tours. Some of the visitors spend time at the bay for

"The seagrass meadows are a particularly fascinating area to explore, as weird and wonderful creatures can be found, and they are highly valued for their support of fish stocks"

scientific reasons. The Australian Wader Study Group has conducted research in the bay for decades, while other bird enthusiasts visit the Broome Bird Observatory each year. The Royal Netherlands Institute for Sea Research has been involved in a benthos monitoring program in the bay for ten years. The ecosystems, including the seagrass meadows, attract marine biologists. The bay is also used as an educational resource by schools and local groups, providing an opportunity for them to develop environmental knowledge. For Yawuru people the Ramsar site is economically important in providing sustenance as a "coastal supermarket" of traditional foods[1] and for providing opportunities for tourism- and conservation-based employment. The seagrass meadows in the Ramsar site, as nursery and habitat, also support the recreational and commercial fishing industry, including pearling, which contribute significantly to the local economy.

For Yawuru people, Roebuck Bay and it's Ramsar site is socially, culturally and spiritually important, with dozens of heritage sites and places of significance found along the beaches,

The Ramsar site has many hidden values. The less obvious services provided by the seagrass ecosystem include nutrient cycling, climate regulation, its improvement of water quality, as well as its role in the processes of near-shore coastal ecosystems and as a coastal health indicator. If the seagrass meadows disappeared, it would be very difficult and immeasurably expensive for the community of Broome to replicate these services. If the services were not replaced, various dependant industries and associated values would suffer.

The good news is that currently, the Ramsar site and the bay's seagrass resource provide all of these functions and products for free. By keeping the Ramsar site and the wider bay healthy, these services will continue, and the many values of the seagrass meadows and the Ramsar site will thrive into the future.

Roebuck scenes:
Anemone in seagrass (left)
Mangrove fringe (above)
Red pindan cliffs (below right)
Dugong feeding trails through seagrass meadow (below)

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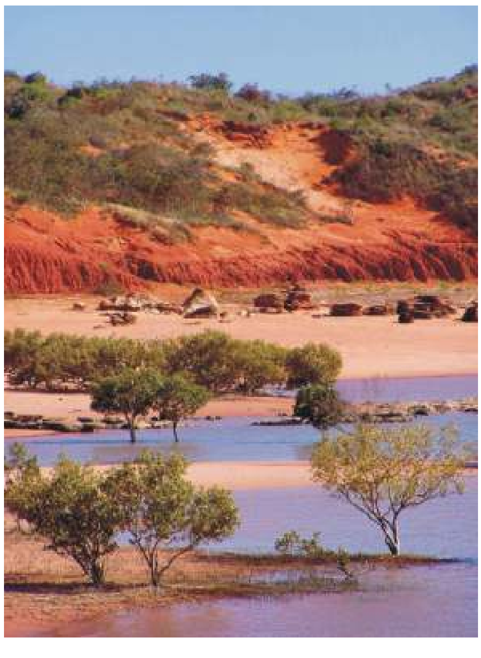

north eastern madagascar seagrasses

Article by Giuseppe Di Carlo
Photography Keith A. Ellenbogen

SEAGRASSES are a major component of the rich and productive coastal and marine ecosystem of East Africa. In this region, seagrasses are typically found in shallow coastal areas, connecting estuarine, mangrove and coral reef habitats, hence the ecological services they provide are considered to have a high global value[1]. Seagrasses colonise coastal and riverine lagoons they often act as a buffer zone for nutrient recycling, improving water quality, altering water flow and stabilizing sediments, with consequent beneficial effects for nearby coral habitats. Moreover, seagrasses are particularly important for the maintenance of sea turtles (*Chelonia mydas*) and dugong's populations (*Dugong dugon*) as well as the role of nursery areas for shrimp, lobster, and several species of fish (i.e. siganids and scarids).

While most seagrass records in East Africa are concentrated along the coasts of Kenya, Tanzania and Mozambique, not much is known about species and distribution of seagrasses along the coast of Madagascar[2]. During a Rapid Assessment Program (RAP) expedition conducted by Conservation International in April-May 2010, to address the lack of biological information along the North-eastern coast of Madagascar, seagrass species diversity, community composition and abundance were assessed between the town of Diego Suarez and Vohemar. This study intended to provide a rapid assessment of coral, reef fish and seagrass species diversity along this coastline, identify current threats and evaluate their resilience. The results, to be published later in 2010, will support the theory that this part of Madagascar can represent another "Coral Triangle" and immediate management actions as well as adaptation strategies need to be undertaken to protect its ecosystems and the coastal communities that depend on them.

