The Future of Indian Ocean and South China Sea Fisheries: Implications for the United States

NATIONAL INTELLIGENCE COUNCIL REPORT

NICR 2013-38, 30 July 2013

This is not an IC-coordinated report.

This paper does not represent US Government views.

Scope Note

The Future of Indian Ocean and South China Sea Fisheries: Implications for the United States

This is not an IC-coordinated report.

In July 2012 the National Intelligence Council (NIC) asked the Stimson Center to examine the role of fisheries in ensuring the food supply and food security of the littoral countries of the Indian Ocean and the South China Sea and resulting implications for US security interests. The Stimson Center produced a draft report analyzing the current status and emerging trends affecting the future sustainability of wild-capture fisheries and marine aquaculture in both regions looking out to 2020 (medium term) and beyond to 2040 (long term). The year 2040 was selected to better allow for the impacts of climate change and potential degradation of fisheries. The draft report assessed potential conflict hotspots in the Indian Ocean and South China Sea related to fisheries and evaluated the roles of relevant regional institutions for the management of fisheries resources. To develop additional details concerning the importance of fisheries to key states, the draft report also included seven regional and national case studies, as well as a study of the potential impacts of climate change.

In September of 2012, the Stimson Center submitted the draft report to a group of six outside experts for peer review. The draft report was then updated and revised to incorporate the experts' comments and inputs. This final report reflects the results of these efforts.

This report is the fourth of five external efforts the NIC has conducted to explore global food security. The first report—***Global Food Security: Key Drivers (NICR 2012-05), 1 February 2012***—was a conference report introducing the topic of food security; the second report—***Global Food Security: Market Forces and Selected Case Studies (NICR 2012-23), 10 May 2012***—explored market forces that will affect food security, and the third report—***Global Food Security: Emerging Technologies to 2040 (NICR 2012-30), 28 August 2012***—identified emerging, potentially breakthrough technologies for agriculture. The fifth report—presently under review—is a detailed case study of over 30 counties. Additionally, a broad report on natural resources developed by Chatham House supported the NIC's ***Global Trend 2030: Alternative Worlds*** report, which was released in early December 2012. Following these external studies, the NIC will lead an Intelligence Community (IC) analytic effort to report on food security and implications for US national security.

This report was prepared by Stimson Center under the auspices of the Director, Strategic Futures Group. It was reviewed by the National Intelligence Council and other members of the Intelligence Community (IC), but was not formally coordinated. The cut-off date for information used in the report was December 2012.

The Future of Indian Ocean and South China Sea Fisheries: Implications for the United States

Executive Summary

The Bottom Line: Stresses in Indian Ocean (IO) and South China Sea (SCS) fisheries might undermine the internal stability of some countries (Bangladesh, the Philippines, Indonesia, and Vietnam) as well as bilateral and regional relations (India-Bangladesh, India-Pakistan, and India-Sri Lanka as well as China and its Southeast Asian neighbors). The fisheries that provide an important dietary staple to many of the 4 billion people living around these two areas are at risk of continued overexploitation. Looking out to 2020 and beyond to 2040, the dual challenge of rising demand from growing populations and economies, colliding with increasing pressure on supply stemming from overexploitation, pollution, habitat destruction, and climate change, will impose serious additional pressures on IO and SCS fisheries. As a result, some fisheries in the region may close down. Aquaculture (farm fishing) in or around the littorals of both the IO and SCS is growing quickly and in some cases offsetting the decline of wild fisheries.

Fisheries provide an important dietary staple—fish protein—to many of the 2.49 billion people of the Indian Ocean (IO) littoral and some 1.87 billion people living in eight Southeastern Asian countries, Taiwan, and three Chinese provinces around the South China Sea (SCS). Fisheries also constitute a key economic resource for many coastal communities.

- Two regions of the world projected to experience some of the heaviest population growth during the next 40 years—Sub-Saharan Africa and South Asia—at least partially or entirely front the Indian Ocean. Thus these marine waters will be relied upon more intensely in coming decades to meet growing food fish demand.
    - In 2010, roughly 14.6 percent of the world's total ocean catch came from Indian Ocean waters, showcasing the Indian Ocean's growing importance as a lynchpin of both regional—and, increasingly, global—food security. Fish protein constitutes a critical dietary element for populations throughout the Indian Ocean region. Populations in Egypt, Malaysia, Mozambique, Seychelles, Tanzania, and Thailand receive at least one-fifth of their animal protein by consuming fish; populations in Bangladesh, Comoros, Indonesia, Maldives, and Sri Lanka receive more than half of their animal protein from this source.
- The countries bordering the South China Sea—Brunei, Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam—rank among the top fish-producing and -consuming countries in the world in terms of both marine catch and aquaculture. Many people in these countries depend upon the fishing industry for both food security and income.

According to the UN Food and Agriculture Organization (FAO), the average daily seafood consumption per person among the littoral states was almost double the global average. Further, three of the top five fishery-commodity-exporting nations also hail from the region, with China at $10.2 billion in 2009, Thailand at $6.2 billion, and Vietnam at $4.3 billion.

Total wild fish capture production in the IO and SCS has risen substantially since the 1970s, but since 1999 it has begun to plateau, or even decline for some species. Aquaculture (fish farming) in or around the littorals of both the IO and SCS is growing fast and in some cases offsetting the decline of wild fisheries.

- The health of fisheries in both the IO and SCS is difficult to assess based on total production, which varies slightly from year to year, and data on catches is also frequently inadequate. Total capture from global marine fisheries has remained relatively stable recently, but it trended downward from 80.4 million metric tons in 2007 to 77.4 million metric tons in 2010. The total national wild fish catch of some countries in the region can include significant amounts of fish harvested outside coastal waters and the 200 nautical-mile Exclusive Economic Zone (EEZ), and in some cases, catches from beyond the IO or SCS. Despite the appearance of relative stability in the composition of the catch by species and distribution by country, some fishing areas and the types of fish caught have been changing markedly in recent years. Fish size has been steadily decreasing and mature fish are increasingly scarce. In general, the most commercially important fish species in both bodies of water are considered to have been overfished.
- The rise of marine aquaculture is an important trend throughout the region, with the potential to reduce the strain on wild fish stocks. India, Indonesia, Bangladesh, Thailand, Egypt, and Burma ranked among the world's top 10 aquaculture producers in 2010. Those countries combined to farm 11.3 million tons of fish in 2010—roughly the same amount as the total tonnage of fish harvested from the Indian Ocean's wild-capture fisheries that year. China's aquaculture production already constituted more than double that of capture fisheries by weight and about 60 percent of total world production in 2010.

Looking out to 2020 and beyond to 2040, the dual challenges of rising demand from growing populations and economies, colliding with increasing pressures on supply—stemming from overexploitation, pollution, habitat destruction, and climate change—will impose serious pressures on fisheries. Total production[1] in 2020 in the IO and SCS is likely to be somewhat less to only slightly more than recent production.

- **Indian Ocean fisheries are at risk of continued overexploitation, a trend that could lead to the outright collapse of some fisheries in the region.** The FAO has reported that of 47 Indian Ocean fish species with sufficient available data to evaluate the condition of those species' wild fish stocks, 41 were either "moderate-full" exploited or "full-overexploited." The status of most Indian Ocean fish species is listed as "unknown," due to inaccurate reporting or lack of reporting.
- **The ability of South China Sea fisheries to accommodate mounting demand is**

[1] Total production is often expressed in "landings"—that part of the fish catch that is put ashore and typically measured in tons.

questionable. Most rich fishing environments, such as shallow reefs and shoals, have already been exploited to their limit or beyond, leaving few relatively underexploited areas. Areas of the South China Sea may have the potential to support more intensive fishing, but data on those fisheries remain unclear, and the technological impediments to efficiently harvesting fish far below the surface may still pose a challenge. In addition, available analyses suggest that climate change could engender substantial shifts in catch sizes and locations by mid-century.

- Coastal and marine areas are among the most vulnerable of all environments to global climate change. Projected impacts from global warming include rising sea levels, stronger tropical cyclones, larger storm surges, increasing sea surface temperatures, and—as the oceans absorb more of the carbon dioxide that human activities emit to the atmosphere—growing acidification of surface waters. Climate change will also interact with other human stressors on marine systems, such as overfishing, habitat destruction, and marine pollution, in complex patterns. Significant portions of the Indian Ocean and South China Sea already are among the most highly affected marine ecosystems on earth.

Stresses in the Indian Ocean and South China Sea fisheries might undermine the internal stability of some countries as well as bilateral and regional relations. Given other security/stability concerns in the region (sovereignty issues, fossil resources, and freedom of navigation), fisheries will likely remain of secondary importance to US security interests. Where competition for fish overlaps with active territorial disputes, contending claims to fisheries will continue to exacerbate bilateral and regional tensions.

- Poor countries with high levels of seafood consumption (such as Bangladesh, the Philippines, Indonesia, and Vietnam) are already facing significant economic losses owing to the collapse of in-shore fisheries, though aquaculture probably will provide some replacement employment in the medium term (out to 2020). As industrial fishing and other intensified practices deplete traditional fishing grounds, many fishers cross maritime boundaries into other fishing areas. These trespasses can exacerbate political tensions between neighbors over undemarcated or contested maritime or territorial boundaries.

    - In South Asia, for example, Indian fishers have clashed with their competitors in Bangladesh, Pakistan, and Sri Lanka, and fishers on all sides have been subject to arrest, seizure of their boats, and even extra-judicial killings.

    - In the South China Sea, maritime boundary disputes and the related competition for control of fisheries and oil and natural gas deposits are exacerbating relations between China and its Southeast Asian neighbors.

The United States has a range of possible initiatives to ameliorate or slow the threat posed by the stresses on food security, livelihoods, and regional stability caused by the degradation of South China Sea fisheries and other aquatic food sources. Some options include scientific and technical expertise, human and institutional capacity-building, support to regional cooperation organizations, the retraining of fishers for other employment, and support to the production of substitution food sources.

This page has been intentionally left blank.

Contents

This page has been intentionally left blank.

This paper does not represent US Government views.

Discussion

The Bottom Line: Stresses in Indian Ocean (IO) and South China Sea (SCS) fisheries might undermine the internal stability of some countries (Bangladesh, the Philippines, Indonesia, and Vietnam) as well as bilateral and regional relations (India-Bangladesh, India-Pakistan, and India-Sri Lanka as well as China and its Southeast Asian neighbors). The fisheries that provide an important dietary staple to many of the 4 billion people living around these two areas are at risk of continued overexploitation. Looking out to 2020 and beyond to 2040, the dual challenge of rising demand from growing populations and economies, colliding with increasing pressure on supply stemming from overexploitation, pollution, habitat destruction, and climate change, will impose serious additional pressures on IO and SCS fisheries. As a result, some fisheries in the region may close down. Aquaculture (farm fishing) in or around the littorals of both the IO and SCS is growing quickly and in some cases offsetting the decline of wild fisheries.

Introduction

Fisheries in the Indian Ocean (IO) and South China Sea (SCS) provide an important dietary staple—fish protein—to many of the 2.49 billion people of the Indian Ocean littoral and some 1.87 billion people across eight Southeastern Asian countries, three Chinese provinces, and Taiwan.

The relationship between fisheries and future food security is multidimensional. The concept of food security emerged in the early 1970s as a consequence of a global food crisis and rising prices that placed basic foodstuffs out of the reach of tens of millions of the world's poorest people. Over time the concept of food security has been expanded. A World Food Summit organized by the UN Food and Agriculture Organization (FAO) and held in Rome in 1996 declared that, "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

The expanded concept takes into account not just food output but also food availability, access, utilization (which is enhanced by clean water, sanitation, and health care), and stability. In the broadest sense, food security does not depend on any one food or commodity, as long as specific diets have not been imposed by social mores, customs, and religions.

Both wild-capture fisheries and aquaculture contribute to regional fish production. Globally, marine fish species constituted about 82 percent of total production of wild-capture fisheries by weight (metric tons) in 2010, followed distantly by mollusks, crustaceans, and diadromous fishes (fish that spawn in fresh water or live part or all of their lives in either fresh or salt water). **Total capture from global marine fisheries has remained relatively stable, but it trended downward from 80.4 million metric tons in 2007 to 77.4 million metric tons in 2010.** The total national wild fish catch of some countries in the region can include significant amounts of fish harvested outside coastal waters and the 200 nautical-mile Exclusive Economic Zone (EEZ). Despite the appearance of relative stability, the compositions of the catch by species and distribution by country, fishing area, and species in some cases have been changing markedly in recent years.

Although the fate of certain fish species during the next 10-30 years is unclear due to heavy rates of exploitation, declines in wild fish availability will be mitigated somewhat by the rise of aquaculture, or fish farming**. Aquaculture in or around the littorals of both the IO and SCS is growing quickly and in some cases supplanting wild fisheries.**

China's aquaculture production already constituted more than double that of capture fisheries by weight and about 60 percent of total world production in 2010. China's aquaculture production—which mainly consists of freshwater carp—is primarily carried out inland. For India and Vietnam, aquaculture is equal to or slightly more than capture fish. Vietnam's aquaculture production, which mainly takes place in the Mekong Delta, is a significant contributor to GDP and exports. Thailand's aquaculture production has reached 40 percent of capture fishing by weight and, as in the case of Vietnam, is a major source of export earnings. The Philippines and Sri Lanka have only begun to develop aquaculture on a large scale.

Aquaculture has its own upper limit, however, owing to many variables and uncertainties. These include the availability of "trash fish" and other sources of fish-based food (except for carp, China's main aquaculture species); pollution from urbanization and agricultural runoff, the impact of upstream dams on water quality and the limits of suitable coastal land and shallows suitable for fish pens; and climate change effects (rising sea levels and more frequent and destructive storms). In addition, aquaculture competes with wild fisheries in several ways, including the destruction of shoreline mangroves and tidal wetlands that are the breeding grounds for shrimp and many wild fish species.

The IO and SCS regions' population—with the exception of China—almost certainly will grow faster than aquaculture during the next 20 years before stabilizing around 2050. The population of IO countries is expected to expand by 25 percent between now and 2030 while that of the SCS is projected to only grow 8 percent by 2040. The slower population growth in the South China Sea is primarily the consequence of a declining population in China. Because of its one-child policy, China's population is projected to peak at 1.4 billion in 2026, by which time it will be surpassed by India, which is growing three times as fast.

The health of fisheries in both the IO and SCS is difficult to assess based on total production, which varies slightly from year to year on either side of stable, but fish size has been steadily decreasing and mature fish are increasingly scarce. **In general, the most commercially important fish species in both bodies of water are considered to have been overfished.**

Looking out to 2020 and beyond to 2040, the dual challenges of rising demand from growing populations and economies, colliding with increasing pressures on supply stemming from overexploitation, pollution, habitat destruction, and climate change, will impose serious pressures on fisheries. Total production[2] in 2020 in the IO and SCS is likely to be somewhat less to only slightly more than recent production.

Growing recognition of the urgent need for cooperative management for sustainability could, if acted upon effectively, contribute to stability, but significant expansion of capture marine fish production is unlikely due to constraints on maximum biomass. Even with the optimum level of policies, laws, enforcement, and

[2] Total production is often expressed in "landings"—that part of the fish catch that is put ashore and typically measured in tons.

regional cooperation, total wild fish production in both the IO and SCS is likely to decline substantially or at best increase marginally by 2020 and 2040 due to the limits of maximum sustainable yield (MSY)[3].

