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# Seagrass-Watch

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

# Threats

## Human impacts & mitigation

- Dredging
- Agricultural runoff
- Trawling
- Ports & shipping
- Boating
- Coastal development
- Invasive species
- Urban/industrial runoff
- Restoration

Local eyes Global wise

# In this issue:



## *From the editors*

In this issue we take a timely look around our world at the impact we are having on our coastal waters. Unfortunately it is these same waters that are the home for seagrass meadows and in many places these meadows are paying the price for living too close to us. The pictures in this edition speak as loud as any words. The challenges are global –no one country is outstanding either in the problems and loss of seagrass or in finding manageable solutions. But it is not all bad news. Many initiatives seek to slow and halt the decline in this vital habitat. Risk mapping and working with farmers in Australia; managing vessel damage in Florida and Wales; restoration and working with local community and indigenous groups in Australia, Indonesia, and the Philippines, are all good examples. There is a role for us all in shaping public opinion and policy and we trust the articles in this issue will encourage useful discussion on positive approaches to a better world.

COVER:
Bait digging at Wynnum, Brisbane, Australia


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# seagrass under pressure

Article by **Rob Coles, Alana Grech** & **Len McKenzie**
Photography by **Len McKenzie, Vedharajan Balaji** & **Helen Taylor**

Seagrass meadows are recognised as one of the most productive of the Earth's ecosystems[1,2]. However, widespread and accelerating losses also place seagrass meadows among the most threatened[3], with almost 14% of all seagrass species considered at risk of extinction (three species are listed as Endangered)[4].

Seagrass are most abundant in coastal regions where available nutrients, light and suitable habitable substrate meet growth requirements. It is also these coastal areas where seagrass are exposed to the impacts from the billion or more people who live within 50 km of them[5]. These impacts have all led to a rapid loss of seagrass ecosystems, at a rate of around 1.5% of seagrass area per year[3].

Worldwide seagrass ecosystems have been impacted or lost under the influence of direct and indirect effects of human activities[6,3]. Direct impacts on seagrass from human activities causes immediate seagrass loss (e.g. removal of plants), while indirect impacts can be potentially more insidious due to their often widespread and chronic nature (e.g. overfishing of predators, which can cascade down the food web and lead to the loss of the herbivores that clean seagrasses of fouling algae, resulting in seagrass loss). Indirect impacts are also less obvious and the decline in seagrass can be slow (sometimes years or decades). Lastly, global climate change is acknowledged to possibly exacerbate these impacts and challenge local coastal management approaches.

As a consequence of these losses, there is an urgent need to identify the threats to seagrass ecosystems. But identifying the threat is only the first step, as we also need to identify the human activity at the root of the problem. This will enable coastal managers to make informed decisions about where to best focus efforts to abate declines or develop solutions to minimise/reverse the decline. For example, the scientific literature lists excessive sediment and nutrients as the key cause of seagrass degradation, both acting to reduce available light to the seagrass plants. From a management perspective, however, that is not particularly helpful; we need to identify the human processes that cause reduction in light before advice can be given on how to make changes in our behaviour. Understanding the relationships between human activities and their ecological impacts and assessing the spatial distribution of these impacts are crucial steps in managing the use of seagrass meadows in a way that maximises commercial and societal benefits while minimising seagrass degradation.

To improve our understanding of the human activities that pose a real threat to seagrass, we used three different approaches to identify human activities posing the greatest threat to seagrass. The approaches we used were: an expert workshop, vulnerability assessment and cumulative impact mapping.

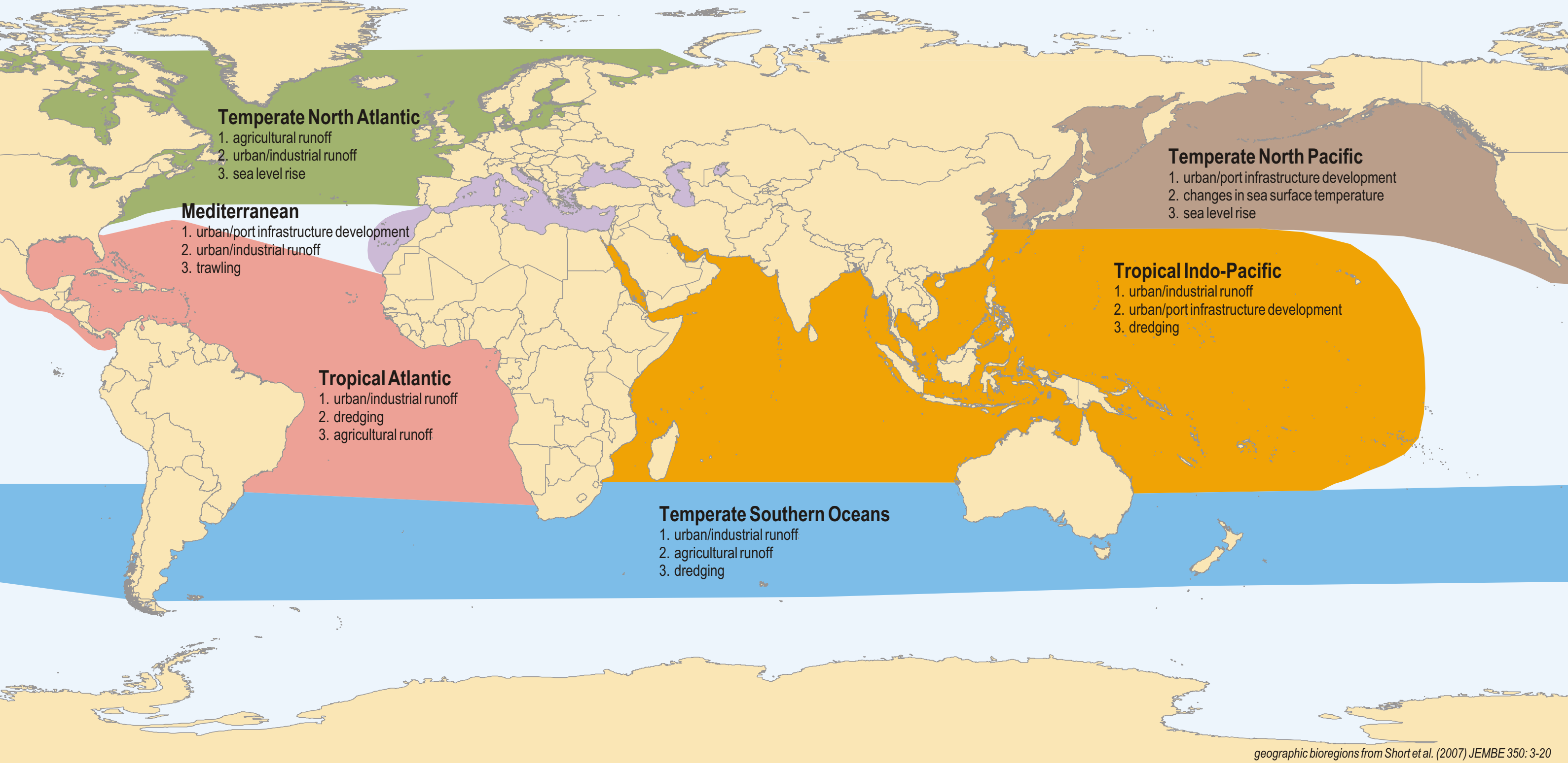
## *Expert workshop*

In Canada in 2008, at a biennial international workshop (ISBW8), we coordinated a simple exercise by asking the world's leading seagrass scientists to list their view of the activities most threatening to seagrass. We divided the world up into the six seagrass bioregions[7] and this gave a good list of all the likely threats across the globe. Across the bioregions, the most common top three threats were, in no particular order, agricultural runoff, urban/port infrastructure development and trawling. But this approach has limitations because scientists, like most people, tend to be influenced by their own experience and by issues that are more dramatic than others. Using this approach a threat such as aquaculture tends to be a highly rated because the damage caused by a poorly designed aquaculture farm in the coastal environment is so visually obvious. To counter this we used an online survey and asked scientists to provide scores for human activities using a systematic vulnerability assessment approach.

## Pulau Semakau meadows

Within one of the worlds busiest ports and adjacent to Singapore's only landfill, Pulau Semakau has vast seagrass meadows with abundant *Enhalus acoroides* (on the horizon is the petrochemical facilities on Pulau Bukom - the largest Shell refinery globally). Through effective management and enforcement by the Singapore Government in conjunction with the public, rich and productive seagrass habitats remain in proximity to the city. TeamSeaGrass monitors this and other key seagrass meadows in Singapore.

LM




### *Vulnerability assessment*

Using SurveyMonkey® (a free online questionnaire and survey tool) we were able to apply a more quantitative, scientific approach. We know many human activities have the potential to act as a threat to the ecological integrity of seagrass ecosystems. However these threats have different impacts depending on the ecological context of where they occur. For instance, ecological recovery from a propeller scar in a *Halophila* meadow will usually be faster than a *Thalassia* meadow due to the slow growth rates of *Thalassia*, making *Thalassia* meadows more vulnerable to propeller scars than *Halophila* meadows. Therefore, we defined vulnerability as a combination of exposure and sensitivity and resilience, in a suite of five criteria related to vulnerability to make basic characterisations of how activities impact seagrass communities and habitats differently[8]. We surveyed 59 scientists from around the world and the five criteria we used were: scale - how big an area of seagrass would be impacted by the human activity; frequency - how often does the activity occur, rare or regularly occurring; functional impact - will the activity damage just one or many seagrass species; resistance - how resistant is a meadow to the risk; and recovery time - how long would it take for a meadow to recover after the activity was removed. We also asked scientists how certain they were of their answers. This produced a slightly different ranking of risks to seagrass than the expert workshop approach, but one which is more scientifically based (*see Table below & Figure above*).

Globally, using the vulnerability assessment approach, we found that the greatest threat to seagrass meadows was urban/industrial runoff, urban/port infrastructure development and agricultural runoff, in that order. However, differences existed across the seagrass bioregions.

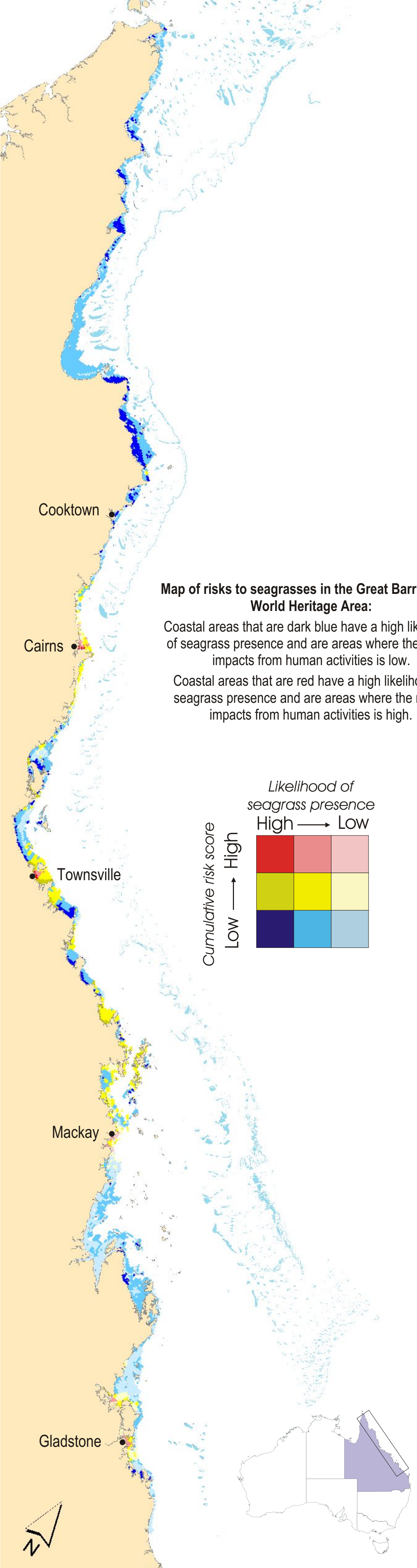
In each of the seagrass bioregions, differences were also apparent between the expert workshop and the vulnerability assessment. In the Indo-Pacific for example, the top two threats are identical, but at position three was dredging (*see Grech et al. 2012*). An alternative approach, was to use cumulative impact mapping.

*Coastal development along Far North Queensland coast*

**Rankings of the relative impact of multiple human activities on seagrasses globally derived from vulnerability assessment** (1 = most threatening activity).

| Ranking | Threatening human activity |
|---|---|
| 1 | Urban/industrial runoff |
| 2 | Urban/port infrastructure development |
| 3 | Agricultural runoff |
| 4 | Dredging |
| 5 | Trawling |
| 6 | Aquaculture |
| 7 | Boat damage (commercial) |
| 8 | Boat damage (recreational) |
| 9 | Shipping accidents (e.g. oil spills) |
| 10 | Changes in sea surface temperature |

*from Grech et al (2012) Environ. Res. Lett. 7, 024006*




**Map of risks to seagrasses in the Great Barrier Reef World Heritage Area:**

Coastal areas that are dark blue have a high likelihood of seagrass presence and are areas where the risk of impacts from human activities is low.

Coastal areas that are red have a high likelihood of seagrass presence and are areas where the risk of impacts from human activities is high.

### *Cumulative impact mapping framework*

An alternative approach we used was Geographic Information Systems (GIS) which allowed us to map spatially the threats to seagrass which have been identified as important. The only restriction of this approach is that we can only complete this where we have good spatial data sets. So, as we have worked many decades within the Great Barrier Reef province, we used it to focus our assessment.

Rarely do threats occur by themselves. They accumulate as composite risk in what is best termed as "hot spots". It is possible that seagrass meadows will survive the impact of one threat, but what if a meadow is subject to multiple threats. For the Great Barrier Reef we found nine good spatial data sets we could use and these were overlaid on a model of likely seagrass presence in coastal waters (<15m). Summarising the result, the urban coast in the south of the Great Barrier Reef has the most threats, with few threats in the north, roughly Cooktown and above. The highest accumulation of threats (as many as eight) was in the urban ports: Cairns, Townsville, Mackay and Gladstone.

So in summary, the processes most likely to damage seagrass are associated with urban and port development and agriculture and the risk accumulate most around key cities and ports along our coast and are likely to do so in other parts of the world. For the Great Barrier Reef province, the key problem is ports, cities and farms which cluster around sheltered bays and estuaries which also support major seagrass meadows providing for a true "hotspot" for likely seagrass damage and loss.

*Townsville Port*

HT

> *"[a] comprehensive global assessment...found that seagrasses have been disappearing at a rate of 110 square kilometres per year since 1980 [3]"*

There is still some way to go if as scientists and citizens we are to slow and finally stop seagrass decline. We have constructed approaches to help us identify those threats to seagrass of most significance, but now we need to develop processes to identify solutions. These processes and solutions will vary but at a fundamental level will require a greater awareness of the importance of seagrass resources and the consequences of their loss. An effective way forward would involve improving community involvement in conservation efforts; developing sustained, long term incentives to protect seagrasses; providing basic information on seagrass ecosystems to inform (science-based) decision-making; and developing stronger policy and regulations for the protection and conservation of seagrass ecosystems (as well as the institutional capacity to implement them).

By working with both scientists and local stakeholders we can influence and advocate as effectively as possible the politicians, management agencies, catchment groups, city managers and the vast array of bureaucracies involved in planning and managing human coastal activities. To protect the valuable seagrass meadows along our coasts, we must work together.

This is a highly edited extract of the results from:

Grech, A., Chartrand-Miller, K., Erftemeijer, P., Fonseca, M., McKenzie, L., Rasheed, M., Taylor, H. and Coles, R. (2012). A comparison of threats, vulnerabilities and management approaches in global seagrass bioregions. *Environmental Research Letters* **7**(2): 024006 (8pp) doi:10.1088/1748-9326/7/2/024006

Grech, A., Coles, R. and Marsh, H. (2011). A broad-scale assessment of the risk to coastal seagrasses from cumulative threats. *Marine Policy* **35**: 560–567

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*2. Zieman & Wetzel (1980) Handbook of Seagrass Biology, An Ecosystem Prospective*

*3. Waycott et al (2009) Proc. Nat. Acad. Sci. USA 106: 12377-12381*

*4. Short et al (2011) Biological Conservation 144: 1961–1971*

*5. Agardy et al (2005) MA Chpt 19 In Ecosystems and Human Well-being: Current State and Trends, Book 1*

*6. Orth et al (2006) BioScience 56: 987-996*

*7. Short et al. (2007) JEMBE 350: 3-20*

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## Shore seine fishing

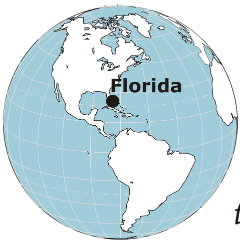
Beach or shore seine nets have been used in fisheries for several thousand years and on every continent. Shore seine fishing is common in India's northern Palk Bay region. The nets are used in depths of 0.5 - 2.5m, with an average net mesh size of 7.5 cm. A typical beach seine has weights attached to the leadline at the bottom of the net and buoys or floats attached to the floatline at the top of the net. The downward force of the weights counteracted by the buoyancy of the floats keeps the net open vertically when it is pulled through the water to entrap fish. A beach seine is often set from shore to encircle a school of fish. To set the net, a boat pulls one end on the net out to sea (approximately 400-500m from shore), then makes a half circle, bringing the net back in to shore. Groups of 6-12 people, then pull both ends, reeling the net in (at times, taking up to 3 hours). Reeling the heavily weighted net, scrapes the sea floor, causing direct physical impact to the seagrass meadows Shore seines operate throughout the year, collecting juvenile fish and invertebrate from seagrass meadows.

