Coral Reefs of the South China Sea – a Need for Action

Satellite photos of Fiery Cross Reef: (left) 2006: small military outpost and largely healthy reefs, (middle) 2014: reef flat has been dug up for giant clams, (right) 2015 during artificial island construction, with plumes of sand and silt spreading onto the reef (a. CSIS Asia Maritime Transparency Initiative / Digitalglobe, b and c Google Earth/Digital Globe 2016).

SUMMARY

The South China Sea (SCS), a marginal sea in the centre of Southeast Asia, is surrounded by ten of the most economically important Asian nations: People's Republic of China (PRC), the Republic of China (Taiwan), the Philippines, Malaysia, Brunei, Indonesia, Singapore, Vietnam, Thailand and Cambodia. It plays a central role in the economy and development of these countries, in terms of shipping, energy and fisheries. The SCS is also of critical ecological importance, abutting the western border of the Coral Triangle, a region of anomalously high marine species diversity. With nearly 600 known species of corals, the SCS rivals the Coral Triangle in coral diversity. It is also home to a plethora of marine life of both ecological and commercial value, including many species on the IUCN Red-List.

The SCS contains over 250 small islands, atolls, cays, shoals, reefs, and sandbars, most of which have no indigenous people. The principal archipelago and island features are the Spratly Islands, Paracel Islands, Dongsha Atoll, and Scarborough Reef. Each of these main reef systems is subject to overlapping sovereignty claims by two or more nations. With intensification of these interests in recent years, threats to the reefs such as overharvesting and pollution, which have been present for many years, have greatly increased. There is now clear evidence of significant damage which, if not halted, will have a long-term impact on the biological diversity of the SCS, the ecosystem services provided by the reefs, and the sustainable development and economic stability of the surrounding nations.

This document lays out the views of the International Society for Reef Studies (ISRS) and concerned coral reef scientists on the ecological importance of reefs of the SCS and the threats posed to them by the activities currently underway.

The United Nations Convention on Law of the Sea is clear on the need for international cooperation in the resource management of seas such as the SCS. There is therefore an urgent need for the public and all relevant governmental, intergovernmental and non-governmental agencies to step up efforts and accelerate international cooperation, in order to alleviate those stresses that are causing the rapid decline of coral reef and related ecosystem resources in the South China Sea. Appropriate, timely and effective action will ensure the recovery of fisheries and the reef and associated ecosystems on which they depend, and the protection of this significant portion of the common heritage of mankind for future generations.

The International Society for Reef Studies (ISRS) is the leading international association for coral reef scientists and managers. Its members carry out and publish work that promotes scientific knowledge and understanding of coral reef ecosystems. *www.coralreefs.org*

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ABOVE: Giant clam harvesting in the Paracel Islands using the propellers of 'cutter boats' to dig up the bottom . Available at http://blog.sina.com.cn/s/blog_51460dc40102e5eq.html as of 10 July 2016.

RIGHT: Map of South Chna Sea with area of offshore reefs indicated in light blue. Approximately 122 surface-breaking reefs are marked in red.

INTRODUCTION

The South China Sea (SCS) is a marginal sea that is part of the Pacific Ocean, encompassing an area from the Singapore and Malacca Straits in the south to the Taiwan Strait of around 3,500,000 km^2. The SCS abuts the western border of the Coral Triangle, a region of anomalously high marine species diversity extending from the Solomon Islands to eastern Java, Indonesia and north to the Philippines, with some authors considering that part of the SCS lies within the boundaries of the Coral Triangle (*see map above right*).

The SCS contains over 250 small islands, atolls, cays, shoals, reefs, and sandbars, most of which have no indigenous people, many of which are naturally under water (5-10 m) at high tide, and many of which are reefs and banks that are permanently submerged, such as the Macclesfield Bank and Truro Shoal between the Paracels and Scarborough, the Reed Bank north of the Spratly area, and numerous reefs scattered across the Sunda Shelf. The principal archipelago and island features are the: Spratly Islands, Paracel Islands, Dongsha Atoll, and Scarborough Reef. Each of the main reef systems is subject to overlapping sovereignty claims by two or more nations.