Carrying capacity is affected by a variety of factors, such as the availability of nutrients and numbers of predators as well as the impacts of climate change. Many fish and other aquatic food sources in the Indian Ocean and South China Sea have already reached or exceeded their MSY, or likely will do so soon. The carrying capacity of the fisheries is likely to continue to decline because of pollution, sea-warming due to climate change, the destruction of coral reefs, and other environmental factors.

Stresses on fisheries in both the Indian Ocean and South China Sea might undermine the internal stability of some countries as well as bilateral and regional relations. Poor countries whose populations consume a lot of seafood, such as Bangladesh, the Philippines, Indonesia, and Vietnam are already facing economic losses owing to the collapse of in-shore fisheries. Aquaculture will probably provide some replacement employment in the medium term.

Overall the state of fisheries is likely to have secondary importance to US national security interests in both the Indian Ocean and South China Sea from the point of food availability and local livelihoods because of the potential for food and employment substitution. **The competition for fish is playing a harmful role in territorial disputes. Maritime boundary disputes between China and its Southeast Asian neighbors and the related competition for control of fisheries and oil and natural gas deposits are currently sources of tensions in the South China Sea. These disputes are being exacerbated by the boundary dispute between Japan and China in the East China Seas.**

Indian Ocean: Current Fishery Status and Future Sustainability

The world's third largest oceanic space by surface area, the Indian Ocean covers more than 72.5 million square kilometers, or roughly one-fifth of the total ocean surface area on earth. In terms of fisheries analysis, the Indian Ocean has two distinct areas: the Eastern and Western Indian Ocean. See Map.

Wild coastal- and deep-sea fisheries across both sections of the Indian Ocean provide an important dietary staple—fish protein—to many of the Indian Ocean littoral's 2.49 billion people, who are spread across small islands and coastal nations extending from South Africa to South Asia to Australia. In 2010, roughly 14.6 percent of the world's total ocean catch came from Indian Ocean waters, showcasing the Indian Ocean's growing importance as a lynchpin of both regional—and, increasingly, global—food security. By 2030, the population of the Indian Ocean littoral is projected to rise to approximately 3.18 billion, or 690 million more people than the region's 2010 population. Such growth will require sustainable use of fisheries if certain fish species are to survive in the wild. At current rates of exploitation, however, this prospect seems unlikely.

[3] Maximum sustainable yield or MSY is, theoretically, the largest yield/catch that can be taken from a species' stock over an indefinite period and is considered to be the optimum catch to maximize the health and reproduction of individual species. It is linked to the ability of aquatic areas to support marine life (often called carrying capacity).

Indian Ocean

DI Cartography Center/MPG 906027AI (G03581) 7-13

Fish protein constitutes a critical dietary element for populations throughout the Indian Ocean region. The populations of Egypt, Malaysia, Mozambique, Seychelles, Tanzania, and Thailand receive at least one-fifth of their animal protein by consuming fish, while the populations of Bangladesh, Comoros, Indonesia, Maldives, and Sri Lanka receive more than half of their animal protein from this source. The daily kilocalories per capita that seafood provides for Indian Ocean littoral countries are shown in the table on page 5.

Seafood Consumption in States Bordering the Indian Ocean, 2002-2009
(Kilocalories Per Capita Per Day)

Country	2002	2003	2004	2005	2006	2007	2008	2009	Total Kilocalories (2009)
Australia	32	36	42	37	38	38	37	36	3,261
Bahrain	-	-	-	-	-	-	-	-	-
Bangladesh	24	25	26	27	28	29	29	33	2,481
Burma	35	37	51	52	63	71	81	88	2,493
Comoros	53	56	57	56	54	56	54	53	2,139
Djibouti	2	2	3	2	4	4	4	4	2,419
East Timor (Timor-Leste)	-	-	-	-	-	-	-	-	-
Egypt	25	27	28	28	29	30	29	29	3,349
Eritrea	3	3	2	1	3	1	1	1	1,640
India	8	8	8	9	9	9	11	10	2,321
Indonesia	42	42	42	45	45	48	50	51	2,646
Iran	10	12	12	13	14	15	15	15	3,143
Iraq	-	-	-	-	-	-	-	-	-
Israel	31	31	35	32	27	33	32	32	3,569
Jordan	9	10	11	9	11	13	14	14	2,977
Kenya	6	5	5	7	8	6	6	6	2,092
Kuwait	16	23	19	20	27	26	25	24	3,681
Madagascar	13	13	13	14	13	14	14	14	2,117
Malaysia	111	105	97	92	102	106	104	102	2,902
Maldives	390	243	169	343	219	292	289	285	2,720
Mauritius	35	29	34	38	48	42	41	41	2,993
Mozambique	3	9	8	8	9	8	10	12	2,112
Oman	-	-	-	-	-	-	-	-	-
Pakistan	4	4	4	4	4	4	4	4	2,423

(Continued on next page…)

(…Continued from previous page)

Country	2002	2003	2004	2005	2006	2007	2008	2009	Total Kilocalories (2009)
Qatar	-	-	-	-	-	-	-	-	-
Saudi Arabia	14	13	16	17	19	19	19	18	3,076
Seychelles	121	118	116	124	125	109	108	108	2,426
Singapore	-	-	-	-	-	-	-	-	-
Somalia	-	-	-	-	-	-	-	-	-
South Africa	14	14	19	16	15	14	14	14	3,017
Sri Lanka	49	51	50	36	45	49	49	48	2,426
Sudan	-	-	-	-	-	-	-	-	-
Tanzania	18	18	16	17	16	13	12	13	2,137
Thailand	58	56	59	61	59	57	48	50	2,862
United Arab Emirates	42	42	45	37	39	36	31	28	3,245
Yemen	13	18	20	16	15	9	9	8	2,109
World Average	29	29	30	31	32	33	33	33	2,831

Figures expressed as kilocalories per capita per day.
Data Source: UN Food and Agriculture Organization.

Seafood possesses high levels of protein, vitamins, and minerals that help ensure a nutritionally balanced diet. Because seafood is low in caloric content, however, it does not appear to figure prominently into human diets when viewed alongside total human caloric intake per day. (According to the FAO, any human diet of less than 1,800 kilocalories per day signifies chronic hunger; in most countries, fish typically accounts for only 20-30 kilocalories per day.) Viewing fish consumption in this context understates seafood's importance in supplying populations with highly nutritious animal proteins, particularly in coastal countries and small island nations of the developing world where populations do not have access to a variety of animal protein sources. In many of these countries, seafood enhances food security and public health by providing a critical protein source, bolstering the nutritional value of diets otherwise largely dependent on a single low-protein staple crop. According to the FAO, seafood protein constitutes about 14-16 percent of humans' total animal protein consumption. Nevertheless, one-fifth of the global population receives at least 20 percent of total animal protein from seafood, and an estimated one billion people depend on seafood as their primary source of animal protein. The Centers for Disease Control and Prevention recommend that 10-35 percent of daily caloric intake be derived from protein.

Fish species tend to migrate seasonally—in some cases within the Indian Ocean basin, and in other cases between the Indian Ocean and adjacent seas and oceans, including the South China Sea and the

Atlantic and Pacific oceans. These seasonal movements are driven by fish species' need to find new food supplies and to reproduce, or by ocean currents. These migrations make it more difficult to gather reliable data documenting the production capacity of fisheries. According to the FAO, "information on shared and transboundary stocks is often missing or inadequate and relevant institutions arrangements are often missing." Although poor and/or insufficient data continues to hamper accurate assessments of fisheries health in the case of some species, regional fishery bodies such as the Asia-Pacific Fishery Commission (APFIC), the Indian Ocean Tuna Commission (IOTC), the Regional Commission for Fisheries (RECOFI), the South West Indian Ocean Fisheries Commission (SWIOFC), and the FAO have collectively found that pressure on Indian Ocean fish species has increased during the last several decades as world population has grown, demand for fish products has increased, and fishing technologies have become more efficient and sophisticated.

In the mid-20th century, for instance, less than 900,000 tons of fish were harvested annually from Indian Ocean waters, according to the FAO. That figure had swelled to 11.3 million tons per year by 2010, as the Indian Ocean fisheries were being harvested with unprecedented intensity. Some of the fish products originating from the Indian Ocean are consumed as far away as Europe, showing that fish caught in the Indian Ocean also contribute protein to the diets of those living far from the Indian Ocean littoral. Although the fate of certain fish species in Indian Ocean waters during the next 10 to 30 years is unclear due to heavy current rates of exploitation, fluctuations in wild fish availability will be mitigated to some extent by the rise of aquaculture, or fish farming. Already an important driver of economic growth in some Indian Ocean countries—particularly in Southeast Asia—the aquaculture industry is poised to further establish itself throughout the region in the years ahead, helping to fortify the food security of the Indian Ocean littoral.

Current Status of Indian Ocean Fisheries

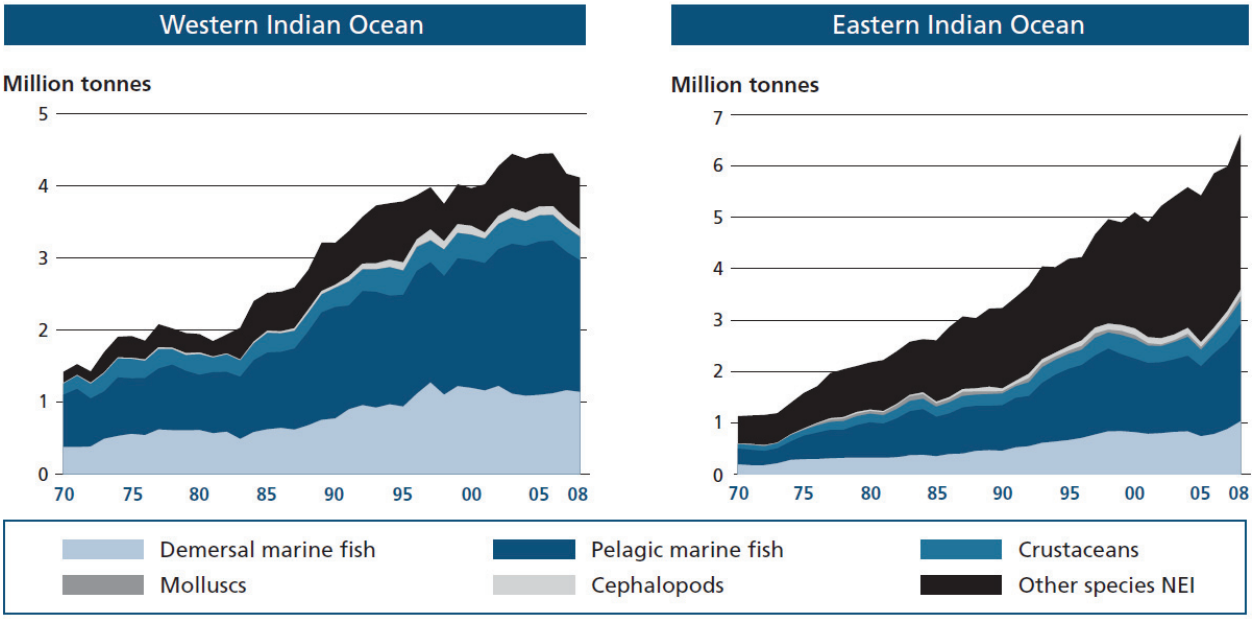
Since 1970 in the Eastern Indian Ocean, annual catch volumes of demersal marine fish, mollusks, pelagic marine fish, cephalopods, and crustaceans have climbed steadily. By 2010, the Eastern Indian Ocean had become the world's second-most heavily fished area of the world in terms of metric tons of fish captured (nearly 7 million), following only the Northeast Atlantic (roughly nine million metric tons). The increase in fishing intensity has been particularly notable in recent years; catch volumes rose by 17 percent between 2007 and 2010 alone, with particularly intensive fishing in the Andaman Sea and the Bay of Bengal.

Most captures from wild fisheries in the Eastern Indian Ocean are not affiliated with a certain species, but the primary fish species harvested in this section of the Indian Ocean include tuna, Indian mackerels, Hilsa shad, herring, and sardines. As certain fish species are drawn down at unsustainable levels, the marine food chain may be eventually thrown out of balance, with unknown long-term impacts on the health of other species either higher or lower on the food chain. Further, despite the increased rates of fishery exploitation, it has been difficult to ascertain the long-term resiliency of many wild fish stocks due to a lack of detailed historical fisheries data. Often, data does not distinguish catch by species. For example, in recent years, 42 percent of annual catch in the Eastern Indian Ocean has been labeled simply "marine fishes not identified." This highlights an enormous contemporary problem in evaluating the production capacity of wild fisheries in the Indian Ocean; without accurate reporting of harvested fish species, it becomes virtually impossible to ascertain their numbers in the wild and determine the sustainability of fish stocks.

In the Western Indian Ocean, annual catch volumes of demersal marine fish, mollusks, pelagic marine fish, cephalopods, and crustaceans rose steadily between 1970 and 2005. However, the level of exploitation has stabilized during the last seven years, possibly reflecting diminished fish stocks that have not yet rebounded from the overfishing during previous decades. In 2006, fish production in the Western Indian Ocean reached an all-time high of 4.5 million tons, but this figure has since dropped, most recently to 4.3 million tons in 2010. The reduced catch of recent years is partially attributed to scaled-back fishing activity in the region as a result of increased piracy off the Somali coast.

In 2010, the Western Indian Ocean ranked as the third most heavily fished area of the world, behind the Northeast Atlantic (#1) and Eastern Indian Ocean (#2), and just ahead of the Eastern Central Atlantic (#4). In the Western Indian Ocean, fisheries data is somewhat more detailed than in the Eastern Indian Ocean. The primary fish species captured in wild fisheries of the Western Indian Ocean traditionally include skipjack tuna, Indian oil sardine, croakers, yellowfin tuna, hairtails, and scabbardfishes. Certain migratory species, such as the narrow-based Spanish mackerel, which travels seasonally in the Red Sea, Arabian Sea, Gulf of Oman, and the Persian Gulf, are already severely threatened by overexploitation. Further, of 140 fish species common in the jurisdiction of the Southwest Indian Ocean Fisheries Commission in 2009, 65 percent of wild fish stocks were being harvested to their maximum sustainable capacity, 29 percent were being over-harvested, and only 6 percent were not harvested to their full capacity.

Capture Fisheries Production in Indian Ocean Marine Areas, 1970-2010



Date Source: UN Food and Agriculture Organization.

Projections on the Future of Indian Ocean Fisheries

Two regions of the world projected to experience some of the heaviest population growth over the next 40 years—Sub-Saharan Africa and South Asia—at least partially or entirely front the Indian Ocean. Thus these marine waters will be relied upon more intensely in coming decades to meet growing food fish demand. The Indian Ocean's many wild fisheries will find themselves heavily depleted to support growing food needs, running the risk of overexploitation and outright collapse of some fish stocks, such as tuna, that are currently being intensively harvested. The situation will be exacerbated by the use of fishery resources for nonhuman consumption, such as livestock feed. Due to their proximity to land, coastal fisheries are more likely than deep-sea fisheries to bear the brunt of heightened fishery exploitation as populations across the Indian Ocean littoral increase.

In the medium-to-long term, the percentage of the regional population's daily dietary needs supplied by fish protein is unlikely to change appreciably. However, the growth in the number of people who will need to be fed will increase the strain on the Indian Ocean's wild fish stocks. Along the Indian Ocean rim sit four of the world's most populous countries: India (#2 at 1.259 billion people), Indonesia (#4 at 240 million), Pakistan (#6 at 180.4 million), and Bangladesh (#8 at 152.9 million). **Collectively, the population of these countries equals 1.83 billion—or one of every four people on earth.** India, Indonesia, Pakistan, and Bangladesh will continue to experience significant population growth in the decades ahead, with serious implications for regional and global food security generally, as well as wild Indian Ocean fisheries in particular.