The RAP survey reported a diversity of seagrass assemblages and habitats along the north-eastern coast of Madagascar, ranging from patchy seagrass meadows to meadows extending over several kilometres. Those meadows harbour an incredibly high diversity of associated macroalgae and epiphytes as well a diversity of benthic invertebrates (i.e. sea cucumber and sea urchins).

The results of the study showed that nine seagrass species *Thalassodendron ciliatum*, *Thalassia hemprichii*, *Syringodium isoetifolium*, *Cymodocea rotundata* and *C. serrulata*, *Halodule uninervis*, *Halophila ovalis* and *H. stipulacea*, *Zostera capensis* are commonly found throughout the northeastern coast of Madagascar, on the shallow platform of reef flats, along coastal areas (both exposed and sheltered) and in proximity of river deltas. Here seagrasses form extensive meadows, generally on shallow sheltered coastal lagoons. Annual meadows formed mostly by smaller, fast-growing species (ie *Halodule uninervis*, *Halophila ovalis*) are often found in exposed environments, such as shallow sand banks and reef flats. Those meadows are largely affected by sediment movements during storms and cyclones. In the intertidal, *Zostera capensis*, *H. uninervis* and *Cymodocea rotundata* are commonly found. Particularly, *Z. capensis* is most commonly present in exposed areas, while *H. uninervis* and *C. rotundata* colonise tidal pools on mudflats. In the subtidal, *T. hemprichii* and *S. isoetifolium* form extensive meadows on sand or muddy sand. In this area, seagrass distribution is largely influenced by sediment composition, and only *T. hemprichii* and *Thalassodendron ciliatum* may colonise rubble substrate where the sediment layer is minimal. On the deeper edge of reefs (8-12 m), or among coral patches on sand, *Halophila ovalis* patches are found, often mixed with *H. stipulacea*.

The RAP highlighted that seagrass meadows are in pristine conditions along this coastline, except in proximity of sewage outfalls or the few larger human settlements.

The RAP highlighted that seagrass meadows are in pristine conditions along this coastline, except in proximity of sewage outfalls or the few larger human settlements

Surveying Madagascar's seagrass:
Giuseppe Di Carlo records data on seagrass (left)
Seagrass and mangrove, Ambodivahibe Bay (above)
RAP team survey seagrass at Vohemar Bay (above right)
Coral and seagrass, in pristine conditions, Ambodivahibe Bay (right)

In these areas, the high organic matter content in the sediment and water turbidity increase epiphyte growth with negative consequences for seagrass growth. However, as interest towards coastal development in the area and population growth continue to increase, seagrasses face growing pressures such as mechanical removal for infrastructure development (hotels, marinas, *etc*), rising use of destructive fishing gear, increasing sediment runoff due to deforestation, propeller and anchor damage as power engines become more readily available. Therefore, immediate management actions need to be taken to mitigate current impacts and ensure the protection of seagrass ecosystems, to maintain the vital functions and ecosystem services seagrass provide in the coastal marine environment of NE Madagascar. Those actions should include the establishment of monitoring programs to assess changes over time and evaluate seagrass response to local threats; the implementation of marine protected areas (MPA) that will reduce or avoid altogether future impacts on coastal ecosystems, including mangroves, seagrasses and coral reefs; the engagement of scientists and NGOs in awareness initiatives that focus on the importance of coastal ecosystems, particularly mangroves and seagrasses, and that target decision makers to ensure coastal management plans are adequately formulated. Finally, recent data shows that climate change will likely affect seagrass ecosystems in the Western Indian Ocean, through increase in sea surface temperature (expected to rise up to 0.6 °C in this area) and sea level rise (predicted up to 50cm by 2100) and changes in storms/cyclone patterns, frequency and intensity. Thus, promoting and enabling an adaptive approach to seagrass management will not only maintain seagrass diversity, ecological functions and ecosystem services, but also enhance the resilience and adaptive capacity of seagrass ecosystems to cope with climate change impacts.

