Intertidal Flats of East and Southeast Asia

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John MacKinnon and Yvonne I. Verkuil

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Abstract

A recent rise in economic prosperity in Asia, the most densely populated region of the world, has created a shortage of land for industry, housing developments and aquaculture. Consequently, large extents of tidal flat habitat in East and Southeast Asia, and especially in the Yellow Sea, have been lost since 1980, some through sediment inflow reduction, some through reclamation to satisfy demand for land. Throughout the East Asian–Australasian Flyway (EAAF), over 600,000 ha of tidal flats were the subject of further proposed land claims in 2012; in the Yellow Sea, planned conversions of >300,000 ha would amount to

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a further loss of 40% of the remaining habitat. Here we articulate five arguments to contribute to convincing governments and other stakeholders in the EAAF that the current rate of loss is a disaster which must be urgently addressed. (1) Global responsibility: the EAAF is a large flyway supporting 176 waterbird species, of which 34 (19%) are globally threatened or Near Threatened. Nine more species are under consideration for such listing. Other flyways have 5–13 threatened species, amounting to 4–12%. (2) Regional responsibility: migratory shorebird species essentially make a single stop, or very few stops, when moving between non-breeding and breeding sites. In the EAAF, most of these critical sites where birds refuel for a few weeks are in the Yellow Sea. (3) Regional effects: shorebird population trends in Japan, and at a single wintering site in Australia showed that shorebirds dependent on the Yellow Sea during migration show the strongest population declines. (4) Local effects: migratory shorebirds that lost their fuelling site due to the largest land claim projects in the Yellow Sea (Saemangeum and Bohai Bay) did not all redistribute to the adjacent tidal flats, resulting in a net population decline. (5) Self-interest: Tidal flats and associated coastal ecosystems provide critical ecosystem services including protection from storm surges and sea level rise. This information was summarized in a 2012 IUCN report and subsequently EAAF governments have committed via IUCN Resolution 28 to protect the EAAF.

Keywords
East Asian-Australasian Flyway · Migratory waterbird · Habitat loss · Reclamation · Coastal protection · Coastal fishery · Population decline · Migratory species agreement

Extent and Location

The intertidal zone of East and Southeast Asia extends for 34,000 km from China and Korea, down along the coasts of Vietnam, Cambodia, Thailand, Peninsular Malaysia, and north around the coast of Myanmar to Bangladesh. An even greater length, 128,000 km, of coasts surrounds the islands of Japan and nations of Association of Southeast Asian Nations (ASEAN) – Philippines, Malaysia (East), Indonesia, Brunei, and Singapore. The intertidal zone is narrow – a few meters to a few hundred meters wide; the total area involved is very small, fragile, and rapidly vanishing. But this small area is of disproportionate significance in terms of biodiversity, ecosystem services, and human livelihoods.

Diversity of Wetland Types

The coasts of Asia range from cold temperate to tropical and offer a range of habitats from muddy mangrove to marshes and sand flats. Of particular value to wildlife are the tidal estuaries of some of Asia's great rivers. Sixteen key areas emerged from analysis as the most important for endangered waterbirds of which six in the Yellow Sea (MacKinnon et al. 2012; see also Battley et al. 2008; Barter 2006).

The East Asian coastline serves as a migration flyway (East Asian–Australasian Flyway (EAAF)) for the many species that nest in the northeastern Russia and Alaska. Large numbers of birds migrate annually through this flyway, to the nonbreeding areas in, for example, the Yangtze valley of China, or south to Australasia, e.g., Indonesia, New Zealand, and Australia.

Conservation Status

Current estimates of intertidal habitat loss in Asia equate to loss rates greater than or equal to global rates of declines of mangroves, tropical forests, and coral reefs (MacKinnon et al. 2012). Losses of up to 51% of coastal wetlands have occurred in China over the past 50 years, and in Singapore 76% of coastal wetlands have been reported lost (An et al. 2007). Loss of staging areas within migratory pathways, where birds must replenish their energy stores during migration, can have extreme consequences for shorebird populations (Conklin et al. 2016; Piersma et al. 2016; Myers et al. 1987; Buehler and Piersma 2008; Verkuil et al. 2012). For the millions of shorebirds that migrate through the East Asian–Australasian Flyway (EAAF), the intertidal areas of Asia are a crucial migratory bottleneck, and extreme habitat losses are driving major population declines in many of these species (Barter 2002; Rogers et al. 2010; Moores et al. 2016).