Mid-Range Population Growth Projections for Select Key States Bordering the Indian Ocean

Population in Thousands				
Country	2010	2020	2040	2040 as Multiple of 2010
Bangladesh	148,692	167,256	190,934	1.3
Egypt	81,121	94,810	116,232	1.4
India	1,224,614	1,386,909	1,627,029	1.3
Indonesia	239,871	262,569	290,223	1.2
Iran	73,974	81,045	85,893	1.2
Kenya	40,513	52,564	80,975	2
Pakistan	173,593	205,364	257,778	1.5
Somalia	9,331	12,237	21,669	2.3
Tanzania	44,841	61,081	107,737	2.4
Total	1,874,375	1,977,893	2,029,574	
World Total	6,895,889	7,656,528	6,874,041	
percent of World Total	27.1	25.8	22.9	

Data Source: UN Department of Economic and Social Affairs, Population Division.

In light of these projections, Indian Ocean fisheries are at risk of continued overexploitation, a trend that could lead to the collapse of some fisheries in the region. For those species for which relatively accurate and comprehensive catch reporting exists (such as yellowfin tuna, Natantian decapods, bigeye tuna, and narrow-based Spanish mackerel), stocks in the Western Indian Ocean in 2005 were ranked as either "fully exploited" or "fully-to-overexploited." In the Eastern Indian Ocean, species for which accurate and comprehensive reporting exists (such as Indian mackerel, Hilsa shad, and tuna) were similarly ranked in 2005 as either "fully exploited" or "fully-to-overexploited." Only herrings and sardines were ranked as "moderately exploited." Further, the FAO's October 2005 *Review of the State of World Marine Fishery Resources* found that of 47 Indian Ocean fish species with sufficient available data to evaluate the condition of those species' wild fish stocks, 41 were judged to be either "moderate-to-fully" exploited or "fully-to-overexploited." The status of most Indian Ocean fish species was listed as "unknown," due to inaccurate reporting or lack of reporting altogether. We do not know how long it may take wild fish stocks to recover once stocks of particular fish have been depleted.

In addition to human population pressures, principal threats to the sustainability of the Indian Ocean's wild fisheries include illegal, unreported, and unregulated fishing; ecosystem degradation; destructive fishing practices such as bottom-trawling; and pollution of coastal zones due to the flushing of land-based pollutants into shallow waters. Anecdotal reports indicate that overfishing and illegal fishing are on the rise, yet concrete statistics on this trend are difficult to obtain. One of the primary drivers of unregulated fishing is the fact that it is generally far more lucrative than regulated fishing; governments and multilateral fishing organizations throughout the Indian Ocean littoral have either insufficient maritime patrol capacity or a lack of political will to enforce fishing quotas of particular species.

The absence of dedicated fishery experts in the Indian Ocean littoral is notable. Since fishery stock assessment is not a common subject taught at the region's institutes of higher- and/or vocational education, the lack of fishery experts may be a problem that lingers for some time. Put in a global context, however, insufficient monitoring capabilities are not limited to the Indian Ocean fisheries. In 2008, for instance, the US Government declared that the United States was facing a looming shortage of doctoral-level fishery experts with the technical background to analyze the health of wild fisheries in US waters. A joint US Department of Commerce and Department of Education report[4] found that there would need to be a 150 percent increase in stock-assessment scientists between 2008 and 2018 to resolve the shortfall.

Aquaculture in the Indian Ocean Littoral

The rise of marine aquaculture represents an important trend throughout the Indian Ocean rim with the potential to reduce strain on wild fish stocks. Across the Indian Ocean littoral, the pace of aquaculture development has been uneven to date—fish farming has developed slower in southeastern Africa than it has in southeastern Asia, for example—yet the growth of the sector throughout the region as a whole has been undeniable. During the mid-2000s, the global aquaculture industry expanded at an annual rate of 6.9 percent, with populous Indian Ocean countries such as India, Indonesia, and Bangladesh among the world leaders, according to the FAO.

[4] Report to Congress: *The Shortage in the Number of Individuals with Post-Baccalaureate Degrees in Subjects Related to Fishery Science*, September 2008.

The foothold of the aquaculture industry in regional economies of the Indian Ocean is poised to grow in the decades ahead, owing in part to the efforts of regional bodies like the Network of Aquaculture Centres in Asia and the Pacific (NACA) that promote best practices and build technical capacity. Fish farming is particularly prevalent in Bangladesh, Burma, Egypt, India, Indonesia, and Thailand, all of which ranked among the world's top 10 aquaculture producers in 2010. That same year, those countries combined to farm 11.3 million tons of fish—roughly the same amount as the total tonnage of fish harvested from the Indian Ocean's wild-capture fisheries in 2010. Meanwhile, marine aquaculture has proven slower to take root in smaller Indian Ocean island nations such as Sri Lanka, which lack the protected coastal bays and inlets that are typically home to fish-farming operations.

Aquaculture in the Indian Ocean region offers many of the same benefits that it does elsewhere: reliability, convenience, dependability, and comparatively low transportation and processing costs. An important source of fish protein for coastal populations, aquaculture farms are typically built in easily accessible areas, such as mangrove swamps and shallow coastal zones. If aquaculture farms are maintained regularly, they can produce protein reliably, providing an important buffer against wild fisheries' seasonal variability in fish availability. Aquaculture has also proven to be an important driver of economic activity and a lucrative stream of export growth in Indian Ocean countries traditionally dependent on tourism, allowing these countries to diversify their economies. Many of these countries have few natural resources.

Despite the vibrancy of the industry and its undeniable contribution to Indian Ocean food security, however, aquaculture is not a risk-free undertaking. Fish farms pose a serious threat to delicate marine ecosystems in shallow coastal waters (such as lagoons and estuaries), as improperly treated wastewater from aquaculture operations can pollute these areas, possibly damaging nearby wild fisheries. Fish farms built in and around mangrove swamps can damage these vital habitats, which provide an important buffer against the tidal surges that accompany tropical storms. Meanwhile, aquaculture can also threaten marine biodiversity because introduced species may compete with native or indigenous species. In particular, aquaculture can place pressure on certain wild-capture fish stocks because some low-value wild fish species—known as "trash fish"—are harvested in large volume to be used as feed to grow farm-raised fish. This reliance on wild fish stocks for feed in some aquaculture operations places an inherent limit on their productive potential.

The crowded conditions of fish farms also lend themselves to the spread of disease, posing an ever-present and potentially serious economic threat to the industry. Until 2011, the Western Indian Ocean had been one of the last maritime domains to avoid the "white spot syndrome," a virus affecting more than 35 species of crustaceans around the world. In 2011-2012 the disease emerged at separate times in Mozambique and Madagascar, whose respective fish farms are separated by a 430-mile wide channel. Outbreaks of contagious disease can disrupt international trade in seafood and necessitate the destruction of entire fish stocks at the farms. This costs businesses millions of dollars in lost profits and deals a heavy blow to countries that have grown economically dependent on export-oriented aquaculture. Finally, rarer events, such as tsunamis, can also wreak havoc on fish farms. The 2004 Indian Ocean tsunami decimated aquaculture operations from the Seychelles and Maldives to Sri Lanka, Thailand, and northern Sumatra in Indonesia, causing tens of millions of dollars in economic damage.

Still, even in light of these many risks, aquaculture appears poised to become a more important staple of food security in the Indian Ocean region. The trend taking root in this region reflects a larger global trend

that has been unfolding since the early 1970s. The FAO anticipates that aquaculture may soon produce more seafood annually than wild fisheries for the first time in human history. Although the industry is already well-established in the eastern Indian Ocean rim, the over-fished waters of the Western Indian Ocean rim could see the greatest aquaculture growth in the years ahead. In the waters off east Africa, countries like Mozambique, Madagascar, and the Seychelles are likely to continue to develop their export-oriented aquaculture industries. Meanwhile, as a sign that the industry is probably in the region to stay, aquaculture also may soon become institutionalized there. During a July 2012 FAO meeting attended by representatives of 124 countries, the body formally endorsed a measure introduced last year by Sri Lanka to set up a Global Aquaculture Fund, which will provide financial and technical assistance to help small-scale farmers participate in the industry.

South China Sea: Current Fishery Status and Future Sustainability

South China Sea

DI Cartography Center/MPG 903291AI (G03263) 7-13

The expansive area of the South China Sea covers some 3.5 million km^2. The coastal zones of this sea are generally shallow, around 200 meters or less in depth, while the deeper abyssal plains of the central and northeast areas, called the South China Sea Basin, descend to a maximum depth of 5,000 meters. Featuring a wide range of islets, reefs, atolls, banks, coastal zones, and the open ocean, the varied waters of the South China Sea are some of the most biologically diverse and productive on the planet. The South China Sea waters include the contested island groups of the Paracels and Spratlys.

Southeast Asia: Large Marine Ecosystem (LME) 36 Line and Major Fishing Area (MFA) 71

DI Cartography Center/MPG 904078AI 7-13

The South China Sea falls within two different zones with different nomenclatures: the FAO's Major Fishing Area (MFA) 71 and the National Oceanic and Atmospheric Administration's (NOAA) Large Marine Ecosystem 36. MFA 71, which contains the Western Central Pacific, does not include the Gulf of Tonkin, Hainan Island, the Chinese EEZ or Taiwan, but it does extend well into the fish-rich South Pacific outside the South China Sea. NOAA's LME 36 conforms to the geographic boundaries of the South China Sea, excluding the Gulf of Thailand (see map above). This latter definition of the South China Sea's geographic boundaries is technically more appropriate for this study than MFA 71 because data from that MFA does not distinguish between waters inside or outside the South China Sea. (The most recent data

available for LME 36—circa 2006, and based on research done by the Seas Around Us project—is older than the most recent data available from the FAO, which is currently available up to 2010.)

The countries bordering the South China Sea—Brunei, Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam—rank among the top fish-producing and -consuming countries in the world in terms of both marine catch and aquaculture, with many people relying on the fishing industry for both food security and income. According to the FAO, the average consumption per person each day of seafood among the littoral states was almost double the global average (see table below). Further, three of the top five fishery commodity exporters are in the region, with China at $10.2 billion in 2009, Thailand at $6.2 billion, and Vietnam at $4.3 billion.

Seafood Consumption in States Bordering the South China Sea, 2002-2009
(Kilocalories Per Capita Per Day)

Country	2002	2003	2004	2005	2006	2007	2008	2009	Total Kilocalories (2009)
Brunei	59	62	59	56	59	45	44	43	3,088
Cambodia	67	56	47	57	72	72	72	71	2,382
China	35	37	38	39	40	43	45	45	3,036
Indonesia	42	42	42	45	45	48	50	51	2,646
Malaysia	111	105	97	92	102	106	104	102	2,902
Philippines	57	58	59	63	64	69	68	70	2,580
Thailand	58	56	59	61	59	57	48	50	2,862
Vietnam	34	40	45	47	43	50	51	54	2,690
Regional Average	58	57	56	58	60	61	60	61	2,273
World Average	29	29	30	31	32	33	33	33	2,831

Figures expressed as kilocalories per capita per day.
Source: U.N. Food and Agriculture Organization.

Despite the high growth rate of the South China Sea's fish production—which has expanded from a little more than half a million metric tons in 1950 to reportedly more than six million metric tons at present—the bio-resources of the South China Sea are not unlimited; such resources face a wide range of threats to their future sustainability and health. Further, as in the case of Indian Ocean fisheries, a lack of reliable data compounds the difficulty of identifying sustainable catch levels for fish species in the South China Sea; insufficient data potentially hides negative trends in production and limits the understanding of impacts from illegal, unreported, and unregulated fishing.

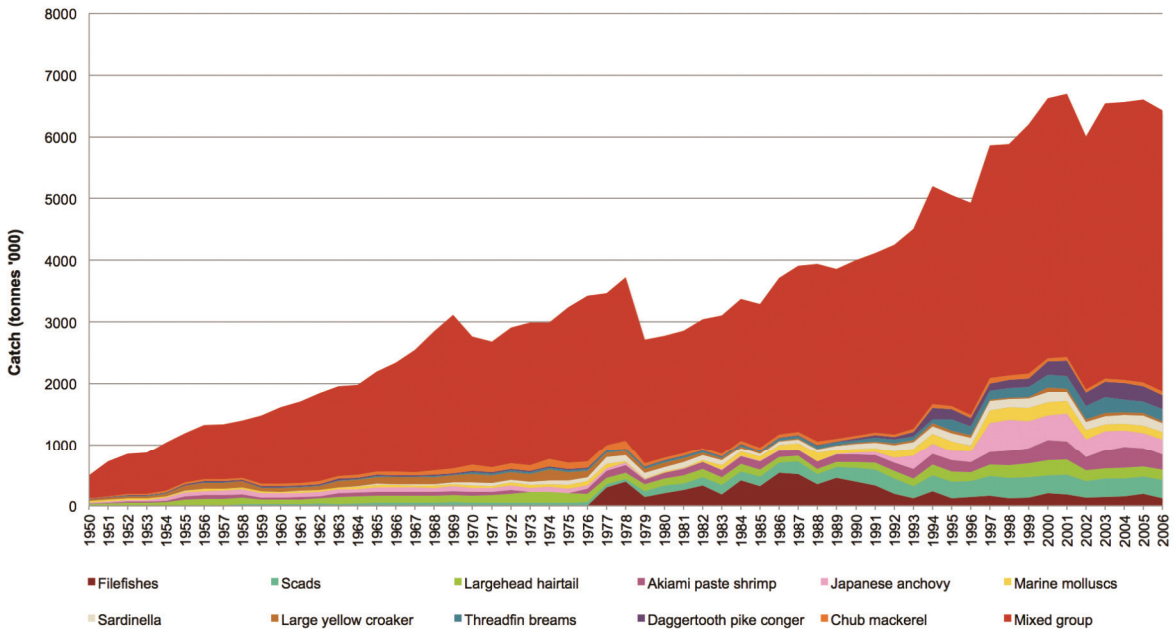
Current Status of South China Sea Fisheries

A recent brief on the South China Sea Large Marine Ecosystem reveals that two-thirds of reported landings in the sea were unidentified fish, indicating shortcomings in the capacity of the regulatory and enforcement systems in the littoral countries. Many of these littoral countries—with perhaps the exception of China, with its expansive fisheries administration fleets—lack the resources to effectively control and monitor fishing activities. Although underreporting of fish catch is an ongoing concern, reported fishery production in the South China Sea might also be overestimated in the case of some species, either through false reporting, unmonitored fishing, or the inclusion of extra-regional catch.

Data from the Seas Around Us project (sponsored by the Pew Charitable Trusts) indicates that roughly 20 percent of the South China Sea's marine stocks are developing or rebuilding while about 50 percent are currently rated as fully exploited. The remaining 30 percent of marine stocks have been overexploited or have collapsed entirely.

Reports stating that the amount of effort required per unit of marine catch has been steadily increasing over the years also underscore the present level of overexploitation of many fish stocks in the South China Sea. One of the side effects of this trend has been to incentivize local small-scale fishers to use increasingly destructive techniques, such as explosives or cyanide, to boost yields and prevent economic losses. However, these techniques further exacerbate the effects of overfishing through the degradation of key marine habitats such as mangroves, coral reefs, and seagrass beds. The use of explosives or cyanide essentially trades long-term fishery sustainability for short-term gains, but an insufficient understanding of these methods' true impacts persists, particularly among small-scale fishers.

