BOOM OR BUST
THE FUTURE OF FISH IN THE SOUTH CHINA SEA

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Asia’s oceans are home to some of the richest and most diverse fisheries in the world and the South China Sea (SCS) is no exception. Its fish resources are crucial for food security, supporting coastal livelihoods and export trade, yet they are threatened by pollution, coastal habitat modification and excessive and destructive fishing practices.

In 2015 the University of British Columbia Fisheries Economic Research Unit and Changing Ocean Research Unit undertook to outline the threats to the SCS and determine what its marine ecosystems, fisheries and seafood supply may look like in the next 30 years under different climate change and management scenarios. Declines in fish biomass were found in all scenarios, but some were better than others. The following presents a summary of the research and finds that if business continues as usual, (status quo scenario) by 2045 compared to now the following is likely to occur:

All fish and invertebrate groups studied will experience a population decline ranging from 9-59%, with groupers and sharks the worst affected.

Over 60% of the fish and invertebrate groups studied will generate less catch, with serious food security implications.

Approximately 55% of the fish and invertebrate groups studied will generate less landed value, causing significant economic consequences.

By contrast, under a sustainable management scenario, by 2045 there will be a significantly positive impact on biodiversity relative to business as usual. In order to achieve this, catch of about 63% of the animal groups will have to decrease.
Spanning an area of around 3.8 million square kilometres, the South China Sea (SCS) is bordered by 12 countries/territories. These countries/territories are home to two billion people and represent some of the fastest developing economies of the world.

The SCS is biologically diverse but knowledge of its marine fauna is relatively incomplete. The most comprehensive catalogue of its marine fishes lists 3,365 species in 263 families. It is also one of the top five most productive fishing zones in the world in terms of total annual marine production, with marine aquaculture also contributing significantly to seafood production capacity in the region. Its fisheries resources are thus crucial for supporting coastal livelihoods, food security and export trade in its bordering countries. Small-scale fisheries are prevalent in SCS countries and inshore waters are subject to intense fishing pressure from heavily populated coastal areas.

Furthermore, it is widely acknowledged that national fisheries statistics of SCS countries do not fully capture all fishing sectors such as subsistence and other small-scale fisheries, and the level of Illegal, Unreported, and Unregulated (IUU) fishing in the region is also poorly known. As a result, fish catch statistics are likely substantially underestimated.
The SCS’s marine ecosystem has changed dramatically from the past, as illustrated by the following examples:

1. Marine resources have been fished down to 5-30% of their levels in the 1950s. This is not a recent phenomenon – even by the mid-1990s, total fish biomass (quantity of fish in the ocean) in parts of the SCS had been reduced to less than 10% of that in the 1960s.

2. Overfishing and habitat destruction has directly contributed to biodiversity loss. Marine megafauna such as dugongs used to be abundant along the coast of Thailand, Malaysia and the southern provinces of China in the SCS, but are rarely found in the present time.

3. Its coral reefs face substantial anthropogenic threats and are estimated to be declining at a rate of 16% per decade, resulting in loss of biodiversity and fisheries.

4. The fisheries on the coral reefs are also in bad shape; even in remote islands, catch rates are one third to one quarter of the level they were two decades ago.

5. In some areas, monthly catches of valuable reef fish species such as Napoleonic wrasse and coral groupers decreased by almost 100% over 8 years, while catch per unit effort declined by almost 80% over the same period.
Intense fishing pressure and over exploitation is prevalent

Reported fisheries landings in the SCS are estimated at around ten million tonnes (t) or about 12% of the global catch (Sea Around Us 2015). In 2012, the landed value for SCS catch was 21.8 billion USD, of which China accounted for 45%. However, the data is likely underestimated. Incorporating estimated unreported catches would increase total catches to 16.6 million t in 2010; overall, estimated unreported catches from the SCS averaged about 8.1 million t annually from 2000-2010.
Targeted fish groups include: pelagic species such as flying fishes, tunas, billfishes and mackerels; demersal fishes such as snappers and soles; invertebrates such as crabs, shrimps and squids; reef fish such as groupers, parrotfish and rabbitfish; small coastal pelagic fish such as herring, sardine and anchovy; and sharks.

SCS fisheries have been under heavy fishing pressure for more than 30 years and decades of intensive commercial trawl fishing in coastal areas have led to overexploitation, indicated by declining catch per unit effort (CPUE), a measure of how much time and effort is put into catching a set amount of fish. As a result, deep-water habitats have been viewed as areas for further fisheries expansion and some SCS governments have developed programs to encourage offshore fisheries.

The use of destructive fishing practices is also a widespread problem that directly damages marine habitats. The impact of dynamite and cyanide on coral reefs is particularly serious, as these techniques are widely used in the region’s reef fisheries. Land reclamation for urban development as well as aquaculture also destroys vulnerable coastal habitats. Pollution, too, from agricultural and coastal development has led to environmental degradation.
REGIONAL PROFILE

Globally, China ranks as one of the top SCS countries in terms of fish production and export. Not surprisingly, fisheries are an important sector within China’s national economy, making up 9.9% of total gross agricultural output value in 2013. However, bottom trawling, being non-selective and destructive to bottom habitats, accounts for almost half of all domestic production in Chinese waters\(^\text{17}\). China also has a significant distant water fleet\(^\text{18}\) and in general, its marine capture fisheries are overcapitalised\(^\text{19}\). Attempts to limit fishing capacity have not been considered successful\(^\text{20}\).

