MINI-REVIEW

Recognising the necessity for Indo-Pacific seagrass conservation

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Abstract

Seagrass meadows are declining globally at an unprecedented rate, yet these valuable ecosystem service providers remain marginalized within many conservation agendas. In the Indo-Pacific, this is principally because marine conservation priorities do not recognize the economic and ecological value of the goods and services that seagrasses provide. Dependency on coastal marine resources in the Indo-Pacific for daily protein needs is high relative to other regions and has been found in some places to be up to 100%. Habitat loss therefore may have negative consequences for food security in the region. Whether seagrass resources comprise an important contribution to this dependency remains largely untested. Here, we assemble information sources from throughout the Indo-Pacific region that discuss shallow water fisheries, and examine the role of seagrass meadows in supporting production, both directly, and indirectly through process of habitat connectivity (e.g., nursery function and foraging areas). We find information to support the premise that seagrass meadows are important for fisheries production. They are important fishery areas, and they support the productivity and biodiversity of coral reefs. We argue the value of a different paradigm to the current consensus on marine conservation priorities within the Indo-Pacific that places seagrass conservation as a priority.

Introduction

It is well acknowledged that the majority of the world's coral reefs are at risk from anthropogenic activities. Less well acknowledged, however, are the global threats to seagrass meadows. Seagrasses are often critical components of coastal and marine environments, providing some of the most economically important ecosystem services of any marine habitat (Costanza *et al.* 1997; Orth *et al.* 2006). Important fisheries in their own right, they also play an important role in coral reef and other fisheries productivity. Seagrass meadows additionally support numerous charismatic faunal species, including species of turtle, dugong and seahorse (Hughes *et al.* 2009). Seagrass meadows also represent an important cultural, economic, and ecological resource, with many traditional ways of life intricately associated with them for food, recreation, and spiritual fulfilment (de la Torre-Castro & Ronnback 2004). Regardless, seagrass meadows are experiencing rates of loss that may be as high as 7% of their total global area per year (Orth *et al.* 2006; Waycott *et al.* 2009).

Within the "coral triangle" in the Indo-Pacific, there is currently impetus from governments and nongovernment organisations (NGOs) to limit and reverse the destruction of coral reefs (Clifton 2009), with a focus on the need to control widespread over-fishing (Newton *et al.* 2007; Wilkinson 2008). But is this conservation overly focused on coral reefs, with not enough consideration and emphasis placed on the wider marine environment?. Although commonly marginalized within the conservation arena, seagrass meadows make a valuable contribution to marine productivity (Dorenbosch *et al.* 2005; Unsworth *et al.* 2008). This productivity, both directly and through association with other habitats such as coral reefs, requires national and internation attention and recognition if these vital habitats are to be placed firmly on the conservation agenda.

Seagrass loss and deterioration is commonly associated with coastal development and poor land management, but in many locations of the Indo-Pacific, seagrass meadows are also increasingly threatened by fisheries overexploitation (Fortes 1990; Tomascik *et al.* 1997; Nordlund 2007). Subsistence fishing is not always sustainable; principally due to increasingly dependent human populations (Newton *et al.* 2007). High fishing effort results from a dependence of coastal populations on seafood for protein at a time of increased fishing technology availability, often in locations with rapid human population growth (Cullen *et al.* 2007).

Some countries (e.g., Australia) recognize the economic and ecological value of seagrass meadows at an institutional level (e.g., in Queensland Australia seagrasses are protected under the Fisheries Act 1994, and seagrasses are generally well managed (Watson *et al.* 1993; Lee Long *et al.* 2000). However, in many nations these meadows, although considered important by fishers and local stakeholders, are largely not recognized as conservation priorities within legal and environmental management frameworks.

Tropical near-shore fisheries support up to one billion people (Burke *et al.* 2002). The proportion of this productivity arising directly from seagrass has previously received limited consideration. We propose that seagrass is a major contributor to fisheries production and food security in the Indo-Pacific. We review evidence of the resource exploitation of seagrass meadows throughout the Indo-Pacific region and discuss the significance of these meadows in terms of the wider productivity of tropical marine ecosystems. We consider whether the conservation agenda is paying due regard to seagrass meadows, which like other tropical marine systems are under extreme pressure from overexploitation.