The Spratly Islands, which are of particular concern, cover an area of 810 x 900 km and include some 175 identified islands and islets, the largest being Taiping Island (Itu Aba). The largest single feature in this area is a 100 km wide seamount called Reed Bank, in the northeast of the group, separated from Palawan Island (Philippines) by the Palawan Trench. Now completely submerged, with a depth of 20 m, Reed Bank was an island until it sank about 7,000 years ago due to the increasing sea level after the last ice age. With an area of 8,866 km², it is one of the largest submerged atoll structures of the world.

Major rivers that flow into the SCS include the Pearl, Min, Jiulong, Red, Mekong, Rajang, Pahang, Pampanga, and Pasig Rivers.

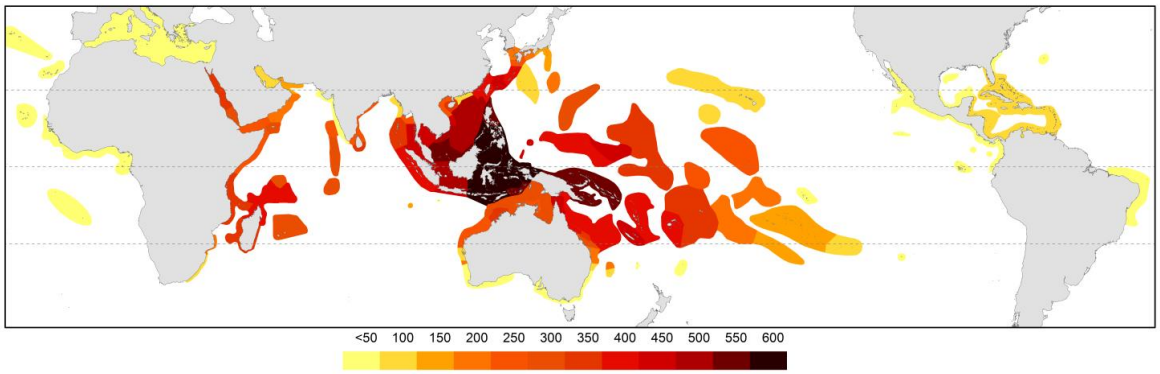

Figure 1. Numbers of shallow-water coral species found globally. The South China Sea has more than five times the numbers of species in most fish and invertebrate groups as in the Caribbean or Hawaii. Source: Veron et al. (2015).

ECOLOGICAL CHARACTERISTICS & SCIENTIFIC IMPORTANCE

The SCS rivals the Coral Triangle for the importance and diversity of its reefs. The total reef area is estimated at about 12,000 km^2, or 4.7% of the world's total reef surface area. Over 300,000 (multicellular) reef-associated species (some 37% of c. 800,000 reef species in the world) are found on the southern reefs of the SCS, many of which have yet to be identified and probably many new to science (McManus, in review). The SCS is home to an estimated 571 known species of reef corals (Huang et al., 2015), with diversity ranging from 95 species on the northernmost reefs of the SCS in southeastern China to 433 species in western Luzon, Philippines. Of the 70 known coral genera, 50 have been found in the area (Vo et al. 2013). The SCS has some 17% less reefs in area than the Coral Triangle but only 5% fewer corals (the Coral Triangle has 605 species of reef corals; Huang et al., 2015). The high species richness is illustrated in Figure 1.

Studies on many groups of marine species, including annelids (Paxton and Chou 2000), molluscs (Norman and Lu 2000; Sachidhanandam et al. 2000; Tan 2000), crustaceans (Jones et al. 2000; Komai 2000; Lowry 2000; Moosa 2000; Rahayu 2000), echinoderms (Lane et al. 2000), sponges (Hooper et al. 2000) and fish (Randall and Lim 2000) document considerable proportions of global richness.

Records exist for 1,766 crustacean species (Pan 2010) and 7 of the 12 giant clam species (Vo et al., 2013; Neo et al., in press). Over 3,000 species of fish are known from the SCS (Randall and Lim 2000), comparable to 3,000-4,000 estimated from the Coral Triangle (Burke et al. 2011). The SCS is also home to 102 non-fish vertebrate species, of which 36% are marine mammals, 36% are seabirds, and 27% are reptiles (Sorongon and Palomares 2010). The SCS also has 20 of the 50 seagrass species and 45 of the 51 known mangrove species (Vo et al., 2013).