The fishery resources in the waters administrated by the Hong Kong Special Administrative Region (hereafter called Hong Kong waters) have been intensively exploited and severely depleted as it has been largely unregulated and unmanaged. The majority of the traditional fish stocks such as yellow croaker, seabream and groupers are now classified as over-exploited or depleted, despite a trawl ban being imposed in 2012\(^\text{27}\).

The Philippines, too, is a major fish-producing country, with much of its fisheries production consumed locally. Heavy fishing pressure has led to the decline of both municipal and coastal fisheries and destructive fishing methods such as poison, cyanide and blast fishing often occur in its coastal waters.

In general all of Indonesia’s fisheries resources are considered to be in a critical condition; almost all are fully exploited, with some being over-exploited. Illegal fishing, which is extensive in the Indonesian portion of the SCS, exacerbates the situation\(^\text{22}\).

Thailand is one of the world’s top fish producing countries and fisheries are important for domestic consumption as well as export. Fish is the primary protein source for the majority of Thailand’s population, especially those in remote villages\(^\text{23}\). The rapid development of trawling in the Gulf of Thailand led to overexploitation in the late 1960s and 1970s,\(^\text{24}\) instigating the expansion of Thai trawlers into the waters of neighbouring countries.

Fisheries play a vital role in Malaysian food security, and are an important source of income and employment for the country’s rural population. However, illegal fishing by Thai vessels on Malaysia’s east coast is a serious concern.
There is a long tradition of fishing in Vietnam and fisheries remain one of the country’s top economic sectors. Fishing grounds frequented by Vietnamese fishers are situated in shallow waters and around 90% of marine fish catch is taken from inshore areas less than 30 m in depth\(^{25}\). Marine catches were largely subsistence and artisanal until the transition to a market-oriented economy in the mid-1980s, following which both inshore and offshore fishing intensified rapidly\(^{26}\). In recent years, Vietnam has been increasing its focus on high value species such as tuna in offshore areas.

### Fishing down the food web

Although marine catches generally show an increasing trend over time, these mask underlying depletions at the species level. In most cases catches of larger species are declining while those of smaller species are increasing. The increase in small species catch is suggestive of “fishing down the food web”\(^{28}\), which occurs when fishing depletes large predatory species while small species or juvenile fishes (generally low-value) become increasing dominant in the fisheries catches. Demand is high for small low value species as a raw material for fishmeal for the aquaculture sector, but these fish are often prey or juveniles of commercially important species; catching these fishes contributes to substantial loss of commercial value. Trawl fisheries continue to be responsible for the majority of low-value catch, in general accounting for 40-60% of the total SCS catch.

### Falling catch leading to economic losses

Stock assessments are not regularly conducted in SCS countries, but one compiled in 2012 (Funge-Smith et al. 2012) showed the majority of assessed stocks or species are overfished or fully fished. Indeed, declines in trawl CPUE show the northern SCS to be particularly overexploited and the majority of the assessed SCS fisheries have shown a decline in catch rates over time\(^{29,30}\). Surveys carried out in Indonesia showed a progressive decline in catch rates and fish stock density over time.

- **Fishery loss:** It is estimated that Vietnam and Thailand may each have lost more than a million t of fish to overfishing from 1990 to 2004 (i.e. each could have caught 1 million t of fish above their current catches if the fishery had not been overfished), while China alone probably lost more than 5 million t in the same period (Srinivasan et al. 2012)\(^{31}\). This is of particular concern because of the food security implications; Vietnam ranks among the global top 30 countries whose economies are highly vulnerable to climate change impacts on fisheries\(^{32}\).
Revenue loss: Up to 10% of revenue generated in 2000 could potentially be lost due to projected fishery loss (Srinivasan et al. 2012). Thailand was an exception, with potential revenue loss of up to 60-70% of actual 2000 revenue. Moreover, it is estimated that potential catch loss for Thailand was 190% of its actual catch (in tonnes) in 2000 (i.e if Thailand fisheries were not overfished, their catch could have potentially been 190% higher than what they actually caught). This makes it the SCS country with highest potential catch loss among assessed countries; Cambodia, Philippines, Vietnam and China had estimated losses of 45%, 10%, 69%, and 7% of actual 2000 catch respectively.

The above examples represent trends that have negative economic and food security impacts on SCS coastal economies now and into the future. Following an assessment by FAO, it has however been suggested that a 50-60% reduction in fishing effort would allow these fish stocks to recover.
Significant socioeconomic importance

Scale of fishing, vessels and jobs - Of the 3.2 million fishing vessels operating in marine waters worldwide an estimated 1.77 million (55%) are in the SCS, of which the majority (86%) are small-scale vessels. However, as the small-scale sector in many SCS countries is often overlooked in national statistics, this number is likely an underestimate, which in turn affects employment numbers reported in national fisheries statistics. Therefore, while employment numbers are not directly included in the numbers below, it is important to note the significant impact of fishing on employment in these regions.
in SCS marine fisheries is estimated at around 3.7 million people\textsuperscript{37}, this is also likely an underestimate, as it does not account for fishers involved in Illegal, Unreported and Unregulated (IUU) fishing. For instance, it was estimated that from 1950 to 2006, the number of small-scale fishers in Sabah, Malaysia was on average three times higher than the number recorded in annual fisheries statistics due to a large population of unlicensed fishers\textsuperscript{38}.