The "hidden" overexploitation of seagrass fisheries

Whilst many people are aware of the importance of coral reef fisheries, the examination of fin-fish fisheries in seagrass meadows is often neglected, as is the role of seagrass meadows in supporting coral reef fisheries. As well as being exploited at low-tide, seagrass meadows make ideal net-fishing areas (Fortes 1990; Tomascik *et al.* 1997; de la Torre-Castro & Ronnback 2004; Nordlund 2007). Seagrass meadows support abundant fish and invertebrates, and their location in shallow water means that they are readily accessible, usually in all weather conditions. Additionally, in Eastern Indonesia, seagrass meadows within an area of highly productive fringe and atoll reefs represent the preferred fishing areas for most fishers (Cullen 2007).

There exists a large volume of academic literature about artisanal coral reef fisheries within the Indo-Pacific: studies quantify fish catch, providing extensive discussion about their ecology, management and socio-economic implications (Newton *et al.* 2007; Cinner *et al.* 2009). In contrast, at first glance there appears to be little available temporal or spatial information on the highly exploited Indo-Pacific seagrass fisheries. However, detailed examination of design and species assemblages of many artisanal "small-scale" fisheries reported from reef environments, together with information about habitats in the fishing areas, reveals that many such fisheries exploit mixed habitats including both seagrass and coral reefs. It is clear that seagrass fisheries, either as stand-alone, or as mixed habitat fisheries exist across the Indo-Pacific (Figure 1, Appendix S1). Additionally, many studies on Indo-Pacific reef fisheries refer to "reef lagoon" fisheries (e.g., Campos *et al.* 1994; Kuster *et al.* 2005) which are commonly areas where seagrass meadows are abundant, and therefore potentially a major source of fishery productivity (see Table 1).

Fish species assemblages from artisanal reef lagoon fisheries catches often have a greater similarity to ecological studies of seagrass fish assemblages and seagrass fisheries (e.g., Gell & Whittington 2002; Unsworth *et al.* 2008) than to those of coral reefs (Table 1). Furthermore, some studies described as investigations of coral reef fisheries are based on seine netting directly within seagrass meadows (McClanahan & Mangi 2001; Mangi & Roberts 2007; Davies *et al.* 2009). Artisanal lagoon and reef fisheries often use tidal gill and fyke nets to trap fish as they move between habitats with the tide or over diel cycles (Tomascik *et al.* 1997; Unsworth *et al.* 2008). This is particularly the case for families such as Siganidae and Lethrinidae, with many tidal migratory species feeding in seagrass meadows (Unsworth *et al*. 2008). Although many artisanal reef fisheries studies are exclusively "reef-based" (e.g., Bellwood 1988), many predatory fish, such as species of the families Carangidae, Lethrinidae, and Lutjanidae use seagrass meadows as a feeding habitat, and hence are important in the trophic structuring of seagrass faunal assemblages (Unsworth *et al.* 2008).

Many studies, although providing a discussion about coral reef fisheries, often do not report (or provide limited discussion) that seagrass might be a major component of the fishing area (e.g., Campos *et al.* 1994; Laroche & Ramananarivo 1995; McClanahan & Cinner 2008; Davies *et al.* 2009). By providing only limited or no discussion about the habitats that support these "coral reef" fisheries, we are led to the assumption that they are

Figure 1 Artisanal fishers collecting seagrass resources at low tide in (A) Seagrass fishing, Bali, Indonesia (B) sale of seagrass shells to tourists, Zanzibar, Tanzania (C) Bajo child fisher, Wakatobi, Indonesia (D) Sepanggor Bay, Malaysia (E) Zanzibar, Tanzania (F) Inhaca Island, Mozambique (Pictures: Chris Smart, Lina Nordlund, and Len McKenzie).

from a single habitat. Although some authors use the term "coral reef ecosystem" to encompass other habitat types, this is rarely defined. Such reporting can have implications for resultant conservation priorities, potentially leading to inappropriate management actions being taken that do not recognize the real value of the range of habitats within a management area.