Landings By Species in the South China Sea, 1950-2006



Data source: Sea Around Us

Threats to South China Sea Fisheries

A wide range of factors influence the health of maritime ecosystems and the sustainability of fish populations in the South China Sea. Chief among them are overfishing, destructive fishing practices, and habitat destruction through coastal development.

Overfishing. Overfishing is arguably the most significant threat to wild fisheries. The trend is exacerbated by the lack of an effective regional management mechanism in the South China Sea, insufficient enforcement of fishing quotas, the growing reliance of coastal regions on fishing for both food security and income, and the lack of accurate fisheries data.

In the South China Sea, maritime border disputes present a strong deterrent to establishing a fishery co-management regime. Most countries want to enforce their own sovereignty over what they consider to be rightfully theirs and avoid giving even implicit acknowledgement to the claims of others, particularly to China's claims. Further, many countries' reporting and regulatory systems lack the capacity to accurately monitor fishing activities, resulting in an abundance of illegal, unreported, and unregulated fishing activity in the South China Sea, both by countries bordering the sea and vessels from outside the region.

Threats to Overfishing

The threat of overfishing can be subdivided into several types, all of which apply to South China Sea fisheries in varying degrees:

- ***Growth Overfishing***: when young fish are captured before they have time to mature.
- ***Recruitment Overfishing***: when a stock is depleted to the point that the number of breeding fish left is insufficient to maintain the population.
- ***Biological Overfishing***: a combination of growth and recruitment overfishing, where the effort exerted by fishers exceeds the Maximum Sustainable Yield.
- ***Economic Overfishing***: when the level of effort by fishers exceeds industry profit.
- ***Ecosystem Overfishing***: when the species composition of an ecosystem changes because a particular species has been overfished.
- ***Malthusian Overfishing***: the addition of more fishers to an already taxed system, potentially leading to the use of destructive fishing techniques.

Destructive Fishing Practices. Poisons and explosives are the most commonly cited destructive fishing methods at play in the South China Sea; both exact a heavy price on the long-term viability of fisheries by reducing fish stocks. Cyanide has long been used as a fishing method in reef habitats, although other types of poison are used in the South China Sea as well. Another destructive technique for harvesting fish is blast fishing, which typically involves dynamite and can have dramatically harmful effects on the coral reefs where explosives are used. The impacts of blast fishing exacerbate the problem of overfishing on South China Sea reefs; 70 percent of the reefs are already overfished according to a Global International Waters Assessment. For example, some estimates suggest that the cost of using explosives for fishing in Indonesia alone may have amounted to $3.8 billion between 1980 and 2000. Bottom trawling for demersal fish also has a highly destructive effect on seafloor environments; this tactic

modifies plant and animal communities on the seabed. The resulting "by-catch" is composed of generally undersized or unwanted species, which are subsequently discarded.

Coastal Development. Many marine species in the South China Sea use coastal habitats, such as mangroves, for spawning purposes. However, a variety of coastal development practices have degraded these critical habitats; mangrove patches now only occupy 70 percent of their original land area. Though regional governments have endeavored to reverse this trend, mangroves and other sensitive coastal ecosystems are still slowly losing ground.

Coastal development also contributes to the degradation of marine environments surrounding the coast, with industrial activity, agriculture, tourism, aquaculture operations, and sediment run off and pollutants from deforestation threatening the quality of near-offshore waters. Seagrass beds, which are at particular risk from land-based pollutants, have been reduced by up to 50 percent of pre-industrial levels. Such drastic changes in marine environments pose a significant challenge to the many marine species that rely on this habitat for feeding or spawning purposes.

Projections on the Future of South China Sea Fisheries

Population growth is a significant determinant of future food security and fishery sustainability in the Southeast Asian region. In 2010, the countries bordering the South China Sea constituted approximately 27.1 percent of the world population; this statistic is heavily influenced by the enormous population of China. Most countries in the region will experience a sizable increase in their populations during the coming years; the Philippines will experience the largest proportional growth. The two notable exceptions to this trend will be China and Thailand, which by 2040 will have a population very similar to present levels. In the long term, the region's lower population growth relative to global population growth will mean that the countries bordering the South China Sea will represent a smaller percentage of the world's total population. However, the region's dependence on seafood both as a staple of food security and as a means of employment—particularly in Cambodia, Malaysia, and the Philippines—will mean that pressure on South China Sea marine fisheries will grow in the decades ahead.

The ability of South China Sea fisheries to accommodate growing demand is questionable at best. Most rich fishing environments, such as shallow reefs and shoals, have already been exploited to their limit or beyond, leaving few relatively underexploited areas. One report from the year 2000 indicated that deepwater areas of the South China Sea may have the potential to support more intensive fishing, but data on those fisheries remains unclear, and the technological impediment to efficiently harvesting fish far below the surface may still be problematic.

Out to 2020, high population growth in all countries across the region will continue to impose pressure on an already overtaxed ecological system, and the unsustainable fishing practices of many fishers in the South China Sea's coastal states can be expected to continue. Of these practices, tactics deemed physically destructive to habitats vital to fish reproduction may have the largest effect on fish availability, due to the often irreversible impact that there practices have on marine environments such as mangrove patches, seagrass beds, reefs, and shoals. The effect of such habitat destruction probably will begin to be felt by 2020, though the lack of precise data on wild fish stocks makes an accurate determination of this time frame difficult.

Mid-Range Population Growth Projections for States Bordering the South China Sea

Population (in Thousands)				
Country	2010	2020	2040	2040 as multiple of 2010
Brunei	399	465	568	1.4
Cambodia	14,138	15,893	18,361	1.3
China	1,341,335	1,387,792	1,360,906	1
Indonesia	239,871	262,569	290,223	1.2
Malaysia	28,401	32,986	40,800	1.4
Philippines	93,261	109,742	141,675	1.5
Thailand	69,122	72,091	72,994	1
Vietnam	87,848	96,355	104,047	1.2
Total	1,874,375	1,977,893	2,029,574	
World Total	6,895,889	7,656,528	8,874,041	
Percent of World Total	27.1	25.8	22.9	

Source: UN Department of Economic and Social Affairs, Population Division.

Another issue that sheds light on the inefficiency of fishing practices in the South China Sea is the improper refrigerated storage of fish on fishing vessels and docks, which results in the loss (and subsequent discarding) of captured fish due to spoilage. The extent to which this occurs varies depending on the type of fishing method and the ultimate destination for the fish. Spoilage is often particularly pronounced in small-scale fishing operations, which constitute a large portion of fishing activity in the South China Sea. Losses from spoilage and discard can be steep. Decreasing spoilage rates among small-scale fishers could generate a net increase of usable catch while avoiding an increase in total catch.

The cumulative population of countries bordering the South China Sea will not significantly increase by 2040, compared to the region's cumulative 2020 population. However, the proportion of population density will shift slightly away from China, as China's population begins to fall sometime after 2020 and the populations of China's Southeast Asian neighbors continue to grow. The population growth of these non-Chinese countries between 2020 and 2040 probably will further increase pressure on South China Sea fisheries, though perhaps not to the same extent as population growth in the region between 2010 and 2020.

A key question regarding the long-term sustainability of South China Sea fisheries is whether the region's countries can adopt sufficient conservation measures to ease overexploitation, particularly pertaining to multilateral management mechanisms. The majority of South China Sea fish stocks stretch across the maritime borders (or the potential but undefined maritime borders) of numerous countries. Thus effective conservation measures would require a concerted effort on the part of multiple states. Despite the fact that nearly all states bordering the South China Sea are highly reliant on the region's marine fisheries and therefore share a common interest in sustainably managing these stocks, it remains to be seen whether such incentives can overcome opposing national priorities centered on the establishment and enforcement of national sovereignty in maritime and territorial disputes.

Southeast Asian countries as a whole participate in a number of regional bodies and agreements, notably the Asia-Pacific Fishery Commission (APFIC), the Southeast Asian Fisheries Development Center (SEAFDEC), and the Regional Plan of Action to Promote Responsible Fishing Practices (RPOA). These organizations play important roles in promoting and improving fishery management in the region, though many of these organizations primarily discuss voluntary provisions, or are limited to conducting research, gathering information, and/or making policy recommendations. Most Southeast Asian fishery agreements contain the type of nonbinding language that typically characterizes regional pacts, but effective co-management and policing mechanisms between most countries bordering the South China Sea are still lacking. Further, many of these regional bodies or agreements lack the participation of one critical country: China. One notable exception is the Gulf of Tonkin fishery agreement between China and Vietnam, which has the potential for expansion to cover broader maritime areas.

Finally, as in the Indian Ocean littoral, many states along the South China Sea probably will expand aquaculture operations in the years ahead to compensate for the overexploitation of wild fisheries. China has been at the forefront of promoting aquaculture for decades, producing 36.7 million metric tons of fish products in 2010—nearly two-thirds of the world's total. Meanwhile, five of the top 10 aquaculture producers worldwide in 2010 were countries bordering the South China Sea. Although the FAO reports that the rate of aquaculture expansion has decreased in some regions in recent years, aquaculture has perhaps the best potential to meet expanding fish demands in the future.

Indian Ocean: Potential Conflict Hotspots and Role of Regional Institutions

Like the South China Sea, the Indian Ocean littoral is rapidly emerging as an essential crossroads of the global fish market and a key focus of international politics. Rising flows of trade, investment, people, and ideas around the region are linking the Indian Ocean countries to each other and to the rest of the world. As a staple of regional food security, fisheries are one of the Indian Ocean region's most important resources. The sustainable usage of those natural assets will be a key to securing the region's future welfare.

The Stakes

Fisheries furnish a crucial food source for communities around the Indian Ocean region. On average, the populations of Egypt, Malaysia, Mozambique, Seychelles, Singapore, Tanzania, and Thailand obtain 20 percent or more of their animal protein from fish. The inhabitants of Bangladesh, Comoros, Indonesia, Maldives, and Sri Lanka get more than half of the animal protein in their diets from fish. Equally important, fisheries contribute substantially to many regional economies, particularly in the small island countries. In the Maldives, for example, fisheries account for some two percent of GDP, but they constitute 90 percent of domestic exports. For the Seychelles, fisheries and associated activities (such as canning) account for 16 percent or more of formal employment and half of foreign exchange earnings. Fisheries are also economic lynchpins for several larger countries. In Indonesia, for example, fishing and fish farming employ nearly 6 million people, a number greater than the labor force working in the country's vaunted textile and apparel industries. In addition, the FAO assesses that for each person directly employed in fish capture or aquaculture, another three to four gain jobs in related activities such as boat construction; gear maintenance; and fish processing, packaging, and distribution. Fisheries thus contribute to human security and social welfare both as a food source and as a source of livelihoods.

Potential Conflict Issues and Areas

Development analysts increasingly recognize food security as a complex challenge linking a web of such interrelated nutritional, agricultural, economic, and sociopolitical elements. Where governments fail to consider these connections, policies may prove counterproductive and social tensions might occur. Bangladesh, for example, has sought to exploit its low-lying river delta topography to expand traditional shrimp farming into intensive commercial farming for international markets. From 1983 to 2004, the coastal land area devoted to shrimp cultivation soared fourfold, and the fisheries sub-sector grew to contribute more than five percent of Bangladesh's GDP. The rapidly spreading shrimp farms have also increasingly encroached on other agricultural lands, while the destruction of mangrove forests and the reconfiguration of embankments to enclose saltwater shrimp ponds has altered drainage and siltation patterns and increased the salinity of surrounding soils and water, rendering large areas unfit for agriculture (or even, in extreme cases, for habitation). The social and environmental impacts of shrimp farming have driven many localities to resist the introduction of industrial shrimp farming, sometimes violently. More than 150 people have been killed and thousands injured in such protests during the past two decades.

Other potential conflicts may arise offshore. Most fishing in the Indian Ocean takes place in coastal waters, and most fishers live at or below the poverty line. As industrial fishing and other intensified practices deplete traditional fishing grounds, many fishers cross maritime boundaries into other fishing areas. These trespasses can often exacerbate pre-existing political tensions between neighbors over un-demarcated or contested maritime or territorial boundaries. **In South Asia, for example, Indian fishers have clashed with their competitors in Bangladesh, Pakistan, and Sri Lanka, and fishers on all sides have been subject to arrest, seizure of their boats, and even extra-judicial killings.**

All told, illegal, unreported, and unregulated fishing is taking a considerable toll on the region's fisheries. A recent British study of selected species representing about half of the total catch in the Indian Ocean assessed that anywhere from 16 to 34 percent of the catches in those stocks were illegal or unreported. Illegal, unreported, and unregulated fishing often occurs not just from small professional hand-fishers, but also from fleets beyond regional waters. The FAO, for instance, estimates that fishers on some 700 foreign vessels were fishing without licenses in Somali waters during recent years. According to many accounts, the resulting displacement of local Somali boats played an early role in pushing local fishers first into reprisals and then to piracy against foreign ships. Though a partial explanation at best, this narrative probably still plays a role in legitimating these otherwise illegal activities in the eyes of the coastal populations where the pirates base, recruit, and refit. Ironically, piracy has in fact reduced fishing activity in Somalia's coastal waters and well beyond into the western Indian Ocean.

Potential Conflict Hotspots Concerning Indian Ocean Fisheries

DI Cartography Center/MPG 903292AI (G03581) 7-13

Regional Organizations and Initiatives for Sustainability Cooperation

Several regional and international agreements exist to promote the sustainable management of the Indian Ocean's resources. Among the most important, the 1982 United Nations Convention on the Law of the Sea (UNCLOS) underpins other international treaty arrangements addressing marine resources by establishing the regime of Exclusive Economic Zones (EEZs) defining national maritime limits and jurisdiction, bringing waters out to 200 nautical miles under the regulation and control of coastal states. Other international instruments such as the 1993 Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas; the 1992 Convention on Biological Diversity; the 1995 UN Agreement on Straddling Fish Stocks and Highly Migratory Stocks; the

1998 International Plan of Action for the Management of Fishing Capacity; and the 2001 International Plan of Action to Prevent, Deter and Eliminate Illegal, Unregulated and Unreported Fishing also contain provisions on cooperation to optimize fisheries' management and protect marine biodiversity. All Indian Ocean states except Iran are party to UNCLOS, but many important fisheries states have not joined the 1995 UN Fisheries Agreement.

Indian Ocean fisheries associations and environmental institutions have not been constructed to encompass the whole region, but instead operate at the level of a subregional system or an individual species. For example, the Indian Ocean Tuna Commission (IOTC) encompasses the entire Indian Ocean, but it only addresses the catch of tuna and "tuna-like" species. Similarly, the Commission for the Conservation of the Southern Bluefin Tuna (CCSBT) covers the migration range of that species across the southern Indian Ocean, but its membership is small. The Southwest Indian Ocean Fisheries Commission (SWIOFC) covers all species of fish in the waters off of East Africa, but it has no management powers. In the Persian Gulf and Gulf of Oman, the Regional Commission for Fisheries (RECOFI) can make management recommendations, but such recommendations are not binding if a country objects. The Bay of Bengal Large Marine Ecosystem (BOBLME) project unites the eight littoral countries from the Maldives to Malaysia to formulate a common program of action for improved management of the coastal environment and fisheries, but it is limited to the Bay of Bengal. The Asia-Pacific Fishery Commission (APFIC) possesses a broad mandate to promote the conservation and management of aquatic resources among its 20 members, but it has no regulatory powers and does not encompass the western Indian Ocean. A new body, the South Indian Ocean Fisheries Agreement (SIOFA), covering all fish in much of the western and southern ocean beyond national EEZs, has only recently entered into force in June 2012.