Village in Ambodivahibe Bay (above)

Syringodium isoetifolium covered in epiphyte, Vohemar Bay (below left)

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2. Green & Short (2003) World atlas of seagrasses.

Conservation International (CI) is a nonprofit organization founded in 1987 and based in the United States. The mission of the Marine Program at CI is to restore and maintain healthy oceans and to support the livelihoods of the millions of people that inhabit the world's coasts. This mission is achieved by implementing global solutions focussed on research, innovative action, and strategic communications. One of these global solutions is Seascapes, multiple-use marine areas in which government authorities, private organizations, and other stakeholders cooperate to conserve the diversity and abundance of marine life and to promote human well-being.
For more information, visit www.conservation.org

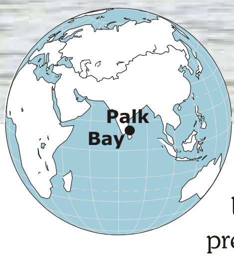
India

Palk Bay

Economic value of fish trap fishery

Article by T.Thangaradjou, S. Raja, E. Dilipan & G. Vijaya Bhaskara Sethupathi

Photography T.Thangaradjou & V.Balagi



Seagrasses of mainland India have attracted considerable attention for research and monitoring activities because they are not only critical habitats for fisheries, but they are also exposed to various anthropogenic pressures.

In May 2010, a rapid survey on the seagrasses of the five marine locations of Palk Bay (Manora, Adukathevan, Somanathan Pattinam, Kattumavadi, Thondi) was conducted. The survey found the distribution of 8 species of seagrasses in this region (*H. ovalis, H. ovata, E. acoroides, T. hemprichii, C. rotundata, C. serrulata, H. pinifolia, S. isoetifolium*). All the species form extensive meadows over a larger area. Shallow water meadows (up to 1 metre depth during low tide) were composed of aggregated and isolated patches, whereas deeper meadows were extensive and continuous in structure, extending to over 10m depth.

The seagrass meadows of Palk Bay are key fishing areas for the local fisherman and provide a significant source of income. Local fisherman of the region use a fishing practice called “Aaddapu valai” (trap netting). The traps are constructed from tree sticks and netting. Fish enter through a narrow opening in one side of the trap and once entered in the main chamber cannot escape. Each morning fishermen collect the trapped fish using scoop nets. Fish usually found inside the net include: *Loligo* spp., *Gerres* spp., *Siganus* spp., *Terapon* spp. and *Arius* spp. (*Lates calcarifer* and *Pampus argenteus* are rarely caught). Depending on the nature of the fish present inside the net, fishermen will earn Rs. 200-500 per day. Usually the nets will be fixed at one location for 15 days but depending on the catch, some times it may extend up to 30 days. Afterward, the location of the net will be changed. Using this method of fishing, approximately Rs.6000-15,000 (~25-320 USD) is generated as income per family per month. Hundreds of such nets are deployed all along the Palk Bay region; evidence that the seagrass meadows provide considerable economic input to the local fisherfolk of the region.

Unfortunately trap netting regularly disturbs the dense seagrass meadows of *Cymodocea, Thalassia* and *Syringodium* in the region. Also, the eutrophic nature of the region increases turbidity and blooms the algal growth (both epiphytic and free floating forms). The algae not only smother the seagrass but also render the sediments anoxic and increase the hydrogen sulfide levels: making the habitat unsuitable for seagrass growth. As the seagrasses die, large quantities of wrack wash ashore and decay: further increasing the anoxia in the shallow areas of the Bay. The consequence of these impacts is the sifting the landward boundary of seagrass meadows into deeper areas. This is the main reason for the patchy seagrass meadows along the shallow regions when compared to deeper waters.

“Local fisherman follow a fishing practice called “Aaddapu valai”, “Trap net”. With a narrow opening at one side, fish entering the nets can not escape from the central chamber”

More importantly seagrasses throughout this region (especially species of *Cymodocea*) are showing “heat-burn” symptoms in the shallow waters up to 2 m depth. Turbid water column, reduced water exchange and increased surface water temperature are possible threats to the seagrasses of this region. Though the seagrasses of this region are supporting the local fishery, the current fishing practices, increasing nutrient enrichment from aquaculture activities and changing global climatic conditions play a detrimental role in collapsing the ecosystem functions and sustainability of fishing of the region.