*Source: Balaji, V. Seasonal variation of fish assemblage in the seagrass beds of Northern Palk Bay.*

# Boating & seagrass

USA

Article by **W. Judson Kenworthy, Margaret O. Hall, Manuel Merello & Giuseppe Di Carlo**
Photography by **W. Judson Kenworthy, Anne F. Glasspool, Charles Costello & Bermuda Zoological society**

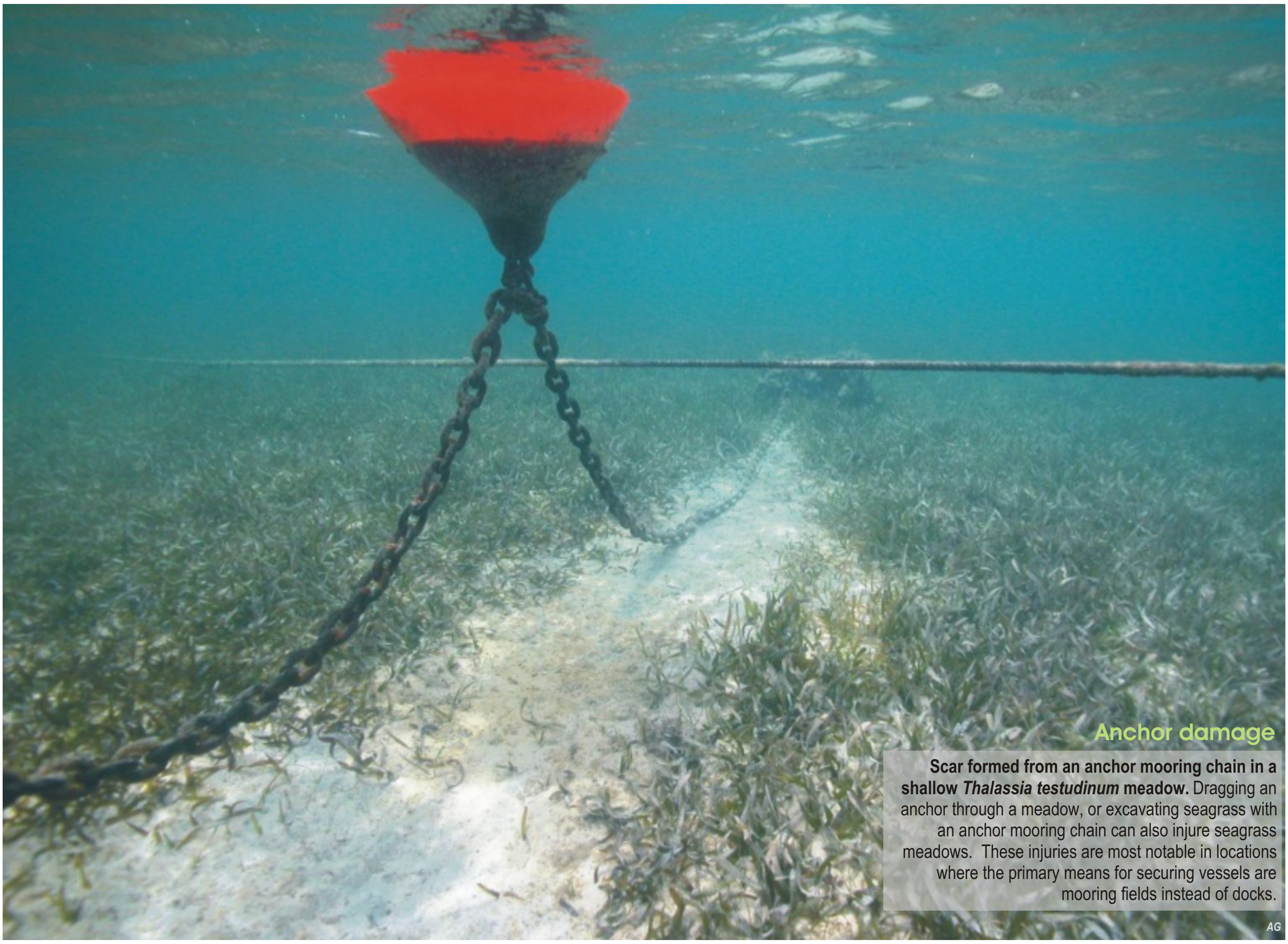



*Motorised watercraft operation is one of the most popular recreational and commercial activities that humans pursue in the coastal environment. During the past several decades rapid growth in coastal populations accompanied by surging affluence and expanding commercial development has led to more and larger vessels operating in close proximity to seagrass meadows.*

Growth in the economic value of the commercial and recreational boating industries has far surpassed many traditional uses of the coastal zone, placing significant pressure on seagrass resources. This pressure is certain to escalate even more in the future, thus resource managers are concerned about the potential ecological consequences of vessel operation in seagrass ecosystems. Surveys and applied scientific research have demonstrated the impacts of boating on seagrass ecosystems and the need for more attention to responsibly manage boating activities[1,2,3,4]. Here we discuss some of the most significant impacts vessels have on subtropical/tropical seagrass ecosystems and review surveys and scientific studies that have documented these impacts. We also briefly discuss methods to mitigate and restore vessel damage, and some potential solutions to the boating issues.

## The Problem

Motorised vessels can impact seagrasses indirectly by affecting water and sediment quality (chemical contamination), sediment re-suspension (turbidity), and wave turbulence (substrate and shoreline erosion)[2]. Construction and maintenance of docks, piers and overwater structures can directly impact seagrass meadows by intercepting light and shading the plants[5].



**Anchor damage**

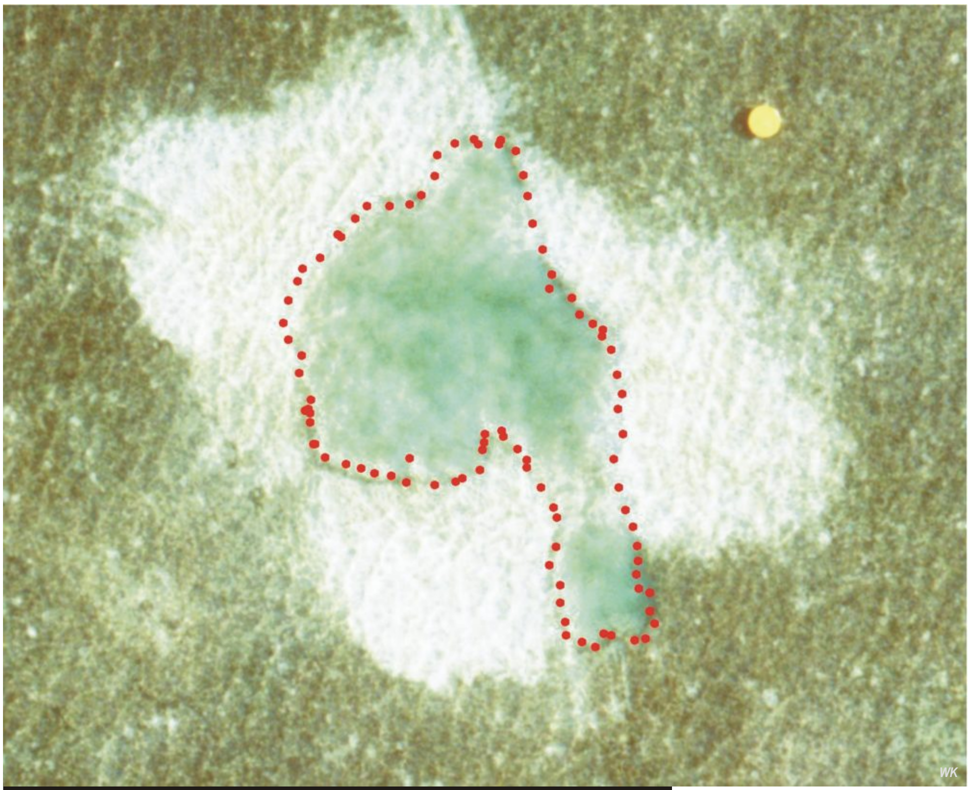
**Scar formed from an anchor mooring chain in a shallow *Thalassia testudinum* meadow.** Dragging an anchor through a meadow, or excavating seagrass with an anchor mooring chain can also injure seagrass meadows. These injuries are most notable in locations where the primary means for securing vessels are mooring fields instead of docks.

AG

Vessel access to docks constructed in shallow water may also encourage propeller scarring and propeller dredging while boaters navigate to and from the structure. Motor vessels frequently encounter seagrass meadows directly when the water is as shallow as the vessel's draft.

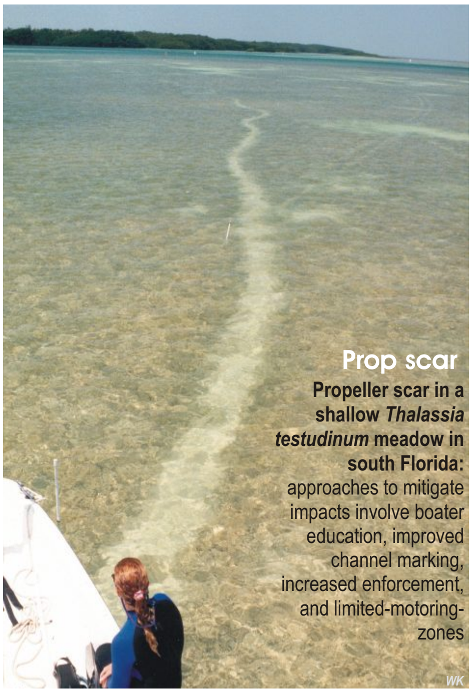
Much like mowing your lawn, propellers shear off seagrass leaves and damage the plant canopy by removing important photosynthetic tissue and disrupting productive epiphyte communities. Known commonly as "prop scarring" these injuries are most frequently associated with relatively smaller motorised vessels; however, when larger deep V-hulled vessels with multiple propellers are involved the injuries can be much worse. The most severe damage occurs when propellers dredge sediments and uproot entire plants. Usually referred to as "prop dredging", this activity destroys apical meristems (growing tips) and the clonal integrity of the meadow, and frequently buries adjacent seagrasses with displaced sediments. When large vessels run their hulls aground they can create deeply excavated blowholes that scrape and scour away the entire mat of seagrass and the upper layers of sediment, leaving behind a gap of unvegetated, exposed, and unstable substrate. These injuries are often exacerbated by the operator's attempts to escape the grounding site by powering off the seagrass meadow, causing significantly greater physical and biological harm than the original injury.

Studies of simulated and actual prop dredging incidents in subtropical/tropical seagrass meadows[6,7,8,9,10], as well as large vessel hull groundings[12,13,14] indicate that these types of activities can be among the most severe human-caused seagrass impacts. Since most seagrasses are rooted vascular plants, they depend on the sediments for attachment and nutrition. Disrupting the sediments destroys these functions that in many subtropical/tropical seagrass ecosystems have taken decades or even centuries to develop[15]. Furthermore, the injuries leave behind unstable and nutritionally deficient substrates, so that natural recovery may be delayed if not completely impaired[12,14]. In some subtropical/tropical seagrass meadows it may be necessary to perform expensive and uncertain restoration to physically and biologically remediate a vessel grounding site to recover the lost ecological services that the seagrass provided before being damaged[13,14,16,17,18].



**Prop dredging**

The photograph above, of a large vessel excavation in a shallow *Thalassia testudinum* meadow in south Florida, indicates (red dots) the perimeter of the excavated blowhole created by prop dredging and the vessel hull collision with the seagrass bank. The bright white areas surrounding the excavation are the berms formed from displaced sediments that bury seagrass. Dark area surrounding the grounding is the undamaged *T. Testudinum* meadows.



**Prop scar**

**Propeller scar in a shallow *Thalassia testudinum* meadow in south Florida:** approaches to mitigate impacts involve boater education, improved channel marking, increased enforcement, and limited-motoring-zones

Most vessel injuries are localised around the immediate area of impact[9], but in places where there are consistently high densities of boat traffic the damage can be widespread and persistent [1,13,4,3]. Seagrass meadows associated with active waterways, shipping channels, urban areas and public access sites are particularly vulnerable, especially where channel marking and other aids to navigation are inadequate. The problem is further compounded by the lack of operator training, limited operator experience, and in many areas, poor water visibility. Many groundings also result from poor operator judgment, lack of common sense, or even flagrant disregard for the potential injury to natural resources. Very few groundings are deliberate because salvage costs and damage to a vessel can be expensive. However, some vessel damage is intentional, especially when operators attempt to free the vessel from the grounding site before there are adequate water depths or professional salvagers to assist. Deliberate injuries also occur when operators navigate in shallow areas where seagrasses are known to exist. This often takes place in the commercial and sport fishing industries when operators attempt to reach productive harvest sites in and around shallow seagrass flats near mangroves, marshes and reefs. Vessels can also injure seagrass meadows by anchoring, dragging an anchor through a meadow, or excavating seagrass with an anchor mooring chain[19]. These injuries are most notable in locations where the primary means for securing vessels are mooring fields instead of docks.

## Documented vessel impacts

The most well documented example of widespread vessel impacts to seagrass meadows was derived from an aerial survey of Florida's coastal waters[1]. In the 1990s scientists and resource managers began to recognise the value of using aerial remote sensing to observe and monitor shallow water benthic habitats at much larger and more relevant scales than previously attempted, yet still providing sufficient detail for ecological assessment[6]. The authors of the Florida study inspected aerial photography covering nearly the entire state's coastal waters and calculated that there was approximately 704km$^2$ injured by motorised vessels. This rather extraordinary revelation of the magnitude and extent of the damage in Florida eclipsed all of the previous smaller-scale examples[20]. Of all the areas in Florida that were impacted by motor vessels, the damage was most extensive in the Florida Keys where the U.S. National Oceanic and Atmospheric Administration (NOAA) had recently established a National Marine Sanctuary (FKNMS), and a damage assessment and restoration program[13]. In 2007, 217 reported boat groundings occurred in the FKNMS, with approximately 80% of these in seagrass meadows[13,18]. These were only those groundings reported to authorities and did not account for the unreported incidents which could easily double the total number of injuries[13].

Funding provided by NOAA, the State of Florida, and non-government organisations led to a series of studies which identified the ecological consequences of vessel damage, rates of seagrass recovery, and the efforts required to physically and biologically restore injured sites[8,10,11,12,13,15,17,18,21]. Most notable was the finding that large gaps in meadows of the climax (late-successional) species *Thalassia testudinum* made by vessel excavations which exceeded 20 cm in depth showed low probability (approximately a 50% chance) of recovery unless they were refilled to grade. Essentially, without sediment re-grading natural recovery was a coin toss, and if seagrass recovery occurred at all it was a slow process of species succession.

From this series of studies much was learned about the impacts of motor vessels in tropical seagrasses ecosystems, as well as the response of the seagrass communities to disturbance[15]. Our knowledge about how important seagrasses are in stabilising sediments during severe storms was acutely revealed when tropical cyclone Georges passed through the Florida Keys in 1996. Gaps formed by vessel disturbances expanded significantly, previously stable seagrass meadows that were injured by motor vessels became vulnerable to further degradation by erosion, and natural recovery was interrupted[12,21].

These observations prompted studies focused on developing and implementing cost effective techniques for repairing tropical seagrass meadows impacted by motor vessels before they could expand and cause further degradation. *Thalassia testudinum* meadows are, by far, the seagrass community most seriously threatened by vessel impacts in the subtropical/tropical Atlantic, Caribbean and Gulf of Mexico region. Unfortunately, *T. testudinum* is the slowest growing species in the community, making it the most difficult and expensive seagrass to restore[8,22,23,24].

To improve the probability of recovery, studies were conducted to test the feasibility of utilising wild bird fertilisation (i.e. bird faeces) to provide phosphorus, the limiting nutrient in carbonate sediments[25].

### Strandings

**Large vessel aground in a shallow *Thalassia testudinum* meadow in south Florida, USA.** When large vessels run their hulls aground they can create deeply excavated blowholes that scrape and scour away the entire mat of seagrass and the upper layers of sediment, leaving behind a gap of unvegetated, exposed, and unstable substrate. These injuries are often exacerbated by the operator's attempts to escape the grounding site by powering off the seagrass meadow, causing significantly greater physical and biological damage than the original injury.


**Roosting stakes and wild birds**

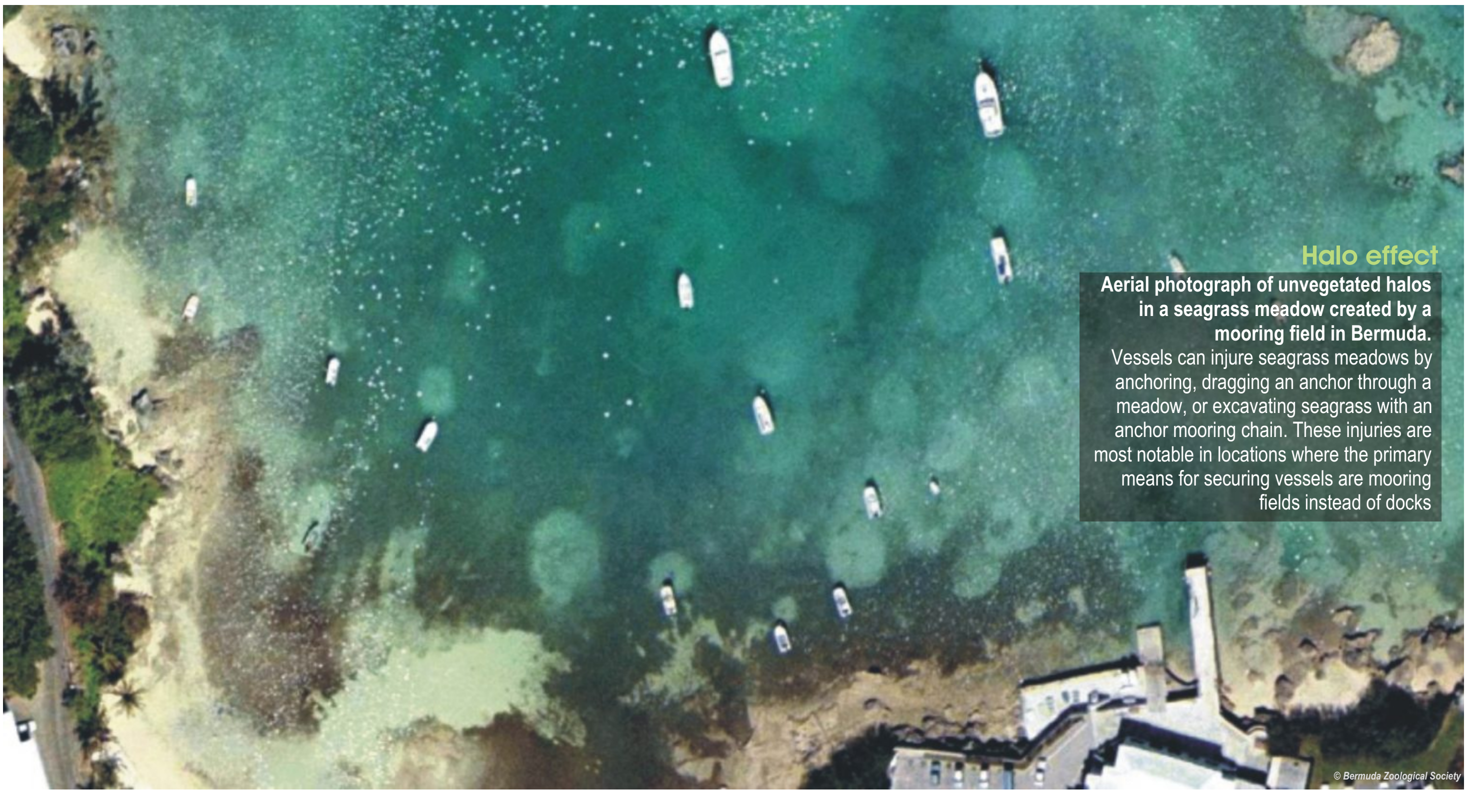
Wild birds (comorants and terns) roosting on bird stakes and defecating phosphorus rich fertiliser in a vessel grounding site in south Florida, USA.

To accelerate recovery, experimental prop scars were passively fertilised by installing bird roosting stakes and re-grading large excavations with native limestone fill[17,18,26,27].

Studies suggested that transplanting a fast-growing pioneer species, *Halodule wrightii*, and fertilising with wild bird roosting stakes would speed up seagrass recovery. The temporary substitution of *Thalassia testudinum* by the faster-growing *H. wrightii*, along with sediment re-grading (topographical restoration) accelerated the biological and physical recovery of larger injuries. This form of "modified compressed succession" is a restoration tool that can be used to regain seagrass ecological services much faster than the sluggish pace of natural recovery, as well as to stabilise the injuries while the slower-growing climax species recovers. In mixed species meadows where *Thalassia testudinum* is the dominant species, but faster-growing species such as *H. wrightii* or *Syringodium filiforme* also occur, it may not be necessary to transplant seagrass. Re-grading and fertilising alone can stimulate the lateral ingrowth of the fast growing pioneer species from the adjacent seagrass meadows[27].

Although we have been successful at identifying and testing seagrass restoration methods for remediation of vessel damage, practical application of these tools is uncertain and expensive. Success rates for seagrass transplanting are about equivalent to a coin toss (50%). In many of our experiments seagrass transplant mortality was initially high (>70%) and we had to re-plant to continue the studies. Seagrass planting in tropical environments near reefs is made difficult by the abundance of herbivores. Herbivorous fish, invertebrates and green sea turtles common in tropical environments readily graze isolated planting units that appear as a "salad bar" in the unvegetated landscape of a restoration site.