Although the management effectiveness and sustainability of the SIOFA cannot yet be evaluated, a recent assessment of the world's Regional Fisheries Management Organizations (RFMOs) found the IOTC and CCSBT to be performing poorly. Comparing fishing mortality and biomass to the rates that would maintain the maximum sustainable yield, the IOTC received a score of 77.8 percent on a scale of 0-100, while the CCSBT received a score of 0 percent. The effectiveness of both international and national-level management and regulation is limited by high levels of noncompliance. Fishers have little incentive to limit their catches because monitoring and enforcement of catch limits is low and much marine legislation is outdated. In response to this problem, some fisheries management has moved toward the decentralization and localization of management authority. Local communities in the southwest Indian Ocean, for example, have increasingly asserted their own regulations and enforcement of fish stocks.

Similarly, the Indian Ocean area is home to a number of regional economic organizations and political associations that also vary in their mandates and membership. Though primarily directed to economic and security issues, many of these institutions have increasingly moved to engage environmental issues and sustainable development policy. As such, they may provide broader fora in which fisheries management challenges that transcend national borders and single issue agencies may be set in larger economic, political, and human security settings potentially amenable to regional cooperation. Even so, these regional economic and political bodies confront some of the same difficulties as Indian Ocean regional fisheries management organizations (RFMOs) in the form of geographical fragmentation and the lack of binding decision authority across their members.

The Indian Ocean Rim-Association for Regional Cooperation (IOR-ARC) has the broadest membership. It includes a wide array of Indian Ocean rim states and aims to foster economic, scientific, and cultural cooperation. The IOR-ARC membership counts 18 IOR states—with some important absences—plus efforts to engage extra-regional powers such as the United States as dialogue partners. Although the IOR-ARC charter does not extend to security issues, piracy off of Somalia has been raised as a matter of mutual concern to maritime trade and fisheries. The IOR-ARC is not perceived as being particularly effective and some member states, notably India, have mooted reform measures that would expand the charter to better facilitate regional cooperation on maritime issues and the environment.

Nevertheless, region wide institutions are lacking. The association of Southeast Asian Nations (ASEAN), the South Asian Association for Regional Cooperation (SAARC), the Southern African Development Community (SADC), the Gulf Cooperation Council (GCC), and the Indian Ocean Commission operate at the subsystem level. Other bodies, such as the African Union and the Asia-Pacific Economic Cooperation (APEC), partly overlap the Indian Ocean region while also incorporating other members beyond it. The ASEAN Regional Forum (ARF) includes South Asian and eastern Indian Ocean states but does not include western Indian Ocean states. Similarly, Australia has proposed an Asia Pacific Community (APC) composed of the 21 members of the Asia Pacific Economic Community (APEC) together with the addition of India. The APC would promote regional dialogue on economic, cultural, strategic, and security issues. The APC's focus is predominantly directed toward the Pacific, with the inclusion of Russia and the United States; Indian Ocean countries such as Pakistan, Bangladesh, Sri Lanka, and East African and Middle Eastern nations may not be included. No Indian Ocean-wide arena exists in which convergent regional security, economic, and environmental issues—including fisheries—can be considered in a collectively inclusive manner.

Indian Ocean: Implications for US National Security Interests

Indian Ocean fisheries probably will create both challenges and opportunities to US policies and interests in the medium and longer term. Existing disputes between littoral countries, such as that between India and Sri Lanka in the Palk Strait, are unlikely to develop into overt conflict. Rather, where they continue, they are more likely to simmer at the level of incidents between fishermen or between fishermen and national coast guards. However, the possibility of a miscalculation or an escalation of incidents between coast guards cannot be excluded. Should such unintended or escalating conflicts arise, commercial traffic, access to ports and other facilities in the area, and perhaps access to offshore resources (e.g., pipelines, drilling rigs, undersea cables, etc.) might be affected.

By 2040, the sustainability of Indian Ocean fisheries could pose a more chronic and widespread challenge to US interests. Recognizing the importance of a strong and interconnected global economy both to fostering productive, responsible, and democratic governance abroad and to ensuring its own continuing prosperity at home, the United States is committed by national policy to advancing sustainable development worldwide. The 2010 US National Security Strategy emphasizes that promoting food security will be an essential component of this endeavor. By the same token, the United States is also committed to building broad cooperative mechanisms and institutions to meet global challenges and protect and sustain global commons such as the oceans and their resources. Mounting strains on Indian Ocean fisheries potentially threaten to undermine these objectives, making the food security and

economic well-being of significant populations in key countries more difficult to achieve and international cooperation in the maritime commons harder to secure.

Indian Ocean fisheries are under rising pressures, not only from growing demand and potentially unsustainable exploitation patterns, but also from an array of interacting environmental issues ranging from coastal pollution and habitat destruction to global climate change. Fisheries are only one element in any country's efforts to ensure food security. As demands on fisheries surge, shortfalls in fishery production from whatever cause will not only affect fishermen and fishing communities directly, but will reverberate through food supply networks to increase the demands and stresses on other parts of the system. Thus, where fish consumption accounts for a large proportion of available protein supplies, it could be difficult for some individuals, communities, or countries to replace fish with other sources of animal protein. Such substitutions may imply higher costs—or increased imports, for example—for some consumers, with potentially detrimental ramifications. In Egypt, for instance, the World Bank calculates that a 30-percent jump in food prices results in a 12-percent increase in poverty.

Much of the current strain on fisheries stems from inefficient over-capacity in the industry. According to the World Bank, fisheries management reforms could deliver more sustainable yields and garner some $50 billion in global annual benefits currently foregone in lost economic production. Yet such perspectives inevitably pose a challenge to collective action because each fishing community and fleet would prefer to reduce over-capacity by trimming its neighbor's fleet rather than its own. These environmental and economic dynamics justify enhanced regional collaboration, but they could easily inhibit cooperation and engender competition instead.

As an extra-regional power not party to UNCLOS and not a member of many of the relevant regional fisheries and economic organizations, the United States cannot readily exercise much direct influence on regional fisheries policies. However, the United States may be able to contribute indirectly to advance regional food security and promote sustainable fisheries practices through education, training, and data sharing. US satellite imagery, remote-sensing technologies, and earth observation systems can contribute to both scientific research and monitoring. The US Government and other US organizations possess considerable technical expertise and practical experience for formulating and implementing coastal and marine management plans, environmental clean-up and ecosystem restoration programs, and disaster preparedness and response. Lessons from these programs could be shared, joint training could be organized, and standards and best management practices could be developed. Similarly, development assistance programs such as USAID's Feed the Future have recognized the importance of sustainable fisheries management to key target countries such as Bangladesh. Finally, the United States may be able to help alleviate the substantial burden of illegal, unreported, and unregulated fishing in the region via cooperation, training, and joint exercises, with the region's Coast Guards and marine legal authorities. Such engagement could not only build local illegal, unreported, and unregulated monitoring and enforcement capacities, but they could have positive spillover effects on other local and regional challenges. For example, efforts to counter piracy and illicit trafficking (of arms, drugs, or people), which also are hampered by a lack of local capacity, might benefit from such engagement.

South China Sea: Potential Conflict Hotspots and Role of Regional Institutions

In the South China Sea, rich fishing grounds are also the main potential conflict hotspots (see map page 26). Many of the most important food species tend to congregate around more than 200 small islands, rocks, atolls, shoals, and banks. Many of these features are essentially the visible or barely submerged tips of vast undersea mountain ranges and remnants of volcanos of Southeast and East Asia's geological "Ring of Fire."

Isolated subsea mountain tops, called seamounts, are often of volcanic origin and can rise hundreds or even thousands of meters from the surrounding seafloor. The most prominent seamount in the South China Sea is the 100 km-wide Reed Tablemount (also known as Reed Bank and Dangerous Ground). One of the world's largest fully submerged atolls, the shallow seamount covers more than 8,800 square kilometers in the northeast part of the Spratlys, separated some 125 nautical miles from the Philippines Island of Palawan by the Palawan Trench, one of the deepest parts of the South China Sea.

Although still little studied, the most productive fisheries are found to the west of the Philippines, including the Spratlys and Scarborough Shoal and Macclesfield Bank, and the Paracels in the northwest nearest to China and Vietnam, which have the largest concentration of atolls, rocks, banks, and shoals. Marine waters near Taiwan in the north, and Thailand, Malaysia, and Indonesia to the south, where the undersea topography is dominated by a comparatively featureless continental shelf, appear less productive. Partly for that reason, fishing boats from Indonesia and Thailand in particular are active in the more productive parts of the South China Sea.

Not surprisingly, the areas with the richest fisheries are also the focus of maritime territorial disputes involving four Southeast Asian countries—Brunei, Malaysia, the Philippines, and Vietnam—with each other and, more seriously, with China. China is well aware of issues concerning the sustainability of fisheries and specific species. China has had a fisheries agreement with Vietnam covering the shared Gulf of Tonkin since 2004. An annual summer fishing ban that China has implemented and enforced since 1999 in the northern half of the South China Sea has been a major irritant with Vietnam, Malaysia, and the Philippines.

The Stakes

With the largest population and biggest fishing fleet in the region, China is the largest consumer and exporter of fish from the South China Sea, but other countries are more dependent on seafood for both consumption and exports. Vietnam is the most seafood-dependent country in the region, with fish providing 7 percent of the country's exports.

Potential Conflict Hotspots Concerning South China Sea Fisheries

DI Cartography Center/MPG 903293AI (G01570) 7-13

The Philippines is less dependent on fisheries for food and wild-caught seafood exports than Vietnam. Most fishing is carried out by small craft within 15 km of the coast by subsistence fishers. Sharp declines in fish populations are aggravated by the use of dynamite and cyanide, the latter for the purposes of catching live fish for high-end markets in China, Hong Kong, Singapore, and elsewhere. For instance, the catch in the Lingayen Gulf, a major fishing ground, achieved its maximum sustainable yield around 1980; as of about 2000 the catch rates had already declined to one-fifth the amount they were in the mid-1980s.

Incidence of Fisheries Conflict

The expected and already discovered oil and gas deposits beneath the waters of the South China Sea are important drivers of maritime territorial disputes, but the rich marine fisheries of the South China Sea which have multiple fishermen from multiple countries are a more likely source of incidents. **Oil and gas remain largely resources of the future, whereas contested fisheries and fishing rights already involve tens of thousands of fishers and boats. Incidents between fishers from different countries, as well as efforts by armed patrol vessels to deter fishing in contested waters, seize boats, and arrest fishermen, occur frequently.**

A growing gap between supply and demand, especially for the varieties preferred by upwardly mobile beneficiaries of Asia's fast-rising GDP, has intensified competition and caused fishing fleets to range farther and farther from coastal waters into distant areas where ownership of islands, rocks, and shoals, as well as attendant fishing rights are disputed. Because of dim prospects for resolving the disputes, sea power is becoming the primary adjudicator and China increasingly has the upper hand.

Although the overall thrust of China's growing assertiveness is clearly a matter of national policy, analysts have raised significant questions about responsibility for specific incidents. China has the largest fleet of patrol vessels of various types deployed by multiple agencies and authorities. Some nine-to-eleven ministerial-level agencies are involved in maritime activity in the area, including the Bureau of Fisheries Administration, China Marine Surveillance, three coastal provinces, the Ministry of Foreign Affairs, and the People's Liberation Army Navy (PLAN).

Vietnam has a major problem with illegal fishing by large foreign boats, which in 2003 numbered as many as 300 to 500. The foreign boats fish offshore by day and inshore by night, often landing and selling their catches in Vietnamese ports. In November 2011 a Vietnamese Coast Guard ship chased and sideswiped a China Marine Surveillance boat that penetrated Vietnam's EEZ. At the same time, because of overfishing and other pressures on coastal stocks, Vietnamese fisherman increasingly have been venturing into the Chinese-controlled Paracels, leading to a growing number of incidents with Chinese fisheries patrol boats.

Incidents at sea involving fishing fleets around disputed areas such as the Scarborough Shoal and Macclesfield Reef have increased in part because governments have in a number of cases subsidized the construction and operation of longer-range fishing craft. Reportedly the Vietnamese Government has encouraged fishing in the disputed areas with fuel subsidies, a credit of $3,500 for the purchase of longer-range craft, and provided compensation for the loss of nets and boats at the hands of Chinese patrols.

Perhaps the single most important flashpoint is the Scarborough Shoal, a huge triangular-shaped reef covering some 150 square kilometers, inside of which is a shallow lagoon of nearly 130 square kilometers almost entirely surrounded by rocks and a fringing reef except for a narrow opening. The entry to the lagoon is sufficiently narrow for Chinese patrol craft to string a rope supported by buoys across its width. The rights of Filipinos to fish in contested areas, and the defense of the country's fisheries laws, have become highly politicized. Despite its limited maritime patrol capability, the Philippines regularly intercepts foreign fishers in its EEZ.

The standoff between China and the Philippines over fishing rights at Scarborough Shoal (called Panatag Shoal by the Philippines and Huangyan Island) during the spring and summer of 2012 underscored the importance of fisheries and the risks of conflict. The confrontation that took place 124 nautical miles from the Philippines's coast was broken only temporarily in mid-June when Typhoon Butchoy caused a Philippines's Coast Guard patrol boat and a fisheries survey ship to leave from the scene, while three Chinese patrol ships remained.

The opposition of China's neighbors to its fishing bans is only partly the result of the infringement on their EEZs and continental shelves. Both Vietnam and the Philippines are just becoming more aware of the threat of unsustainable fishing practices, although the literature to date suggest that Hanoi thinks first of aquaculture when it thinks of sustainability. From 2005 to 2010 the Chinese Bureau of Fisheries Administration reported the detention of 63 Vietnamese fishing boats along with 725 crew members. Half the arrests occurred in 2009, when Beijing began to link its fishing ban to its marine territorial claims. The Chinese complain that Vietnamese, Malaysian, and Filipino fishing boats regularly violate the ban while Chinese boats are restricted to port.

Regional Organizations and Initiatives for Sustainability Cooperation

Although all of the South China Sea countries realize the threat posed to their economies and food security from the current lack of cooperation to ensure sustainable fisheries, the maritime disputes will long present major obstacles to any regional approach. There are no regional organizations or South China Sea-wide initiatives for cooperating to sustainably manage fisheries except nongovernmental organizations for training or professional bodies for networking and personal cooperation. For example, the Asian Fisheries Society, founded in 1984, facilitates cooperation among scientists, technicians, and researchers.

An ASEAN Roadmap for Integration of the Fisheries Sector is, as its title indicates, an initiative connected with regional trade and economic integration, not cooperative fisheries management. Since 1999 the ASEAN Foundation and the Southeast Asian Fisheries Development Center have been carrying out human resources capacity-building programs with some $1.6 million from the Japan-ASEAN Solidarity Fund.