Declining seagrass fisheries catch: fin fishery

Although "hidden" literary evidence can be found of the spatial distribution of seagrass fisheries throughout the Indo-Pacific (see Figure 1), there is limited understanding of the status and temporal changes in parameters such as catch per unit effort (CPUE) and maximum sustainable yield. A rare example comes from the Wakatobi in Indonesia where seagrass meadows are under increasing pressure from the use of large, fixed tidal fishing nets (or "fish fences"). These fish fences are laid for up to 100 m across the seagrass and indiscriminately catch all fish moving with the tide (Exton 2010). The catch includes species from Lethrinidae, Siganidae, and Scaridae families known to migrate between coral reef, mangrove and seagrass areas (Unsworth *et al.* 2008). Fish fences catch high numbers (up to 40% of the catch) of juvenile fish as well as commercially and nutritionally undesirable species such as the blue spotted ray *Taeniura lymma* (Exton 2010). Recorded juvenile catch in the Wakatobi has included species whose growth and development might depend on the availability of specific resources such as abundant seagrass crustaceans (Nakamura & Sano 2004). Indonesian fixed fence fisheries in seagrass meadows have shown large declines in CPUE

Table 1 Example artisanal coral reef lagoon fisheries studies that have known seagrass components (e.g., fish caught directly in seagrass) but which focus discussion around coral reefs

Study	Location	Habitat and fishing method	Key seagrass species/families	Key finding (s) of study	Ratio of reference to seagrass versus coral, and seagrass versus reef	Evidence of seagrass in locality
Acosta & Turingan (1991)	Cape Bolinao, Philippines	Reef and lagoon. Hook and line and spear.	*Siganus fuscescens* and *S. canaliculatus* high% of catch—both species commonly utilise seagrass, see Gell & Whittington (2002) and Unsworth *et al*. (2008)	144 species caught in reef fishery. Catch dominated by Siganids (42%) and Labrids (26%)	–	Within Fortes (1990)
Davies *et al.* (2009)	SW Madagascar	Beach seine, gill net and hook and line.	High numbers of *Leptoscarus vaigiensis* Quoy & Gaimard), see Unsworth *et al.* (2007)	Socio-economic dependency upon fishery. Predominance of small juvenile fish in catch	4/28 4/44	Within MS
Laroche & Ramananarivo (1995)	South Madagascar	Fixed or mobile gill nets in reef	Lethrinidae, Scaridae, Siganidae High numbers of *Hemiramphus far* (Forsskål), see Unsworth *et al.* (2008)	Siganids and Lethrinids dominate catch.CPUE comparable to other regions of Indo-Pacific	1/25 1/81	Within MS.
Mangi & Roberts (2007)	Mombasa, Kenya	Reef and lagoon	Lethrinidae (Emperors), Scaridae, Siganidae, Mullidae	Number of fishers and coral cover strongest factors determining fish catch	3/82 3/74	Within McClanahan & Mangi (2001)
McClanahan & Mangi (2001)	Mombasa, Kenya	Beach seine in reef, sand and seagrass	Scaridae (Parrotfish), Siganidae (Rabbitfish), Mullidae (Goatfish) High numbers of *L. vaigiensis* Quoy & Gaimard), see Unsworth *et al.* (2007)	Declining fish catch over 5 years	3/81 3/74	Within MS. Mention of fishing in seagrass
McClanahan & Cinner (2008)	Papua New Guinea	Gill nets and line fishing	Catches dominated by *Lethrinus harak*	Artisanal fishing on coral reefs in Papua New Guinea is an important livelihood	2/62 2/53	Within MS. Seagrass within fishing grounds.
Rhodes *et al.* (2008)	Micronesia	Reef and lagoon	Common seagrass species *Lethrinus erythropterus, Parupeneus barberinus, L. harak*	Catch dominated by juveniles. Fishery in need of management	1/67 1/101	Within MS. Additional reference to use of coral reef fishes utilising seagrass as nursery grounds
Wright & Richards (1985)	Tigak Islands, Papua new Guinea	Seine nest and line fishing	Species of Lethrinidae and siganidae commonly observed in seagrass meadows	253 fish species caught. Fishing important to local livelihoods.	–	Reference to fisheries being linked to coral reefs and associated habitats such as seagrass.

A ratio of the count of the terms “seagrass”: “coral,” and “seagrass”: “reef” within each manuscript is provided.