In Southeast Asia, the use of human trafficking to supply labour for fishing vessels is a serious concern. It is widely reported that migrants from Myanmar and Cambodia are ‘recruited’ or forced to work on Thai fishing vessels under inhumane conditions\textsuperscript{39}. There is insufficient information on how large this work force is; nevertheless, it is critical that this becomes a priority issue to deal with regionally as we already see some consequence of this. For example, the US Government has already downgraded the standing of Thailand in part because of this unethical fishing\textsuperscript{40}.

**Economic development versus environmental impact** -
Unreported cross-border trade in endangered marine species is also a serious conservation concern for SCS countries. Many people from poorer, more rural fishing communities are more concerned with economic development despite recognizing the environmental impact of the trade (substantial decline in the abundance and size of fish stocks). As a result, local residents of areas like Balabac in the Philippines see the live reef fish trade as a significant form of economic assistance. The growing consumer demand for certain high-value marine products provides financial incentives for fishers to participate in supplying these luxury markets. Consequently, demand increases simultaneously as stocks fall.
Aquaculture in Asia comprises the vast majority (about 88%) of total global aquaculture production. By 2010, five of the top ten global aquaculture producers in terms of both quantity and value were SCS countries (China, Vietnam, Indonesia, Thailand and the Philippines). The expansion of this sector has helped to fill the gap between supply and demand for fish in the region, as well as contributing to economic development via exports.

However, a significant proportion of aquaculture is carnivorous fish that require vast amounts of trash fish as feed, thus increasing the fishing pressure on the marine sector. The proportion can be reduced by partially substituting with plant proteins, such as soybean, but complete substitution has not yet been achieved. The use of trash fish in feed is also wasteful due to inefficient feed conversion rates (e.g. 15:1 for grouper cultivation), which diverts fish protein from human consumption. The use of fish offal in feeds can provide much better feed conversion efficiency than low-value fish inputs.

Coastal habitat degradation is a major negative effect of aquaculture development. The loss of habitats like mangroves means a loss of important feeding, spawning and nursery grounds, which not only impacts marine fisheries productivity, but also threatens the survival of endangered species populations. Effluents from aquaculture, such as faecal matter and excess feed, can also have negative impacts on surrounding marine environments through degraded water quality, eutrophication and disease, to name a few. These can be fairly mitigated by situting the facilities in areas with high flushing and deep water. Effluents can be treated before they are discharged and the use of specific chemicals and antibiotics can be banned, while avoiding overfeeding can minimize the excess nutrients that are released. Regrettably, most fish farmers in the SCS do not follow such measures.
REGIONAL PROFILE

In 2012, China’s aquaculture production comprised 62% of the global aquaculture production\textsuperscript{44}, as well as 72% of China’s total reported national fish production\textsuperscript{45}. In the same year, the Philippines produced around 7% of total SCS marine aquaculture production by volume\textsuperscript{46}.

Aquaculture in Hong Kong includes marine fish, pond fish and oyster culture. Total production in 2013 was around 3,300 t, equal to 2% of Hong Kong’s total fisheries production that year.

Indonesia has had a long history of aquaculture and in 2014 it was the fourth largest producer (by volume) in the world\textsuperscript{47}, as well as comprising 22% of SCS marine aquaculture by volume (or 68% when China is excluded).

In 2012, Vietnam was the third largest producer of farmed food fish in the world\textsuperscript{48}. However, this has significant environmental implications as by 2012, Vietnam had lost 80% of its mangroves to shrimp aquaculture.
By 2010, Thailand was the sixth largest producer (by volume) globally, and the ninth largest producer by value\(^49\). However, in 2012, Thailand produced less than 1% of the SCS region’s marine aquaculture by volume, or around 3% when Chinese production is excluded. This production has also been at the expense of half the country’s mangroves\(^50\).

Based on the 1999 estimate of fish availability and the calculated total population of 11.7 million, the maximum consumption of fish in Cambodia would have been between 25.2 and 37.1 kg/year per capita. The Mekong River Commission (MRC) puts the equivalent consumption of fresh fish as high as 75.6 kg/year per capita among fishing communities close to main fishing waters\(^51\). This seems very high, especially because it would leave the rest of the Cambodian population with fewer than 16 kg/year per capita equivalent of fresh fish in the current most optimistic estimate of fish availability. These data support the presence of considerable regional differences in fish consumption in Cambodia\(^52\).
SCS countries play a major role in the global fish trade

China is the world’s leading exporter of fishery products, with an export value of USD 18.2 billion in 2012. Two other SCS countries – Thailand and Vietnam – were the third and fourth largest exporters in 2012 in terms of value with exports of USD 8.1 and 6.3 billion, respectively. China is also among the top three global importers of fish and fishery products (USD 7.4 billion in 2012), while Hong Kong makes up the 10th largest global importer (USD 3.7 billion in 2012). This is significant given the size of Hong Kong.
In 2011, export of fishery products from SCS countries totaled USD 38.7 billion.

By 2011 exports of fishery products from the SCS comprised 27% of global exports.

**South China Sea exports:** For many SCS countries, export earnings from fish are considered to be an important source of foreign exchange for importing other foodstuffs. According to data extracted from the FAO Fisheries Global Information System (FIGIS) database, export of fishery products from SCS countries totaled USD 38.7 billion in 2011. China was the dominant exporter, accounting for 44% (USD 16.9 billion) of total exports.