It isn't easy to generalise cost estimates for vessel remediation because they vary widely by geographic location, injury size, and proximity of the restoration site from land-based operations. Due to their relatively small size, it is difficult to minimise costs by "economies of scale". Underwater planting requires special skills and the transportation and deployment of sediment fill is not routinely done by




**Halo effect**

**Aerial photograph of unvegetated halos in a seagrass meadow created by a mooring field in Bermuda.**

Vessels can injure seagrass meadows by anchoring, dragging an anchor through a meadow, or excavating seagrass with an anchor mooring chain. These injuries are most notable in locations where the primary means for securing vessels are mooring fields instead of docks volunteers, thus the costs are subjected to contractor fees inflated by profit margins and mobilisation and de-mobilisation expenses. Where vessel injuries are actively regulated by local, state or federal governments, prescriptive management and litigation fees for damage assessment and restoration must also be considered as part of the cost. Recent cost estimates for seagrass restoration at scales comparable to vessel injuries range from USD570,000 to USD972,000 per hectare, far surpassing the cost of land-based restoration[29].

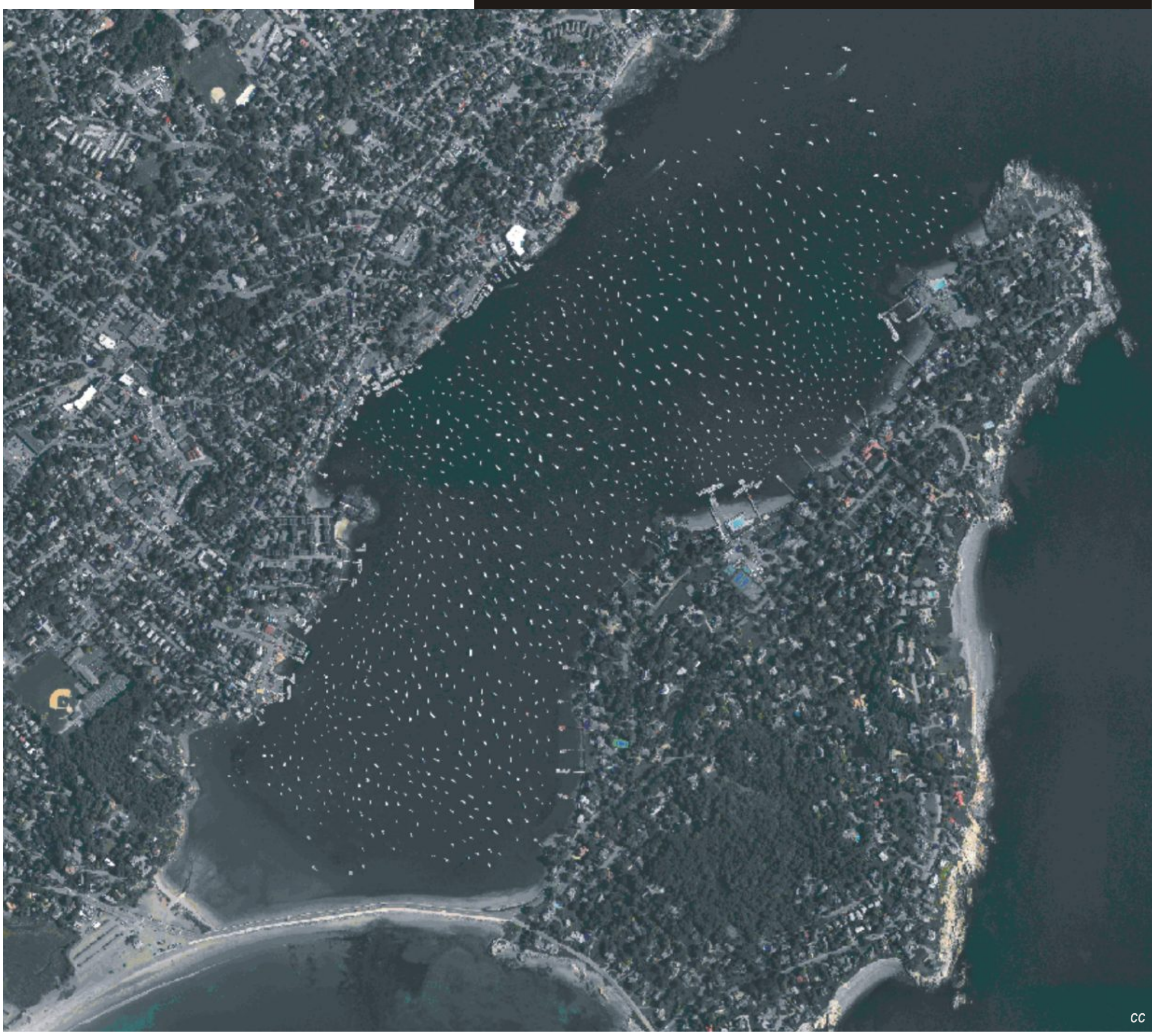
Given the uncertainty and high cost of restoration it appears scientifically and economically feasible to recommend that managers give priority to protecting seagrass habitat from vessel damage rather than to focus primarily on repair and restoration. Seagrasses can be protected by adequately marking channels and the location of meadows with buoys and signage for a fraction of the cost of restoration[28,29]. However, restricting power vessels from seagrass flats requires a sustained investment in maintenance and enforcement which must be supported by dedicated government policies, public awareness, prescriptive regulations and reasonable budgets[3, 4]. A recent cost-benefit analysis suggests that the additional cost of enforcing "no power vessel" zones was worth the benefit of added seagrass protection[4]. Mandated boater education and licensing programs that require operators to learn how to "read the water" and navigate to avoid injuring seagrass meadows or how to properly remove a vessel from a grounding site can provide the foundation of an effective seagrass protection and conservation program.

To date, there are no comprehensive assessments of the outcomes of the many different local, state and federal programs aimed at limiting vessel damage. Where assessments of individual programs have been evaluated the results are inconclusive, because many of the programs have lacked the capability to sustain the infrastructure, enforcement and financial resources needed to have meaningful long-term effects. With respect to vessel impacts, seagrass conservationists have several feasible options to work with, but a long way to go before we can say we have adequately addressed the problem.

*This article contains supporting information online at www.seagrasswatch.org/magazine.html or contact hq@seagrasswatch.org*

**Moorings**

Aerial photograph of a vessel mooring field over seagrass meadows in Marblehead Harbour, MA, USA. Small white features in the harbour are moored vessels.



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# dredging impacts can they be prevented ?

Article by
**Paul Erftemeijer,**
**Erik Paling & Russell Hanley** (SKM)

Photography by
**Paul Erftemeijer**
**Jaclyn Davies & Karenne Tun**

## Backhoe Dredger

**Backhoe / dipper dredger at work in Gladstone Harbour, Queensland, Australia:** Backhoe dredgers are mechanical dredgers that come in a variety of forms, each involving the use of grab or bucket to dig the sediment then raise and transport it to the surface. They are stationary dredgers, moved on anchors. The excavated material is either directly placed onshore or loaded into barges for sea disposal.

JD


***Turbid dredge plume*** *reaching a seagrass meadow in Singapore.*

DREDGING is often required to deepen and maintain navigation channels and harbour entrances or for commercial extraction of sand or aggregate to meet an ever-increasing demand for construction and reclamation. However, dredging and disposal of dredged sediments (spoil) at sea can lead to impacts on the environment, especially when these operations are carried out in the vicinity of sensitive marine environments such as seagrass meadows.

Dredging and spoil disposal are harmful to seagrasses when dredges excavate in seagrass meadows or when large amounts of sediment are mobilised into the water column and in due course settle into seagrass meadows. The disposal of spoil into seagrass environments can not only smother the seagrasses completely, but the dredging and dumping activities will also inevitably increase the turbidity (cloudiness) of the water which in turn will reduce the amount of sunlight reaching the seabed. This can be harmful to seagrasses because they need sunlight for photosynthesis.

At least 45 cases of dredging operations in and near seagrass meadows have been studied worldwide, accounting for a total loss from direct and indirect impacts of about 21,000 ha of meadows. In recent years, improved management measures, such as avoiding dredging or disposal directly in or into seagrass environments or controlling turbidity and sedimentation effects in the vicinity of these environments, appear to have succeeded in reducing dredging impacts on these fragile habitats, at least in some parts of the world.

Most of the impacts on seagrass from sedimentation are found relatively close to the sites of dredging and spoil disposal, but fine particles can be carried long distances and when plumes of sediment move over seagrass meadows they can (temporarily) reduce or even completely block out the light available to the seagrasses.

Each seagrass species has its own particular requirements for the minimum amount of sunlight needed to meet the energy demands of growth, root oxygenation and successful reproduction. Such requirements can be determined using controlled shading experiments. The levels of turbidity and sedimentation, and how long and often these levels can be tolerated, is site- and species-specific and influenced by the natural range of local background turbidity that particular seagrasses experience. The turbidity of seawater also fluctuates naturally (sometimes by several orders of magnitude), for example as a result of storms and estuarine flooding events after heavy rainfall over land.

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**Controlled shading experiments** *of seagrasses to study their response to reduced light due to dredging plumes.*

## PIANC Working Group 157

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A new PIANC working group (157) on 'Environmental Aspects of Dredging and Port and Waterway Construction around coastal plant habitats' was launched in February 2012 to review and summarise "best management" practices for dredging operations, and waterway and port construction near coastal plant habitats, such as seagrass meadows, macroalgal communities (e.g. kelp), mangroves and salt marshes. The group comprises experts from around the world, including scientists, consultants, dredging experts and port authorities. The best management practice guidelines, aimed to minimise damage to coastal plant habitats, will become available in early 2014

PIANC, established in 1885, is the global organisation providing guidance for sustainable waterborne transport infrastructure for ports and waterways. PIANC is the forum where professionals around the world join forces to provide expert advice on cost effective, reliable and sustainable infrastructure to facilitate the growth of waterborne transport. PIANC continues to be the leading partner for government and the private sector in the design, development and maintenance of ports, waterways and coastal areas.

*For more information: www.pianc.org/downloads/envicom/tor%20157-EnviCom-Coastalplanthabitats-final.pdf*

So, not all seagrasses are equally sensitive to the effects of dredging. Larger, slow-growing climax species with substantial energy reserves in their below-ground rhizomes (e.g. *Posidonia* or *Thalassodendron*) show greater resilience than smaller, fast-growing opportunistic species (e.g. *Halophila* spp.), but the latter display much faster post-dredging recovery (often from natural *in situ* seedbanks) as long as water-quality conditions return to the typical background range.

Monitoring and detecting impacts from dredging operations to seagrass meadows can be challenging, especially in areas that are naturally subject to frequent storms and floods and consequently display major seasonal or year-to-year changes in abundance and distribution.

Environmental impact assessment prior to dredging allows the identification of alternative designs to avoid or mitigate any impact. If some impact is unavoidable, then adoption and enforcement of effective and tight control measures, accompanied by monitoring before, during and after dredging, can manage the risks of adverse impacts on seagrasses from dredging down to an acceptable minimum. Mitigating measures that have been applied during dredging operations near seagrasses include minimisation of spill, overflow and leakage from the dredges and barges; judicious selection of dredging equipment; seasonal or tidal restrictions; turbidity limits triggering specific management responses; and reactive (feedback) monitoring. These measures can be costly but avoid the likely greater costs associated with loss of ecological functions and the costs of seagrass meadow restoration.

The good news is that such "best management" practices seem to have been effective in preventing or minimising impacts to seagrasses in many recent dredging projects, in particular around Australia and in the USA.

*Further reading*
*Erftemeijer, PLA and Lewis III, RR (2006). Environmental impacts of dredging on seagrasses: a review. Mar. Poll. Bull. 52(12): 1553–1572.*

# dredging effects on food webs

Article & photography by **Kathryn McMahon**


*A third of the world's population lives in coastal areas. As a consequence there is significant development and infrastructure here. Ports with associated access channels and facilities are a key part of the transport system supporting the coastal infrastructure. For example, in Australia 20% of the gross domestic product is from the export industry, which relies on ports.*

Dredging is carried out to maintain existing ports and for expansion to allow access for larger ships, and for the construction of new ports, as well as other activities such as land reclamation, beach nourishment and laying of pipelines and cables.

Seagrasses, which live in coastal waters, are vulnerable to dredging activities. They can be impacted directly through physical removal at the dredge site, or smothering by sediments at the dredge disposal site. Indirect impacts also occur through the generation of turbid plumes by sediment particles, which are suspended in the water column and reduce light reaching the meadows. Seagrasses are incredibly sensitive to reductions in light as they have a high light requirement. Dredging-related seagrass losses have occurred at scales of km and it has been estimated that up to 21,000 hectares of seagrass meadow has been lost world-wide in the past 50 years, most likely an underestimate.

Dredging does not always result in impacts to seagrass, but in some cases it can cause the complete loss of seagrass meadows and therefore the ecological services that these meadows provide is also lost. In other cases, meadows are not lost but are impacted through reductions in the amount and structure of seagrass present. Research in Western Australia found that reductions in the amount and structure of the seagrass present, including the associated algal epiphytes resulted in about a 40% decline in small invertebrates living in the seagrasses, gastropods were most sensitive. This has significant consequences for the associated food webs that the seagrass meadows support. Modelling studies suggested that although the macroinvertbrates could recover once the seagrass meadow recovered, within approximately one year, there were longer term implications for larger fauna such as fish, which could take from 2-10 years to recover.

> although macroinvertebrates could recover once the seagrass meadow recovered, within approx. one year, there were longer term implications for larger fauna such as fish, which could take from 2-10 years to recover

So impacts to seagrasses from dredging can also affect the fauna living in seagrass meadows, and those that pass through to feed, and over longer time scales than the actual dredging event.

Over the past decade, management of dredging has improved significantly, largely through an improved ability to predict where and how intense the turbid plumes will be, but also through a greater understanding on the potential impacts on marine biota. Generally, dredging projects must go through an environmental impact assessment and develop an environmental management plan with the aim of minimising impact to the environment. Yet, in many cases linking the predictions of changes in the environment due to dredging i.e. where and how much turbidity will be generated, and the potential impacts to the seagrass meadows is difficult to do. While the ability to predict habitat loss is improving, the capacity to predict the loss of ecological function associated with less severe dredging impacts remains poor i.e. if there are reductions in seagrass how does this affect the foodweb.

At present there are a number of research programs around the globe focusing on improving the capacity to predict the impacts of dredging. Some of the key questions researchers are addressing are:

- *what levels of stress can different seagrass species tolerate, how much for how long, and how does this vary at different times of year?*

  This type of information can inform managers of the best time and duration to dredge to minimise impact to the seagrass meadows

- *how do seagrasses respond to dredging-related stressors such as light reduction or sedimentation, are there any early-warning signs that they are stressed?*

  This type of information can help during monitoring of a dredging event to assess whether the plants are stressed or not, and can act as a trigger to notify managers of the dredge who could potentially modify dredging operations to minimize the stress.

Due to the importance of ports and shipping around the globe, dredging is likely to continue. However, we can improve our management of dredging events through increasing our capacity to predict impacts and effectively manage the associated threats.


*Further reading:*
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*Erftemeijer, PLA & Robin Lewis III, RR. (2006) Mar. Poll. Bull. 52: 1553-1572.*
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*GDP, http://wwwdfat.gov.au/aib/trade_investment.html*
*Ports Australia http://www.portsaustralia.com.au/*

Indonesia

# Pari Islands

## Seagrass threats & restoration

Article & Photography by **Wawan Kiswara**

*Household and other waste along the shoreline of Pari Islands, within the Kepulauan Seribu archipelago (Jakarta Bay).*


Located in the north-west of Jakarta Bay, the Pari Islands are under pressure from multiple threats, the most significant originating from the nearby city of Jakarta, the capital of Indonesia.

The Pari islands are a group of five islands (Pari, Tengah, Kongsi, Burung and Tikus) which form part of the Thousand Islands (Indonesian: Kepulauan Seribu) chain stretching 45 km north of Jakarta's coast into the Java Sea. Pari Island is the biggest island of the group with a total area of about 12 square kilometres. Seven seagrasses (*Enhalus acoroides, Cymodocea rotundata, C. serrulata, Halodule uninervis, Halophila ovalis, H. minor, Syringodium isoetifolium* and *Thalassia hemprichii*) grow in the intertidal and subtidal reef flat of the group to the depth of 2m.

Human activities in Jakarta Bay are a cause for concern to the seagrass of the Pari islands. Jakarta Bay is a giant receptor of pollution from both coastal (e.g., shipping, dockyards, oil and gas industries) and inland areas (e.g., industries, households, and farms). The inland area is considered the primary source of waste and pollutants because almost all untreated wastewater from households (20 million people) and 2050 industries[1], end up in Jakarta Bay. The 13 rivers that flow through the Jakarta metropolitan area pick up approximately 1,400 cubic metres of solid waste per day. Of this total solid waste, around 1,100 cubic metres flows directly into the bay. A survey on the extent of solid waste pollution on 24 islands of Kepulauan Seribu in 1985 and 1995 indicated that the total litter onshore had increased twofold during the last ten years and had reached the islands located 60 km from the shoreline of Jakarta Bay[2]. It only takes 22 hours for the household waste from Jakarta to reach the Pari islands. Within an hour of household waste reaching the islands, the seawater over the seagrass meadows can change to yellow/brown.

Additional threats to Pari Island seagrass meadows are from seaweed culture and the tourist development at Tengah Island. Tourist cottages have been built around the island by digging and burying seagrass meadows, especially those of *Enhalus*.

*Coastal development on Tengah Island*

It is estimated that 678,300 $m^2$ (25%) of the seagrass area in the Pari island group has been lost between 1999 to 2004 [3]. As a consequence of the seagrass losses, there was also a reduction of associated biota (e.g., giant calm, sea cucumber, shells and fish). To offset the seagrass losses, we decided that the seagrass ecosystems of the Pari Islands needed rehabilitation to restore them to good condition. Unfortunately, there are no guidelines or protocols available for transplantation of tropical seagrasses in Indonesian waters, so we conducted an experimental restoration program in the Pari Islands to investigate several transplantation techniques. The seagrasses transplantation techniques trialed were: single shoots[4]; sprig[5]; and a bamboo frame modification of TERFS (Transplanting Eelgrass Remotely with Frame System)[6].

**Potting & Transport:** *The polybag units of Enhalus shoots and compost mixture transported to transplant site*

**Transplanting:** *The shoot and compost bag units are transplanted into the sediment with the aid of a bicycle pump*

**Cutting leaves:** *the leaves of transplanted shoots are cut to a height of 25 cm from the reference stake*

## Single Shoot method

Transplant shoots of *Enhalus* were collected from a healthy, monospecific meadow with muddy substrate. Roots of the *Enhalus* shoots were removed and the shoots separated into polybags of compost (sheep dung, household waste and woodchips). The shoot and compost bags were then transplanted into the sediment with the aid of a bicycle pump or PVC pipe. A bamboo stake was placed next to each transplanted shoot and the leaves were cut to a height of 25 cm from the stake as a reference point for measuring the survival and growth rates (number, weight and height of leaves). Within 15 months of transplantation (May 2010), the shoots had grown 2 – 8 new shoots and were flowering. After 28 months (June 2011) the shoots had produced fruits and we collected the seeds by enclosing the fruits in a net.