Slowly, regional countries are recognizing threats to fisheries from climate change and trying to bring illegal fishing and fishing methods under cooperative and regulatory regimes. The "Regional Plan of Action (RPOA) to Promote Responsible Fishing Practices (including combating illegal, unreported, and unregulated fishing) in the Region" was adopted by ministers responsible for fisheries from six ASEAN countries and Australia, Papua New Guinea, and Timor-Leste at a meeting in Bali, Indonesia, in May 4 2007. The countries agreed to combat illegal, unreported, and unregulated fishing in three sea areas: the South China Sea (including the Gulf of Thailand); the Southern-Eastern South China Sea and Sulu-Sulawesi Seas; and the Arafura-Timor Seas. Among other efforts, the countries seek to identify and deny port access to boats involved in illegal, unreported, and unregulated fishing. Notably, China is not a participant in RPOA.

The intergovernmental Southeast Asian Fisheries Development Center (SEAFDEC), established in December 1967, seeks to promote sustainable fishing. The center's member countries are Brunei, Cambodia, Indonesia, the Lao PDR, Burma, the Philippines, Singapore, Thailand, and Vietnam (all

members of ASEAN), plus Japan. At the 41st meeting of its policymaking Council of Directors, the Council adopted a new SEAFDEC Program Framework, which includes a mandate "to develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies research and information dissemination activities."

At the bilateral level, some indicators suggest the possibility that the most serious disputes could be managed in the interests of the sustainability of fisheries, even if resolving the underlying disputes is very unlikely. One possible model is the 2000 Boundary Agreement between Vietnam and China over the Gulf of Tonkin, which the two countries share.

- The Tonkin Gulf agreement marked the limits of the territorial seas, contiguous zones, and the EEZ of both China and Vietnam. The agreement followed precedents of proportionality in determining these borders when islands are in question. For seabed resources that straddled the border between the two states, the agreement included a provision stating that the two countries would jointly develop those resources on a negotiated "equitable" basis. The Chinese National Offshore Oil Corporation (CNOOC) and PetroVietnam entered into joint exploration agreements based on this principle in 2007, though no development projects have been completed.

The agreement on boundaries entered into effect in 2004 with ratification by both the Chinese and Vietnamese; it coincided with a parallel agreement on fishery management that was ratified on the same day. The fisheries agreement was intended to allow for successful co-management of fish stocks that crossed the newly created maritime border in order to prevent depletion of those resources. Though clashes have occurred between fishermen and fishery administrations of both sides and frictions in the South China Sea continue to test the Chinese-Vietnamese relationship, joint patrols of the Gulf of Tonkin have continued since 2005.

Some observers have noted that the basic principles of the Gulf of Tonkin fisheries agreement have the potential to be expanded by China and Vietnam to waters outside of the Gulf itself. Although the Gulf of Tonkin agreement could be a useful precedent for cooperation between the two biggest and most antagonistic claimants in the South China Sea, the agreement is a special case because the countries share adjacent land borders and the agreement addresses some very practical problems. In addition, it also was negotiated during a better period in China-Vietnam relations than exists at present, or is likely to emerge in the short term.

Ultimately, political will and serious participation by all South China Sea countries and external long-distance fishing fleets will be required to promote effective regional cooperation. Most current efforts remain nascent and involve far more talk than action. Nonetheless, the regional organizations that have been created have identified many of the most important threats to sustainability, food security, and regional peace. The question is whether regional and bilateral cooperation will develop fast enough to prevent a long-term catastrophe.

South China Sea: Implications for US National Security Interests

In the South China Sea, US national security interests are likely to be tested by the poor outlook for sustainability of important wild fish stocks and continued population growth in several countries. This will occur despite the coming peak and subsequent decline in China's population. Effective measures for regional cooperation to maintain the sustainability of important wild fish stocks will be extremely difficult due to the problems of nationalism, territorial disputes, and threats to the marine ecosystem from continuing urbanization, deforestation, climate change, and sea-level rise. All of these will undermine regional food security.

- Territorial disputes may be ameliorated by agreements for cooperative development of oil and gas resources and preservation of sustainable fisheries, but the underlying territorial disputes are unlikely to be resolved.

A probable slowdown in Chinese economic growth is unlikely to alter the disparity of military power between China and its neighbors by 2020. Assessing the structure of regional relationships and the course of China's continuing rise between 2020 and 2040 is difficult. Both China's and Vietnam's political systems are being challenged by corruption; the related public loss of confidence in the leadership of the Communist Party; and the need to shift their economies away from excess and often unproductive public investment and exports in favor of more balanced relationships among government, investment, and consumption.

The most immediate risk to regional stability, and ultimately to US national security interests, will be from increasing violations of other countries' EEZs and extended continental shelves, leading to the arrests of fishermen and seizure of their boats and catches. This risk is increasing as a result of the change throughout the South China Sea from coastal to offshore and even more long-range fishing.

China has a growing gap between the capacity of its coastal fisheries, which are near collapse, and the capacity of its fishing boats, which are large, numerous, and capable of transiting long distances. Nevertheless, the gap heightens the potential for incidents at sea, but the desire to protect the long-distance fishing fleet has led to a rapid increase in the capabilities of China's coast guard, marine surveillance, and fisheries law enforcement fleets. The People's Liberation Army Navy's (PLAN) drive for a blue water fleet—in part rationalized by a need to protect the oceangoing fishing—is a national security concern of the United States. This fleet has also been used to positive effect by working with the United States to suppress illegal drift net fishing. China has attempted, with limited success, to bring its excess fishing capacity more in line with the supply of fish along its coastal waters.

Overall, the nexus among fisheries, food security, and broader concerns about human security in Southeast Asia are, by themselves, unlikely to have a direct impact on US strategic interests. However, the competition for scarce food and protein resources among South China Sea countries is likely to generate regional instability and inhibit cooperation.

- Several of the most populous countries, especially the archipelagic states of Indonesia and the Philippines, as well as Vietnam, are likely to witness serious and possibly politically disruptive issues arising out from the impacts of ongoing depletion of coastal fishing on food security and income. Malaysia and Thailand have much more balanced economic development that should facilitate a

relatively smooth transition of fishing communities either into the manufacturing and services sectors or into aquaculture.

- Vietnam and Cambodia are likely to experience serious food insecurity and degraded work opportunities for farmers and fishermen from the ongoing and planned construction of hydroelectric dams on the mainstream and major tributaries of the Lower Mekong River. The Mekong is the world's most productive fresh water fishery after the Amazon and provides the main source of protein for tens of millions of the region's poorest people.

- The capture of silt by China's massive cascade of hydroelectric dams on the Upper Mekong and dams on the mainstream and tributaries in the Lower Mekong will exacerbate the effects of sea-level rise in the Mekong Delta. The Delta, currently home to 17 million people, could lose nearly half of its area by 2050. The harm to aquaculture from changing water turbidity, pollution, and the loss of coastal land could be severe. Vietnam's rice crop is also expected to suffer. The Delta currently provides half of the nation's rice production, and its rice exports are an important food source for much of Southeast Asia.

The United States has a range of possible initiatives to ameliorate or slow the threat posed by the stresses on food security, livelihoods, and regional stability caused by the degradation of South China Sea fisheries and other aquatic food sources. Some options include scientific and technical expertise, human and institutional capacity-building, support to regional cooperation organizations, the retraining of fishermen for other employment, and support to the production of substitution food sources.

This page has been intentionally left blank.

Annex A
Case Study: East Africa (Kenya, Madagascar, Mozambique, and Tanzania)

The East African coast fronting the Indian Ocean extends several thousand miles from South Africa northward to Somalia. Owing to the region's wild marine fish stocks and its growing aquaculture industry, East Africa is poised to play a significant role in regional food security in both the medium- and long-term. Sub-Saharan Africa in 2011 was home to around 900 million people. Its population is projected to grow to 1.2 billion by 2025, and to 2 billion by 2050 according to UN projections. This analysis will concentrate on four countries that collectively illustrate the current status of and potential future viability of the East African fishing industry: Kenya, Madagascar, Mozambique, and Tanzania. The cumulative population of these four countries is projected to more than double in the next 30 years, growing from roughly 128 million in 2010 to 169 million in 2020 and reaching 274 million by 2040. These demographic trends will necessitate heightened food production generally, and increase pressures on maritime capture fisheries and aquaculture operations in East Africa in particular.

Mid-Range Population Growth Projections for States Bordering the Bay of Bengal

Country	Total Population in 2010 (in thousands)	Total Projected Population in 2020 (in thousands)	Total Projected Population in 2040 (in thousands)
Kenya	40,513,000	52,564,000	80,975,000
Madagascar	20,714,000	27,366,000	44,132,000
Mozambique	23,391,000	29,177,000	43,021,000
Tanzania	44,841,000	61,081,000	107,737,000

Population data taken from the UN World Population Prospects, the 2010 Revision.
Population growth estimates based on the medium-fertility variant.

Seafood has been an important staple of East African diets for the last 40 years and has remained a relatively consistent source of aquatic protein. Seafood provided 5 kilocalories/capita/day in 1969 in Kenya, a figure that fluctuated to some degree in the ensuing decades, but it stood at 6 kcal/capita/day in 2009. In Madagascar, average seafood consumption has remained relatively constant during the past 40 years at 13-14 kcal/capita/day. Mozambique has seen significant fluctuations in its seafood consumption, moving from 9 kcal/capita/day in 1969 to 2 kcal/capita/day in 1999, and then upward to 12 kcal/capita/day in 2009. In Tanzania, seafood has historically been a bigger component of local diets than in other East African countries, accounting for 20 kcal/capita/day in 1969, jumping to 28 kcal/capita/day in 1989, and subsequently dropping to 13 kcal/capita/day in 2009.

If these per capita seafood consumption levels are to remain constant (or increase) as East Africa adds some 146 million people over the next 30 years, wild fisheries will have to be harvested more intensively or aquaculture operations will have to be far more productive than current rates. Further, national fish consumption figures for countries in the region can obscure the fact that some coastal communities obtain close to 100 percent of their animal protein from fish; therefore, the food security threat that declining fish stocks pose to those populations is significant.

The fishing industry plays a key role in the economies of East Africa. In Mozambique, for instance, fishery products have accounted for roughly 40 percent of total exports in recent years. Nevertheless, as in other areas of the Indian Ocean littoral, documentation of wild fish catches in East African waters remains highly unreliable due to a combination of lax reporting on the part of fishermen, inconsistent-to-nonexistent government enforcement of fishing quotas in offshore fisheries, and limited financial resources to bolster the technical capacity of naval patrols.

The inability of the region's governments to accurately document the rates at which East African primary marine resources are being harvested—among them crustaceans (crab, lobster, and prawn), shellfish, pelagic and demersal fish, and seaweed—makes local management of fisheries more difficult. Governments' reliance on inaccurate data to guide policymaking makes policymakers more likely to set high ceilings for fishing quotas or issue an excessive number of new fishing licenses that could ultimately accelerate depletion of wild fish stocks. Finally, although accurate catch documentation cannot be found in either large-scale fishing operations or among subsistence fishermen, the small-scale fishing sector in East Africa (a group composed of primarily of subsistence fishermen and artisanal[5] fishermen) has proven particularly difficult to monitor. Statistics documenting that sector of the fishing industry are considered to greatly underestimate the extent of annual catches in the region.

One emerging sector of the fishing industry not prone to poor data collection is aquaculture. Fish farming has gained a foothold throughout East Africa in recent decades, supplementing wild fisheries as a source of affordable protein in local diets. Although the industry is not yet as established in East Africa as it is in Southeast Asia, aquaculture is a potentially lucrative driver of local economic growth. It can also reliably bolster regional food security and mitigate the impacts of seasonal variations in wild fish availability.

Fish farms can help provide new streams of employment and income for both large-scale commercial operations and small-scale artisanal fishermen, but the industry is not without its downsides. Fish in captivity must be fed, and they often feed on a substance derived largely from fish caught in wild fisheries. Consequently, fish farms can impose significant pressures on the same wild fisheries that they are meant to help stabilize. Fish farms also pose a potential threat to delicate marine ecosystems in shallow coastal waters. Improperly treated wastewater from aquaculture operations can pollute these areas and possibly damage nearby wild fisheries. In other cases, fish farms built in and around mangrove swamps can damage these vital habitats, which provide an important buffer against the tidal surges that accompany tropical storms.

[5] Artisanal fishing is characterized as low-technology, small-scale commercial, or subsistence fishing.

Finally, the crowded conditions of fish farms also facilitate the spread of disease, posing a potentially serious economic threat to the industry. Until 2011, the Western Indian Ocean had been one of the last maritime domains to avoid the wrath of "white spot syndrome," a virus affecting more than 35 species of crustaceans around the world. During the last year, the disease has emerged at separate times in Mozambique and Madagascar, whose respective fish farms are separated by a 430-mile wide channel. Outbreaks of contagious disease can disrupt international trade in seafood, necessitating the destruction of entire fish stocks at the farms. This would cost businesses millions of dollars in lost profits and deal a blow to countries that have grown economically dependent on export-oriented aquaculture.

Despite the risks, aquaculture is projected to assume a progressively larger role in the East African regional economy during the coming decades. The fate of wild fisheries in Western Indian Ocean waters is uncertain owing to incomplete data on the true extent of fishery exploitation off East Africa. Nevertheless, aquaculture development offers the opportunity to ensure continued delivery of aquatic proteins to coastal communities. If implemented in an environmentally sustainable fashion—an effort that would likely require some degree of external assistance—fish farms in Kenya, Madagascar, Mozambique, and Tanzania may prove strategically important in meeting the rising food demand that will accompany East Africa's population boom between 2010 and 2040.

This paper does not represent US Government views.

This page has been intentionally left blank.

Annex B
Case Study: Bay of Bengal (India, Sri Lanka, and Bangladesh)

The Bay of Bengal, forming the northern extremity of the Indian Ocean, is bounded by eight nations: Bangladesh, India, Indonesia, Malaysia, Maldives, Burma, Sri Lanka, and Thailand. Across the region, artisanal fishing fully or over exploits coastal fisheries and dominates total marine fishery production. Offshore fisheries contained within national Exclusive Economic Zones (EEZs) are largely underexploited, primarily due to the absence of a developed deep-sea commercial fishing industry. In an attempt to increase production of wild-caught fish, nations are expanding marine fishery catches, having over exploited inland, freshwater fisheries. The expansion of deep-sea fishing will increase the prospect for "fisher-to-fisher" and "government-to-fisher" conflict. In the medium- and long-term, population growth within the region (see table below) will exceed the sustainable yield of wild stocks in under-exploited fisheries, increasing the reliance upon inland and coastal aquaculture to meet demand.

Mid-Range Population Growth Projections for States Bordering the Bay of Bengal

Country	Total Population in 2010 (in thousands)	Total Projected Population in 2020 (in thousands)	Total Projected Population in 2040 (in thousands)
Bangladesh	148,692	167,256	190,934
India	1,224,614	1,386,909	1,627,029
Indonesia	239,871	262,569	290,223
Malaysia	28,401	32,986	40,800
Maldives	316	356	398
Burma	47,963	51,688	55,410
Sri Lanka	20,860	22,344	23,433
Thailand	69,122	72,091	72,944

Population data taken from the UN World Population Prospects, the 2010 Revision.
Population growth estimates based on the medium-fertility variant.

According to the Food and Agriculture Organization of the United Nations (FAO), the fishing industry's contribution to GDP varies across the region from a low of 1.3 percent in India to a high of 8.94 percent in Burma. Marine fisheries sustain a number of coastal communities and provide employment to millions of citizens in the primary and secondary sectors. Additionally, capture and aquaculture production form an important export commodity for national economies.