Singapore

Oil Spill..

The hidden casualties

Article by Ria Tan **Additional text by** Len McKenzie
Photography Ria Tan (www.wildsingpore.com), Andy Dinesh & Toh Chay Hoon

JUST BEFORE DAWN on the 25th May, a bulk carrier collided into a double-hulled crude oil tanker about 13km southeast of Changi East, resulting in a 10m gash in the tanker. An estimated 2,000 tonnes of crude oil spilled into the Singapore Straits. This is equivalent to about 14,500 barrels or enough to fill an Olympic-sized swimming pool. The amount spilled was later revised to 2,500 tonnes.

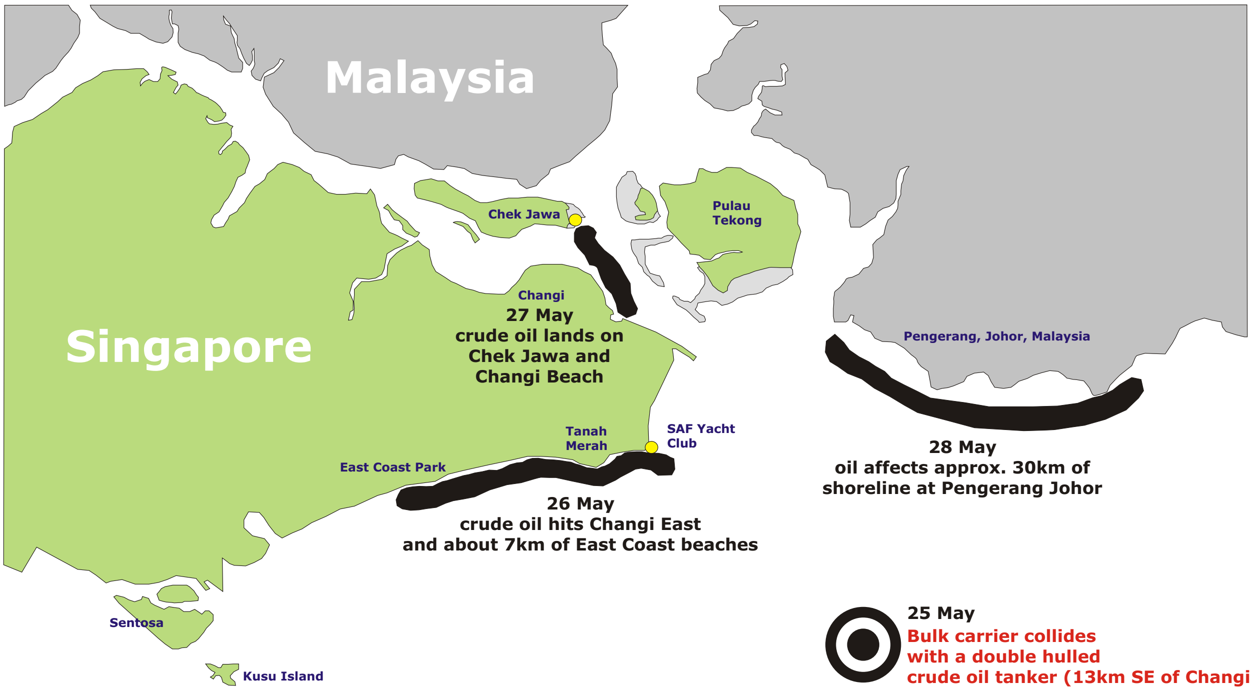
By 2pm, the spill produced a slick about 4km long and 1km wide floating at sea, 6km from Changi East. There was a strong smell of petroleum in the air even well inland on the East Coast, but no sign of crude on the shore.

The crude oil washed ashore at Changi East, and onto another 7km of East Coast beaches on 26th May. By the 28th May, crude oil had landed on the shore at Chek Jawa and Changi Beach. The oil slick also hit the Malaysian coast at Pengerang Johor on 28th May, affecting about 30km of shoreline there, with more shores being affected over the following days.