Currents of the SCS vary greatly over the year as a result of the reversing monsoons and other weather factors, and sometimes reverse directions themselves. This may partly explain why fish species targeted by fisheries here do not go extinct. Genetic studies of three reef fish species (the false Moorish idol *Heniochus acuminatus*, the six bar wrasse *Thallasoma hardwickii*, and the threespot dascyllus *Dascyllus trimaculatus*) in the SCS has shown that connectivity in the SCS is very high, but that there may be some population differences in some areas (Ablan et al. 2002; Chen et al. 2004).

ECONOMIC IMPORTANCE

This region is vitally important economically. South East Asia is home to more than half a billion people and, as of 1997, the Association of Southeast Asian Nations (ASEAN) has been the world's fourth largest trading bloc (Chandler et al. 2005). Countries with an influence on the SCS include oil-rich Brunei, the highly successful 'tiger economies' of Singapore, Hong Kong, and Taiwan, and the rapidly rising economies of Indonesia, Malaysia, the Philippines, and Thailand, and Vietnam (Glover 2013). To the north lies the PRC which may achieve economic dominance in Asia within the next two decades

(Davies 2002). The maintenance of the national prosperity of these nations depends heavily on their location on important global shipping routes, and their abundant natural resources such as oil for energy and fish to feed the rising populations.

Shipping: The SCS contains the second most used sea lane in the world, and the area between the Spratly Islands and PRC is particularly important. About half of the world's shipping tonnage passes through the area annually, supplying roughly 60% of the energy needs of South Korea, Japan and Taiwan, as well as 80% of PRC's crude oil imports (Figure 2; Kaplan 2014). Some USD 5.3 trillion worth of international trade passes through each year, including up to half of the world's oil shipments (Cronk 2015), about 80% of the shipping trade with PRC, and a large part of the shipping trade connecting Europe, Africa and Asia with Japan, Hawaii and the Americas.

Oil and gas: The South China Sea has approximately 11 billion barrels of oil and 190 trillion cubic feet of natural gas in proven and probable reserves (EIA, 2013). However, these are to be found primarily along near-shore continental shelf areas, and not among the offshore reefs, perhaps because the porous carbonate sediments associated with coral reefs have prevented the build-up of oil and gas (Hayton 2014). The Spratly and Paracel Islands are believed to have negligible amounts of oil and less than 0.1% of the total natural gas found within the SCS (EIA 2013).

Fisheries: The SCS supports major fisheries, and many of the surrounding nations are expanding their fleets by providing subsidies and/or improved technology. The coral reefs provide critical habitats that support fisheries production. The Spratly Islands, in particular, are a source of larvae to replenish locally extirpated fish populations throughout much of the SCS (e.g. McManus 1994, Juinio-Meñez et al. 2003, Kool et al. 2011, Treml and Halpin 2012). The pelagic fisheries from the Kalayaan Island Group in the Spratly Islands are estimated to be worth about USD 47-105 million/km2 annually, in addition to USD 39-60 million from commercial reef fisheries (Aliño et al. 1998). The capture fisheries contribute about 10 million tons a year, which is 12% of the world's landed catch (Sumaila and Cheung 2015). Fish contribute 28% of the protein to the area outside of the Gulf of Thailand and 38% within it. The protein is particularly important to the over 43,500,000 impoverished people living within 100 km of the coast (TWAP 2015a,b; Talaue-McManus and Estevanez 2016).