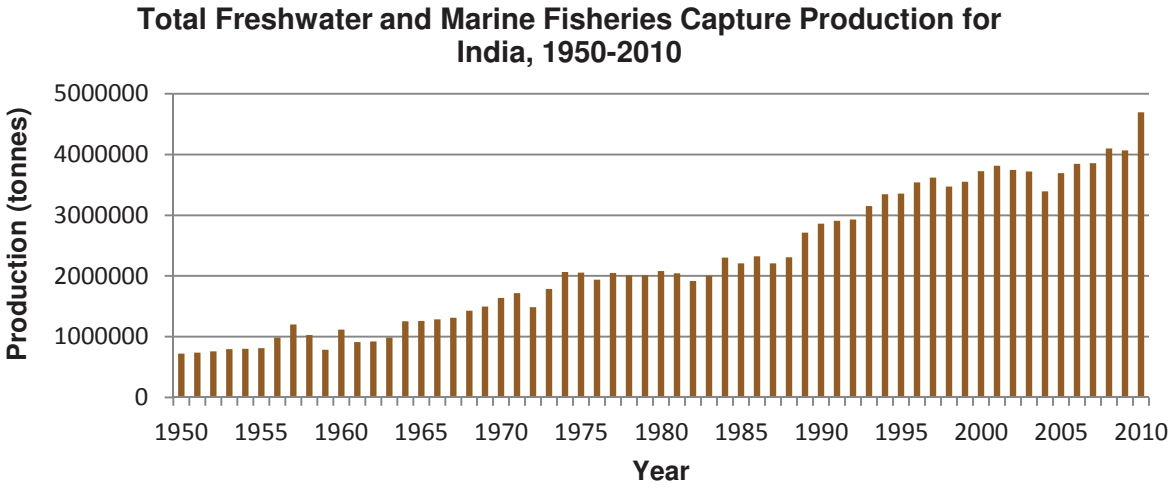
Fisheries management practices within the Bay of Bengal are currently unsustainable. Inadequate regulation and oversight of artisanal fishing within the Bay threatens the collapse of coastal fisheries. Lacking quality data on fish stocks, fisheries departments are unable to determine the maximum sustainable yield for species populations, further impeding effective fisheries management.

Transboundary migratory patterns among large, commercially profitable pelagic species, including yellow fin and skipjack tuna, complicate offshore fisheries management in the absence of a regional fisheries organization. Although all eight nations surrounding the Bay of Bengal have signed and ratified the United Nations Law of the Sea Convention, coordination among national and provincial fisheries departments is lacking. The Indian Ocean Tuna Commission (IOTC), an organization dedicated to the sustainable harvest of tuna and related pelagic species, currently operates within the Bay, but, of the eight bordering nations, member states of the IOTC include only India, Malaysia, Sri Lanka, and Thailand. The Bay of Bengal Programme Inter-Governmental Organisation (BOBP-IGO), which evolved from Bay of Bengal Programme of the UN FAO, is another actor within the region. Focused on sustainable development of coastal fisheries, BOBP-IGO is composed of India, Sri Lanka, and the Maldives. Overall, organizations operating within the region are limited by a lack of regional participation, in addition to a limited management focus.

Environmental pressures unique to the Bay of Bengal endanger fisheries in the medium- and long-term. On average, three cyclonic storms strike India, Bangladesh, and Burma annually. The continued increase of water temperatures due to global climate change threatens to intensify the monsoon season, leading to the damage of fishing fleets and harbors. Furthermore, pollution is a growing problem within the Bay. Agricultural and urban runoff has already destroyed a number of coastal fisheries; increasing populations will intensify the problem in the future. Finally, the world's largest mangrove forest, located along the coast of India and Bangladesh, forms an essential nursery for many commercial species in the Indian Ocean. The forest is currently threatened by deforestation and shrimp aquaculture practices.

India

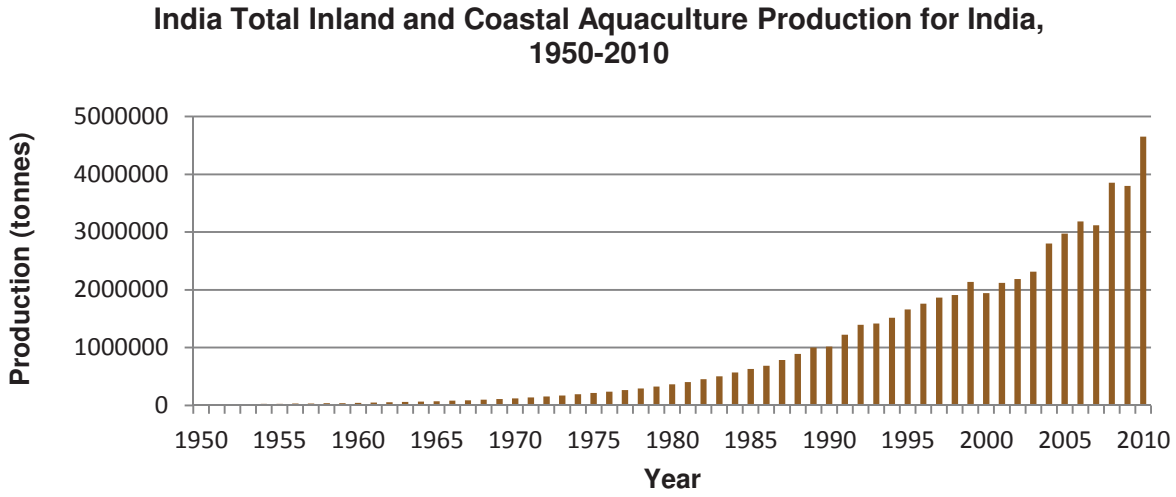
The fishery industry in India, a nation possessing about 8,100 km of coastline, employs over 14.5 million people in the primary and secondary sectors. Accounting for 1.3 percent of the national GDP, the value of fish exports in 2004 was $1.36 billion. In 2010, the total volume of catch landed by Indian fishermen in freshwater and marine fisheries was nearly 4.7 billion metric tons. The most commonly landed species are Indian oil sardines, drums or croakers, and penaeid shrimp. Shrimp species possess the highest landed value among all catch, accounting $352 million in revenues annually since 2000.



Data Source: UN Food and Agriculture Organization.

India's Ministry of Statistics and Programme Implementation estimated the marine resource potential of the nation's EEZ at 3.93 million tons per year in 2011. Marine fish production in 2009-2010 was 3.07 million tons, landed by about 175,000 registered fishing vessels (down from the 2005 National Marine Fisheries Census figure of 244,000 fishing craft). According to a stock assessment conducted by the Ministry of Agriculture in 2000, India is exploiting 65 percent of total marine resources, while surface waters are currently fully exploited. Commercial species facing local extinction due to overfishing include the whale shark and select species of marine catfish, white fish, flat head, threadfins, perch, sciaenids, and eel. In the medium- and long-term, fishing pressures will reduce the biodiversity of catch, forcing the harvest of less commercially valuable species. Additionally, deep-sea fishing by commercial fleets will expand, creating the conditions for potential conflicts between rival fishermen and foreign governments.

Depletion of fish stocks in marine fishing grounds has led to the growth of aquaculture. In 1950-1951, marine fisheries consisted of 71 percent of all fish production. By 2005-2006, marine fisheries contributed only 43 percent to fish production, of which approximately 40 percent was landed in the Bay of Bengal. Since the 1970s, government initiatives have established 650,000 hectares of freshwater aquaculture and 157,000 hectares of brackish-water aquaculture. According to the FAO, coastal aquaculture contributes 5 percent to total aquaculture production within India and is composed primarily of small-scale farming operations on less than 2 hectares of water. The expansion of aquaculture in India has created a number of environmental concerns. In a four-year period (1991-1995), 50,000 hectares of coastal wetlands were lost to shrimp aquaculture, increasing coastal exposure to storms and flooding. Additionally, intensive aquaculture practices enabled the outbreak of white spot syndrome among cultivated shrimp in 1994-1995. Through government-led efforts, farmers have begun to implement sustainable management practices in brackish-water aquaculture. Much work remains to be done, however.



Data Source: UN Food and Agriculture Organization.

Sri Lanka

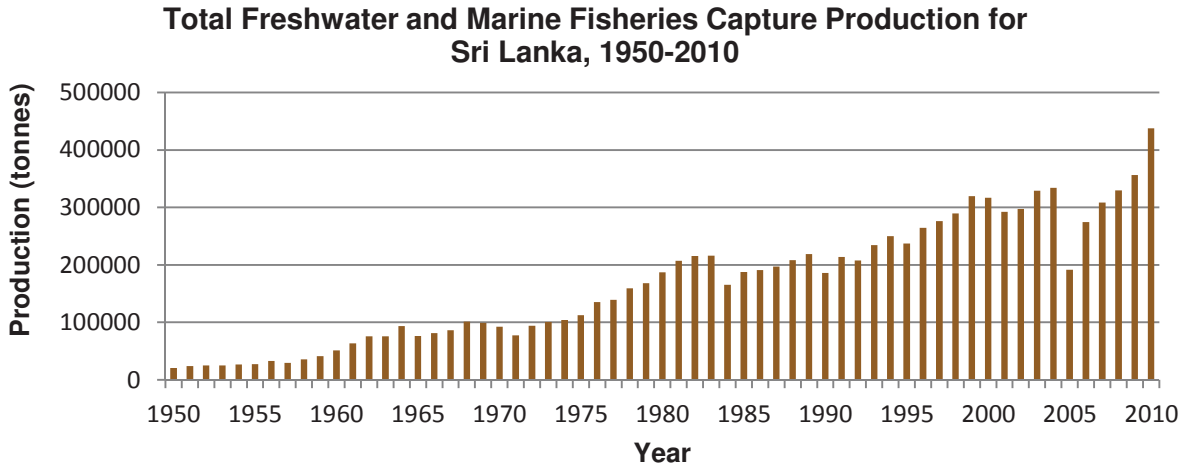
Within Sri Lanka, the fishing industry supports one out of 20 citizens. On average, 65 percent of animal-based protein comes from fish in the Sri Lankan diet. Sri Lanka has 1,770 km of coastline. The fishing industry contributes 2 percent to national GDP, and, in 2004, generated $94 million in exports. In the same year, the size of Sri Lanka's marine fishing fleet was about 31,700 boats, of which nearly half were traditional wooden canoes.

In 2010, total capture production in marine and freshwater fisheries was some 437,000 tons, with small pelagic species accounting for 40 percent of total fish production. The current status of Sri Lanka's fisheries is mixed; demersal species are fully exploited beyond the continental shelf, yet an abundant tuna stock exists within the nation's EEZ. The FAO estimates that the maximum sustainable yield within Sri Lanka's coastal fisheries is 250,000 tons. In 2004, coastal fish production was only 154,000 tons.

The fishing industry in Sri Lanka has only recently recovered from the prolonged conflict between the Liberation Tigers of Tamil Eelam and the Sri Lankan Government. During the Sri Lankan civil war (1983-2009), fishermen were displaced from their homes and access to fishing grounds was severely restricted. Across Palk Bay, the Indian trawler fleet, already too large for the available fishing grounds, expanded across the International Maritime Boundary Line. Although total capture production within Sri Lanka stagnated during the civil war (as seen in the figure on page 41), marine capture production in Palk Bay between 1980 and 1996 doubled due to the technology and presence of the Indian trawler fleet. By 2005, nearly half of the trawler fleet based in Tamil Nadu was wholly or partially dependent upon Sri Lankan fishing grounds. Resource conflicts between localized Sri Lankan fishermen, Indian commercial fleets, and government maritime forces are likely to intensify in the medium- and long-term as the Sri Lankan fishing industry attempts to fully exploit national marine resources.

The devastation of the 2004 tsunami on Sri Lanka illustrates the vulnerability of the fishing industry to environmental threats. About 75 percent of the marine fleet was destroyed, and 10 of 12 harbors

were severely damaged. As a result, in 2005, capture production within Sri Lanka decreased by over one-third (as seen in the figure below). The massive influx of aid in the aftermath of the tsunami also proved misguided in certain respects. Donors provided more boats than the number of fishers in some countries, while some aid recipients who had never fished previously received boats as aid.



Data Source: UN Food and Agriculture Organization.

Bangladesh

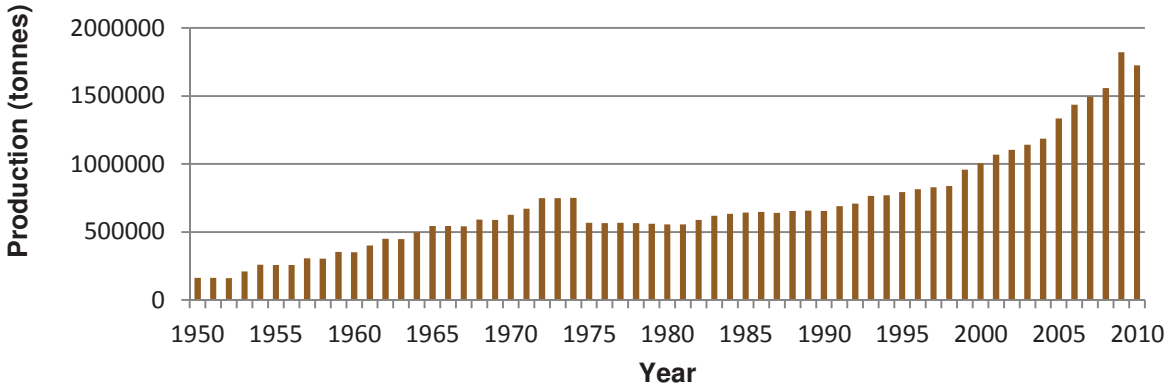
The over exploitation of freshwater and marine estuary fish stocks has increased Bangladeshis' reliance on aquaculture and marine fishing. The country has over 4.5 million hectares of inland water bodies. Freshwater production has increased from 591,000 metric tons in 1994-1995 to 957,000 tons in 2005-2006-a growth of 61.8 percent. During the same time period, marine capture from the Bay of Bengal increased by more than 80 percent to 480,000 tons. More significantly, aquaculture increased by 180 percent in less than a decade. Today, aquaculture is the largest fish production source within Bangladesh.

Contributing nearly 5 percent to national GDP, the Bangladeshi fishing industry, including aquaculture, employed 24.3 million citizens in the primary and secondary sectors in 2005-2006 according to the FAO. Bangladesh has 480 km of coastline, and coastal fisheries hold a standing stock of 150,000-160,000 tons of fish. Marine catch is dominated by shrimp and finfish: 40 percent of total marine catch is *hilsha*, 10 percent is shrimp, 8 percent is Bombay duck, 7 percent is jewfish, and the remaining 35 percent are other assorted finfish. More than 90 percent of catch is landed by artisanal fishing; as a result only one-third of the Bangladeshi EEZ is exploited while the remaining two-thirds are undeveloped. Estimates of pelagic fish stocks vary between 66,000 and 133,000 tons over the continental shelf, and the possibility of formation for a commercial tuna fleet exists in the medium-term. Without a thorough assessment of unexplored regions of the EEZ, the overall status of fisheries in Bangladesh's full EEZ is difficult to discern.

The status of Bangladesh's presently used fishing grounds is poor. Demersal populations are fully or over exploited, and the indiscriminate nature of fishing practices, specifically the use of trawl fishing and small mesh gillnet vessels, is exerting additional pressures on fish populations. In 2000-2001, catch per unit of effort (CPUE) for small mesh gillnet vessels, an indicator of fishery status, was 650

kg/boat/day. By 2005-2006, CPUE had dropped to 100 kg/boat/day. An increase of 20,000 fishing vessels from the late 1980s to 2000 accompanied a decrease in annual catch per vessel from 41 tons to 7 tons. Additionally, despite the lack of a formal stock assessment since 2003, researchers aboard finfish trawlers have observed a marked decrease in biodiversity, with high-value commercial species disappearing among catch.