The immediate Singapore response was to apply dispersants (41 tons), install booms (1.5km), and operate two skimmers to deal with the spill at sea. After the oil hit Singapore shores, dispersants continued to be applied to the slick, as well as to areas of sea covered by oil sheen. Where there were heavy deposits of crude on sand, the sand was removed manually. At the end of the clean up, it was reported that 60 tonnes of contaminated sand was removed (and disposed off at Semakau Landfill). Oil absorbent booms and paddings were also used to soak up oil on the water and shore.

At Chek Jawa, about 150m of shoreline was affected, even though a 1km boom was put up shortly after the accident. In response, oil contaminated sand was removed and oil on rocks and mangrove roots were manually removed using oil absorbent cloths.

On the 2nd June, the National Environment Agency (NEA) said it had "tested samples of seawater from the affected beaches and found no trace of harmful chemicals". On 4th June, the NEA said it was safe to conduct water activities at East Coast Beach and Changi Beach as "the water at the two beaches have returned to normal".



Impact on marine environment

Tanah Merah

A day after the oil spill hit Tanah Merah, volunteers visited a short stretch of this shore at low tide. There were signs of crude on stretches of the shore, and sheen on the water. There were many dead and dying moon crabs (*Matuta lunaris*), swimming crabs (*Portunus pelagicus*), large prawns (Family Penaeidae), conch snails (*Strombus canarium*) and several dead octopuses. Many animals that are usually well hidden or buried emerged into the open. Countless peanut worms (Order Sipuncula) and bristleworms were writhing on the surface. Also sighted were several heart urchins (*Maretia ovata*) our first on this shore, and many brittlestars (Order Ophiuroidea) which are seldom see here. The wide variety of fishes usually seen here were still present, although these were thought to appear distressed. Most of the hard corals appeared normal though a few were bleached.

A week after the spill, volunteers visited another stretch of Tanah Merah shore. The small patches of seagrass, together with the fish and coral communities appeared healthy, with no obvious signs of deterioration.

Three weeks after the spill, volunteers revisited the same seagrasses and saw some evidence of habitat deterioration. The small patches of *Cymodocea rotundata* near the high water were oiled, and some had turned brown and black. These were in an area where several large 'puddles' of crude oil had settled. The small patch of *Thalassia hemprichii* closer to the low water mark seemed less impacted, as did a small deeper water patch of

Oil spill slick along the beach at National Service Resort & Country Club, Tanah Merah

Enhalus acoroides that appeared healthy and was flowering! A small clump of *Enhalus acoroides* on the high shore, usually exposed at low spring tide, looked 'crispy' and dry and some parts of the leaf blades looked withered.

Changi

Volunteers also checked the seagrass at Changi a day after, and then two weeks after the oil spill washed ashore. The seagrasses and marine life there seemed unharmed and not as distressed as those seen at Tanah Merah. But there were unusually abundant sightings of Pink sand dollars (*Peronella lesueuri*) in the weeks after the spill, something never before experienced.

Casualties of the oil spill *(below, left to right)*

A ghost crab covered in crude oil.

Oiled Cymodocea rotundata leaves. Some turned brown and black.

Rarely seen striped mantis shrimp, lying dead at it's burrow. Nearby, was another.

Pigment loss in Halophila ovalis leaves, Chek Jawa.

Chek Jawa

TeamSeagrass monitored Chek Jawa three weeks after the oil spill hit the seagrasses there. While the team conducted their usual monitoring, a few of us did a quick survey of the rest of Chek Jawa. The relatively large expanse of *Halophila beccarii* on the southern shore of Chek Jawa seemed unharmed. The patches still covered about 20m square and the tiny leaves looked healthy. It's good to know that this globally rare seagrass seemed unaffected by the spill.

Most of Chek Jawa is dominated by *Halophila ovalis*. Patches of these were bleached on both the southern and northern shore. The large expanse of *Cymodocea rotundata* near the boardwalk seemed relatively unharmed.

Large numbers of sand dollars, the usual assortment of sea cucumbers and even a sea star was encountered on the northern shore. On both northern and southern shores a few bleached carpet anemone (*Stichodactyla haddoni*) were encountered, representing about 10% of total numbers seen.