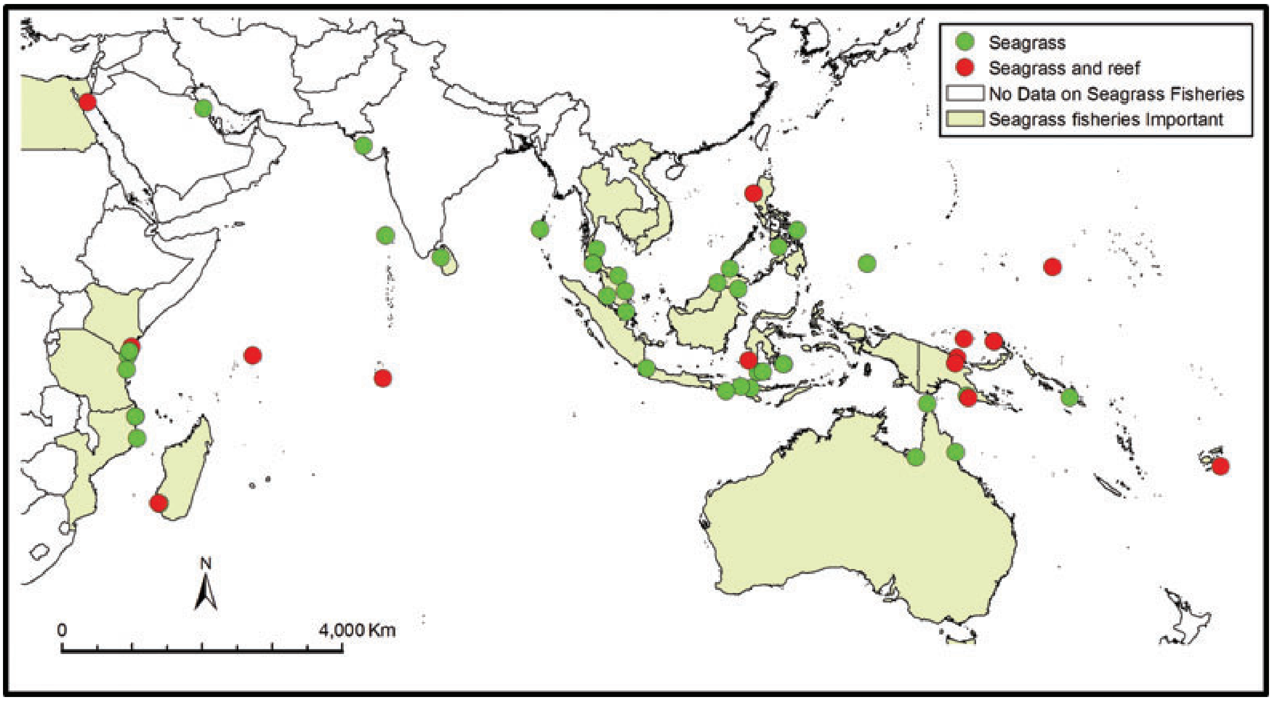

Figure 2 The location of a range of fisheries determined to be of seagrass origin (specific seagrass fisheries, mixed seagrass, and reef fisheries). Map also shows those countries where data are sufficient for reports to determine seagrass meadows to be an important component of national fisheries production. For all data see Appendix 1.

over only 5 years (Exton 2010). Examination of satellite imagery (e.g., www.googleearth.com −5.058102°, 119.477085°) across many parts of Indonesia and the coral triangle illustrates the growing use of this intensive fishing method across intertidal areas, many of which are probably seagrass-dominated. Declining seagrass fisheries catch rates (specifically species of Siganidae) have also been observed in Banten Bay, Central Indonesia, and attributed to over-exploitation (Tomascik *et al.* 1997).

Declining seagrass fisheries catch: invertebrates

When intertidal seagrass meadows (particularly reef-associated seagrass) become exposed during low tide, they become the focus for local community fishing activity. Fishers collect nocturnally active invertebrates, as well as fish stranded in tide pools (Fortes 1990; Tomascik *et al.* 1997; Nordlund 2007), with seagrass leaves directly harvested as emergency foodstuffs, or as fodder for cattle and captured turtles (Fortes 1990).

Low tide gleaning is commonly a subsistence and recreational community-based activity often involving small family fishing collectives earning a basic living selling excess catch (de la Torre-Castro & Ronnback 2004; Cullen 2007). Gleaning exists as an economic, recreational, cultural, social, community, and family activity. Exploitation rates however remain largely unquantified, except in isolated examples (e.g., Gell & Whittington 2002; de la Torre-Castro & Ronnback 2004), but the activity is commonly observed throughout the Indo-Pacific (e.g., Tanzania, Indonesia, Malaysia and Mozambique—see Figures 1 and 2, and Appendix S1).