There are indications of serious problems along the migration flyway. Monitoring on beaches of Australia shows declines in the numbers of most flyway migrant shorebirds wintering there (Rogers et al. 2008; Wilson et al. 2011; Clemens et al. 2016). Analysis of monitoring data of Japanese shorebirds between 1975 and 2008 shows declines in most species but interestingly a much higher proportion among species that are dependent on Yellow Sea stopover sites (Amano et al. 2010).

Management

All countries of the region have well-developed protected area systems. Most countries are well over the 10% target proposed by the UN Convention on Biological Diversity (CBD). More specifically, most of the countries are parties to the Ramsar Convention of Internationally significant wetlands and have established country focal points for the protection and monitoring of wetlands, especially Ramsar Sites (BirdLife International 2005). So why cannot adequate intertidal zone habitat be acquired and protected?

Analysis of the impressive protected areas of the region (BirdLife International and IUCN 2007) reveals that there is a bias in establishment toward mountain reserves and inland wetlands but a significant lack of representation of lowlands and coastal and marine areas. Awareness of conservation needs is lowest, and due to reasons of demography and access, competition for coastal lands is greatest. Conservation agencies have low financing, limited resources resulting in weak protection, and management of existing sites combined with generally low political influence.

Threats

The fast pace and nature of human developments affecting this zone is not in harmony with the natural environment and jeopardizes both those species that depend on this zone and the valuable ecological services that intertidal zone ecosystems deliver. Shoreline viability and the health of bird populations are negatively affected by a wide range of threats and destructive processes.

- *Loss and fragmentation of habitat*. According to the China National Wetland Conservation Action Plan (2000), some 1.19 million ha of coastal tidal flats has been lost and 1 million ha of coastal wetlands has been urbanized or used for mining. This constitutes a loss of 50% of all China's coastal wetlands (CCICED 2010). Mangroves had decreased from ~50,000 ha in 1950 to 22,000 ha by 2000 – a 44% loss (Chen et al. 2009). Loss of coastal wetlands has continued and indeed accelerated during the following decade (see MacKinnon et al. 2012 for overview).
- *Damming of the major rivers* of the region leads to changes in silt discharge, seasonality and quality of freshwater discharge (Wang et al. 2010a; CCICED 2010).
- *Overuse of chemicals in agriculture* leads to excessive nitrogen in freshwater systems and growing threats from toxic algal blooms in many coastal reaches (CCICED 2010).
- *Pollution* due to industrial emissions, oil spills, wastewater, and sewage discharges both directly into the coastal zone and also into the rivers that flow into it (Li and Daler 2004).
- *Tidal energy developments*, which involve the construction of sea walls and tidal barrages, lead to direct loss of tidal flats. These developments also change nearshore tidal flows, which leads to increased impacts to siltation dynamics and damage to nearshore areas (Gill 2005).
- *Overharvesting* and overuse of intertidal resources, including fish, mollusks, sea cucumber, sea urchins, and seaweeds. The recent industrialization of harvesting methods has resulted in far greater harvests with less manual labor required, which is undoubtedly impacting ecosystem processes throughout the intertidal zone (CCICED 2010).
- *Hunting using* mist nets, fine fishnets, snares, poison, and guns is used on or adjacent to beaches throughout the region (e.g., Zöckler et al. 2010a).
- *Competition for food* by human fishermen together with associated disturbance by humans, boats, and dogs.
- *Anthropogenic climate change* leads to raised temperatures, sea levels, acidity, and reduced oxygen. Tropical cyclones and floods are becoming more frequent resulting in loss of many beaches and intertidal habitats and seasonal mismatch between migration times and habitat productivity.

Ecosystem Services

The intertidal zone has long provided a wealth of services to humans. Shorelines function as physical collecting zones of sand, mud, pebbles, and fringe vegetation that help slow and break the action of waves. Gentle beaches tame ocean waves providing safe places for villages, harbors, and towns and the protection of adjacent agricultural areas. The binding of sand, mud, and other sediments helps keep seas clean and productive and removes many pollutants from the air and water. Increasingly, these habitats are being recognized for their ability to store carbon (blue carbon) (Decho 2000).

Healthy strand vegetation, sea grass beds, algal beds, and mangroves provide significant shelter in the face of typhoons and storms and against the tsunamis that are frequent in a zone prone to devastating earthquakes. Coastal damage seen after the great tsunami in Aceh, Indonesia, in 2004 and again in Japan in 2011 revealed that sites protected by intact healthy coral, mangrove, or other coastal vegetation were dramatically less damaged than sites where these same habitats had been destroyed (Chang et al. 2006).

