

## CRITICAL LINKS AMONG THE SEA, LAND AND AIR: SOUTHEAST ASIA'S COASTAL SOFT-SEDIMENT COMMUNITIES

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**ABSTRACT.** — Compared with coral reefs and mangroves, the soft-sedimentary habitats of Southeast Asia have received relatively little attention from conservation ecologists. This is a brief review of the importance of, and threats to, sedimentary benthic habitats of the region. Artisanal shellfisheries are highlighted due to their value to local communities and the region's economy. Furthermore, the relationship between the health of local benthic communities with that of migratory shorebirds on the East Asian Flyway is discussed to illustrate the complex scales of conservation. Lastly, the interdependence between migratory shorebirds and sustainable shellfisheries is examined as an opportunity for different stakeholders to leverage on each other's resources to form mutually beneficial partnerships for improved management.

**KEY WORDS.** — soft-sediments, artisanal, shellfisheries, migratory shorebirds, wetlands

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### INTRODUCTION

Soft-sediments occupy over 80% of the world's ocean's bottom and nearshore habitats in particular, provide critical ecosystem functions and goods (Lenihan & Micheli, 2001). In Southeast Asia, considerable attention on marine conservation has focused on coral reefs and mangroves. However, the region's coasts also possess extensive sedimentary environments that support extremely high species richness, with many unnamed species (Broom, 1982b; Warwick & Ruswahyuni, 1987; Frojan et al., 2005; Frojan et al., 2006; Purwoko & Wolff, 2008). Due to the accessibility of tidal flats and their rich resource of crustaceans and molluscs, soft-sediment communities are also extremely important to the livelihoods and nutrition of Southeast Asians (Alkarkhi et al., 2008; Ewel, 2008; Reid et al., 2008). Consequently, the conservation of the biodiversity of coastal sedimentary environments in Southeast Asia is essential to the maintenance of the ecosystem services provided to the human population of the region. The United Nations Millennium Development Goals (MDGs) recognises the importance of conserving and maintaining natural ecosystems in poverty eradication (Sellamuttu et al., 2011). The relationship between the soft-sediment community health and poverty is especially tight in Southeast Asia because of the predominantly artisanal nature of the region's fisheries (Reid et al., 2008). Artisanal fisheries described in this review refers to "traditional fisheries involving fishing households (as opposed to

commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption" (FAO, 2005–2012). Furthermore, small-holder fisheries have been found to provide 'safety net[s] against failures from income in other sectors' (Stobutzki et al., 2006). Consequently, the ecology of Southeast Asia's soft-bottom habitats and the sustainability of associated fisheries are critical to the social and economic stability of the region (Reid et al., 2008), and warrant in-depth and extensive examination. This brief review uses the cockle (*Anadara granosa*) and mud crab (*Scylla* spp.) fisheries in Southeast Asia to illustrate the importance of, and threats to, soft-bottom habitats and potential collaborative approaches to their conservation.

### BLOOD COCKLES

#### *Anadara granosa*

The blood cockle *Anadara granosa* is harvested mainly from the mudflats of Malaysia and Thailand. Production of *A. granosa* in Southeast Asia has increased exponentially since the 1980s, reaching a total of \$435 million in 2006 (Ellison, 2008). The cockle fishery is described as a semi-culture (Kechik, 1995). Juveniles are collected from mudflats and transplanted to 'culture beds' (Broom, 1985). The Fisheries Department of Malaysia stipulates that only

recruits larger than 6.4 mm may be collected and recruits can only be transplanted in areas outside of naturally recruiting sites (Broom, 1985; Kechik, 1995). Transplanted cockles are harvested three months after transplantation. While the recruitment period of *A. granosa* in Malaysia has been found to occur between December and July, recruitment was found to fluctuate significantly between 1985 and 1991 (14,931 tons in 1985, 1,800 tons in 1982, 3,481 tons in 1991) for unknown reasons (Kechik, 1995). In spite of its commercial importance and ubiquity, there appears to be very limited published research on the ecology of the species, except a series of papers by Broom in the 1980s (Broom, 1982a, 1982b, 1983, 1985). The majority of research has been concerned with effects of pathogens and heavy metals in *A. granosa* on human health (e.g., Alkarkhi et al., 2008; Yamamoto et al., 2008). Apart from gastropods *Natica maculosa* and *Thais carinifera*, skates, catfish, and wading shorebirds have been reported to be important predators of *A. granosa* (Broom, 1985). Studies of European cockles *Cerastoderma edule* showed that densities of cockles have significant influence on the soft-sediment community structure (Flach, 1996), which suggests that *A. granosa* would play a similarly important role in the soft-sediment communities of Southeast Asia.