Seagrass invertebrate fisheries are in decline in many areas of the Indo-Pacific, with the sea cucumber (e.g., *Stichopus chloronotus, Holothuria scabra,* and *Holothuria atra*) fishery in particular, a major concern (e.g., Baine & Choo 1999; Price *et al.* 2009). Within the Chagos Archipelago, Holothurian density declined by at least 70% in the 4 years up to 2009, and numbers within exploited locations in 2009 were 10-fold less than in unexploited sites (Price *et al.* 2009). Nordlund (2007) showed that direct invertebrate exploitation can alter and reduce seagrass invertebrate biomass and diversity at even subsistence levels. Although exploitation of seagrass fauna is observed across the Indo-Pacific it is difficult to assess the status of these fisheries due to limited data. Overexploitation results from commercial and subsistence activity, and is confounded in many areas by the widespread curio trade

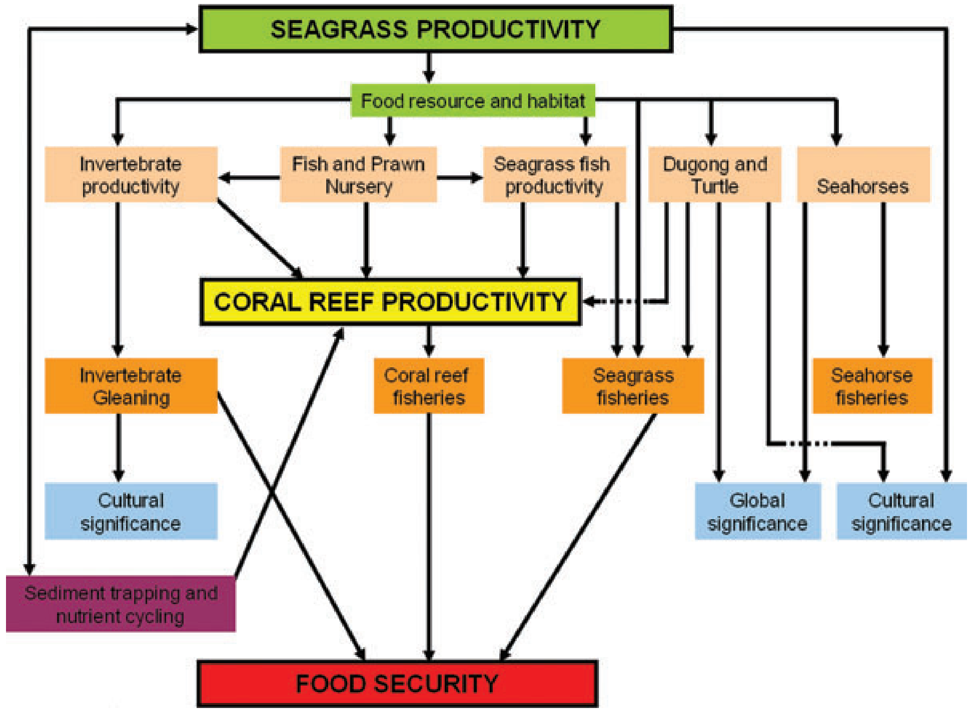

Figure 3 The interaction between seagrass meadows and coral reefs, and the support that seagrass meadows provide directly and indirectly to food security.

for shells from genera such as the Strombidae, Muricidae, and Volutidae. Invertebrate fisheries require greater consideration as a vital and accessible source of protein, hence food security (Figure 3) for local communities. Seagrass invertebrates also represent important prey resources for coral reef fishes foraging in seagrass.