**Success:** *Transplanted Enhalus acoroides successfully produced flowers (above) 15 months after transplantation, and fruit (below) after 28 months. Seeds were collected from the fruit using a net.*

## Sprigs

Sprigs (bare-root transplant units consisting of small rhizome sections with a small number of leaf-bearing shoots and rhizome/root nodes) of *Cymodocea rotundata, C. serrulata, Halodule uninervis, Syringodium isoetifolium* and *Thalassia hemprichii* were selectively removed from a donor meadow by hand. Bundles of sprigs were then planted into a hole in the sediment created using a crowbar. Beside each sprig was laid a bamboo stake as a reference point. Unfortunately, only shoots of *Thalassia* survived in the transplant site.

***Success:*** *Transplanted sprigs of Thalassia hemprichii surrounded by single shoots of Enhalus acoroides.*

## TERFS method

In this method, a weighted bamboo frame, to which seagrass shoots are tied with biodegradable plastic, was dropped onto the transplant site. TERFS are usually made from a steel frame, but this was expensive and prone to theft. Bamboo stakes on the other hand were inexpensive, easy to work and safe from theft. The frames were made of bamboo stakes 2cm diameter and 40 - 60 cm long. They are arranged in a 10cm grid and tied with plastic at the meeting point. Shoots of *T. hemprichii, C. rotundata, C. serrulata, H. uninervis* and *S. isoetifolium* were collected from a donor meadow, and their leaves were trimmed to 2cm of the leaf midrib. Seagrass shoots (25 per frame) were mounted upside down at each bamboo join using biodegradable plastic (i.e. roots + rhizomes upward and leaves downward). Bricks were mounted at each corner of the frame for ballast. At the transplant site, the bamboo frames were inverted and dropped to the seafloor (i.e. roots and rhizomes into the substrate and the leaves pointing to the water surface). The frame was removed once the plastic ties had degraded after a month and the shoots had anchored into the sediment. Using the TERF technique, only *T. hemprichii* survived – all other species died.

***Limited success:*** *using the TERF technique, only T. hemprichii survived – all other species died.*

Transplantation of single shoot plugs of *Enhalus* and sprigs or TERFs of *Thalassia* were successful but transplantation of other seagrass species (*C. rotundata, C. serrulata, H. uninervis, S. isoetifolium*) failed. It is possible that transplanting failed due to ecological stress, rather than the technique, as the shoots were collected from subtidal sites but transplanted at intertidal sites. The study was also conducted in east monsoon when low water spring tides coincide with high water temperatures, which may have stressed the transplanted shoots. The *Enhalus* may have survived because the leaves were covered by epiphytic algae which may have protected the shoots from the heat of the sun.

Our trials are continuing at the Pari islands, as we still have a lot to learn before we have successful guidelines or protocols for transplantation of tropical seagrasses in Indonesian waters.

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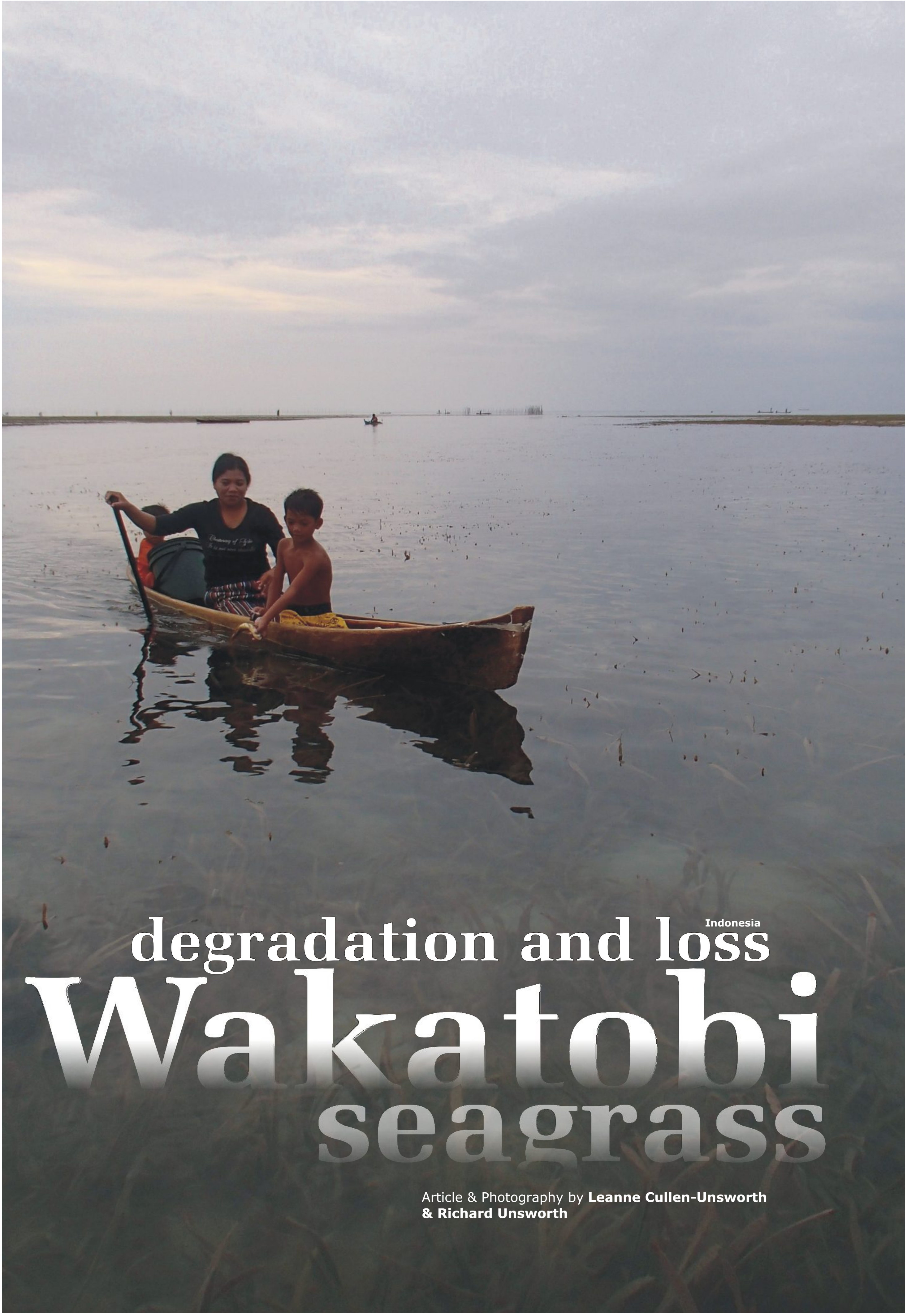
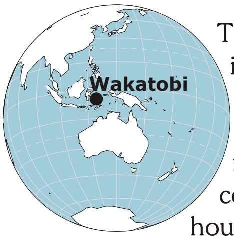


Indonesia

# degradation and loss
# Wakatobi seagrass

Article & Photography by **Leanne Cullen-Unsworth & Richard Unsworth**




THE WAKATOBI NATIONAL PARK (WNP) in Indonesia is situated within of one of the world's recognised centres of biological diversity. It is known in particular for its coral reef diversity and contains an estimated coral reef area of 600 $km^2$; however, it also houses exceptional mangrove and seagrass habitats with high conservation value. These habitats provide vital resources for local communities. In recent years the marine ecosystems in the region have been regarded as relatively “healthy”, however, concern is growing over the rapid deterioration of some of the more accessible areas of reef, mangrove and seagrass meadows. The major drivers of change, degradation and loss are human related. Similar to other coral reefs, seagrasses and mangroves worldwide, these habitats in the Wakatobi are being degraded or destroyed by human activities with more damage predicted as human populations increase and economic activities intensify correspondingly.

Seagrass meadows are extensive throughout the Wakatobi, some stretching for several kilometres, they are also highly productive and an important source of carbon for adjacent systems. Seagrass meadows in this region provide vital ecosystem goods and services with high economic importance; these include the provision of critical habitat for many subsistence as well as commercially and recreationally important fish and invertebrate species, and the provision of habitat for endangered dugong and green turtle. Seagrass meadows are not just important on their own but as part of a connected seascape. The presence of seagrass, coral reef and mangrove habitats in continuum within the tropical coastal ecosystem of this region, supports significantly higher densities of fish, including important commercial species', than a system missing any of these component habitat types.

Within the Wakatobi, there are two very distinct cultures: Islanders (known locally as Pulo) and traditionally nomadic sea people (known locally as Bajo) who now live in permanent houses on stilts over the intertidal seagrass meadows. The Bajo, sometimes known as the Bajau Laut, were the largest and most widely dispersed group of sea nomads in Southeast Asia and were traditionally entirely dependent on the marine environment for food, raw materials, livelihoods and their homes. A forced shift from traditional nomadic lifestyles to a more sedentary lifestyle meant that Bajo peoples developed semi-permanent settlements in the shallow intertidal or subtidal areas in coastal regions but they remain predominantly fishers and intertidal gatherers. As such, the Bajo can supply high value items such as sea cucumber, giant clam, top shell and live reef fish using highly specialised techniques such as free-diving and spear fishing to island dwelling communities.

For many people in the Wakatobi, gleaning in coastal areas represents a source of livelihood, seagrass meadows in particular represent a currently reliable resource when all other resources are for whatever reason not accessible. Most gleaning activity (82%) is conducted within the intertidal and shallow subtidal seagrass meadows, but the role of this resource is changing rapidly. A household survey in 2005 outlined gleaning (within seagrass meadows) as a supplementary food source or recreational activity, with no households stating any gleaning products as their major of first choice food source. Conversely in 2012, several Bajo households suggested that seagrass gleaning was far more important as a primary source of protein. Furthermore, for the Bajo, seagrass meadows are seen as a 'back up' livelihood that people can depend on to find food or a guaranteed minimum daily income.

Although the Bajo represent the majority of fishers in the WNP, the Pulo are also dependent on seafood as their main (and for many only) source of protein. In fact all marine resources in WNP are heavily relied upon by both the Pulo and the Bajo for food and raw materials as well as income.

It is clear that Wakatobi seagrass meadows are an essential resource base for local people contributing significantly to their welfare through the provision of fishing grounds, substrate for seaweed cultivation, nutrient cycling and, for the Bajo, a place to live. But, despite the recognised importance of seagrass meadows, these habitats are suffering from increasing anthropogenic pressures including some new and somewhat unexpected direct and significant threats.

Previously identified threats to seagrasses include those related to global climate change such as increases in sea surface temperatures, sea level rise, and frequency and intensity of storms.

**Tomia Island:** Mixed shallow water seagrass and reef habitats typical of those in the Wakatobi under threat from coral mining.

Seagrass meadows are extensive throughout the Wakatobi, some stretching for several kilometres, they are also highly productive and an important source of carbon for adjacent systems.

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These impacts are in addition to the currently recognised direct anthropogenic impacts such as those from the discharge of domestic waste and the associated reduction of water quality, increased sedimentation and nutrient loading, mechanical damage from boats, and overexploitation of seagrass fauna.

The environmental effects of excess nutrients or sediments are commonly considered the most widespread and significant causes of seagrass decline, however, recently, greater attention has focused on the role of top-down control in seagrass declines and outlined the impact of overfishing. Overexploitation is of particular concern within the Wakatobi region where seagrass meadows offer an easily exploitable and abundant food source for local people. Both Bajo and Pulo fishers have resorted to exploitation of marine resources using more efficient methods due to the need for more economically profitable catches, sometimes using both cyanide and bombing techniques.

The use of cyanide and bombs by fishers in the Wakatobi reportedly began in the 1940's and is not restricted to coral reefs but is also used as a method within seagrass meadows. The use of static fishing gear, fish fences (known locally as sero) is also of concern. Both coral and sand is mined in the region for infrastructure construction and repair, the demand for which appears to be increasing with an increasing population and influxes of developmental government funding to the region, and with knock on impacts for water quality.

Household surveys, focus groups and visual observations conducted in 2012 have outlined disturbing evidence of some new and significant threats to the seagrass meadows of WNP, including:

- mining for 'dead' coral beneath the seagrass meadow. This activity involves physical removal (by digging) of large areas of seagrass to access the coral 'rock' underneath.
- use of poison to remove seagrass from areas selected for static fishing gear (fish fence, or sero, pens). Organically derived poison is extracted from terrestrial plant material and squirted directly onto seagrass trapped within the fish holding pens. These pens are made of typical mesh and therefore the devastation of seagrass is not confined only to the target area but spreads to affect the heath of surrounding seagrass.
- cutting seagrass to limit its impact on seaweed (agar-agar) growth. Seaweed cultivation has been an important livelihood in the Wakatobi since the 1980's, however in recent years there has been a decline in the activity due to issues with disease and slow growth. Seaweed is cultivated over seagrass meadows and many seaweed farmers believe that when seagrass makes contact with their growing seaweed stock, it causes damage and the spread of disease. This has led to physical removal of seagrass though 'pulling' or more often cutting the longer blades beneath the seaweed lines.


## Wakatobi National Park

The Wakatobi National Park lies towards the centre of the 'Coral Triangle' region of high biodiversity in southeast Asia. The Park encompasses 13,000km$^2$ and includes a diversity of reefs, seagrass and mangrove habitats whilst also being home to around 100,000 people. The water depth varies, the deepest parts reaching 1,044 metres with sand and coral at the bottom. The Park has 25 chains of coral reefs, and the total circumference of the coral islands is 600 km. Marine resources in the Wakatobi National Park are heavily utilised for food, raw materials and income. The sustainable use of resources within the Wakatobi is therefore of significance with regard to both global marine conservation issues and the well-being of the resident population.

*Source: Clifton et al (2010) Marine Research and conservation in the coral triangle: the Wakatobi National Park.*

## The Bajo

The Bajo (nomadic sea people) were the largest and most widely dispersed group of sea nomads in Southeast Asia & were traditionally entirely dependent on the marine environment for food, raw materials, livelihoods and their homes. A forced shift from traditional nomadic lifestyles to a more sedentary lifestyle meant that Bajo peoples developed semi-permanent settlements in the shallow intertidal or subtidal areas in coastal regions but they remain predominantly fishermen and intertidal gatherers. **Clockwise from left:** Bajo lady gleaning by Sampela village at low tide; typical seagrass 'catch' in dug out canoe; catch monitoring at Sampela village; Bajo houses built over the seagrass meadow."

## Education, gleaning and seagrass

Wakatobi seagrass meadows are an essential resource base for local people contributing significantly to their welfare through the provision of fishing grounds, substrate for seaweed cultivation, nutrient cycling and, for the Bajo, a place to live. Despite the recognised importance of seagrass meadows, these habitats are suffering from increasing anthropogenic pressures. Recent Seagrass-Watch education and awareness raising held in Wakatobi, highlighted the importance of seagrass and the importance of minimising threats to ensure sustainable use of the resource. **Clockwise from top:** bringing in the gleaning 'catch', low tide gleaning typically a female activity; *Halophila ovalis* off Tomia Island ; Seagrass-Watch workshop on Hoga Island

The destruction of seagrass meadows has been well documented and has wide ranging consequences, the most significant of which include a reduction of detritus production, which changes the fish community and alters the food web, beach erosion due to the loss of the binding roots, and loss of structural and biological diversity. Evidence from focus groups with the Pulo and Bajo communities indicates that significant areas of seagrass in the Wakatobi has already been destroyed or reduced in species and/or density. Few people in the Wakatobi are more aware of the significant threats to seagrass meadows than the Bajo, and for few people will the consequences of seagrass decline be more devastating. Fish are just one of many edible seagrass organisms. At low tide, nearly every accessible intertidal seagrass meadow in the Wakatobi is picked over by men, women and children gathering a major portion of their daily nutrition, and in many cases for fishing families this "gleaning" activity provides more essential nutrition than fishing itself. As each full moon approaches, the exposed intertidal zone at sunset becomes a significant fishing area, with numerous fishers and families collecting invertebrates, trapping fish stranded in tide pools, or bringing in their nets laden with fish after the tide has receded. Much of this fishing is subsistence and community-based activity, but it also includes small family fishing collectives earning a basic living selling excess catch. In many locations it involves the whole family, including small children, and as a result exists as a social and recreational activity. Therefore, not only are these threats to seagrass threatening an important resource, they are also threatening a way of life.

# Trawling impacts on mediterranean seagrass

Article by **Gérard Pergent, Christine Pergent-Martini & Charles F. Boudouresque**
Photography by **Gérard Pergent**

Healthy *Posidonia oceanica* meadow

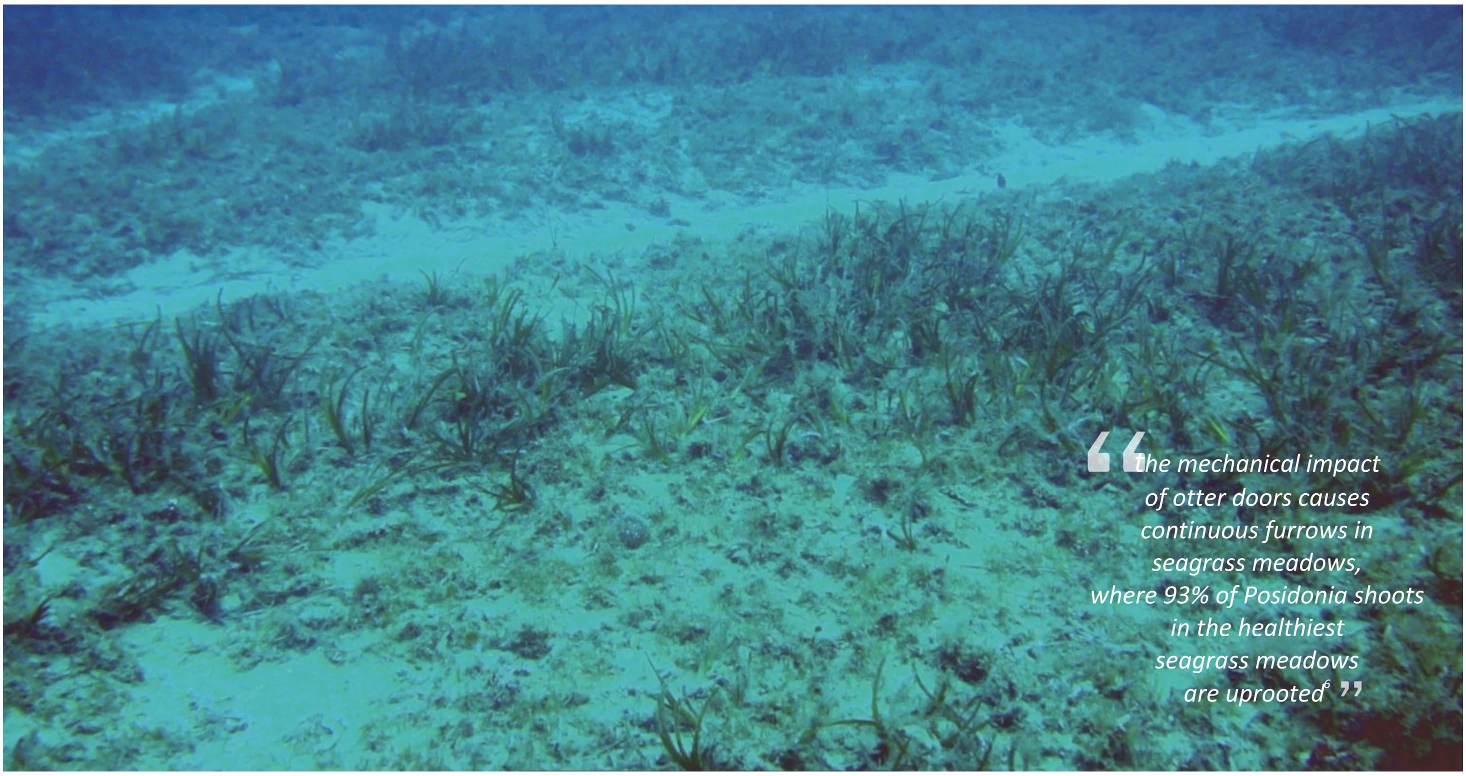
THERE IS GROWING CONCERN about the worldwide decline of seagrass meadows. The amplitude of the decline varies depending on the species, the area and the human pressure[1]. In the Mediterranean Sea, loss of seagrass meadows is mainly due to coastal development, trawling (fishing with towed gear), pollution, anchoring, competition with invasive species and sea level rise[2].