Intertidal habitats are among the most productive ecosystems on earth. Intertidal habitats, including tidal mudflats, tidal marshes, and mangroves, provide safe spawning areas and nurseries for countless species of fish and crustaceans on which coastal fisheries depend.

Constanza et al. (2014) valued the ecosystem services of the tidal marshes and mangroves globally at US$ 24.8 trillion per annum (or 20% of all global ecosystem services), and a 10 fold increase in value since 1997, due to factoring in their role in safeguarding human lives, property and crops from storms, tsunami and the like). More precise economic assessments of the values of these services need to be undertaken regionally. One preliminary study by the Korean Ocean Research and Development Institute (KORDI 2006) came up with the following estimates: annual value of a hectare of the ROK's intertidal habitats (US$ 32,660), which includes marine products (US$ 9,993), ecosystem preservation (US$ 8,548), habitat (US$ 7,533), water purification (US$ 3,702), recreation (US$ 1,443), and disaster prevention (US$ 1,442). Ecosystem service values for 170 km^2 of intertidal flats planned for reclamation in Xinghua Bay, Fujian, China, were estimated at US$ 0.65 billion/annum or US$ 38,235/ha/annum with an estimated loss of value of US$ 8,250/ha/annum if the land were reclaimed for agriculture or ponds (Yu et al. 2008). Given that there are more than 1 million ha of intertidal habitats in the Yellow Sea (including the Bohai Sea), these estimates point toward service values exceeding at least US$ 30 billion per annum.

An et al. (2007) estimate that the historical loss of 51% of China's coastal wetlands (not all intertidal) resulted in an annual loss of US$ 46 billion. The loss of ecosystem services caused by sea enclosures and land reclamation in China has been estimated at US$ 27.76 billion/annum (CCICED 2010).

Mangroves not only deliver a huge boon of services, but they also provide livelihood to large numbers of people. There are high social and financial losses when intertidal habitat is destroyed. These values are often not appreciated until they are lost (Wang et al. 2010b).

Significant Biodiversity

Asian intertidal habitats are vital for the survival of tens of millions of birds of more than a hundred species, as well as nesting beaches for endangered sea turtles, breeding areas for seals, spawning grounds for important economic fisheries, and homes of thousands of species of invertebrate crustaceans, worms, and mollusks. Many species which rely on intertidal habitats are in trouble; five regional species of intertidal sea grasses are globally threatened (Short et al. 2011), and the estuarine Indo-Pacific humpback dolphin is critically endangered. The clearest evidence of the high number of globally threatened species dependent on these habitats is among the birds, particularly waterbirds, with 24 globally threatened species among the shorebirds, waterfowl, spoonbills, cranes, seabirds, and pelicans (BirdLife 2005) that use Asian intertidal habitats and 9 more shorebird species under review to be listed.

At least 33 globally threatened/near-threatened birds occur (of which 24 depend on the tidal zone) with as many as nine additional shorebirds that may be added to these lists soon (see Appendix 1, in MacKinnon et al. 2012). The East Asian - Australasian Flyway is characterized by more threatened waterbird species than any other major migratory flyways, with less waterbird species listed as least concern and far more waterbird species listed as near threatened or globally threatened (Kirby 2010) (Fig. 1).

The fastest declining migratory shorebirds in the EAAF are the long-distance, Arctic-breeding migrants, such as the spoon-billed sandpiper *Eurynorhynchus pygmeus* (Amano et al. 2010; Zöckler et al. 2010b) and the red knot *Calidris canutus* (Wilson et al. 2011). At the current rate of decline (26% per annum), spoon-billed sandpipers could be extinct within the decade despite ongoing conservation action. Similarly, with the current rates of decline, for every 100 red knots migrating along the EAAF in 1992, only 7 will be left in 2020.

Of the 155 waterbird species in the flyway, at least *50* species of migratory shorebirds and *21* migratory gulls and terns in the flyway are strongly dependent on intertidal habitats. Fifteen globally threatened or near threatened migratory intertidal species, including the endangered spotted greenshank *Tringa guttifer* and the critically endangered spoon-billed sandpiper and Chinese crested tern *Sterna bernsteini*, have more than 95% of their entire global population in the EAAF; at least one species, entirely confined to the EAAF and currently listed as least concern, gray-tailed tattler *Heteroscelus brevipes*, is likely to be listed as threatened in the near future (Appendix 1 in MacKinnon et al. 2012). A further six migratory shorebird species, currently listed as least concern, also have more than 95% of their entire global population in the EAAF (sharp-tailed sandpiper *Calidris acuminata*, red-necked stint *C. ruficollis*, long-toed stint *C. subminuta*, Pacific golden plover *Pluvialis fulva*, oriental pratincole *Glareola maldivarum*, and Swinhoe's snipe *Gallinago megala*.