Seagrass supports coral reefs and their fisheries

For increased chance of success, coral reef conservation must consider the inter-connection of ecosystems. Seagrass meadows support coral reef productivity (Figure 3) principally due to their role as feeding habitat for predatory fish that move into seagrass meadows during high tide and at night to forage on crustaceans (Unsworth *et al.* 2008). Productive seagrass meadows also provide nursery habitat for a range of important commercial and subsistence fisheries (e.g., deeper-water prawns) (Fortes 1990; Watson *et al.* 1993; Unsworth *et al.* 2008). Seagrass meadows also play a major role in nutrient cycling, principally filtering nutrients from the water column (Hemminga & Duarte 2000), and potentially reducing the availability of nutrients to adjacent, naturally oligotrophic coral reefs. These meadows also provide a large subsidy of organic matter to adjacent and even distant habitats (Heck *et al.* 2008). Seagrass meadows can act as a trap for sediments reaching the coastal environment from riverine catchments, assisting in reducing sediment loads to coral reefs (Hemminga & Duarte 2000).

Consequences of overexploitation to seagrass

High fishing intensity, resulting in the removal of particular slow-developing and economically important fish and invertebrate species can alter the trophic structure of any fished habitat. Within seagrass meadows there is increasing evidence that communities are defined by "top-down" predator control (Eklöf *et al.* 2009). Loss of predators can lead to increased urchin abundance and associated episodes of seagrass over-grazing, resulting in a loss of cover or changes in seagrass assemblage structure (Rose 1999). Overexploitation could therefore be a major driver of seagrass loss (Heck & Valentine 2007; Moksnes *et al.* 2008; Eklöf *et al.* 2009).

The removal of species of some herbivorous fish families from seagrass meadows such as Siganidae and Scaridae (e.g., *Siganus canaliculatus*) can also have long-term implications for coral reefs because both these families support reef resilience and recovery from impacts such as coral bleaching (Mumby *et al.* 2006). This resilience is principally provided by preventing algal overgrowth, allowing new coral recruitment when corals die (Hughes *et al.* 2007). Species of the Siganidae family also feed on the abundant epiphytes of the larger tropical seagrass genera, such as *Enhalus*, *Thalassia*, and *Cymodocea* (Lugendo *et al.* 2006). The impact of removing herbivores that graze upon epiphytic cover on seagrass is largely untested. Reduced herbivore densities could cause increased epiphytic overgrowth on seagrass which may impact upon the resilience of seagrass in a manner similar to the epiphytic overgrowth on kelp and coral reefs caused by overfishing of herbivores (Mumby *et al.* 2006). It is important to acknowledge that such impacts are not mutually exclusive and intricately interact with other factors such as water quality (Connell *et al*. 2008).

Overexploitation of seagrass meadows is not just through direct harvesting. Cultivation of marine algae, principally *Gracilaria* spp. and *Euchema* spp., is of increasing economic importance in the Indo-Pacific (Cullen, 2007). Although currently used exclusively for making polysaccharide gelling agents, algae farming has the potential to expand into the future, particularly as biofuel technology further develops. Algae are cultivated throughout the Indo-Pacific on floating strings in shallow subtidal seagrass meadows. Recent evidence from Tanzania suggests that seaweed cultivation can result in a loss of up to 40% of seagrass biomass, probably due to light reduction (Eklöf *et al*. 2006). This creates a dilemma where the cultivation of marine algae presents an alternative income to fishers and is often a favoured management policy in order to reduce pressure on marine habitats. It is important that conservation management and the future expansion of seaweed cultivation considers the potential impacts that aquaculture might have upon marine ecosystems.

Education, conservation and research

Improved and widespread education on their importance is required to activate support for seagrass conservation. In some areas this is enhanced by successful volunteer programmes such as SeagrassWatch (www.seagrasswatch.org) and SeagrassNet (www.seagrassnet.org). A notable example of developing education initiatives and capacity to manage seagrass in the Indo-Pacific has been within the South China Sea (SCS) project funded by the UNEP/GEF which was set up to reverse the degradation trends in marine habitats. The project created demonstration sites of seagrass management best practice. The SCS initiative has so far been an isolated example of strategic regional Indo-Pacific seagrass conservation. Notable successes have been establishing a number of seagrass-based marine reserves (under national and/or international protection), and creating an improved understanding of the regional economic value of seagrass meadows. Capacity development such as the SCS project is needed across the region, but this needs to integrate with other region-wide marine and coastal conservation initiatives, as well as with the work of governments and NGOs.