Trawling in the Mediterranean is probably the most severe and worrying current cause of loss of the seagrass *Posidonia oceanica*[3]. In theory, trawling is prohibited between 0 and 50-100 metres depth and/or within the ca. 5,600 m coastal strip in almost all Mediterranean countries. However, this legislation is rarely enforced.

## slow growing:

*Posidonia oceanica* is a large, long-living but very slow-growing seagrass. Its shoots, which are able to live for at least 30 years, are produced at a slow rate from rhizomes which grow horizontally by only 1-6 cm each year. Over centuries the rhizomes form mats which rise up into reefs that help to trap sediment and mediate the motion of waves, thus clarifying the water and protecting beaches from erosion. *Posidonia oceanica* is an important habitat forming species and provides habitat for many species, nursery grounds for the juveniles of many commercially important fishes and invertebrates. *Posidonia oceanica* is also grazed on by the Green Sea Turtle (*Chelonia mydas*).

*Source: Pergent, G., Semroud, R., Djellouli, A., Langar, H. & Duarte, C. 2010. Posidonia oceanica. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. www.iucnredlist.org.*



> “the mechanical impact of otter doors causes continuous furrows in seagrass meadows, where 93% of Posidonia shoots in the healthiest seagrass meadows are uprooted[6]”

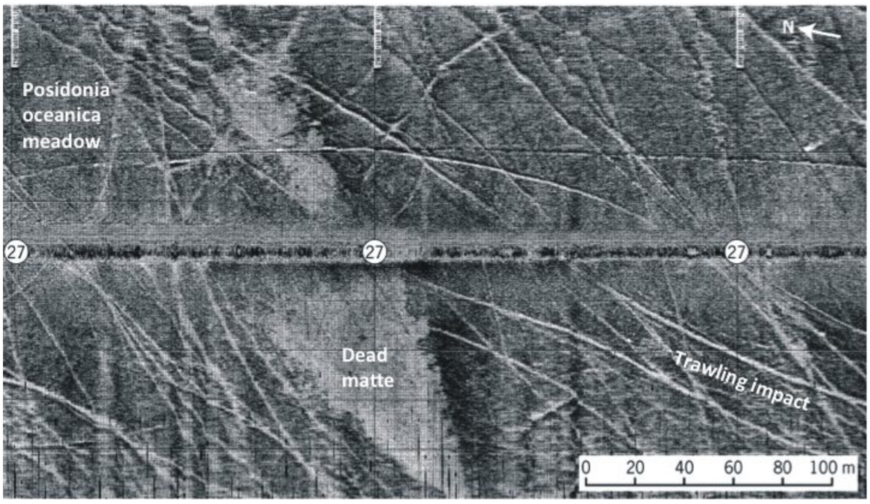
The damage caused by trawling is linked to the lead weights fixed to the lower part of the net's opening, which keep it in contact with the seabed, and to the heavy 'otter boards' fixed to the net, in a way that widens the opening of the trawl. Trawling opens up furrows in the *P. oceanica* meadow, uproots 100,000 to 360,000 shoots per hour[4], severely reduces the seagrass cover and induces resuspension of the sediment. In addition, trawling constitutes a vector of dissemination of invasive species (e.g. *Caulerpa taxifolia* and *C. cylindracea*).

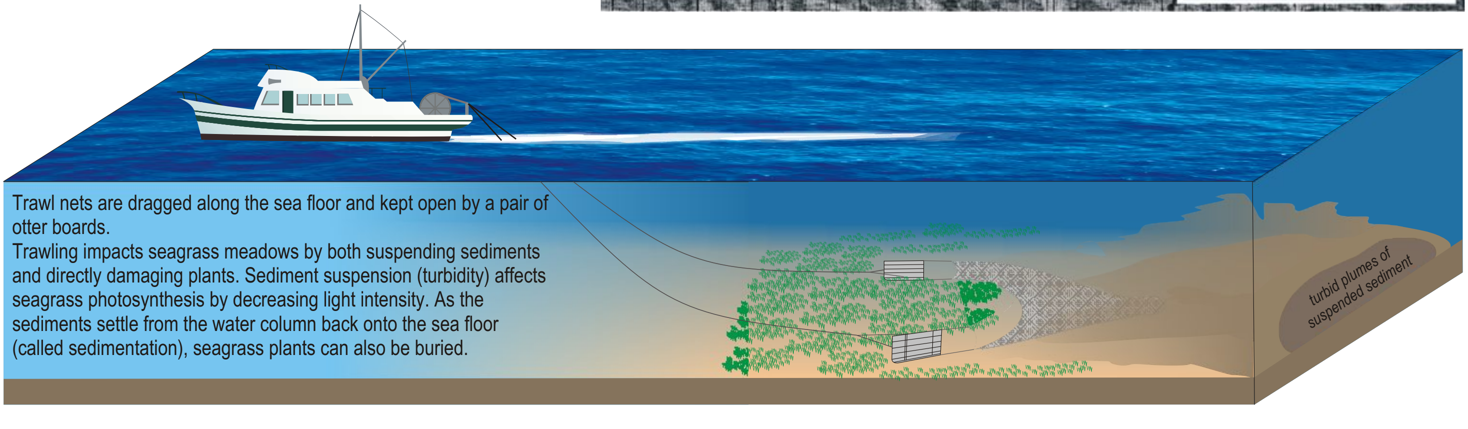
Otter trawling has also resulted in major changes in the structure of demersal communities with differences in fish assemblages inhabiting healthy and disturbed *Posidonia* meadows[5,6].

The effects of trawling on the megabenthos in *Posidonia* meadows has resulted in the reduction or elimination of species typical of hard bottoms and their replacement by ubiquitous species and others typical of sandy/muddy bottoms, as a result of the sediments being enriched with finer particles[5,6].

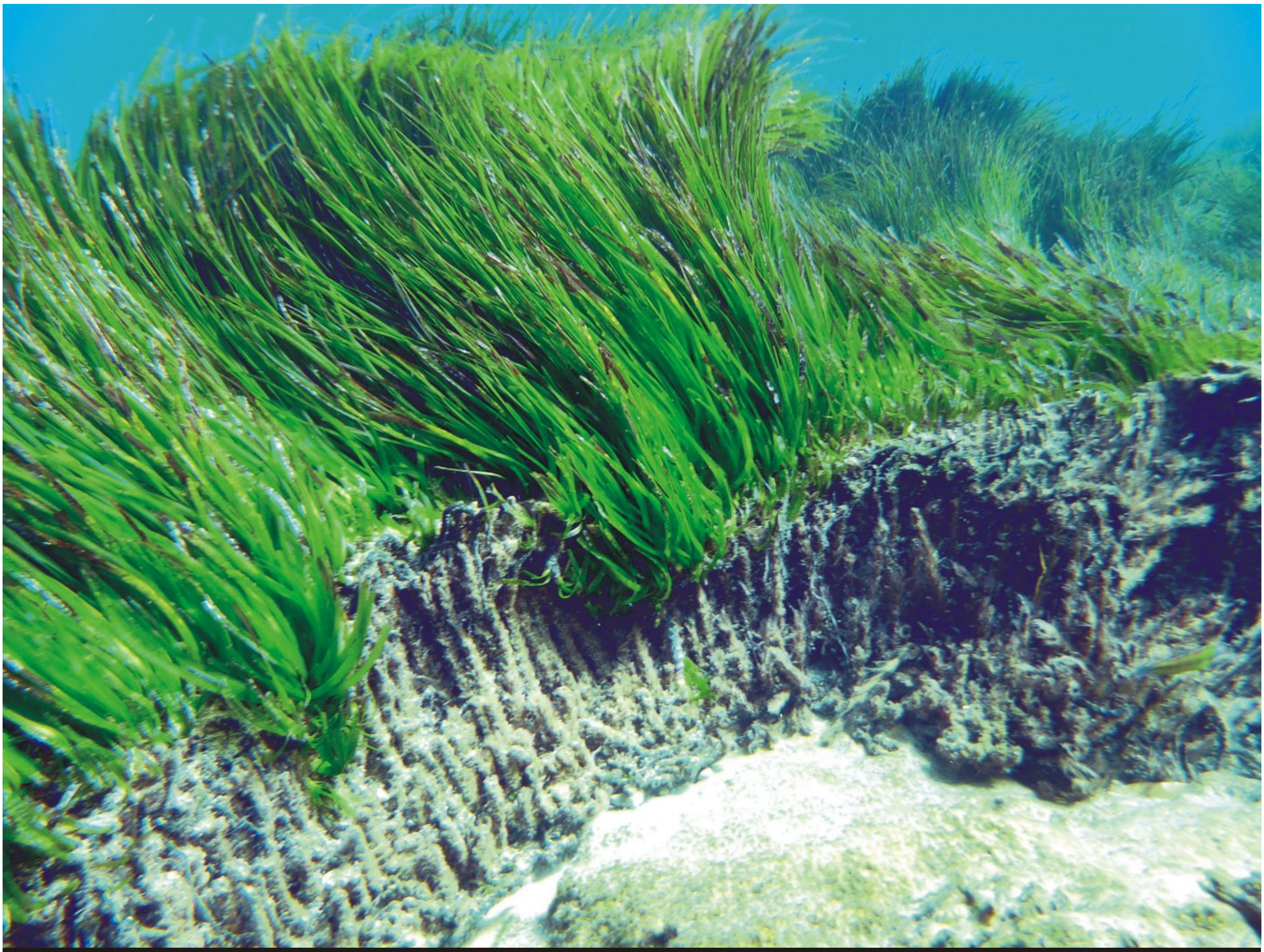
## meadow scarring:

*Traces of trawling detected along Cap Corse (France) with the help of a side-scan sonar (right) and validated by divers (top). Efforts have been made to prevent physical damage caused by trawler-fishing by placing artificial reefs, consisting of spiked concrete blocks, along certain stretches of the coast, and also by mounting a coastal watch to prevent illegal trawling.*




Trawl nets are dragged along the sea floor and kept open by a pair of otter boards.
Trawling impacts seagrass meadows by both suspending sediments and directly damaging plants. Sediment suspension (turbidity) affects seagrass photosynthesis by decreasing light intensity. As the sediments settle from the water column back onto the sea floor (called sedimentation), seagrass plants can also be buried.



## threats:

*Posidonia oceanica* is threatened at depth by mechanical damage from trawling, boat anchoring, and turbidity. Coastal development including shoreline hardening, urban and harbour infrastructure, and sand mining affect the upper limit of *Posidonia* meadows. Eutrophication (fertiliser from agriculture and urban waste) and pollution, especially in coastal regions that are heavily populated, is a problem. Fish farm activities and aquaculture affect surrounding *Posidonia* meadows. Invasive species also compete for habitat (e.g., seaweeds species such as *Caulerpa taxifolia* and *Caulerpa cylindracea*). Climate change will be an additional threat through warming of waters (in excess of 28°C) and erosion from sea level rise.
*Posidonia oceanica* is protected by EU legislation (Habitat directive), the Bern and Barcelona Conventions and national legislation (10 Mediterranean countries such as France, Spain, Italy, etc.). Fishing regulations limit trawling activities near the shore (either above 50 m or a certain distance from the coast), which constitute an indirect protection measure for the species (EC Council Regulation N° 1967/2006 and national regulations).

*Source: Pergent, G., Semroud, R., Djellouli, A., Langar, H. & Duarte, C. 2010. Posidonia oceanica. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. www.iucnredlist.org.*

Trawling has caused marked reductions of some *P. oceanica* meadows: 12% of the surface area in northeastern Corsica, France; almost 50% in the region of Alicante, Spain; at least 80% in the Gulf of Gabès, Tunisia; and trawling is the main cause of deep meadow losses along the Latium coast, Italy[3].

Recovery of seagrass meadows may occur after trawling is banned, but the very low growth rate of *P. oceanica* rhizomes (a few centimetres per year) results in a recuperation time in the order of at least one century[7].

To ensure seagrasses continue to thrive in the Mediterranean coastal waters, they must be protected from bottom trawling and fishing pressure reduced as much as possible; current regulations banning trawling on *Posidonia* meadows in most Mediterranean coastal areas need to be enforced and greater areas of seagrasses included in marine protected areas totally closed to fishing. Campaigns to raise awareness together with effective monitoring and surveillance may be an effective way forward[8].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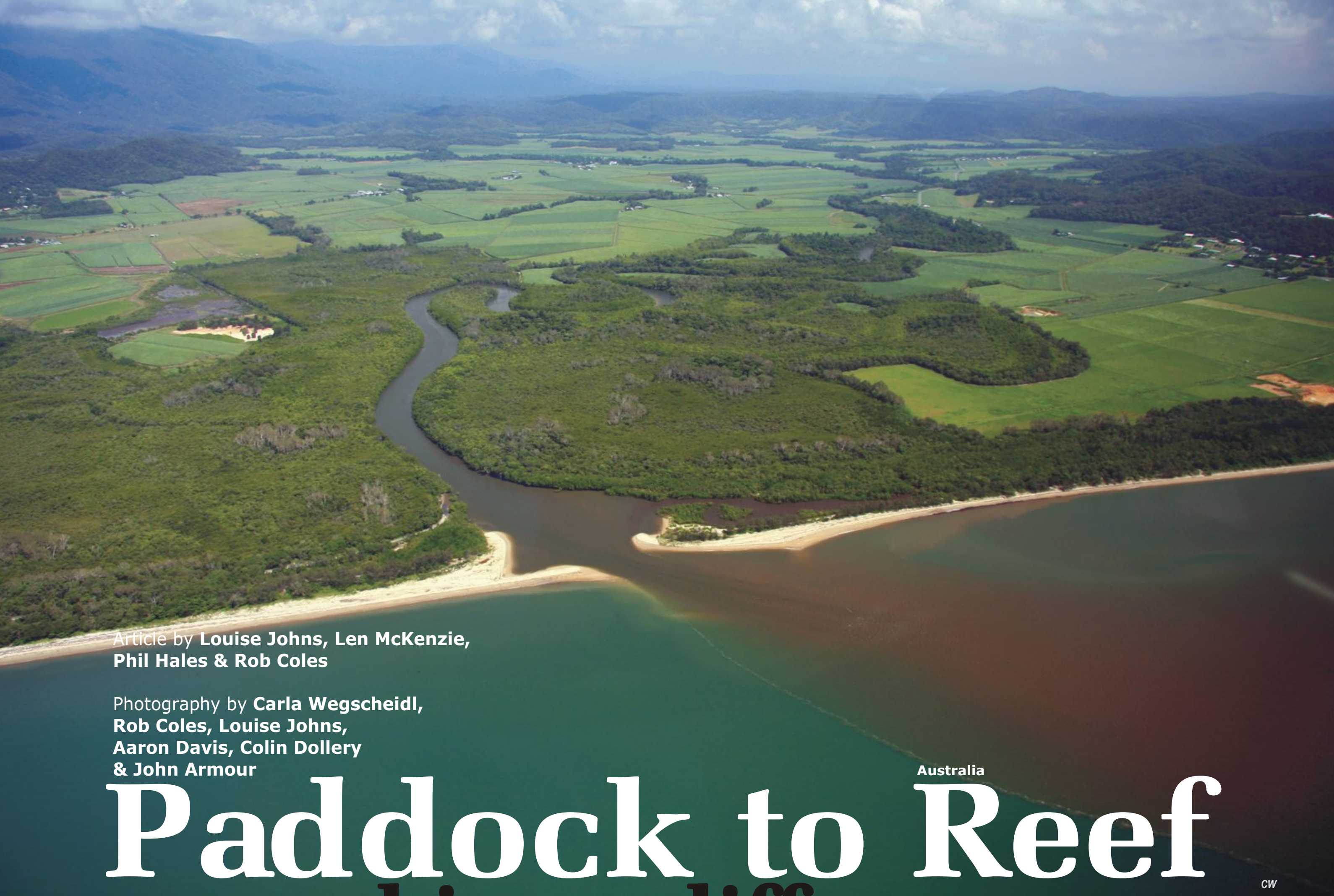


Article by **Louise Johns, Len McKenzie, Phil Hales & Rob Coles**

Photography by **Carla Wegscheidl, Rob Coles, Louise Johns, Aaron Davis, Colin Dollery & John Armour**

# Paddock to Reef

## making a difference


The Great Barrier Reef (GBR) is under pressure from many factors, one of which is the poor quality of water running into it from adjacent catchments[1]. Sediments, nutrients, and pesticides are entering the GBR coastal waters, primarily from broad scale agricultural land use[2]. This is impacting not only the health of the inshore coral reefs, but the inshore seagrass meadows and their capacity to withstand and recover from climate related impacts.

The Australian and Queensland Governments established the Reef Water Quality Protection Plan (Reef Plan) to halt and reverse the decline in water quality entering the reef and to ensure that by 2020 the quality of water entering the reef from adjacent catchments has no detrimental impact on the health and resilience of the GBR. Reef Plan identified and prioritised 11 actions critical to ensuring success, and these were categorised as: focusing the activity; responding to the challenge; and measuring success.

Research and development enables Reef Plan to focus the activity, and through government assistance, such as Reef Rescue, the farmers and land managers in GBR catchments are responding to the challenge, by increasing the adoption of improved land management practices that will reduce runoff of nutrients, pesticides and sediment from agricultural lands.

To measure the success of Reef Plan, the Queensland and Australian Governments in 2009 committed to the implementation of a comprehensive monitoring, modeling and reporting program to assess the progress of the Reef Plan. The program, referred to as the Reef Plan Paddock to Reef Integrated Monitoring, Modeling and Reporting (Paddock to Reef program), incorporates activities across geographic regions and scales. It involves monitoring and modeling a range of farming attributes, including management practices and water quality at the paddock, sub-catchment, catchment and marine scales to report against targets under the Reef Plan.

Activities being undertaken to date "on farm" to improve water quality are many and varied, and are across industries and regions. Improvements for sugar cane, bananas and horticulture include:

- better calculation and recording of fertiliser use.
- improvements in fertiliser application efficiency, particularly in the sugar cane and horticulture industries.
- innovation in herbicide spray technology improving application techniques and potentially reducing the need for residual herbicides.
- incorporating legume fallow crops to return nutrients and organic matter to the soil.
- implementing a controlled traffic system to minimise soil compaction.

*Grassed inter-rows and improved fertiliser rates in banana crops reduces nitrogen loss into runoff JA*

Improvements for the grazing industry include:

- better monitoring and management of ground cover at the end of the dry season.
- the fencing of riparian areas.
- better construction of roads, tracks and watering points.

Farmers are being assisted in making these changes through financial incentives and research, development and extension support from the Australian and Queensland Governments and Industry Groups. For information on the case studies, visit *www.reefplan.qld.gov.au/measuring-success/case-studies/case-studies.aspx*


CD

## Improved farming practises

Water quality and ecological integrity of some coastal waters are affected by material originating in adjacent catchments as a result of agricultural activities. Delivery of sediments and nutrients to rivers discharging into Great Barrier Reef waters is estimated to have increased four times since 1850. Applying best management practices such as green cane trash blanketing (right) reduces sediment erosion into waterways. Sediments in runoff reduce water clarity, leading to seagrass loss.