The volume of exported fishery products from SCS countries shows an increasing trend over time, doubling from 4.5 million t in 2000 to 9.2 million t in 2011. From the late 1980s to the early 1990s, exports of fishery products from the SCS comprised an average of 11% of annual world exports. Based on FAO export data, this has since increased to 27% of global exports by 2011.
In 2013, Hong Kong imported USD 3.2 billion of seafood.

**South China Sea Imports:** China is also among the top three global importers of fish and fishery products. The value of total imports by SCS countries totalled USD 18.1 billion in 2011, with China accounting for almost half of this. It is followed by Thailand at 21% and all other SCS countries accounted for less than 10% of the period total. Historically, Hong Kong has met most of its needs from fish taken from its waters. Due to the depressed state of its marine fisheries and the increasing demand both from domestic consumption and re-export to regions like mainland China, Hong Kong is now a major seafood importer. In 2013, for example, it imported USD 3.2 billion of seafood.
The next largest SCS source country for Hong Kong’s imports is Vietnam, accounting for 11% of imports from SCS countries in 2012. Philippines rounds up the top three SCS import sources, accounting for 8% in 2012.

In terms of volume, mainland China is also by far the largest source of Hong Kong imports, accounting for 75% of total imports in 2012 alone. It is followed far behind by Thailand (9%) and the Philippines (5%). The top three items Hong Kong imported from mainland China in volume were molluscs (inclusive of cuttlefish, clams, abalone, oysters, and octopus) (31,349 t), crustaceans (25,755 t) and fresh whole fish (21,705 t). The main imported items from both Thailand and the Philippines in 2012 were crustaceans and molluscs.
Hong Kong is a major global market for high value seafood that is ecologically vulnerable and poorly governed. Shark fins are the most valuable seafood product imported to Hong Kong and Hong Kong alone accounts for around half of the global trade. According to the HKSAR Government Census and Statistics Department, in 2011, over 80 countries exported 10.3 million kg of shark fin products to Hong Kong, with the top five exporting areas being Spain, Singapore, Taiwan, Indonesia, and Saudi Arabia. Recent imports of shark fins to Hong Kong appear to have dropped, declining from more than 11 million t in the early 2000s to around 5.7 million t in 2014.

Hong Kong is also a major hub for the sea cucumber and live reef fish trades. Although not as valuable as the shark fin trade, the sustainability of these trades is just as threatened. High demand has led to the serious depletion of reef fish populations in the region, particularly of groupers; the main exploited species. Unfortunately, the type and quality of trade data is such that it is difficult to obtain a good estimate of the actual quantity of fish taken from each SCS country. High-value seafood such as shark fin is formally undocumented because it enters China via Hong Kong or Vietnam to avoid higher taxes and tariffs.
Although there are some management regimes in place in some SCS countries, challenges to the effectiveness of these include lack of enforcement, low levels of compliance, and poor coordination between different government bodies, among others. Within each of the SCS countries (except China) there is some degree of protection for the marine environment within the national constitution. However, these constitutional protections are only effective when supported by national laws, and effective compliance and enforcement. The legislation is also largely centralized, which may be contradictory to the growing emphasis on the need for community participation in ecosystem management.

Each SCS country does have regulations at local levels for preventing land-based marine pollution. There has been some implementation of marine protected areas in the SCS nations, although current coverage is below the Aichi Biodiversity Target of 10% coverage within nationally administered marine areas by 2020. Even when there is an area that is protected, levels of protection and effectiveness inevitably vary.

The SCS countries tend to employ different management techniques from each other, despite having the same marine environmental issues. Ideally they should be working together as a whole to address problems such as overfishing. For example, China’s primary measures to manage fisheries include a fishing license system, minimum mesh size for trawl nets and establishment of artificial reefs, whereas Malaysia’s government manages its fisheries by controlling the size and power of vessels, alternative livelihoods projects and closed fishing areas, among others.

It is concerning that with the majority of SCS countries, weak law enforcement has essentially created open access to resources. Gear regulations and licensing laws are often violated and fishing zones by some countries are largely determined by historical patterns of use, rather than by something more pertinent like spawning grounds.

* The full list of Aichi Biodiversity Targets, established through the international legally binding Convention on Biological Diversity (CBD), are available at https://www.cbd.int/sp/targets/.
Several multilateral instruments (e.g. the Convention on International Trade in Endangered Species of Wild Fauna and Flora - CITES) and regional bodies are relevant to the conservation and management of marine resources within the SCS\textsuperscript{69}. These multilateral instruments are diverse in their form: binding or voluntary, global or regional, and covering fisheries specifically or indirectly\textsuperscript{60}. In addition there are several bodies that focus on various aspects of the marine environment in the SCS including Coordinating Body on the Seas of East Asia (COBSEA), the Southeast Asian Fisheries Development Centre (SEAFDEC), The Asia-Pacific Fishery Commission (APFIC), as well as Regional Fisheries Management Organisation (RFMOs).

There are, however, strong barriers to intergovernmental cooperation on marine environmental and fisheries issues including competing territorial claims and a historical animosity amongst and between the Southeast Asian nations and China. More barriers to environmental cooperation in the SCS have been the rapid industrialization of the region and national governments’ prioritization of economic development over environmental protection.