In many locations seagrass habitats remain largely unmapped, even at a broad-scale (e.g., low spatial resolution), so incorporation into marine conservation initiatives is difficult when managers are unaware of the full spatial extent of the resource. Monitoring programmes need to occur with greater investment from funding agencies and NGOs; when led and conducted by local communities in a manner appropriate to the local culture they may provide an important role in empowering people to connect (or re-connect) with their natural resources enhancing social capital (Pretty 2003). There exists intrinsic difficulties in actively engaging local communities in "conservation" and "monitoring," and if such work is to be a success, activities need to be tailored to the local socio-cultural context.

In addition, such programmes need to integrate faunal fisheries assessment with floral assessment. No protocol currently exists to monitor seagrass fauna, but monitoring of the faunal component of seagrass meadows is required alongside improved education, research and conservation effort (Kirkman & Kirkman 2002). The need to expand seagrass ecological understanding through research and monitoring also has broader implications when considering the effects of climate change, particularly given the dearth of studies documenting long-term marine ecological variability (Richardson & Poloczanska 2008).

Citations in the ISI Web of Knowledge© and ScienceDirect© highlighted that despite its high ecological importance, seagrass research output continues to trail research on other tropical marine habitats (e.g., Search Terms: "Coral reef" vs. "Seagrass" 2000–2010) by ≈60%. This also needs to be put into the perspective of the imbalance of ecological science towards terrestrial ecology (Richardson & Poloczanska 2008). Whilst marine protected area (MPA) development has increased worldwide, and particularly within the Indo-Pacific, it has included minimal protection of seagrass meadows (Orth *et al.* 2006). In 2002 there were globally 247 MPAs that contained seagrass. This is 37% of the number that incorporated coral reefs, despite estimates suggesting that global coverage of coral reefs and seagrass meadows is similar (Spalding *et al.* 2003). There is currently no evidence available to suggest that these ratios have changed since 2002. Further applied multidisciplinary research focused on ecosystem function, socioeconomic impacts and effectiveness of management actions is needed to help decision makers minimise and mitigate for loss and degradation of habitats. For example, understanding the impacts of the removal of detritivores such as sea cucumbers, and herbivores such as Siganids on the trophic dynamics of seagrass meadows, and how these changes interact with management measures such as the use of MPAs are important for their long-term management. Future research needs to interact with understanding critical issues such as water quality and climate change. Better economic estimates and financial valuations are also required (UNEP 2006) along with an understanding of human resource use patterns and dependence for any given area.

Discussion

This review demonstrates that seagrass meadows throughout the Indo-Pacific are highly used as fishing areas, particularly those seagrass meadows associated with coral reefs. This exploitation has implications not just for seagrass meadows, but for the conservation of coral reefs due to processes of connectivity, principally fish migrations and nursery functions (Figure 3). Over-exploitation represents a major immediate threat to seagrass meadows in the Indo-Pacific (ISBW 2008). However the motivation of governments, other scientists and NGOs to quantify seagrass losses and address the issue of direct overexploitation is lost, with tropical marine conservation, and particularly fisheries management, firmly focused on coral reefs. An example of the marginal focus given to seagrass is provided in the text of the "Coral Triangle Initiative" which classifies seagrass within the section "other ecosystems." Coral reefs in the Indo-Pacific are unquestionably important conservation targets due to their high biodiversity, fisheries production, and the provision of other essential ecosystem goods and services such as coastal protection (Wilkinson 2008). However, Indo-Pacific marine conservation efforts could be better placed in the context of the whole tropical coastal marine environment that integrates key habitats such as seagrass meadows alongside coral reefs and mangroves.

Seagrass meadows in the Indo-Pacific exhibit low floral and faunal species diversity relative to other more charismatic benthic habitats. Due to the wide geographic distribution and high abundances of the flora of these meadows, they can mostly be considered to be composed of floral species that are common. This may be one of the major reasons that marine conservation in the Indo-Pacific does not currently focus on these important habitats and that commonly conservation of seagrass meadows in the Indo-Pacific does not yet always "sell" successfully to donor funding agencies.