Strategic application of photosystem inhibiting (PSII) residual herbicides (atrazine, diuron, hexazinone) can reduce their transport in runoff to the Great Barrier Reef, impacting seagrasses and coral. Pre-emergent residual herbicides such as diuron can suppress photosynthesis in seagrasses if concentrations in seawater are above 0.1 µg/L. Using shielded sprayers is one of the new tools being implemented as part of a long-term weed management strategy as it reduces the application amount of residual by half. The strategy also includes appropriate timing of herbicide application and suitable chemical selection. This has facilitated a shift away from 'residual' herbicide control in early crop stages to a reliance on contact ('knockdown') herbicides, with significant reductions of residual PSII herbicides leaving paddocks through the crop cycle.


*Green cane trash blanketing*
AD


*Applying herbicides with a shielded sprayer*
AD

**Cape York monitoring**

*Seagrass meadows which have little or no impacts from agricultural runoff are being assessed in northern Cape York.* LJ

To assess the health of key marine ecosystems (inshore coral reefs and seagrasses) and the condition of water quality in the inshore GBR lagoon, the Great Barrier Reef Water Quality Protection Plan Marine Monitoring Program (MMP) was established by the Great Barrier Reef Marine Park Authority. This program is critical for the assessment of long-term improvement in water quality and in marine ecosystem health deriving from the adoption of land management practices in the GBR catchments *(see issues 35 & 39)*.

Until 2011 the MMP monitored seagrass at 16 locations along the Queensland coast from Cooktown south to the bottom of the GBR World Heritage Area[3]. However a criticism of the existing monitoring was the lack of reference sites and a "bias towards seagrass meadows in close proximity to human disturbance", in particular, the lack of sites north of Cooktown in Cape York.

Funding provided through the Queensland Government's Reef Plan section of the Department of Agriculture, Fisheries and Forestry (DAFF) has supported an enhanced MMP by extending the monitoring sites to include five more locations including the Princess Charlotte Bay region and north of Lockhart River at Piper Reef and Shelburne Bay. A location at Bowling Green Bay (a Ramsar site) has also been included as it is a well-defined agricultural area closely linked with an important, productive estuarine fisheries habitat and where improved land-management practices can be related to water quality outcomes.

Monitoring of the four new Cape York locations occurred during May (late wet) and September 2012 (late dry). Although it is early days yet to report on the health of these northern sites they appeared to be in a fair state with expected species diversity and abundance. Analysis of seagrass leaf tissue nutrient levels and reproductive health is currently in progress and will contribute to the 2012/13 Paddock to Reef report card.

Any modifications to farming practices under the Reef Plan program will take time to be reflected in the health of the marine ecosystem. It is anticipated that changes in water quality are expected within adjacent coastal waters (end of catchment) within 10-20 years[4]. Farming practice modifications occurring now will have long term outcomes for the reef environment and monitoring will need to be continued as a long-term project.

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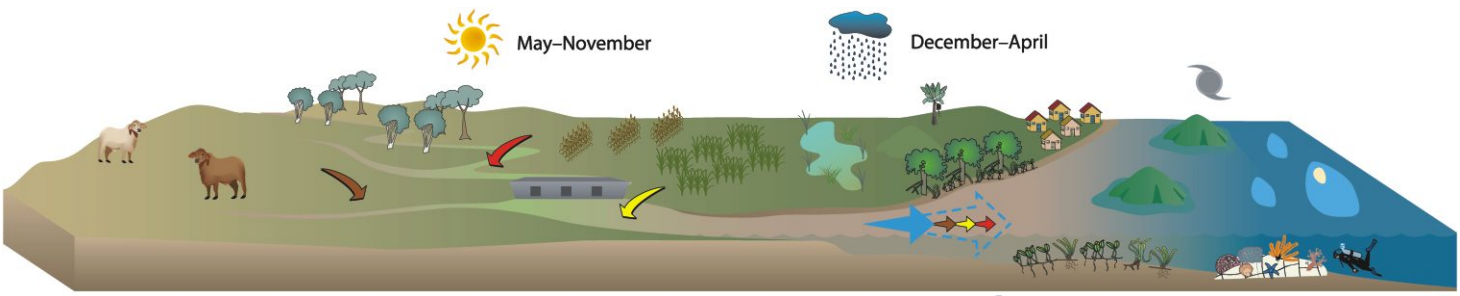



The Great Barrier Reef catchments are largely rural and dominated by summer monsoonal rains and occasional cyclones delivering sediments , nutrients and pesticides to the inshore and sometimes offshore portions of the reef in pulsed flows , which can be affected by water reservoirs and dams . Grazing is the largest single land use, and sugarcane , horticulture and other cropping make up other agricultural land uses. Small urban centres are located on the coastal strip. Habitats include wetlands , reef , seagrass and mangrove habitats, and continental and coral islands are present. Reef-based tourism is a major source of income.


Australia

# northern Shipping channels

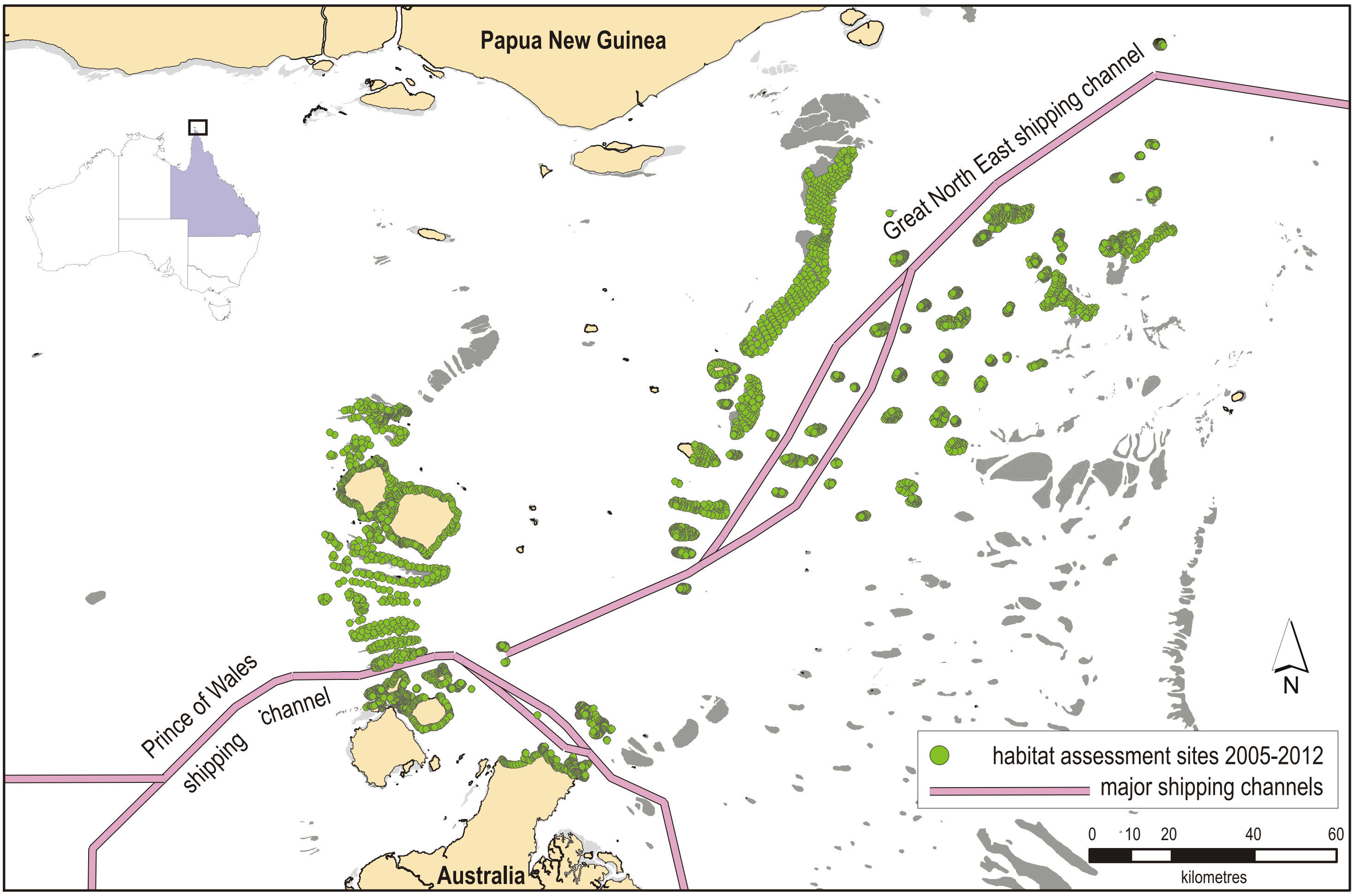
Article by **Helen Taylor**
Photography by **Helen Taylor & Skye McKenna**

Torres Strait was created as an island archipelago approximately 9,000 years ago on a land bridge connecting Australia with Papua New Guinea[1]. It comprises 247 islands, eighteen of which are permanently inhabited. The region has long been recognised for its ecological complexity and biodiversity: 6.2% of the area is tidally inundated flats which include ecologically important coral reefs, seagrass meadows and sand cays. These coastal marine habitats are important to island communities for subsistence as well as having strong cultural and spiritual value. Despite the remote location of the Torres Strait region, pollution, particularly associated with shipping activities, threatens the viability of the habitat, wildlife and in turn, the way of life for the local communities.

The ports and shipping industry is an essential component of Australia's trade and underpins the viability of many of Australia's export and import industries. The Torres Strait is a vital economic link, being the only connection between the Arafura and Coral Seas. Two major shipping lanes transit the region: the Great North East (GNE) Shipping Channel and the Prince of Wales (PoW) Shipping Channel. These channels have been identified as being the first and second most high-risk to local marine environments in Queensland[2].

They were ranked as such because the channels contain significant navigation risks as they weave their way through the shallow water maze of reef and island habitats. At their narrowest, these channels are only a few hundred metres wide and are bordered by a high diversity of economically and ecologically important habitats. In these areas there is a heightened risk of shipping accidents, including collisions and groundings of vessels, which may result in oil, fuel and chemical spills. Many marine habitats such as seagrass, algae, mangroves and coral reefs are vulnerable to oil and fuel spills, particularly when they occur in intertidal areas. In many instances, however, there is a lack of detailed information on the marine habitats that occur adjacent to these shipping lanes.

Approximately 3,000 voyages are undertaken by shipping vessels through the GNE channel each year, making it a high use passage in Queensland waters[3]. Of these vessels passing through the Torres Strait, the majority are oil and product



tankers, and general cargo ships. The Torres Strait region has a high rate of shipping incidents compared to other shipping passages. There are at least 20 separate accidents recorded back to 1970, 18 of which were ship groundings on reefs[2]. Of these 20 accidents, four caused large quantities of oil and fuel to be spilt into the sea[4]. The most recent incident occurred in February 2009, where a products tanker grounded on a small reef. There was no damage to the ship and no spill of pollutants, however, there was damage to the reef flat and associated habitats[4].

Shipping accidents in Torres Strait also pose a serious risk to commercial and indigenous fishing. Commercial fishing is one of the most economically important activities in the Torres Strait and provides a significant opportunity for financial independence for community fishers. As traditional inhabitants of the Torres Strait, the people are able to fish for both commercial and non-commercial fish species. There are a large number of commercial fisheries operating in the region including the Torres Strait prawn, tropical rock lobster, trochus, finfish and beche-de-mer fisheries. The Torres Strait prawn fishery is the most valuable commercial fishery with 6,722 tonnes of product taken in the 2008-2009 fishing season valued in excess of AUS$73 million[6]. The extensive seagrass habitats located around the GNE and PoW channels provide vital nursery habitats for juvenile prawns associated with the fishery.

For the indigenous people of Torres Strait, dugong and turtle are the most significant and highest ranked marine food source in the traditional subsistence economy[7,8]. The Torres Strait contains the largest population of dugongs in the world[9] and seagrasses are the primary food source for dugong and turtle. Therefore, the constant threat of shipping accidents and oil spills is of great concern to the local communities.

Despite the GNE and PoW Shipping Channels being high risk channels to marine habitats, the vast area of the region (48,000km$^2$) coupled with the low local population (and resources) mean that it is particularly difficult to plan for shipping accident and oil spill response actions. The Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) Seagrass Team based in Cairns, with support from the Torres Strait Regional Authority, developed a program to examine key areas of the intertidal habitats adjacent to the GNE and PoW Shipping Channels to aid in decision making and emergency response to shipping accidents and oil spills.

Since 2005, annual helicopter surveys have been conducted to produce detailed maps of critical intertidal habitats. To assist priority setting for accident response, the habitats are sorted into three distinct categories of vulnerability from shipping accidents: low, moderate and high. The categories are based on the habitat's quality and biological susceptibility to oil. While all of the intertidal area could be considered vulnerable, some ability to discriminate was considered important when there are limited resources available to respond to an oil spill or shipping accident. The resultant spatial data is fed into a National Oil Spill Response Atlas at the end of every survey.

*Approximately 3000 voyages are undertaken by shipping vessels through the GNE channel each year, making it a high use passage in Queensland waters . Of these vessels passing through the Torres Strait, the majority are oil and product tankers, and general cargo ships.*

To date over 78,000 hectares of intertidal habitat has been surveyed adjacent to the GNE Shipping Channel alone; including 58,000 ha of healthy, diverse seagrass habitat. Of the surveyed area, 67% is habitat that is highly vulnerable to shipping impacts. In most cases, highly vulnerable areas were those that retained shallow pools of water during low tide events with higher seagrass cover, algae and other benthic macro-invertebrates (giant clams, *etc.*) as well as the reef crest area with very high cover of hard and soft corals. Less than 10% of the habitats surveyed are considered to be at low risk. These low risk areas were typically fully exposed areas which had lower concentrations of structurally complex habitats interspersed with areas of open sandy substrate[10].

We hope that this program will continue on until all of the important intertidal marine habitats in the entire Torres Strait are mapped. For now, local Torres Strait Islanders sit, wait and pray that the detailed maps that we have created so far will never need to be pulled out of the drawers and used to avert a major environmental catastrophe.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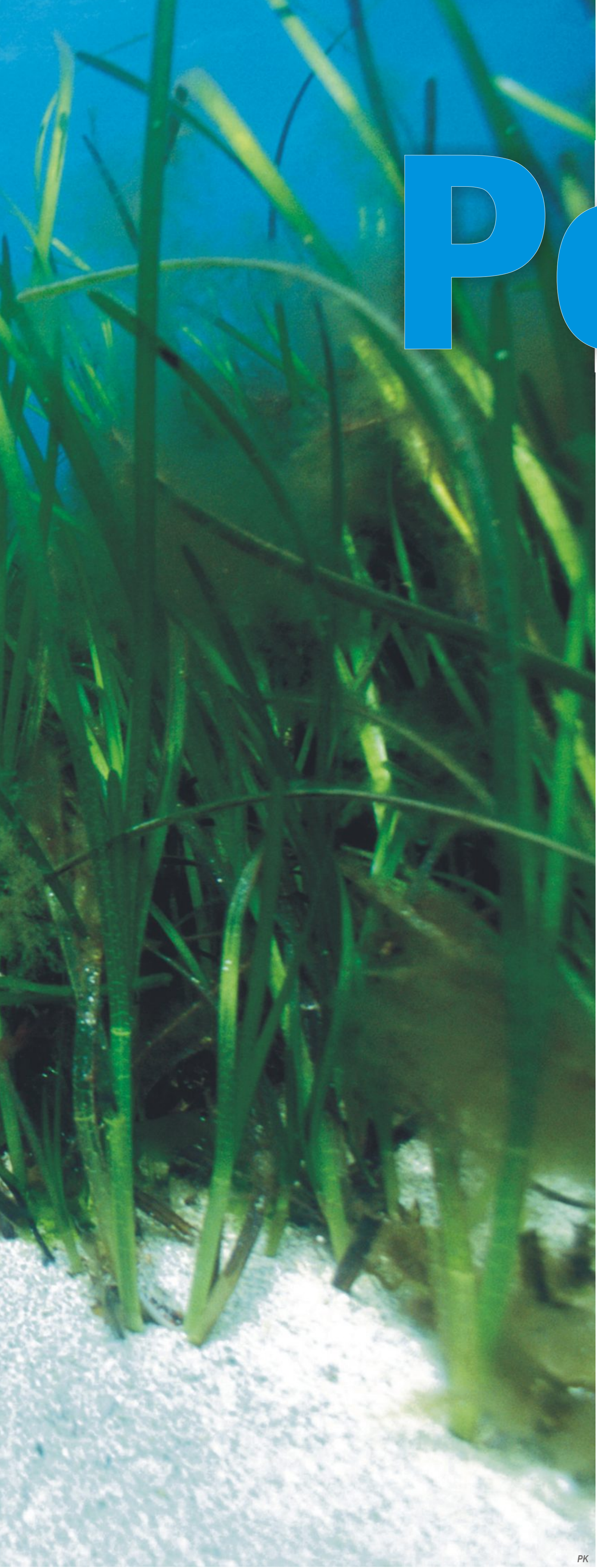


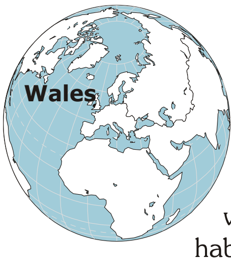

Wales

# Porth Dinllaen

## impacts & solutions

Article by
**Alison Palmer Hargrave**
**& Richard Unsworth**

Photography by
**Paul Kay, Rosemary Mc Closkey,**
**Tom Mercer & Rohan Holt**




Wales has an amazing coastline ranging from wind swept cliff tops to sheltered bays. Amongst this we have some unique and rare habitats such as methane reefs, honeycomb worm reef and seagrass. Due to this amazing range of habitats and species much of the Welsh coast is designated as Special Areas of Conservation (SAC). One of the largest SACs in the UK is in north Wales and spans from Nefyn on the north coast to about a mile north of Aberystwyth and is called Pen Llyn a'r Sarnau.

There are many habitats and species that make Pen Llyn a'r Sarnau a special and important place, one of which is seagrass. A bay within the SAC called Porth Dinllaen contains one of the largest and densest seagrass meadows in Wales and is estimated to be the size of 46 football pitches. This bay is vital to the local community not only because of its beauty but because of its traditions and historical links as a small but functional fishing port. The bay is also used by a large number of recreational and other commercial craft, especially through the summer months.

Mooring boats and seagrass favour the same sheltered conditions and more than 90 moorings have been counted within and around the seagrass at Porth Dinllaen. Aerial images and dive surveys have shown that this is having an enormous impact on the seagrass meadow.

***Clockwise from left:*** *Mooring damage in a seagrass meadow. Vehicle tracks through meadows*

Moorings within the seagrass typically have a scar with a 10- 20m radius. These occur as the mooring chains sweep across the seabed ripping up the seagrass. It is estimated that we have lost between 10% and 20% of the seagrass due to the impact of the mooring systems alone. Other impacts from regular intertidal vehicle use are also a problem.

The loss of seagrass at Porth Dinllaen is of major concern due to the key role that it plays as a fish nursery ground, as a carbon sink, and in protecting the shoreline. It is also important in producing oxygen and filtering the water which helps to create cleaner water and more golden sands which help draw in tourists. The SAC steering group in partnership with SEACAMS at Swansea University are now conducting a number of studies to determine the importance of this particular seagrass meadow.