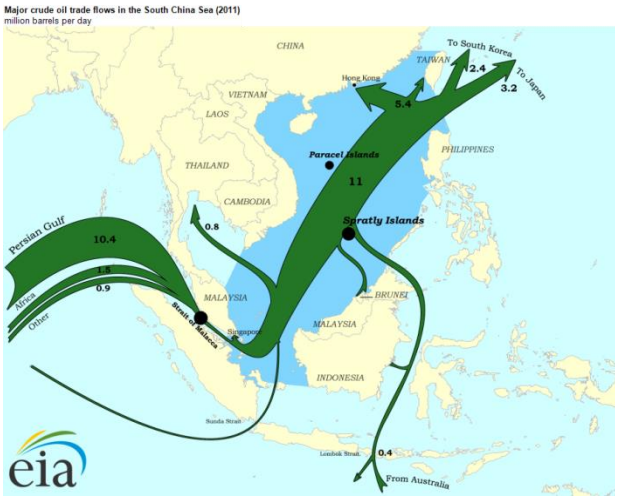

Figure 2. Major crude oil shipping routes through the South China Sea in millions of barrels per day in 2011. Source: EIA 2013. (US Energy Information Administration http://www.eia.gov/todayinenergy/detail.cfm?id=10671, as of 10 July 2016.

Defence and military bases: There are now more than 40 military outposts (McManus, in review) and a wide range of associated infrastructure, facilities and activities (Morton 2016).

Potential for pharmaceuticals: The high level of species diversity indicates that the potential for new medical drugs from the sea from these offshore reefs is likely to be very high.

Potential tourism: There are at least a hundred reefs in the Greater Spratly Islands, and another twenty or so in the Paracel Islands with potential for world class tourist diving (McManus, in review). There has also been interest by some of the surrounding countries in other forms of tourism (Morton 2016). At present, the only tourist resort in the Spratly area is the Malaysian resort at Swallow Reef. The PRC base of Sansha (Woody Island) in the Paracels and Taiwanese-occupied Taiping Island in the northern Spratlys and the Dongsha Islands are being prepared for increasing tourism, with much emphasis on environmental protection.

Figure 3. Filling to extend Woody Island in the Paracel group. Source: Google Earth 2016 (Google Earth and DigitalGlobe 2016).

THREATS TO THE REEFS OF THE SCS

Experts associated with the SCS Large Marine Ecosystem Assessment (Feary et al. 2014) rated much of the SCS and Gulf of Thailand as "poor" in terms of biodiversity in terms of nearshore ecosystems and species. Although ecosystem health was largely "good," most areas were also rated as "poor" in terms of human-induced pressures. Most of the parameters evaluated were stable or declining, and there was little indication that ecosystem health or biodiversity was improving. Three habitats (coral reefs, seagrass, and mangroves) and fourteen species groups were found to be in the poorest condition because of coastal development and exploitation. While there are national and international conservation actions to protect some of these species groups, such as groupers and giant clams in national waters, there is no significant coordination or extension of these efforts into offshore areas.

An earlier transboundary diagnostic analysis in 2000 had identified that coastal habitat degradation and loss in the surrounding countries, overexploitation, and marine pollution were the major threats to the SCS and adjacent Gulf of Thailand (Talaue-McManus 2000). In particular, many of the coral reefs fringing the major land masses are threatened by coastal development and overexploitation (McManus 1997; Burke et al. 2011).

Reefs of less inhabited island clusters, such as the Spratly and Paracel islands, have previously been under less threat but are now subject to major pressures. Surveys in February 2016 of the reef flat and lagoon at Thitu (Pag-asa) Reef in the east Spratly Islands showed that these reefs had been overfished (piscivorous fish generally absent), but that there was good coral cover behind the breakers and on the outer reef flat: mostly small, dense, relatively fast growing *Acropora* and *Montipora* colonies interspersed with some low microatolls of various more storm-resistant and slow-growing species. The coral community was clearly adapted to rapid recovery following the frequent typhoons which affect the area, and was well-flushed with very clear oceanic water (McManus 2016).

Figure 4. Extensive coral mortality from giant clam 'cutter boat' activity observed on a reef east of Thitu Reef in the Spratly Islands, February 2016. Photo (c) John McManus

Dredging and filling. Most of the nations claiming the Spratly Islands have engaged in some level of dredging and filling to expand and reinforce small islands, create access channels and obtain construction materials (Fig. 3). While PRC has done this in the Paracel Islands, it has primarily built new artificial islands in the Spratly area totalling at least

13 km^2. Prior to this construction, each of these areas was subject to extensive damage from giant clam extraction (McManus, in review). While focussed on a smaller total area than the widespread damage from clam extraction, the filling operations are of particular concern because reef recovery is impossible in such areas.