#### MUD CRABS

##### *Scylla* spp.

Mud or mangrove crabs *Scylla* spp. are a group of four portunid species that are found in intertidal and subtidal sheltered soft-sediment habitats throughout the Indo-Pacific region and are a valuable source of income for coastal communities (Le Vay et al., 2008). *Scylla* spp. has traditionally been harvested to supply local coastal communities, and is increasingly popular among consumers in Malaysia, Singapore, Taiwan, and China (Le Vay et al., 2007). Production of *Scylla* in the Indo-west Pacific has grown exponentially since 1950 and had a production value of US\$252 Million in 2004 (Ellison, 2008). However, production of individual countries appears to have declined since the 1980s with a concurrent reduction in landing size (Ellison, 2008; Jirapunpipat et al., 2009). Due to the lack of regulation, crabs of all size-classes are harvested (Le Vay et al., 2001). Adults and sub-adults are fattened in mangrove ponds before being sold to market, while juveniles are captured for more long-term cultivation, also in mangrove ponds (Ellison, 2008). Only Vietnam has viable commercial hatcheries (Ellison, 2008). In spite of the dependence of the fishery on wild populations, the settlement and recruitment patterns of *Scylla* are poorly known (Jirapunpipat et al., 2009). This information gap is further compounded by taxonomic confusion over the genus. Recent revision by Keenan et al. (1998) revealed four species, exacerbating the lack of understanding of the basic ecology of the genus, and differences among the species. *Scylla* species create burrows in estuarine and mangrove sediments. Studies of benthic invertebrates that exhibit similar burrowing behaviour suggest that *Scylla* significantly alters abiotic and biotic characteristics of soft-sediment habitats (Botto et al., 2005).

#### CLIMATE AND ENVIRONMENTAL IMPACTS

Overharvesting, human development, and habitat loss are commonly cited threats to the sustainability of *A. granosa* and *Scylla* fisheries (Le Vay et al., 2007; Ellison, 2008). Proposed management measures have focused on mitigating these impacts (Lebata et al., 2007). While biologists who 'bemoan our general state of data scarcity are akin to fiddlers while Rome burns' (Peres, 2010), management for the long-term sustainability of tidal flat fisheries is still hampered by the lack of basic ecological information (but see Broom, 1985; Le Vay et al., 2001, 2007; Walton et al., 2006; Lebata et al., 2007). This information gap is worrying in view of the threat of climate change. The limited understanding of the coupling between species abundance and environmental factors places the future of these fisheries and the well-being of local human communities at great risk. As the interface of marine and terrestrial environments, coastal sedimentary communities are doubly vulnerable to impacts of climate change (Walton et al., 2006). For example, larvae and juveniles of *A. granosa* and *Scylla* are likely to be highly sensitive to changes in salinity, turbidity, water temperature, and nutrient content, all of which are influenced by marine and terrestrial factors (Broom, 1985; Walton et al., 2006; Webley et al., 2009). The dramatic annual fluctuations in *A. granosa* recruitment point to possible discontinuities bounding periods of population stability (regime shifts), which can be the result of a combination of environmental and fishing influences (Powell et al., 2008). Studies of commercial bivalve species in the United States and Europe strongly implicate climate variation as the principle cause of recruitment and population variability (Deksheniaks et al., 2000; Beukema & Dekker, 2005; Kimmel & Newell, 2007). Therefore, the management practices such as stock enhancement and habitat restoration would be dependent on a sound understanding of environmental influences.