Quick Response: *Oil contaminated sand was removed and oil on rocks and mangrove roots were manually removed using oil absorbent cloths*

oil on seagrass

At Chek Jawa, about 150m of shoreline was affected, even though a 1km boom was put up shortly after the accident

The primary effect of oil on seagrass is induced by the absorption of the sea water-soluble fraction (SWSF) of oil rather than the more spectacular oil slick. The SWSF of oil is an oil-seawater mixture containing a spectrum of dissolved, partially solvated or dispersed molecular and particulate aggregations of hydrocarbons, resulting from turbulence and wave action in oil polluted seawater. Water-soluble fractions are the organic enriched aqueous phase in contact with the oil.

The toxic components of petrochemicals are thought to be able to pass from the SWSF through lipid membranes of the leaf and tend to accumulate in the thylakoid membranes of the chloroplasts. Some seagrass species are more sensitive to oil exposure than others, although the reasons for this remain unclear.

Oil spills and their associated cleanup can have significant impacts on seagrasses. The most serious known effects of oil on seagrasses have been observed when leaves of intertidal plants have been in direct contact with oil. Intertidal seagrass can be smothered when oil is stranded on intertidal banks, leading to reduced growth rates, blackened leaves and mortality. Oil can also affect flowering and leaf chlorophyll content. For example, loss of pigmentation in *Halophila ovalis* leaves was observed immediately after a minor oil spill in southern Queensland in February 2006 and the Exxon Valdez oil spill in 1989 caused seagrass blades below oiled beaches to be bleached white and ultimately killed. Another study of the Exxon Valdez oil spill noted a decrease in the density of leaves and flowering shoots of *Z. marina* after the event. In general, when seagrasses are exposed to oil, sub-lethal quantities of petrochemicals are incorporated into the tissue, causing a reduction in tolerance to other stress factors (e.g. desiccation).

Dispersants used to treat oil spills increase the bioavailable fraction of oil by spreading petroleum derived hydrocarbons on the water surface throughout the water column and altering the interaction of these compounds with biological membranes. Dispersants consist of a surfactant in a carrier or solvent. Dispersants can be toxic in their own right, but the solvent can also encourage the breakdown of the waxy leaf cuticle, allowing greater penetration of oils into seagrass leaves and increasing phytotoxicity (i.e. a mixture of oil and dispersant in some instances can be more toxic than oil alone). One of the most difficult decisions that oil spill responders and natural resources managers face during a spill is evaluating the environmental trade-offs associated with dispersant use.

Following oil spills, blooms of algae on intertidal seagrass meadows has been well documented. The blooms attributed to factors such as an increase in nutrients released from oil-killed organisms, stimulating compounds in oil, and a reduction in herbivore presence. Increased growth of macroalgae often leads to a smothering of seagrasses and subsequent losses. Studies that have monitored oil impacted seagrass meadows have documented that algal levels may return to pre-spill levels approximately 12 months after the event. Similarly, investigations of spills (e.g. Exxon Valdez; Gulf War) have found no apparent impact on seagrass productivity, biomass, density, flowering or seed production one year after the spill. But there may be lingering sublethal impacts to plants and animals for five years or more. Unfortunately, these results are limited as there is a general lack of substantial long-term field data pre and post impact of petrochemical contamination.

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Suva monitoring

Fiji

Introduction by Nina Ferry
Article by Sisimaile Lolohea
Photography Nina Ferry, Gilianne Brodie & Len McKenzie

International School Suva is a small school located in the capital city of the Fiji islands. Our school is composed of over 39 different nationalities and participates in ACT, IB, IGSE and WASC curriculums. As part of our IB curriculum, our students are encouraged to seek community involvement to be active participants of their local and global communities. As the Community and Service Coordinator, I have inherited the Seagrass-Watch project, which our school has been involved with for three years. We have our own site to monitor and have found it enjoyable exploring our marine area over the past few years. The following is an observation by one of our Year 9 students who participated in our latest field excursion on Saturday May 29th, 2010.

Before Dr. Skelton came to my school to teach us about the importance of seagrass, my classmates and I had never even thought of it.