Initial findings confirm that a number of commercial species use the meadow as a nursery ground, these include Plaice, Pollock, Sole, Saithe and Cod. Numerous other interesting fish species have also been found in the seagrass at Porth Dinllaen including stickleback, pipefish, scorpion fish and a very large congor eel. Engineers at SEACAMS are also helping to develop practical simple solutions to the problems of the damage caused by the moorings.

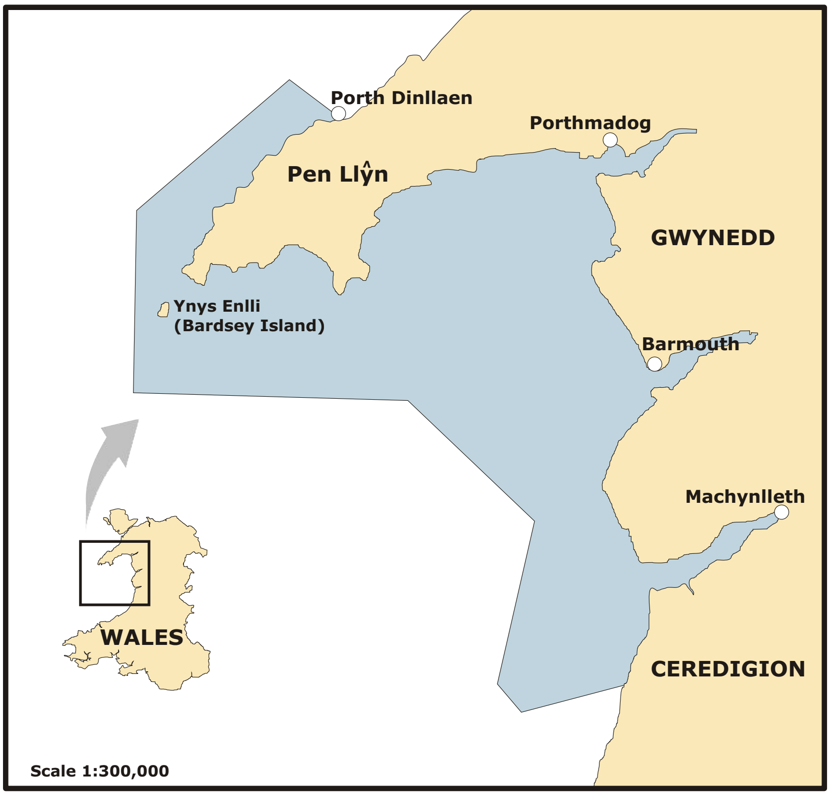
In order to reduce the impact of both anchoring and mooring in the bay, and save these important seagrass habitats the SAC steering group has commenced a local conservation project. The key to the success of this project is stakeholder engagement. Discussions have begun with a large number of users and interested parties and aim to develop management measures together. The ideas so far include:

- *creating an anchor zone, this will protect both seagrass and mooring systems from anchors. Having an anchor zone rather than a no anchor zone has more positive connotations*
- *adapting the existing moorings so that they have less of an impact, this could be a number of small and relatively cheap ways to adapt an existing mooring*
- *developing an eco mooring system that can cope with the tidal range and conditions in the bay, many existing systems have not been fully tested in UK waters*
- *producing interpretation material so people are aware of the situation and what they can do to help protect the seagrass*
- *creating a snorkel and rocky shore trail in partnership with local businesses*




***Clockwise from the top:*** *Spider Crab hiding in seagrass. Vehicle tracks scarring the meadow. Porth Dinllaen seagrass meadows.*

The key idea of the project is to try and safeguard the seagrass meadow with as little impact on users as possible. The SAC is aiming to get the balance right between all users' needs and the environment. If we can create attractions like a snorkel trail that could benefit local business whilst highlighting the conservation importance of seagrass then hopefully we'll have a better chance of success. The main aim of this project is to safeguard the seagrass but to do it by working closely with stakeholders and the local community.




## Pen Llyn a'r Sarnau

### Special Area of Conservation (SAC)

*Pen Llyn a'r Sarnau represents a huge site encompassing Pen Llyn (the Llyn peninsula) to the north and the Sarnau reefs to the south, as well as the large estuaries along the coast of Meirionnydd and north Ceredigion. Named after the Welsh word for causeway, the Sarnau are three rocky reefs that extend up to 24 km out to sea. The SAC covers 230 km of coastline and is the second biggest SAC in the UK!*

*Source: penllynarsarnau.co.uk*


EJ

# Cornwall discovery

Article by **Emily Jenkinson**
Photography by **Emily Jenkinson** & **Clare Marshall**


*After centuries of shipping traffic and maintenance dredging, seagrass and its diverse faunal assemblage were found to persevere in Fowey estuary.*

The Fowey River is situated in Cornwall, south west England; over 33 km from its source on Bodmin Moor to the mouth of the estuary at Fowey[1], the tidal limit of the estuary approximately 8 km up river at Lostwithiel. Fowey is a deep water harbour that is a very important exporting port on the south west peninsula, being the largest in tonnage terms. It is also in the top twelve ports for non-oil product exports in the United Kingdom[2], and accommodates over 7000 visiting craft through the summer season with up to 1500 resident craft. Cargoes through the port include: the export of copper, tin and china clay; the import of coal, timber, limestone; and general cargo such as coal was unloaded at Berrills Wharf as late as the 1960s[1], and Lostwithiel in the 13th century was a key stannery town for the county's mining industry[3]. This historical and contemporary commercial interest has necessitated a maintenance of deep water channels because sediment accretion in the lower harbour from mining activity further upstream since the late 16th century has silted up the intertidal regions of the river[4].

Maintenance dredging in the lower harbour in the early part of the 20th century gave access to the berths upstream by larger vessels, allowing china clay to be shipped regularly through the port. Regular dredging continues with support of annual hydrographic surveys[5], however due to historic heavy metal contamination[6] sediment removal is minimised[5].

It is in areas which were possibly previously dredged that Cornwall Wildlife Trust and Fowey Harbour Commissioners have carried out a preliminary survey and assessment of the Fowey Estuary seagrass meadows (early October 2011).

*Snakelocks anemone (Anemonia viridis) in Zostera meadow, Fowey Estuary*
CM

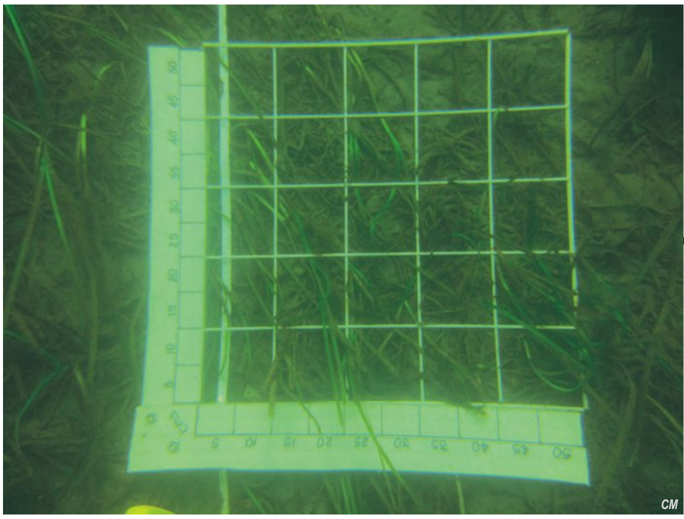
## Anemonia viridis

*Snakelocks anemone (Anemonia viridis) has long flexuous tentacles which are a grey-brown or bright green in colour. The green variety has purple tips to the tentacles. The tentacles rarely withdraw into the column, which is reddish or greyish brown. They are found on the western coasts of Britain from Portsmouth all around to the west coast of Scotland where it extends northwards to just south of Cape Wrath. Absent from the east basin of the Irish Sea. Mainly in the intertidal especially in pools from mid-tide downwards but not extending far into the sublittoral. However, frequently present, often in large numbers on the leaves of seagrass (e.g. Zostera marina).*

*Source: Dr Keith Hiscock 2008. Anemonia viridis. Snakelocks anemone. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 04/01/2013]. www.marlin.ac.uk/speciesinformation.php?speciesID=2517*

The aim of the survey was to confirm seagrass presence in the river, its general location, and assess the best methods for a future detailed investigation. The seagrass *Zostera marina* was successfully found in several locations, the largest of which was opposite the quay on Polruan side, amongst residential moorings and downstream, adjacent to a beach replenished with dredged shellfish material. It was this site that became the focus for future surveys.

On the 10th September 2012 the first survey was undertaken to assess the extent of the meadows using a 'VideoRay' Remote Operated Vehicle (ROV) and covered an area of 150 m over five transects. A follow-up survey to assess the density and biodiversity of the meadows was undertaken on 22nd September 2012, by a dive team of volunteer SeaSearch divers, supported by the Fowey Harbour Commissioners. The dive team laid two 30m transects, between 4 - 6m depth, which were surveyed for both habitat and species present. Faunal abundance was recorded using the SACFOR scale as applied within SeaSearch protocol, with $0.25m^2$ quadrats laid every 5m and photographed for later analysis. Species identified during the dive included the snakelocks anemone (*Anemonia viridis*), daisy anemone (*Cereus pedunculatus*), and sand mason worms (*Lanice conchilega*)[7]. SeaSearch observation data forms from the second dive have been submitted. It is hoped that further analysis of video data will produce additional results in regard to species diversity and that GIS maps will be produced from the initial ROV survey data.



A further dive is planned once initial data has been fully assessed. All future dives will benefit from a means of assessing contemporary health status from the historic baseline currently being created.

## Zostera marina

*Zostera marina* was found in several locations in Fowey estuary. In the UK, *Zostera marina* is the most widely distributed seagrass and dominates sandy and muddy sediments in coastal areas of low to moderate wave exposure. This species is a widespread and dominant species, usually monospecific meadows. It has declines mostly in developed and populated areas in Europe and North America. Ongoing restoration efforts since the 1940s in Europe and North America transplanted to re-establish populations of eelgrass in part of their former range from which they had been extirpated.

There has been a global decline of area covered by *Zostera marina* by 1.4% per year based on 126 documented changes in area that have been conducted over a 10 year period from 1990-2000.

*source: Short, F.T, Carruthers, T.J.R., Waycott, M., Kendrick, G.A., Fourqurean, J.W, Callabine, A., Kenworthy, W.J. & Dennison, WC. 2010. Zostera marina. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2.*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# Davao gulf threats

Article by
**Della Grace G. Bacaltos**
& **Helen W. Noel**
Photography by
**Della Grace G. Bacaltos,**
**Helen W. Noel**
& **Len McKenzie**


DAVAO GULF IS LOCATED in the southeastern part of Mindanao, the second largest island in the Philippines. The Gulf if a vast area covering about 6,550 square kilometres with a coastline measuring approximately 464 kilometres. A key marine ecosystem of Davao Gulf is its seagrass meadows, which cover approximately 305 hectares.

Eleven seagrass species have been identified in Davao Gulf including: *Cymodocea rotundata, C. serrulata, Enhalus acoroides, Halodule uninervis, H. pinifolia, Halophila decipiens, H. minor, H. ovalis, H. spinulosa, Thalassia hemprichii, Syringodium isoetifolium,* and an unidentified species of *Halophila*. The five most dominant species in terms of percent frequency and abundance were *Halophila ovalis*, *Enhalus acoroides, Thalassia hemprichii, Halodule uninervis*, and *Cymodocea rotundata*. Among the dominant seagrass species identified, *Halophila ovalis* has the highest percent frequency of occurrence (64%), which could be found in all areas in Davao Gulf, while the least was the *Halophila decipiens* with a percent frequency of 1%.

The highest shoot density was for *Halophila ovalis* (240 shoots $m^{-2}$). Relatively high density mean values were also obtained for *Halodule uninervis* and *Thalassia hemprichii* (64 shoots $m^{-2}$), and *Cymodocea rotundata* (60 shoots $m^{-2}$).

The Davao Gulf seagrass meadows are important nursery areas which support fisheries of the region. However catches over the last decade have declined


dramatically, and seagrass loss has been cited as one of the causes. The seagrass meadows are also important foraging areas for turtles and the endangered dugong. The Gulf is home to at least 14 dugong which are reported to mainly appear in the morning, during neap tides, and during dry season (January to May). However, their dependence on the sustained high abundance of their food *Halophila ovalis* and *Halodule uninervis* may be threatened by human activities.

As part of our assessment, we identified a number of human activities threatening seagrass around Davao Gulf, these were:

- *siltation due to run-off from vast agricultural areas of banana plantation and rice fields;*
- *presence of fish pens, fish cages and fish ponds;*
- *gold panning activities;*
- *presence of beach resorts;*
- *settlement areas;*
- *presence of wharf;*
- *floating power plant;*
- *presence of factories; and*
- *gleaning and the use of destructive fishing gears.*

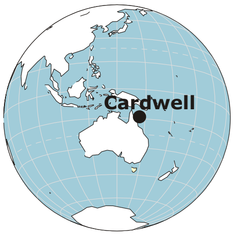
Based on the assessment findings, we recommended that the following actions should be considered:

- *banning the use of destructive fishing gears which may cause uprooting of the seagrass;*
- *adopting the landscape approach method in protecting seagrass meadows;*
- *formulating a gulf wide management conservation plan with an inter-agency collaborative partnership;*
- *intensifying the awareness and information program;*
- *organising a monitoring team with the assistance of Seagrass-Watch; and*
- *lobbying to local government units to fund seagrass ecosystem management and protection.*

Australia

# Girringun Rangers

## monitoring turtle and dugongs




Article by **Matt Gillis & Louise Johns**
Photography **Girringun rangers, Louise Johns Len McKenzie & Fiona Croft**

AFTER EXTREME CLIMATIC EVENTS resulted in significant seagrass losses, sea country rangers are using satellite trackers to provide insight into where turtle and dugong are now feeding.

The Girringun Rangers, based in Cardwell North Queensland, are a group of 12 sea country and terrestrial rangers that monitor and manage the land of nine tribal groups (Nywaigi, Gugu Badhun, Warrgamay, Warungnu, Bandjin, Girramay, Gulgnay, Jirrbal and Djiru people) that are incorporated into the Girringun Aboriginal Corporation. Of these nine groups, six are associated with the sea. Since February 2010, the Rangers have been funded through the Working on Country and Queensland Land and Sea program.

Girringun sea country (729,000 hectares) includes part of the Great Barrier Reef Marine Park and 10 declared Fish Habitat Areas and includes over 200km of coastline. In 2009, the six Girringun sea country groups signed a new TUMRA (Traditional Use of Marine Resources Agreement) with the Great Barrier Marine Park Authority (GBRMPA) that focuses on the management of sea country. The original TUMRA was signed in 2005 and was the first of its kind in Australia. The TUMRA is advised through the Girringun TUMRA Steering Committee which collectively manages the traditional take of turtles and dugong.

The Girringun rangers have been using the CyberTracker / I- Tracker program to record sightings of turtle and dugong within the Girringun Sea Country. This information gives the presence and absence of turtle and dugong throughout the sea country that the rangers patrol on a regular basis. The information collected will provide the rangers with an insight into where turtle and dugong are feeding due to the number of sightings within specific areas.


*Girringun Ranger Chris Muriata holding a Green Turtle caught for a tagging program around Goold Island near Cardwell*

Goold Island August 2012

LJ

Five turtles have also had satellite trackers fitted on them in the sea country area. These turtles have remained around the Hinchinbrook and Goold Island areas. Named Arana, Shanaya, Daku, Puku and Marcus by the Girringun Junior Rangers from the Cardwell State School, the details of turtle movements can be seen at www.seaturtle.org. The 12 junior rangers are actively involved in the Girringun rangers work, not just the turtle tagging but also beach clean-up and a variety of environmental educational activities.

It is planned for more satellite trackers to be fitted on turtles, focussing on the female turtles to identify were they are nesting to help to preserve the hatchlings to give them a better chance in life. It is also planned for satellite trackers to be fitted to dugongs some time soon.

The rangers have also been assisting James Cook University with turtle research at the southern extent of Girringun sea country at Ollera Beach This has included tagging, taking measurements, looking at general well-being, taking of biopsy samples to check for viruses and taking gut samples to look at the variable diet of the turtle.

It is planned for more trackers to be fitted on turtles, focusing on the female turtles to track where they are nesting to help to preserve the hatchlings to give them a better chance in life.

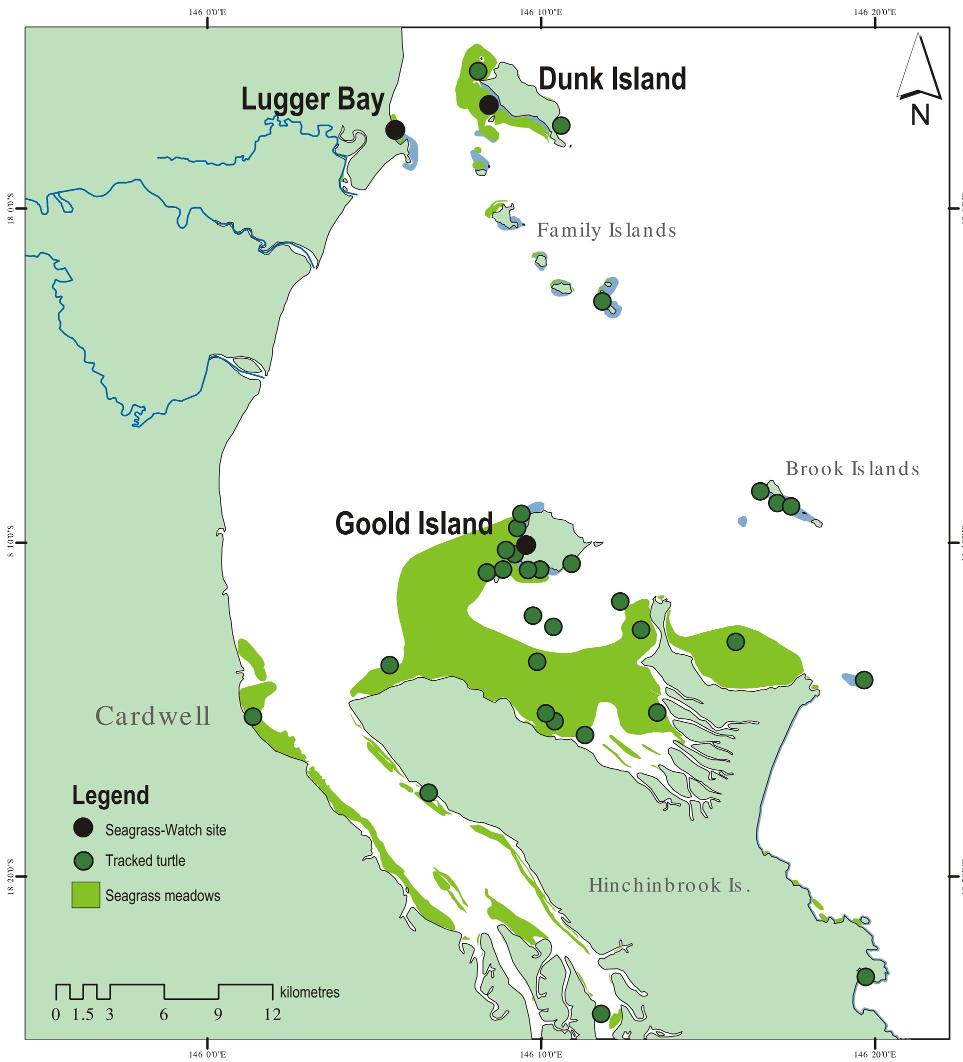
Goold Island September 2011

LM

For the future management and conservation of turtle and dugong and their habitat, the rangers will have a lot of information that will not only benefit the turtle and dugong and the traditional owners but will play a key role in the longevity of these important marine fauna.