There have recently been some attempts to shift SCS ocean management to an ecosystem-wide approach. In particular, the SCS Project of the United Nations Environment Program (UNEP) and the Global Environment Facility (GEF) has focused on promoting strong and effective regional cooperation in order to reverse trends of ecological degradation.\textsuperscript{61} The SCS Project identified the following three issues as priority regional environmental problems: loss and degradation of coastal habitats, fisheries depletion, and land-based pollution. A priority focus of the Project has also been to address coastal poverty. In many poor fishing communities, fish catch is often a primary source of dietary protein as well as income. A Small Grants Programme has subsequently funded national and local activities that aim to enhance household incomes in coastal areas through improved fishing methods and alternative livelihoods.
Introduction

Using the above information as a foundation, the SCS was studied and models were developed to understand how the fisheries are likely to be affected under different management and climate scenarios over the next 30 years. Three models, using a foodweb modelling technique called Ecopath with Ecosim, were built covering coral reefs, shelf seas (i.e. 50 - 200 meters maximum depth), and deep water areas (i.e. over 200 meters maximum depth) of the South China Sea ecosystem. We projected the future changes in fish stocks within each of these three areas, in terms of ecology (i.e. change in biomass) and economics (i.e. change in prices and landed value) under two scenarios: (a) status quo under high greenhouse gas emissions; and b) sustainable management under low greenhouse gas emissions.

Fish population, catch volume and value were looked at as indicators under three scenarios:

1. Three areas are being modeled to cover the SCS ecosystem:
   - Coral reefs
   - Shelf area
   - Deep water

2. Two fishing scenarios are modelled, over a 30-year time horizon for each area:
   - Status quo: current trajectory
   - Sustainable management: healthy ocean

3. Two climate scenarios are modelled for each of the fishing scenarios:
   - Sea surface temperature rises at 0.4°C by 2045 (current emission levels)
   - Sea surface temperature rises at 0.9°C by 2045 (current emission levels)

2000 as base year
The status quo scenario: This is the ‘business-as-usual’ scenario assuming that fisheries in the SCS will remain unmanaged as they are today. It is assumed that total number of fishing boats does not change substantially, but with technological improvement and lack of effective management, the effective fishing effort will increase at a global average of 2% per year. This scenario is consistent with a continued fossil-fuel intensive development, with the rate of greenhouse gas emissions remaining similar to that in the last few decades.

The sustainable management scenario: A balanced portfolio of marine conservation, economic benefits and food security is proposed for the SCS. Under this scenario, through changing the fishing effort of different fishing fleets, total catch would continue to meet the demand for seafood by the growing population, while the integrity of ecosystem structure would be kept at its best possible state by conserving vulnerable species, especially those at higher trophic levels. Fishing effort is usually measured by the number of days and boats fishing and the power of the fishing boats. In this study, fishing fleets are categorized by the types of fishing gear used. Economic benefits would then be maximized after the ecological objective and food security goals are met. To achieve sustainable management, collaboration among the SCS countries in managing their marine resources is much needed. Globally, major agreement in limiting greenhouse gas emissions is necessary, and alternative development models such as one driven by alternative energy sources need to take place.

Future prices projections: Given the predicted changes described above, it is important for the public in Hong Kong to understand how these changes would affect their pocket books. The impact of the above projected changes in catch on the prices of the main fish species imported into Hong Kong from the SCS, was therefore estimated. The goal is to inform the public and policy makers, and contribute to local dialogue and debate on not only the problems of the SCS but also how this would affect consumers of fish financially.
Two types of prices are applied in this analysis, i.e. historical prices (available at www.seaaroundus.org)\textsuperscript{82} and predicted future prices\textsuperscript{83}. To project future prices, two aspects were taken into account. Firstly, the time-dependent changes in price using the historical prices of the species under study were calculated. Second, the effect of changes in supply on the price of fish, all things being equal, was computed based on the approach used in Sumaila and Lam (2015)\textsuperscript{84}. This approach is based on the simple economic fact that for most goods, the price of the good is determined, for the most part, by the interplay between supply and demand. Several economists have studied the sensitivity of fish price to changing quantities of fish supplied to the market and found that decrease in supply generally results in increase in price.

**Projected Changes in Quantity of Fish, Catches and Catch Values**

**Business as usual**

If nothing is done to improve fisheries management and reduce CO\textsubscript{2} emissions, the simulation models project that by 2045 relative to 2015, all the species groups studied will decrease in biomass, ranging from 9 to 59% as a result of overfishing, warming, ocean acidification and changes in primary productivity. Particularly, groups that are more vulnerable to fishing, such as groupers, large sharks, threadfin breams and large croakers are projected to drop by 50% or more during this period.

The majority of the species groups (7 out of 11) that contributed substantially to existing fisheries are projected to generate less catch in 2045 compared to 2015, with serious food security implications (Table 1). Groups that can sustain the high fishing pressures are invertebrates and small fishes that are intrinsically more productive. As a result, we expect a decrease in overall values of the fisheries. These results suggest that without improvements in fisheries management and mitigation of carbon emissions, there will be economic consequences such as decrease in revenues and the resulting loss of livelihoods.
The analysis obtained under the sustainable management with low emissions scenario, on the other hand, indicates that efforts to improve fisheries management and reduce carbon emissions would have a significantly positive impact on the wild population biomass of all species except for crabs. The decrease in crabs is because of the large increase in abundance of their predators, resulting in a decrease in their biomass and fisheries production. To rebuild biomass of key species groups to a healthy level, fishing effort of all fishing fleets has to be substantially reduced. As a result, catches of 7 of the 11 species would have to decrease. However, catches of some of the over-exploited species, such as groupers and threadfin breams, are projected to increase because of the increase in their abundance back to a more productive level.