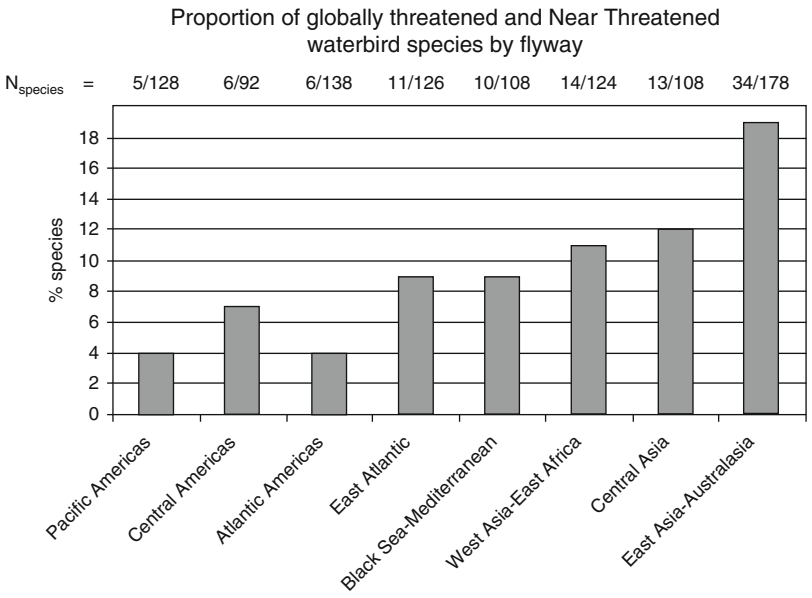

Fig. 1 Total number and proportion of globally threatened and near threatened waterbirds in the flyways of the world (Analysis and graphs reproduced from Kirby (2010))

Human Dependence

The loss of and degradation to intertidal flats are more than just the sad loss of our fascinating natural heritage but constitute a threat to the lives, health, safety, and welfare of hundreds of millions of our fellow humans, a threat to trillions of dollars worth of land and property and a risk to the health of the great oceans on which we all depend. The intertidal zone, with its sand and mud bars, beaches, and mangroves, delivers a vast list of valuable ecological services that are being discarded too causally in favor of nearsighted development goals (MacKinnon et al. 2012).

The bird declines are a sure warning that the productivity and health of the intertidal zone face an urgent crisis. Confirmation of these trends is paralleled in other taxa (WWF et al. 2006) and the growing frequency and scale of ecological disasters. Important stocks of economically important fish, crustaceans, shellfish, and cephalopods are all collapsing with associated loss of livelihood for hundreds of thousands of traditional fishermen. Sea mammals and turtles also show sharp declines. The frequency of toxic algal blooms increases dramatically; temperature, acidity, and water levels are rising (Nicholls and Cazenave 2010); the frequency of catastrophic storms increases and the damage to coastlines from cyclones and tsunamis becomes more serious wherever the natural coastline has been destroyed.

International Initiatives

In recognition of the fact that the problems transcend national boundaries, conservation efforts along the intertidal zone have been encouraged through the Convention on Migratory Species. Several bilateral migratory species agreements have been signed such as between Australia and China, Australia and Japan, and China and Japan. More recently, the activities of 13 countries and a number of international agencies (IUCN, WWF, Birdlife International, Royal Society for Protection of Birds (RSPB), Wildfowl and Wetlands Trust (WWT), and Wetlands International (WI)) have become coordinated through the establishment of the East Asian–Australasian Flyway Partnership (EAAFP) supported by the South Korean government. A recent situation analysis of the issue was commissioned by International Union for Conservation of Nature (IUCN), and a special motion was proposed and approved at the 2012 Jeju World Conservation Conference, urging countries along the flyway and especially around the Yellow Sea convergence area to restrain further land reclamation and undertake more detailed studies of the impacts to and conservation needs of these fragile mudflats.

Future Challenges

The challenge of harmonizing the conservation efforts and land reclamation policies of so many countries is big enough, but in the face of additional threats of increased pollution, poaching, decreased silt discharge, and climate change offer a bleak prospect. There will undoubtedly be more biodiversity losses, but it is important to acquire protection for the most important sites to salvage as much as one can.

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