As the diet of the turtle and dugong is so closely linked to seagrass health, monitoring of the regional seagrass is important to understand the potential impact on these species populations. Seagrass has been monitored at Goold Island north of Hinchinbrook Island annually since 2008. This particular area of seagrass suffered from a sudden decline in 2009, possibly due to increased rainfall events with high concentrations of sediments running off from major waterways that include the Herbert, Tully and Murray Rivers. This is a regional decline seen in other areas such as Dunk Island and Lugger Bay.

On 30th August 2012 the Girringun rangers along with Cardwell QPWS and Seagrass-Watch HQ headed back out to check on the seagrass at Goold Island. While the seagrass at the monitoring site was still very low in abundance there appeared to be signs of recovery occurring north east of the monitoring site where there was quite dense *Halophila ovalis* meadows with dugong feeding trails present. It is hoped that with further more regular monitoring events we will see the recovery of the seagrass which support the local turtle and dugong populations




**CyberTracker:** CyberTracker Conservation is a non-profit organisation whose vision is to promote the development of a worldwide environmental monitoring network. CyberTracker software, which is free, has been downloaded more than 30 000 times and the CyberTracker website has received visits from more than 3000 cities in more than 150 countries. CyberTracker is also being used in education, forestry, organic farming, social surveys, crime prevention and disaster relief. CyberTracker is the most efficient way to gather large quantities of geo-referenced data for field observations, even by non-literate users, at a speed and level of detail not possible before. Scientists and conservationists benefit from the icon interface enabling significantly faster data collection than text interfaces or written methods. Involving scientists and local communities in key areas of biodiversity, CyberTracker combines indigenous knowledge with state-of-the-art computer and satellite technology.

**I-Tracker:** is short for 'Indigenous Tracker'. It is a project that supports Indigenous land and sea managers across north Australia to undertake natural and cultural resource monitoring, research and management activities using digital technology and equipment. The North Australian Indigenous Land and Sea Management Alliance (NAILSMA) I-Tracker provides training and on-going technical support to Traditional Owners and Indigenous ranger groups.

NAILSMA consults with Indigenous land and sea managers to find out what natural resource data and information they want to collect about their country. From this NAILSMA develops digital applications that can be downloaded onto a handheld computer with GPS, camera, voice recording functions (called a PDA). The rangers take this PDA on land or sea patrols and use it to record data electronically. This data is then downloaded to their office computers, where the information can be viewed on a map and used to create reports for future planning and management practices.

*Source: nailsma.org.au*

***Image:*** *Junior ranger Telia Robinson catching turtles off Ollera Beach with JCU staff (above)*

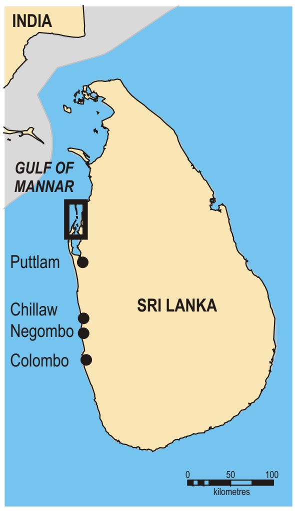
*Map (left) showing sightings of turtles around the Cardwell, Hinchinbrook and Dunk Island areas. This information is recorded with the I-Tracker program on regular patrols that the Girringun Rangers undertake within the six Sea Country Tribal Groups.*

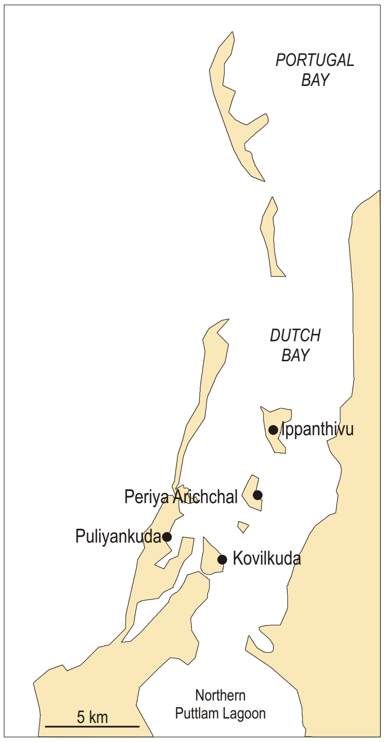

# Dutch Bay seagrass

Article & Photography by **Bandara W M D K**

Future development site


*If you happen to drive north from the capital city of Colombo, along the western coastline of Sri Lanka, you will stumble upon three large lagoon systems. One is Negombo lagoon, which is located close to Colombo, and another is Chillaw lagoon, which is relatively unexplored and located approximately 40km northward of the former. However, near to the coastal city of Puttlam is the largest lagoon of Sri Lanka: Puttlam lagoon.*




Puttlam lagoon is a shallow water body covering an area of 32,700 hectares(1), providing suitable conditions for a diverse community of seagrasses. The northern sector of Puttlam lagoon (near to its opening to the sea) is called Dutch Bay.

Due to the war which prevailed on the island, tourist access especially to the northerly regions of the lagoon were restricted for nearly 30 years. As a result, sandy beaches, pristine coral reefs, seagrass meadows and salt marshes were inaccessible to scientists and tourists. Regions such as Dutch Bay, the many islets nearby, and the Gulf of Mannar were primarily accessible to the military. However when the 30 year war ended in 2009, all restrictions perished and the region was opened to tourists of foreign and local origin. With the intention of expanding the local tourism potential, the Sri Lanka Tourism Development Authority (SLTDA) launched the Kalpitiya-Dutch Bay Tourism Development Project in late 2008.

According to SLTDA, the Kalpitiya-Dutch Bay tourism zone covers 1672.67 hectares, including 14 islets that are located in and to the north of Dutch Bay. Seventeen hotels (14 ongoing constructions), shopping centres, a domestic airport, open access aquatic landing facility, a theme park, an underwater amusement park, play grounds, golf courses and a race course were some of the main proposed constructions for the tourism zone[(2)]. Most of these developments proposed to use the shallow Puttlam lagoon (i.e. Dutch Bay) as an access route, means of transportation, water-sports zone or as a recreational fishing ground. As a result, it is possible that the rich seagrass ecosystems of the Dutch Bay will face numerous human stressors in near future.

In 2009 and 2010, I had the opportunity to prepare the Environmental Impact Assessment (EIA) reports for the establishment of two large scale hotels (including the largest proposed hotel of the Kalpitiya-Dutch Bay Tourism Development Zone). The data collected and experience from those assessments and field visits in 2011, provided some insight into the meadows in the Dutch Bay region of Puttlam Lagoon and the potential impacts.

Seagrass species composition and abundance from four different localities (within a study area of 73705 $m^2$) in the region was high. Seagrass meadows covered 47% of the study area, which was higher than reported elsewhere around Sri Lanka. Nine seagrass species were identified, while three species (*Thalassia hemprichii*, *Cymodocea rotundata* and *Enhalus acoroides*) were found to be the dominant ones.

The density of these seagrass meadows was highest near-shore of the islets and much lower in more open areas. *Enhalus acoroides* was found in the relatively deeper (>0.5m) and turbid waters of the lagoon: whereas, all other species were observed to thrive in shallow silt-rich substratum near to the shores.

## Cleared for development

Mangroves were cleared at 8 locations for future jetty access *(below and right)*.
A small resort (south of Dutch Bay) where mangroves were cleared along the lagoon bank *(bottom right)*

*"The impacts of destroying seagrass meadows could trigger a network of collapses: such as loss of biodiversity, productivity, lagoon-fisheries, local economy and tourism as well...."*

Apart from seagrass communities, this section of the lagoon was also rich with macro-algae, benthic molluscs and many commercially viable fish species. All of the sampled islets were bordered with mangroves, whose root systems provided an excellent habitat for juvenile fish and crustaceans, while acting as spawning grounds and safe-heavens. All together, these communities gave rise to the diverse benthic ecosystems of the Dutch-Bay region of the Puttlam Lagoon. However, these communities are now threatened by the developmental activities of the ongoing tourism development project.

All prescribed development activities are executed under the environmental law of Sri Lanka. Depending upon the magnitude and the degree of the impact(s) to the ecosystems, respective EIA or Initial Environmental Examination (IEE) studies have been and will be conducted. So, theoretically, these development projects would be environmentally sustainable. But this has not always been the case.

A gap in Sri Lanka's environmental law enforcement is the lack of post-development monitoring. Nobody knows whether a project proponent has followed the environmental guidelines of the EIA document until an environmental problem occurs. Therefore, some projects are likely to squeeze through the legal framework and potentially modify or destroy sensitive ecosystems (such as seagrass meadows).

The impacts of destroying seagrass meadows could trigger a network of collapses: such as loss of biodiversity, productivity, lagoon-fisheries, local economy and the tourism as well. To avoid such consequences, government will need to reinforce the legal framework. Conducting environmental assessments (as parts of EIA process) prior to project design and implementation is only part of the process and not sufficient on its own. Post-development monitoring and evaluation is a key tool to assessing the developers compliance to environmental guidelines.

It is clear that if proper management is not implemented when large scale activities are proposed, such as Kalpitiya-Dutch Bay Tourism Development Project, which includes numerous environmental modifications and impacts, sensitive ecosystems such as seagrass meadows would immediately drop from their pristine state. These ecosystems would then degrade over time, generating large scale environmental, economical and even social controversies. Avoiding or mitigating losses, particularly in cases such as Dutch Bay, is very important, especially where most of the native community is fully or partly dependent on natural resources of the Puttlam lagoon.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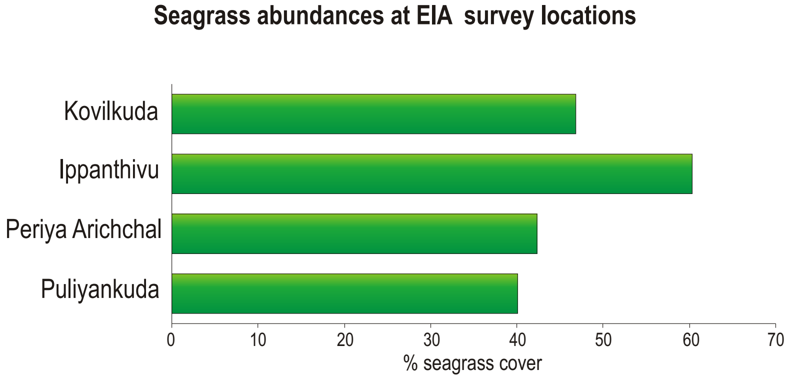
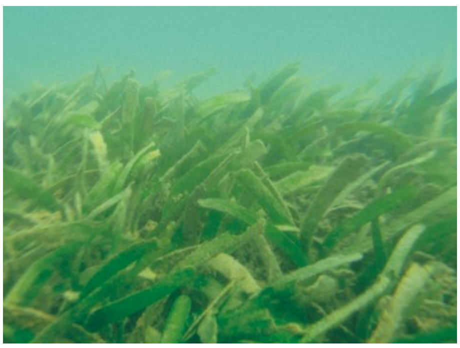


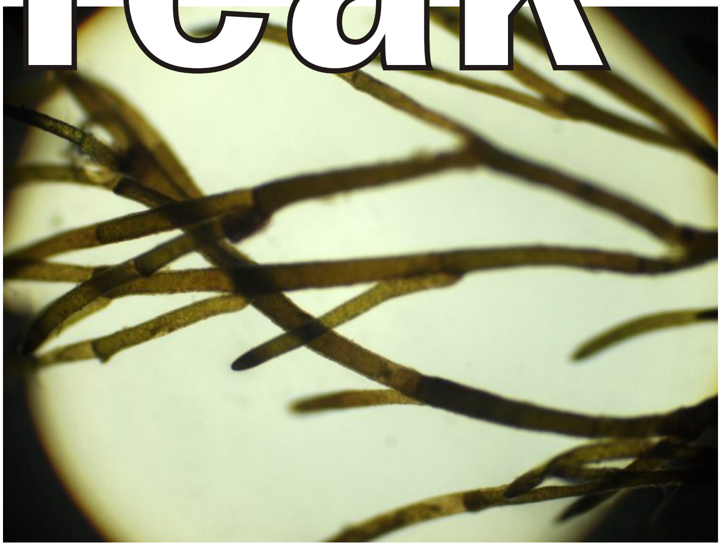



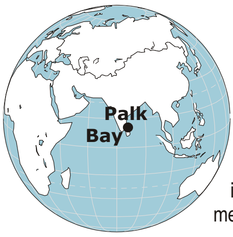
## Seagrass found

Samples of *Halodule uninervis* and *Halophila ovalis (left)*, collected from Dutch Bay. The density of these seagrass meadows was highest near-shore of the islets and much lower in more open areas. *Enhalus acoroides (below)* was found in the relatively deeper (>0.5m) and turbid waters of the lagoon: whereas, all other species (*Thalassia hemprichii, left*) were observed to thrive in shallow silt-rich substratum near the shores.

India

# Outbreak






### Altered state

Macroalgae can outcompete seagrasses under high levels of nutrient pollution, because macroalgae grow rapidly in low light and quickly uptake the nutrients. This ultimately results in the loss of seagrass and an altered state, where green meadows and clear waters are replaced with unstable sediments, turbid waters, hypoxia, and poor habitat conditions for fishes and invertebrates.

**Images** (clockwise from top left): The invasion of moss balls over *Thalassia hemprichii* meadow; Moss balls start to establish in the *Thalassia hemprichii* meadow in Kattumaavadi; Microscopical view of the macroalgae showing varied degrees of branching; Moss balls bought in by wave action invade a *Halophila ovalis* meadow.

## challenging seagrass survival

Article by **T.Thangaradjou, Pon. Subhashini and S.Raja**
Photography by **T.Thangaradjou**

PALK BAY LIES between the central east coast of Tamil Nadu state (India) and the island nation Sri Lanka. It is bestowed with pristine seagrass ecosystems comprising fourteen species. The livelihoods of the coastal fisher population of this region are largely dependent on the fisheries the seagrass meadows support. The most significant threat to seagrass in this highly productive region is nutrient enrichment from aquaculture waste water runoff. This enrichment has resulted in the proliferation of epiphytes and macroalgae in the seagrass meadows.

Our surveys since 2010 in the Palk Bay region have recorded the increasing dominance of macroalgae in Manora, Somanathapattinam and Kattumavadi. Although there are several macroalgae species noticed on the seagrass meadows, either as floating mats or filamentous layers, the most predominant form was "moss balls"; locally known as "pandhu (ball) paasi (algae)". The name itself denotes the shape of the macroalgae that occur as either clumps floating at the water surface or dense beds on the seafloor. The algae is *Cladophora aegagropila* and belongs to the family Cladophoraceae. It is believed to be an alien species that is native to Sri Lankan waters and commonly represented as "drift macroalgae". It is possible the algae originated from Sri Lanka and drifted into Indian waters. *Cladophora* is a filamentous chlorophyte with varied degrees of branching, and the filamentous structures together forms a moss ball shape, when influenced by the tidal action[1].

These macroalgae out compete seagrass because they grow more rapidly in low light and quickly take up the nutrients. This results in a loss of seagrass biomass. Due to the dominance of this algae, the food web in the coastal intertidal region becomes altered and it diminishes seagrass photosynthesis due to competition for light, $CO_2$ and nutrients. Growth of *Cladophora* reaches nuisance

**Taking over**

Seagrass meadow completely smothered by the moss balls. Growth of *Cladophora* reaches nuisance proportions at times often as a result of eutrophication.

*Microscopical view of the macroalgae showing varied degrees of branching*

proportions at times often as a result of fertiliser runoff and sewage discharge. The macroalgae clumps fragment due to tidal and wave action, and these fragments then multiply as individual balls, multiplying in numbers. Due to their greater multiplication potential, the algae starts competing with seagrass for space and also spreads to adjacent barren areas. The biomass of the algae was 2-4.5 $kg.m^{-2}$(wet weight) at established algal beds. It smothers the smaller leaved seagrass species (*Halophila* spp. and *Halodule* spp.) and over time the entire meadow become dead and decayed. Though the quantitative algal cover estimates are missing from our survey, observations from 2010 onwards record the expansion of the algal mats across the region with its growth and successional spread along the shore from village to village.

The Palk Bay region is influenced by the northeast monsoon (October-December) and is prone to periodic nutrient inputs that stimulate the productivity of the moss balls. Only *Enhalus acoroides* with its greater canopy height successfully out-competes these macroalgae, followed by *Cymodocea serrulata*. The small leaved seagrass meadows of *Halodule* spp. and *Halophila* spp. were completely smothered. To worsen the scenario, as the algae die the substratum becomes anoxic (deprived of oxygen) with high levels of sulphides. Anoxic conditions were observed in the survey sites ranging between 3.1 and -24.3 mV. Such hypoxic conditions prevailing within the roots of seagrass pose a severe threat by inhibiting growth. The debris of the decayed algal mats also elevates turbidity in the water column and competes with large leaved seagrasses.

The rapid growth of macroalgae in the region of Palk Bay is alarming, with about sixty percent *Thalassia hemprichii* and ninety percent of *Halophila ovalis* and *Halodule* meadows already destroyed. This problem may ultimately lead to a major ecological phase shift that must be prevented by suitable management action plans.

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*1. Dodds, W.K. and D. A. Gudder, 1992. The ecology of Cladophora: Review. J. Phycol., 28: 415-427.*

# nymphs of the sea

Article by **Carmen B. de los Santos**
Photography **Len McKenzie**

> *"...while Cymodocea, the most glorious of all the nymphs, swam and made music from the depths of the sea, from time to time bedewed me sweetly with her kisses, and carried the iron keel from below..."*

THE SEAGRASS GENUS *Cymodocea* was first published by German naturalist Charles König in 1805. By far, this is one of the most fascinating seagrass names since it transports us to the days of yore, when Greeks described the natural phenomena as divine manifestations.

In Greek mythology, fifty beautiful daughters of the sea, the Nereids, were born from Nereus and Doris. These goddesses were empathic and kind and helped sailors and fishermen when struggling with perilous storms. They liked to ride the waves on dolphins or sea horses, playing with sea creatures, and each of them personified a marine facet. Jointly with the Tritones, the Nereids formed the entourage of *Poseidon*, God of Seas and protector of all waters.

The seagrass genus *Cymodocea* was named after *Kymodoke* (Cymodoce), one of the Nereids, the one who speed Cyriaco's ship across the Aegean Sea. *Kymodoke* was the sea-nymph of "steadying the waves" and, together with her sisters *Amphitrite* ("surrounding third") and *Kymatologe* ("wave-stiller"), possessed the ability to "still the winds and calm the sea". This is quite startling since the sea nymph *Kymodoke* represents one of the well-acknowledged ecological function of seagrasses: wave attenuation, seagrass meadows baffle waves and, as a result, smaller waves reach the adjacent shoreline, and sediments are settled, preventing from their resuspension and contributing to coastal protection.

The practice of naming organisms after divinities is quite common, but in many cases there is only a remote connection between the name and the myth, as it is believed for many marine plants and animals that were named after sea-nymphs simply because both inhabit the sea. Is this the case of the seagrass genus *Cymodocea*? We will never know whether Charles König chose *Kymodoke* among the fifty Nereids just because he liked that name or because he was already conscious of the function of seagrasses in wave attenuation. Whatever it was, there is a riveting link between seagrasses and the Greek mythology.

*In memory of Pepi Recamales, whose eagerness enlightened the volunteering programme for monitoring Cymodocea nodosa in Cádiz Bay (Spain)*