Overfishing. Most fish stocks of tuna, mackerel, jacks, and sharks subject to offshore commercial fishing underwent a reduction of more than 50% from 1960 to 2000 (Christensen et al. 2003). The impact of commercial fishing is compounded by fishing for consumption by military personnel stationed in the area. Most coastal waters, including reefs, are fished at estimated levels of at least twice that for optimal fisheries production, leading to low catches per hour fishing (McManus, in review), a problem compounded by widespread coastal reef degradation from a wide range of stressors (Chou 2013).

Use of destructive fishing methods. In prior decades, the Spratly islands were often fished using *muro-ami* methods, in which hundreds of fishers drove fish into anchored nets using weighted ropes which damaged coral. This practice is now rare. There have been apprehensions of fishers using blasting devices in shallow waters, which leads to wasteful depletion of fish populations and considerable damage to corals and other ecosystem components (Akamine 2006).

Most recently, giant clam hunters have taken to digging up large areas of reef flat in search of shells. The boats are anchored and pulled laterally in arcs with the propeller spinning to dig up the bottom (Lee 2016). The combination of damage directly from the propellers and indirectly from the suspension of sand and silt is causing extensive mortality among bottom dwelling species (Fig. 4). Over 100 km^2 of coral reef in the Paracel and Spratly areas has been estimated to have been severely damaged in this way (McManus, in review). Although corals in the SCS are typically adapted to recover within a few years from typhoon damage, the destabilization of substrates may extend this recovery time to more than a decade. Efforts are underway by relevant authorities to halt this destructive harvesting practice but need support and strengthening.

Harvesting of threatened species. Large fleets of boats ranging in size from small outriggers (often carried or towed in by larger vessels), to large, modern, well-equipped fishing craft collect a variety of marine wildlife from the offshore reefs of the SCS. Sea turtles, sharks, large groupers, wrasses, and giant clams are specifically targeted. Their populations are likely much lower now than they were a few decades ago. Giant clam shells can be worth around US$1000 per pair and are used to produce many products, including carvings worth far more (Fig 5).

Figure 5. Carving produced from giant clam shell. Photo: www.taobao.com.

POTENTIAL MITIGATION & SOLUTIONS

There are a wide range of potential measures that could be used to manage the environmental issues that have arisen in the SCS, such as gear restrictions, spatial closures, seasonal closures and licensing systems. For example, the UNEP/GEF project "Reversing Environmental Degradation Trends in the South China Sea and the Gulf of Thailand" (http://www.unepscs.org), which ran from 2002-2009, initiated the establishment of a network of demonstration sites in the region for coastal habitat and land-based pollution management that integrates local government and community initiatives (Vo et al. 2013), but was unable to include the offshore reefs because of the issue of overlapping claims.

Regulation of any kind is difficult in a situation of overlapping claims. Should any one claimant declare a management measure, compliance by other claimants may be interpreted as recognition of another claimant's authority. Thus the annual ban on fishing in the Spratly area during summer months mandated by PRC (Xieyuan 2015) tends to be violated by other nations (Cabacungan et al. 2014). In the coastal waters of Brunei, fishing is prohibited around the numerous oil rigs and interconnecting pipes which act as no-fishing reserves, and the high levels of fish populations in that area are a testament to the effectiveness of such spatial fishery management.

However, within areas subject to multiple claimants, any one claimant's declaration of a park or reserve tends to be met with official protests by others. Clearly, there must be multilateral coordination of fishery and environmental regulations, such that all regulations are declared by all claimants simultaneously.

Many international agreements call for multinational cooperation in fishery management and environmental protection, including the United National Convention on Law of the Sea, the Convention of Biological Diversity, Agenda 21, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the FAO Code of Conduct for Responsible Fisheries, the Convention on Wetlands and others.