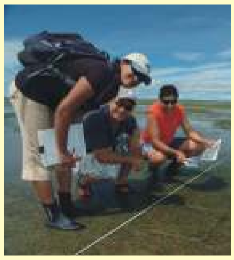
We met Dr. Skelton at the Nasese foreshore, where he told us that there are four different types of seagrass important to our area and showed us pictures of *Halodule pinifolia*, *Halophila ovalis*, *Halodule uninervis* and *Syringodium isoetifolium*. Normally, my classmates and I do not go out on to the mudflats, as the water there is polluted, however, it turned out to be a peaceful environment filled with life away from the noise of the city. There were crabs, shells, algae, worm holes and of course seagrass. Most of the time, we saw only one type of seagrass per quadrat and it was difficult to assess the percentage of cover, especially with the long grasses. It helped that there were five people in our group, which allowed us to discuss and debate what we were seeing.

I have learnt a lot during the excursion and am glad Dr. Skelton was able to share information with us and that our teachers were able to accompany us onto the flats. I learnt that helping the environment doesn't mean only helping with things you can see like bushfires and the trees in the Amazon, but also smaller things that are important to our own environments and the ecosystems that surround us. I am thankful that we have a Community program at our school which allows us to get involved in global projects like Seagrass-Watch, meet interesting people and help our environment at the same time.

Sadly this was Dr. Skelton's final seagrass monitoring in Suva as Local Coordinator. He is leaving for a new post with the Secretariat of the Pacific Regional Environment Program (SPREP) in Samoa. A huge vinaka vakalevu (Fijian thank you) to Dr. Skelton for a job well done. He will be very much missed, we wish him well. USP's Institute of Marine Resources led by Cherie Morris will now be taking over the local coordination of the Suva seagrass monitoring site.

We are looking forward to the next survey with IMR support and hope that we will be able to fully utilize this Year of Biodiversity as a vehicle for increased awareness and spreading the seagrass word. A big vinaka vakalevu to all the volunteers that turned up on the day.

Text Matereti Iakobo Mateiwai

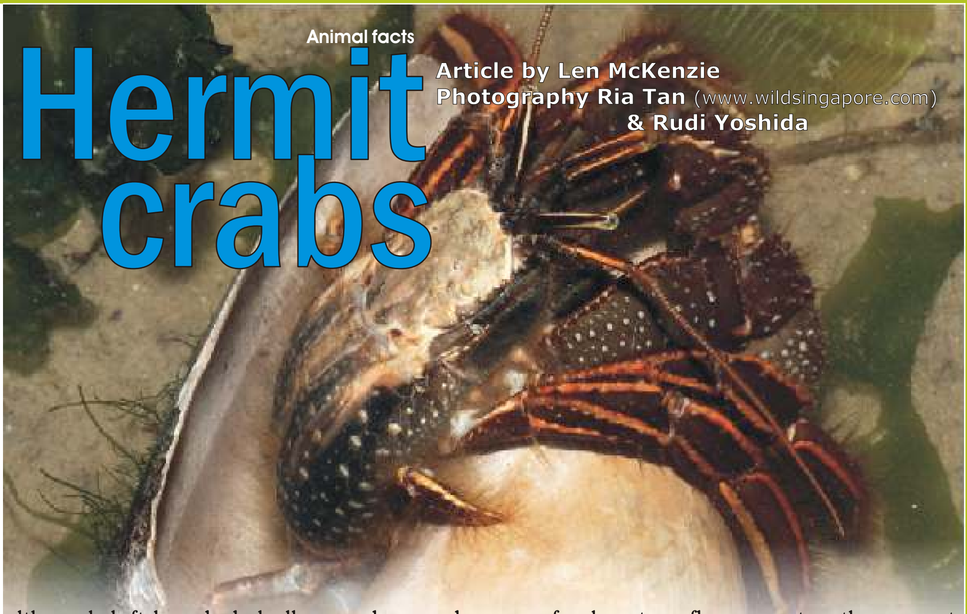


***Left:** Posa (far left) with USP team.*
***Below:** On site with Prerna Chand and Naushad Yakub*

Animal facts

Hermit crabs

Article by Len McKenzie
Photography Ria Tan (www.wildsingapore.com) & Rudi Yoshida