#### SCALES OF CONSERVATION

Recent reviews by Sodhi et al. (2011a, 2011b) discussed approaches to conservation at different spatial scales and emphasized the importance of local initiatives. The limited dispersal of estuarine organisms such as *A. granosa* and *Scylla* spp. and the influence of local fishing impacts suggest that management is best implemented on a local-scale (Ewel, 2008). Moreover, in the absence of long-term monitoring and research programmes, local fishermen can provide valuable qualitative information on variables critical to formulating conservation plans. Examples of important local knowledge include recruitment patterns, population distribution and fluctuations, and their relationship with environmental conditions.

Local or 'bottom-up' conservation is most likely to succeed in conserving habitats critical to local populations (Sodhi et al., 2011b). However, due to the multi-use nature of tidal flats, small-scale efforts have to be placed within a larger context. Presence of overlapping stakeholders often result in conflicts (Adger & Luttrell, 2000), but may also

reveal potential for facilitation of compatible uses. There are numerous conservation frameworks that address marine management at multiple scales. The Integrated Coastal Zone Management (ICZM) framework has been adopted by many Southeast Asian countries (UNEP/COBSEA, 2009). ICZM's holistic approach can be strengthened by the basic principles of ecosystem-based management (EBM) and coastal and marine spatial planning (CMSP). EBM differs from conventional single-species management, because it places the species or habitat in question within a larger ecosystem context, and strives to reduce management redundancies by managing entire ecosystems (Sievanen et al., 2011). The EBM approach may be particularly effective in habitats that contain multiple species of management interest. CMSP examines spatial patterns of various types of activities, manages conflicts and facilitates compatible uses (Sievanen et al., 2011). The conservation of Southeast Asia's tidal flats and local livelihoods can benefit from both ecosystem-based and spatially-explicit approaches.

One of the most often cited reasons for conserving Southeast Asia's wetlands is the protection of migratory and/or shorebird habitats (Bamford et al., 2008; Giesen et al., 2007). Over a global scale, the tidal flats which support *A. granosa* and *Scylla* fisheries are critical sites on the East Asian–Australasian Flyway (Adger & Luttrell, 2000; Sripanomyom et al., 2011). Therefore, in addition to providing valuable ecosystem goods and services to local communities, the soft-sediment communities of Southeast Asia are also vital to ecosystem health throughout the Flyway. A recent study in Moreton Bay, Australia, found no evident local causes for the declining abundance of migratory shorebirds, and it was hypothesized that declining quality of stopover sites in the Yellow Sea region in Asia to be the principle driver of migratory bird decline in Australia (Wilson et al., 2011). Similarly, declines of red knots *Calidris canutus* in Mauritania have been linked to the commercial dredging of cockles in the Wadden Sea (Kraan et al., 2010). Therefore local benthic and human communities associated with *A. granosa* and *Scylla* can be considered with migratory shorebirds within an integrated management framework, and sites where these species and activities overlap should be identified.

There exist numerous international conventions and initiatives to protect essential migratory bird habitats along the East Asian–Australasian Flyway (Bamford et al., 2008). Conservation plans for migratory bird habitats usually recommend reduction of human development and impacts (Kirby et al., 2008). This is in line with the conventional top-down approach of excluding human activities to preserve essential wildlife habitats (Ancorenaz et al., 2007; Sodhi et al., 2011b). But artisanal fishing activities in migratory bird habitats may not necessarily be antagonistic to bird use. Overlapping use of tidal flats by local fishing communities and migratory birds can provide excellent opportunities for bird conservationists, local fishing communities, and managers to leverage on each other's resources to achieve mutually beneficial outcomes. With appropriate efforts to engage the local population, such collaborations may be particularly

fruitful as local fishermen are highly invested in local wetland health and the charismatic nature of migratory birds can draw increased public attention to wetlands conservation. By nesting local fisheries management with international conservation, resources available to large-scale conservation can support local-scale efforts, thus increasing likelihood of success on multiple scales.

'Think globally, act locally' is a principle commonly used to motivate environmentally responsible actions of individuals and local communities. This article has highlighted the local and global significance of Southeast Asia's coastal soft-sediment communities. While the ecological and social importance of healthy marine ecosystems is obvious regardless of scale, the take-home message here is that conservation of Southeast Asia's rich tidal flats can be furthered by innovative and dynamic thinking across species and spatial scales.

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