Reasonable goals for natural resource management of the offshore reefs of the SCS include:

- Ecologically sustainable fishing
- Ecologically sustainable tourism
- Regionally coordinated management arrangements
- Standardized environmental impact assessment procedures

If sustainable management is introduced, there is potential for recovery of many of the reef systems. Recovery from local extinctions of the species that have been over-exploited has proved possible in other areas. For instance, giant clams have been restored on many reefs elsewhere in the region (Gomez and Mingoa-Licuanan 2006). Sea turtle populations in Hainan are recovering as a result of rescue and release practices (Ruggeri 2015). Large predatory fish have been shown to recover quite well when fishing pressures on them are alleviated for long periods of time (Russ and Alcala 2004).

The development of sustainable tourism among these offshore reefs could involve some combination of low-impact development on islands and a strong emphasis on keeping tourists on live-aboard dive boats. An example of the former is Taiping Island (Jennings 2015), where sustainability is being promoted via careful land-use and innovations such as solar power generation. The value of live-aboard tourism is exemplified at the Tubbataha Reefs World Heritage Site. This offshore Philippine reef system in the Sulu Sea due east of the Spratly Islands was previously over-fished and subject to a number of disturbances. Two-decades later, after a gradually improved system of park management and enforcement, the area teems with large predatory fish such as groupers, snappers, jacks and sharks (Dygico et al. 2006), a positive sign of a return towards a near-pristine state. A significant part of the management costs of this reef come from tourist entry fees (Subade 2007). The true economic value of the park includes a wide variety of sources of income to the country, such as income from tourists in the course of their journey to the park, via airports, hotels, shops, restaurants, dive-tour operations, and a multitude of other activities. A peaceful and environmentally

well-managed SCS would lead to substantial growth in tourism across the region, and provide major boosts to industries such as yacht-building, in which the PRC is prominent primarily for the vessels it sells to be used outside the region (Wilkinson 2015).

There have been several proposals for protecting the Spratly Islands area (White 1983; Valencia et al. 1999; Alcala 2011). The Philippines has identified priority sites for protection (Aliño et al. 2006) and Taiwan (Shao and Lin 2014). It has also been recommended that whole of the Spratly Islands group be designated as an international protected area or peace park (McManus 1992, 1994; McManus et al. 2010). Given the multi-decadal relative success of the Antarctic Treaty System, a similar model could be used for a Peace Park. For this, a time-limited, renewable treaty could be developed with a freeze on claims and claim supportive activities, and a plan for joint resource management. This idea has been supported by several authors (Hughes et al. 2010; Zhao et al. 2013; Mora et al 2016). The recent Arctic Ocean agreements (Tai et al. 2015) also provide a model, as does the Binational Red Sea Marine Peace Park in the Gulf of Aqaba (Toán and Đăng 2016).

Regardless of the approach, there is an urgent need for a system of coordinated, effective fishery management and environmental protection, in conjunction with programmes to restore key populations of giant clams and other regionally depleted species. This would ultimately lead to the recovery of many of the coral reef resources in the SCS to the benefit of all nations.

Reef flat, Thitu Island. Photo (c) John McManus

CONCLUSIONS

The United Nations Convention on Law of the Sea, to which all claimants in the SCS belong, is clear on the need for international cooperation in the resource management of seas such as the SCS. Article 123 on Cooperation of States bordering enclosed or semi-enclosed seas states that:

"States bordering an enclosed or semi-enclosed sea should cooperate with each other in the exercise of their rights and in the performance of their duties under this Convention. To this end they shall endeavour, directly or through an appropriate regional organization:

- to coordinate the management, conservation, exploration and exploitation of the living resources of the sea;
- to coordinate the implementation of their rights and duties with respect to the protection and preservation of the marine environment;
- to coordinate their scientific research policies and undertake where appropriate joint programmes of scientific research in the area;
- to invite, as appropriate, other interested States or international organizations to cooperate with them in furtherance of the provisions of this article."

There is therefore an urgent need for the public and all relevant governmental, intergovernmental and non-governmental agencies to step up efforts and accelerate international cooperation, in order to alleviate those stresses that are causing the rapid decline of coral reef and related ecosystem resources in this important region, the South China Sea. Appropriate, timely and effective action will ensure the recovery of fisheries and the reef and associated ecosystems on which they depend, and the protection of this significant portion of the common heritage of mankind for future generations.

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