Table 2 below presents the projected changes in the quantity of fish in the ocean, catch and catch value under a sustainable development management scenario in which the world community is assumed to have succeeded in limiting emission to a low level, relative to the status quo scenario when an assumption of high emission is assumed (by 2045).
If we compare the SCS fisheries that were to be managed sustainably to the business as usual case, the study found that there is substantial increase in ecological status of the sustainably managed SCS. Specifically, benefits to the wild stocks of all major fish groups would be substantial. Wild stocks of tunas and mackerels would recover substantially—by 17 fold—in comparison to business as usual, while population biomasses of groupers, large croakers, threadfin breams and shrimps would recover by about 3-5 fold in comparison to business as usual.

Also, although crab biomass in a sustainably managed SCS would be lower than business as usual in 2045, it would still be higher than the biomass level in 2015. Catches of groupers and threadfin breams are projected to increase by about 32-57%. Catches of crabs and large croakers would decline substantially by 81-85%, while catch of shrimps would drop by 21% in comparison to business as usual. This would overall result in a loss of 44% of the total catch in comparison to business as usual.

### TABLE 2: PROJECTED CHANGES IN BIOMASS (QUANTITY OF FISH IN THE OCEAN), CATCH AND VALUE UNDER SUSTAINABLE MANAGEMENT WITH LOW EMISSIONS SCENARIO RELATIVE TO THE STATUS QUO SCENARIO WITH HIGH EMISSIONS BY 2045.

<table>
<thead>
<tr>
<th>Species Groups</th>
<th>Biomass</th>
<th>Catches</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reef fishes</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>Shrimps</td>
<td>▲▲▲▲</td>
<td>▼▼</td>
<td>▼▼</td>
</tr>
<tr>
<td>Cephalopods (e.g squid, cuttlefish, octopus)</td>
<td>▲</td>
<td>▼▼▼▼</td>
<td>▼▼▼▼</td>
</tr>
<tr>
<td>Threadfin bream</td>
<td>▲▲▲▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>Groupers</td>
<td>▲▲▲▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>Large croakers</td>
<td>▲▲▲▲</td>
<td>▼▼▼▼</td>
<td>▼▼▼▼</td>
</tr>
<tr>
<td>Sharks</td>
<td>▲▲▲▲</td>
<td>▼▼▼▼</td>
<td>▼▼▼▼</td>
</tr>
<tr>
<td>Small pelagics (e.g. sardines)</td>
<td>▲</td>
<td>▼▼▼▼</td>
<td>▼▼▼▼</td>
</tr>
<tr>
<td>Crabs</td>
<td>▼▼</td>
<td>▼▼</td>
<td>▼▼</td>
</tr>
<tr>
<td>Large pelagics (e.g. tunas)</td>
<td>▲▲▲▲</td>
<td>▼▼</td>
<td>▼▼</td>
</tr>
<tr>
<td>Demersal fishes (e.g. seabreams)</td>
<td>▲▲</td>
<td>▲</td>
<td>▼▼</td>
</tr>
</tbody>
</table>
Projected changes in the Future Price of fish

Table 3 presents numbers for (i) 2010 ex-vessel fish prices; (ii) change in price under the status quo high emission scenario relative to 2010 numbers; and (iii) change in price under the sustainable management low emission scenario relative to status quo high emission scenario.

<table>
<thead>
<tr>
<th>Seafood group</th>
<th>2010 ex-vessel price (US$ per tonne)</th>
<th>Change in price under status quo high emission relative to 2010s (# of times)</th>
<th>Change in price under sustainable development low emission relative to status quo high emission (# of times)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrimps</td>
<td>5,671</td>
<td>3.4</td>
<td>-0.1</td>
</tr>
<tr>
<td>Crabs</td>
<td>2,949</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Threadfin bream</td>
<td>3,249</td>
<td>4.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Large croakers (&gt; 30 cm)</td>
<td>2,077</td>
<td>2.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Groupers</td>
<td>6,394</td>
<td>8.7</td>
<td>-0.7</td>
</tr>
<tr>
<td>Tunas and mackerels</td>
<td>4,652</td>
<td>5.8</td>
<td>-0.9</td>
</tr>
</tbody>
</table>

Note: ex vessel price is the price received by the fisherman at the dock

Under the status quo scenario, all prices are projected to increase with increases of over three times for 4 out of the 6 species in our list. The changes for some species are more dramatic than those of other species because change in supply is different for different species under the same scenario. In addition, different species respond to supply changes differently. In the case of sustainable management, the prices under the sustainable management low emission scenario for 4 out of the 6 listed species are projected to decrease relative to those under the status quo high emission scenario. This is due to the increase in the biomass of these species under the former scenario, which makes it possible to catch more fish sustainably.
Conclusion

The analysis indicates that currently many of the key species of fish consumed in Hong Kong that are sourced from the South China Sea are under serious threat, with many of them currently at only a fraction of what they used to be only a few decades ago. Looking into the future, we find that the combined effects of unsustainable management and the impact of climate change would lead to further erosion of the valuable resources of this important marine ecosystem. This erosion is projected to have deep food security, ecological sustainability and financial consequences both for businesses and individuals, as revenues to the former drop while individuals face high prices with declining catches.