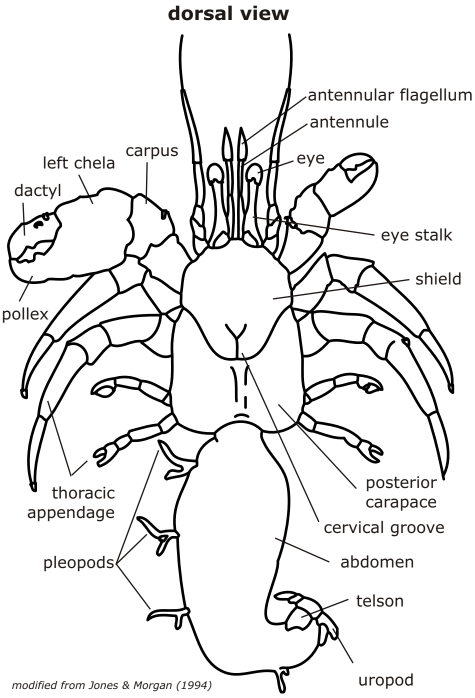


Hermit crabs are decapod crustaceans of the superfamily Paguroidea which live within discarded gastropod shells. Despite what their name belies one to believe, hermit crabs are more closely related to lobsters than to true crabs! There are about eight hundred known species of hermit crabs in the world and they are found in all coastal areas, except in the Arctic and Antarctic. They are commonly seen in the intertidal zone, particularly in seagrass meadows.

Hermit crabs have stalked eyes and very good vision. They also have two pairs of antennae, one of which is used for feeling, while the other is used for smelling and tasting. They have a large left claw, which they use to grab objects, to defend themselves and to balance. The smaller right claw, and subsequent appendages are used for collecting food and passing it to the mouth.

The front half of a hermit crab has a hard exoskeleton, but the abdomen is soft and protected from predators by the adaptation of carrying around gastropod shells, into which the whole crab's body can retract.

The hermit crabs abdomen is modified to fit within the spiral chamber of gastropod shells. It is asymmetrically developed, with a thin, soft, non-segmented cuticle, and the pleopods on the short side have been lost. Those on the long side are retained in the females to carry eggs. The twist of the abdomen is adapted for right-handed spirals, although left-handed shells may be used. The tip of the hermit crab's abdomen is adapted to clasp strongly onto the columella of the gastropod shell.



modified from Jones & Morgan (1994)

As the hermit crab grows, it has to find a larger shell and abandon the previous one. Hermit crabs use empty shells and never kill the original occupant. They locate a prospective shell with their eyes and then inspect it with the chelae. If the shell appears suitable, the crab will first try it out before abandoning the old one. Coral, stones, wood and other structures (even broken coke bottles) have been adapted as houses by certain species, depending on what is available.

Hermit crabs are largely scavengers, feeding on dead and decaying animals and plants.

Hermit crab reproductive organs are located just below the heart and open at the base of the last pair of walking legs in males and the middle pair in the females. Females usually lay their eggs shortly after copulating, however they can store sperm for many months. The eggs are fertilized as they are laid by passing through the chamber holding the sperm. The eggs are carried and hatched in a mass attached to the abdomen inside the shell. Hermit crabs release their eggs in the ocean, near the shore. Most crabs hatch at the zoea (planktonic larvae) stage and settle as megalopa onto the sea bed.

Hermit crabs can be effective indicators of environmental change. Recent studies have found that striped-leg hermit crabs (*Clibanarius taeniatus*) are more numerous where there is an influence of freshwater, while yellow-footed hermit crabs seem to favour areas where little or no freshwater flows onto the coast (*Clibanarius virescens*)[1,2]. Therefore, changes in the relative numbers of these species over time can indicate unnatural freshwater flows (such as increased stormwater runoff) and changes in salinity that may have ecological impacts.

Hermit crabs are shy and expert at hiding. They can live 6 to 15 years, but many live only 6-12 months. Hermit crab predators include sea birds, fish, octopuses, crabs, and other hermit crabs. Unfortunately, people are the biggest threat to these creatures. People can not only destroy their habitats (such as seagrass meadows), but many hermit crabs are accidentally collected with shells every year, dying a slow death, or taken deliberately for pets. You can protect hermit crabs, by conserving their habitats and before collecting shells on the beach, always checking to make sure there is no hermit crab inside. Better still, do not collect shells at all, but leave them on the beach to provide hermit crab homes.

1. Kay & Coates (2002). Rocky Reef Watch Project Report 2000 - 2002.
2. Dunbar et al., (2003). Memoirs of Museum Victoria. 60(1): 27 - 34.
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