Whilst conservation actions often rightly look towards protecting biodiversity and focusing on rare or endangered species or systems (i.e., coral reefs), it is often the common uncharismatic species that have a far greater ecosystem-scale role (e.g., seagrass meadows) (Gaston & Fuller 2008). The conservation of so called "foundation species" (e.g., canopy-forming plants, reef-building organisms) (Hughes *et al.* 2009) is important because the services these species provide (e.g., fish/invertebrate nurseries) can be degraded long before the species itself disappears. Historical records reveal that it is mostly common species rather than rare ones that have undergone substantial and serious rapid declines, typically without first becoming threatened with imminent extinction (Gaston & Fuller 2008). Loss of common species is confounded by the limited ability of humans to perceive small incremental declines until it is too late (Gaston & Fuller 2008), leading to long-term conservation objectives and perceptions of loss becoming affected by the concept of a shifting baseline (Papworth *et al.* 2009).

Whilst the majority of floral seagrass species are not presently at risk and are common, the habitats that they create are likely being lost at a rate of 7%/yr (Waycott *et al.* 2009); therefore, the ecosystem services they provide (Figure 3) are also being lost. Specifically within South-East Asia, the extent of estimated loss during the last 50 years is greater than 50% in some areas (Kirkman & Kirkman 2002). This has implications for those species residing in seagrass that are ecologically rare and in some cases vulnerable to extinction (Hughes *et al.* 2009). From an Indo-Pacific coral reef perspective, loss of seagrass should be of concern because seagrass meadows not only support fisheries and biodiversity directly and indirectly, they also act as biological filters (Figure 3). This is a critical role in a region subjected to increasing sedimentation and nutrient run-off from increasing deforestation, agriculture, and urbanization.

The conservation of marine and coastal ecosystems in the Indo-Pacific, where financial resources are either scarce or are single-application funds aimed at achieving specific goals, could benefit from the use of decision-support tools such as "triage" at a habitat scale (Murdoch *et al.* 2007). By assessing the potential ecosystem outcomes and benefits of relative funding (e.g., different habitats), different management priorities could be revealed than those currently planned. Conservation triage could offer such a means to assess and prioritize explicitly meagre conservation resources (Murdoch *et al.* 2007). This is a complex task that requires value decisions to be made about conservation priorities based on the best scientific information available. Considerations such as the probability of success in a project need to be balanced against factors such as the biodiversity benefits of an action, and the value of any given species or habitat in providing ecosystem goods and services (Bottrill *et al.* 2008). The recent large-scale funding of marine conservation in South-East Asia from the Coral Triangle Initiative, that has goals orientated not just towards biodiversity conservation, but also towards social and economic development, potentially may benefit from using "triage" to consider the merits of just conserving coral reefs relative to seagrass and other coastal habitats.

Whilst coral reefs are predicted to decline due to rising sea temperatures, ocean acidification, and increased industrialization, tropical seagrass meadows contain some physiological characteristics that might make them better placed to adapt to global climate change than other tropical marine habitats (Hall-Spencer *et al.* 2008). Seagrasses might also mitigate for localized elevated ocean acidity (Semesi *et al.* 2009), with corresponding implications for the current decline in coral calcification (De'ath *et al.* 2009).

The economic value of the ecosystem goods and services that seagrass meadows provide to humanity might equal or be in excess of those provided by coral reefs as a result of their nutrient cycling capacity that stimulates fisheries production (Costanza *et al.* 1997; Orth *et al.* 2006). Although developing-world economies are often at odds with the vision of developed-world conservation ethics (i.e., top-down approaches to conservation led by western organizations that do not consider the needs and wishes of local people such as the availability of food and a sustainable income), the conservation of seagrass meadows could represent a long-term approach to the maintenance of food security (Figure 3) as well as marine biodiversity protection.

Seagrass meadows are not always an aesthetically pleasing habitat, and can be muddy, turbid water environments that do not immediately stand out as colorful, biodiverse wonders of the world in magazines. But these uncharismatic ecosystems (Duarte *et al*. 2008) do support IUCN Red List "threatened" species (Hughes *et al*. 2009) and are undoubtedly an important economic and ecological resource that necessitates conservation management.

We have demonstrated that Indo-Pacific seagrass meadows provide a myriad of ecosystem goods and services, both directly and through a supporting role to coral reefs (Figure 3). Seagrasses importantly represent a source of food security in a rapidly altering global environment. Regardless, seagrass meadows are experiencing unprecedented rates of loss and growing overexploitation. These issues must be addressed by adoption of a new paradigm on marine conservation priorities within the Indo-Pacific that places seagrass meadows firmly on the conservation agenda.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1: Location of seagrass fisheries within the Indo-Pacific region and their associated literature references

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