The findings reported herein suggest the need to immediately take action across all sectors of the community: governments, regional organizations, businesses, civil society and individuals. The national governments of countries in the SCS need to work, both individually and collectively with the international community, to immediately and substantially reduce CO₂ emissions. They need to significantly improve the management of their fisheries by eliminating harmful subsidies, such as those for fuel, and by investing in science and monitoring activities to address IUU fishing. There needs to be enforcement as well as monitoring and investment in fisheries improvement plans. Private actors (businesses, NGOs and individuals) need to make a conscious effort to reduce their carbon footprint and to source the food they eat from sustainable suppliers. With the help of Sea Choice, Sea Wise and other certification programs such as Marine Stewardship Council (MSC), traders and consumers have the opportunity to purchase sustainably sourced fish. These actions would contribute to both addressing overfishing and preventing the massive and mostly irreversible impacts of climate change and ocean acidification on ocean ecosystems and the fish they provide.
### Reef Fishes

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Sustainable</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>▼</td>
<td>▲</td>
<td><strong>Business as usual:</strong> Continued overfishing and stronger climate change impacts reduce biomass, while catches continue to increase by heavy unsustainable fishing.</td>
</tr>
<tr>
<td><strong>Catch</strong></td>
<td>▲ ▲ ▲</td>
<td>▲</td>
<td><strong>Sustainable management:</strong> Reducing fishing rebuilds biomass and productivity, and thus catches increase in a more sustainable pathway.</td>
</tr>
<tr>
<td><strong>Values</strong></td>
<td>▲ ▲ ▲</td>
<td>▲</td>
<td>Price increases over time and, with increase in catch, the value of fish landed also increases.</td>
</tr>
</tbody>
</table>

### Shrimps

<table>
<thead>
<tr>
<th></th>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>▼▼▼▼</td>
<td>▲ ▲ ▲</td>
<td><strong>Business as usual:</strong> Continued overfishing and stronger climate change impacts reduce biomass, while catches decrease because of stock depletion.</td>
</tr>
<tr>
<td><strong>Catch</strong></td>
<td>▼</td>
<td>▼▼</td>
<td><strong>Sustainable management:</strong> Reducing fishing rebuilds biomass. However, to do that, fishing and catches have to be substantially reduced as fishing effort from trawling is largely reduced. Decrease in catch leads to a price increase under status quo but the price remains about the same in the case of sustainable management because the decrease in catch is much smaller under this scenario. The combined effects of price and catch changes results in overall decrease in catch value.</td>
</tr>
<tr>
<td><strong>Values</strong></td>
<td>▼</td>
<td>▼▼</td>
<td></td>
</tr>
</tbody>
</table>

### Cephalopods (e.g. squid, cuttlefish, octopus)

<table>
<thead>
<tr>
<th></th>
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<th>Sustainable</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>▼</td>
<td>▲</td>
<td><strong>Business as usual:</strong> Continued overfishing and stronger climate change impacts reduce biomass, while catches continue to increase by heavy unsustainable fishing.</td>
</tr>
<tr>
<td><strong>Catch</strong></td>
<td>▲ ▲ ▲</td>
<td>▼▼▼▼</td>
<td><strong>Sustainable management:</strong> Reducing fishing rebuilds biomass. However, to do that, fishing and catches have to be substantially reduced as fishing effort from trawling is largely reduced. Under status quo both price and catch increase resulting in increase in catch value. In the case of sustainable management, price increases but the catch drops enough to make the catch value lower.</td>
</tr>
<tr>
<td><strong>Values</strong></td>
<td>▲ ▲ ▲</td>
<td>▼▼▼▼</td>
<td></td>
</tr>
</tbody>
</table>
### Threadfin Breams

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Sustainable</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Biomass**            | ▼▼▼       | ▲▲▲        | **Business as usual**: Continued overfishing and stronger climate change impacts reduce biomass, while catches decrease because of stock depletion.  
**Sustainable management**: Reducing fishing rebuilds biomass and productivity, and thus catches increase in a more sustainable pathway. |
| **Catch**              | ▼▼         | ▲           | Under status quo, the price increases by about 400% while the price increase under sustainable management is only 60%. This is because under the latter scenario catches of this species increase. |
| **Values**             | ▼▼         | ▲           | In the business as usual scenario, the decrease in catch was large enough to drive the catch value down. On the other hand, the catch value is higher under sustainable management. |

### Groupers

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Sustainable</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Biomass**            | ▼▼▼       | ▲▲▲        | **Business as usual**: Continued overfishing and stronger climate change impacts reduce biomass, while catches decrease because of stock depletion.  
**Sustainable management**: Reducing fishing rebuilds biomass and productivity, and thus catches increase in a more sustainable pathway. |
| **Catch**              | ▼▼         | ▲▲          | Under business as usual, the price increases by about 870% while the price decreases under sustainable management by 70%. This is because under the latter scenario, catches of this species increase significantly. |
| **Values**             | ▼▼         | ▲▲          | In the case of status quo, the decrease in catch was large enough to drive the catch value down. On the other hand, the catch value is higher under sustainable management. |

### Large Croakers

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Sustainable</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Biomass**            | ▼▼▼       | ▲▲▲        | **Business as usual**: Continued overfishing and stronger climate change impacts reduce biomass, while catches decrease because of stock depletion.  
**Sustainable management**: Reducing fishing rebuilds biomass. However, to do that, fishing and catches have to be substantially reduced. |
| **Catch**              | ▼          | ▼▼▼        | Under both scenarios, the combined effects of price and catch changes leads to decreases in catch value. |
| **Values**             | ▼          | ▼▼▼        |                                                                          |
## RESULTS BY SPECIES GROUPS

### Sharks

<table>
<thead>
<tr>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>▼▼▼</td>
<td>▲▲▲</td>
<td><strong>Business as usual:</strong> Continued overfishing and stronger climate change impacts reduce biomass, while catches decrease because of stock depletion.</td>
</tr>
<tr>
<td>Catch</td>
<td>▼▼</td>
<td>▼▼▼</td>
<td><strong>Sustainable management:</strong> Reducing fishing rebuilds biomass. However, to do that, fishing and catches have to be substantially reduced.</td>
</tr>
<tr>
<td>Values</td>
<td>▼▼</td>
<td>▼▼▼</td>
<td>Under both scenarios, the combined effects of price and catch changes leads to decreases in catch value.</td>
</tr>
</tbody>
</table>

### Small Pelagics (e.g. sardines)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>▼▼</td>
<td>▲</td>
<td><strong>Business as usual:</strong> Continued overfishing and stronger climate change impacts reduce biomass, while catches continue to increase by heavy unsustainable fishing.</td>
</tr>
<tr>
<td>Catch</td>
<td>▲</td>
<td>▼▼▼</td>
<td><strong>Sustainable management:</strong> Reducing fishing rebuilds biomass of small pelagics which are prey species that also support the higher abundance of predatory species.</td>
</tr>
<tr>
<td>Values</td>
<td>▲▲▲</td>
<td>▼▼▼</td>
<td>Under status quo, both catch and price increase resulting in an increase in catch value.</td>
</tr>
</tbody>
</table>

### Crabs

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Sustainable</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>▼▼</td>
<td>▼▼</td>
<td><strong>Business as usual:</strong> Depletion of predators leads to increased productivity. Continued increases in fishing and stronger climate change impacts reduce biomass, while catches continue to increase by heavy unsustainable fishing.</td>
</tr>
<tr>
<td>Catch</td>
<td>▲▲▲</td>
<td>▼▼▼</td>
<td><strong>Sustainable management:</strong> Reducing fishing rebuilds biomass of predatory species, leading to decrease in productivity of benthic crustaceans.</td>
</tr>
<tr>
<td>Values</td>
<td>▲</td>
<td>▼▼▼</td>
<td>Under status quo, both catch and price increase resulting in an increase in catch value.</td>
</tr>
</tbody>
</table>

Under sustainable management, catch decreases enough to neutralize the projected price increase resulting in a decrease in catch value.
# RESULTS BY SPECIES GROUPS

### Large Pelagics (e.g. tuna)

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Sustainable</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>▼▼</td>
<td>▲▲▲</td>
<td><strong>Business as usual:</strong> Continued overfishing and stronger climate change impacts reduce biomass, while catches decrease because of stock depletion.</td>
</tr>
<tr>
<td><strong>Catch</strong></td>
<td>▼▼</td>
<td>▼▼</td>
<td><strong>Sustainable management:</strong> Reducing fishing rebuilds biomass of predatory species, leading to decrease in productivity of small pelagic fishes.</td>
</tr>
<tr>
<td><strong>Values</strong></td>
<td>▲</td>
<td>▼▼▼</td>
<td>Under sustainable management, both catch and price decrease resulting in a decrease in catch value.</td>
</tr>
</tbody>
</table>

### Demersal Fishes (e.g. sea breams)

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Sustainable</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>▼▼▼</td>
<td>▲▲</td>
<td><strong>Business as usual:</strong> Continued overfishing and stronger climate change impacts reduce biomass, while catches decrease because of stock depletion.</td>
</tr>
<tr>
<td><strong>Catch</strong></td>
<td>▼▼</td>
<td>▲</td>
<td><strong>Sustainable management:</strong> Reducing fishing effort back to long-term sustainable levels rebuilds demersal fish stocks and increases catch. However, some of the slower growing and often more valuable species would take a longer time to recover. Thus, total value is projected to decrease.</td>
</tr>
<tr>
<td><strong>Values</strong></td>
<td>▼▼</td>
<td>▼▼</td>
<td>The combined effect of the two changes results in a decrease in catch value.</td>
</tr>
</tbody>
</table>

Under sustainable management, the combination of catch and price changes leads to a decrease in catch value.

2. although pelagic (fish occupying upper layers of the ocean) and demersal fishes (those occupying lower depths) are poorly represented.


12. Data is available at www.seaaroundus.org


43. Southeast Asian Fisheries Development Center (SEAFDEC). (2012). The Southeast Asian state of fisheries and aquaculture. Bangkok, Thailand: SEAFDEC.


51. Consumption of processed products was reported as their equivalents in fresh fish

52. (http://www.fao.org/docrep/004/ab561e/ab561e05.htm)


62. Obtained from the FERU/SAU (Fisheries Economics Research Unit/Sea Around Us) ex vessel price database described in Sumaila et al. (2007)