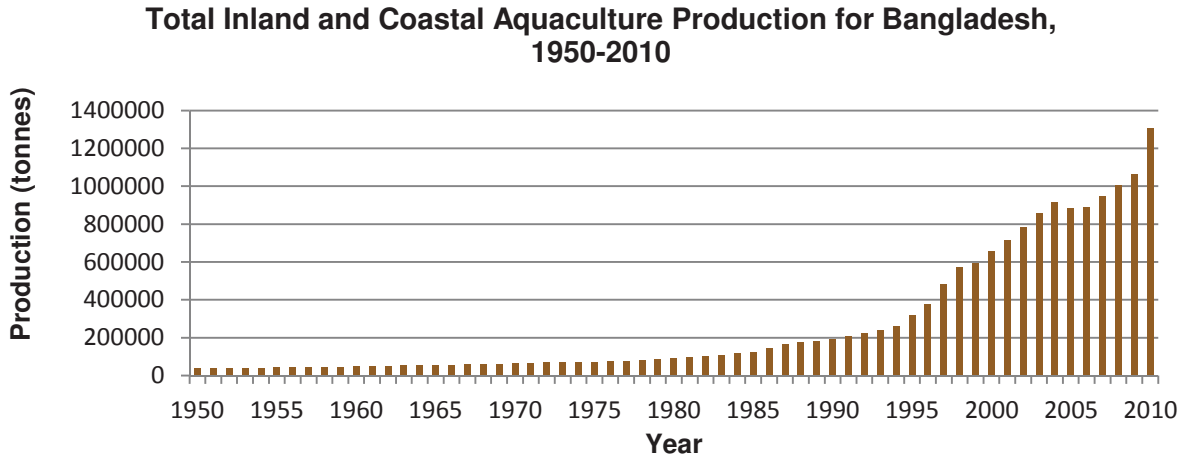
Total Freshwater and Marine Fisheries Capture Production for Bangladesh, 1950-2010



Data Source: UN Food and Agriculture Organization.

Marine management in Bangladesh focuses on regulating the one-hundred industrial trawlers licensed to fish in national waters, ignoring the impact of artisanal fishermen on species populations. Similar to India, Sri Lanka, and Burma, Bangladesh restricts access to vulnerable fishing grounds, maintains closed seasons, and regulates vessels through licensing. Additionally, Bangladesh restricts trawl fishing to the 40-meter depth contour. The significant decrease in catch per unit of effort has led trawlers to violate the depth requirement, fishing in water as shallow as 10 meters and destroying the critical ecological region at the lowest level—including the sediment surface and some sub-surface environments.

Shrimp aquaculture in Bangladesh, although lucrative (yielding an average of $153,000 per hectare in 2002 and contributing nearly 5 percent to total exports), is responsible for severe degradation of coastal environments. The Sunderbans form the largest mangrove forest in the world, covering 12,000 km^2 of coastland. Forming a critical aquatic nursery for the Bay of Bengal fishery, mangrove forests also protect coastal communities from erosion and storm surges (which can reach 7 meters high during cyclones). Currently, deforestation of mangrove forests is occurring due to the expansion of shrimp aquaculture, leaving coastal communities vulnerable to extreme weather and the rising ocean.



Data Source: UN Food and Agriculture Organization.

The destructive impact of shrimp aquaculture extends beyond the near-shore environment. Shrimp farms release chemicals and untreated waste into surrounding waters, adversely affecting fisheries. Additionally, the seed for shrimp farms is collected from wild stocks, which provide 90 percent of post-larvae in estuary nursery grounds. Using push nets and drag nets, shrimp seed is only 1 percent of catch. By-catch is discarded on shore, resulting in the death of approximately 200 billion organisms annually.

Upstream development on the Ganges and Brahmaputra Rivers is further stressing coastal environments. The Ganges River formerly supplied 2.4 billion tons of sediment to the coastal delta annually, protecting Bangladesh against delta subsidence and sea-level rise. Infrastructure construction on the Ganges River, particularly the Farraka Barrage, is retaining 25 percent of sediment, reducing sediment loads to 1.8 billion metric tons. In 1988, the US Environmental Protection Agency estimated that sea-level rise will occur at a rate of 1 cm/year. If no additional sediment retention occurs, current sediment loads are capable of counteracting rising ocean levels.

Reduced water inflows into the Bay of Bengal due to upstream diversions have also led to salinity intrusion in ground and surface waters. When accessing underground aquifers in coastal areas, wells must be drilled to a depth of 250 meters to find acceptable drinking water. In surface waters, salinity intrusions reach 180 km north of the Bay. As a result, spawning grounds have migrated further inland, threatening the livelihoods of coastal communities. Additionally, by shifting upstream, nursery grounds are further exposed to overexploitation by inland fishers.

Over the medium- and long-term, global climate change will dramatically alter the coastal environment in Bangladesh. According to the UN Development Program, Bangladesh is the world's most vulnerable country to tropical cyclones, which cause 32.1 deaths for every 1,000 citizens exposed. By 2030, climate-change scenarios predict a sea-level rise of 30 cm accompanying an 11 percent increase in monsoonal precipitation as compared to 1990, and, by 2050, a sea-level rise of 50 cm and a 28 percent increase in precipitation. As a result, floods, which inundate 26 percent of the country each year, will increase the area of extremely vulnerable land in 2030 by 14.3 percent. According to the World Bank, a one-meter sea-level rise will result in the total loss of the Sunderbans. Finally, the severity of cyclones (currently striking once every three years) is expected to increase due to warmer ocean surface temperatures.

This page has been intentionally left blank.

Annex C
Case Study: Malaysia

Malaysia ranks in the top 20 countries fish production via capture methods. However, unlike many of its neighbors, the inland capture sector of Malaysia's fishing industry is nearly nonexistent, contributing a mere 0.23 percent of all fishery production in 2010 with little room for expansion. Marine capture forms the vast bulk of Malaysian fisheries production, accounting for most of Malaysia's 1,810,000 metric tons of production from all fisheries sources in 2010. In terms of marine capture, the vast majority of Malaysia's production comes from fishing near the shore at a level that has remained relatively static over the years, indicating very little room for expansion of coastal fishing activities. Total capture production has increased steadily from 1,200,000 tons in 2001 to 1,430,000 tons in 2010, with most of that increase coming from offshore fishing activity. Aquaculture, primarily from brackish water sources, amounted to 373,000 metric tons in the same year, mirroring a widespread trend among Southeast Asian countries of quickly expanding aquaculture operations.

Malaysia

DI Cartography Center/MPG 903294AI (C00228) 7-13

Of all countries bordering the South China Sea, Malaysia has the highest reliance on seafood to meet its dietary needs. In 2010, seafood contributed 102 kilocalories and 16.2 grams of protein per person each day. The next highest consumers of seafood around the South China Sea, Cambodia and the Philippines, each received approximately 70 kilocalories and 11 grams of protein from seafood each day.

However, Malaysia also has one of the smallest populations of any country bordering the South China Sea at 28 million in 2010, larger than only Cambodia and Brunei. Malaysia does have a high population growth rate over the long term (rising up to approximately 40 million by 2040, 1.4 times the current population), particularly along the coastal regions. Nonetheless, Malaysia's total population will still be greatly overshadowed by its neighbors. Furthermore, the majority of the Malaysian population (and 63.5 percent of Malaysia's marine fishing fleet) is based on peninsular Malaysia, rather than on Malaysian Borneo. With slightly over 70 percent of the peninsular fleet found on the westward coast of the peninsula, a sizable portion of the Malaysian fishing fleet generally does not operate in the South China Sea. Consequently, Malaysia's portion of South China Sea capture production is among the smallest in the region. As of 2006, the Malaysian fishing fleet only captured approximately 291,000 tons from the sea out of a total 6,430,000 tons in the South China Sea.

Malaysia's waters are host to extensive coral reef systems equaling 4,000 km^2, though this number is dwarfed by a few of Malaysia's neighbors—the Philippines has over 26,000 km^2, one of the highest anywhere. Many of these reefs are at risk from a variety of threats, including both direct manmade impacts, such as overfishing or destructive fishing practices, as well as environmental concerns such as climate change and a shift in ocean temperature, which could lead to "bleaching" events that kill wide swaths of coral reef. Malaysia has taken steps to address these problems, such as temporary bans on tourism around endangered reefs and the creation of marine protected areas. Much work is yet to be done, however.

One of the largest problems in this regard, as it is in many other Southeast Asian states, is ensuring that sufficient monitoring and enforcement capabilities exist to stop illegal fishing. However, the legal instruments in place at present are generally only national legislation with a few international agreements.[6] As a result, comprehensive regional fisheries agreements are lacking to tackle the transboundary issues in fishery policing and management. The rest of Malaysia's participation in fishery management in the region is generally limited to promotional and research bodies, such as the Southeast Asian Fisheries Development Center (SEAFDEC, established in 1967) and the Agreement on the Network of Aquaculture Centres in Asia and the Pacific (1988).

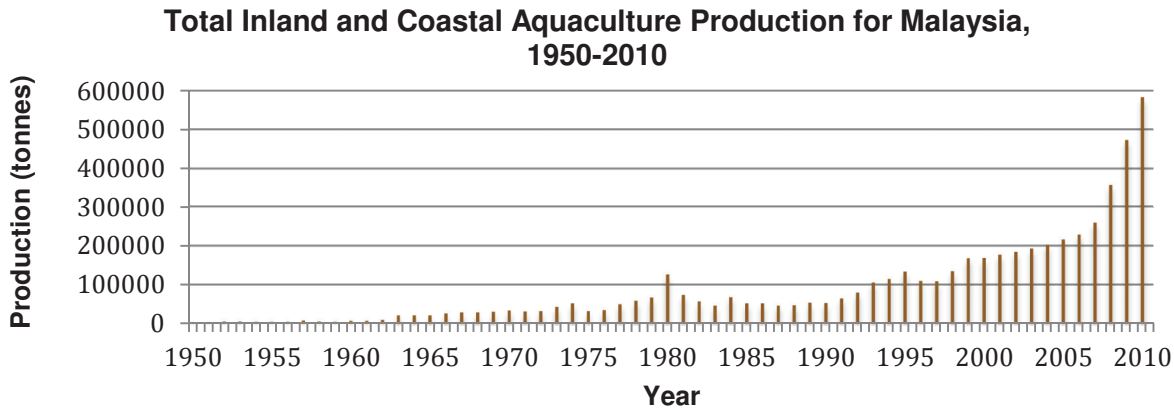
SEAFDEC has a number of extension programs focused on a variety of issues, such as outreach to rural communities and testing new technologies. It has instituted initiatives to expand awareness, such as training programs on Ecosystem Approaches to Fisheries Management, and was central to a 2011 ASEAN resolution on sustainable fisheries management.

Overall, Malaysian production from South China Sea fisheries is expected to rise along with its growing population with rising income levels. However, owing to Malaysia's relatively small population and the heavy inshore focus of its fishery activities, its impact on the South China Sea as a whole will likely be small relative to its larger neighbors. Still, the transboundary nature of many fish stocks, combined with Malaysia's extensive coastline and significant coastal reef environments, make it an important player in the region in any future fishery management schemes. In addition, with Malaysia's coastal waters labeled as either fully exploited or overexploited, the pressure for Malaysian fishers to expand to deeper waters farther offshore will intensify. However, the extent to

[6] Such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora or the Regional Plan of Action (RPOA).

which it is possible for Malaysia's fleet to do so is limited by technological capabilities. In 2010, out of 49,800 licensed fishing vessels, most of which are traditional fishing boats, only 1,170 were licensed and capable of fishing in deep-sea waters, though this statistic excludes certain classes of vessels, such as those licensed specifically for tuna capture.

As with most states bordering the South China Sea, Malaysia will continue to look to aquaculture rather than capture as a means to expand its capacity to produce fish. Malaysia has been actively promoting aquacultural activities as an alternative, particularly brackish water production, for over a decade. The result of this has been a massive expansion of production in recent years (see figure below), with molluscs, shrimp, and prawns holding the largest share of the industry. Although the industry is still small when compared to the size of Malaysia's capture industry, it has achieved a much higher level of growth and continues to grow in importance to the Malaysian economy.



Data Source: UN Food and Agriculture Organization.

This page has been intentionally left blank.

Annex D
Case Study: Indonesia

A vast archipelagic nation, Indonesia is composed of more than 17,000 islands that lie between the Indian and Pacific oceans and span more than 285,000 km^2 of maritime space. Fishing is one of the key industries uniting the nation, which has a wide range of different cultures. Fish protein constitutes a key component of local diets. From Papua in the far southeast to Sumatra in the northwest, the islands of Indonesia are divided among a number of seas that have historically boasted rich wild fisheries. These include the: Arafura Sea, Timor Sea, Banda Sea, Sawu Sea, Flores Sea, Java Sea, Sulawesi Sea, Maluku Sea, and Seram Sea. However, as a result of rapid population growth since the mid-20th century and growing evidence of climate change impacts in the region, these fisheries are coming under mounting pressure.

Indonesia

DI Cartography Center/MPG 903295AI (G00669) 7-13

Indonesia is the fourth most populous country in the world with a population of nearly 240 million as of 2010, placing it behind only China, India, and the United States. Although Indonesia's population is projected to grow substantially in the medium- and long-term, the country's rate of demographic change is demonstrating a gradual deceleration compared to the latter half of the 20th century. During that time period, Indonesia's population doubled from 75 million in 1950 to over 150 million in 1980. By 2020, medium-range scenarios project comparatively slower growth as the country adds another 20 million people, placing its population at over 262 million. Between 2020 and 2040, another 30 million people are expected to live in Indonesia, putting the total population at over 290 million.

The addition of roughly 50 million people between 2010 and 2040—and the attendant increased depletion rates of Indonesia's fisheries—could have serious implications for the country's food security. The importance of fish as a source of aquatic protein in the diets of Indonesians has

increased in recent decades. In 1969, Indonesians consumed 18 kcal/capita/day of seafood, a figure that rose to 24 kcal/capita/day in 1979, 31 kcal/capita/day in 1989, 38 kcal/capita/day in 1999, and 51 kcal/capita/day in 2009 (the most recent year for which data is available). Today, Indonesians obtain more than 50 percent of their animal protein from seafood, a percentage comparable with other nations in the Indian Ocean littoral, such as Bangladesh and Sri Lanka.

Population growth, combined with the rising profile of fish protein in Indonesian diets, has necessitated intensified harvesting of the country's fisheries, yet the exact extent to which they have been depleted is an open question. As has been the case with many other nations of the Indian Ocean littoral, inaccurate documentation of catch levels by commercial operations and small-scale fishers alike is a persistent problem due to illegal, unreported, and unregulated fishing. Consequently, no hard statistics exist to fully document the extent of Indonesian fishery exploitation across the country's various seas or fish species.

Anecdotal reporting, however, indicates that fisheries in Indonesia's seas are being depleted at rates that may have long-term implications not only for the health of certain local fish populations, but also for the region's maritime ecosystem. Indonesian fishers particularly like to catch a fish at the top of the food chain—sharks—and Indonesia is the world leader in shark-hunting as measured by volume caught, according to the FAO. During the last 10 years, Indonesia's collective catch of various shark species has constituted more than 13 percent of the documented global shark catch. In the Indian Ocean in particular, the country operates nearly all of the major shark-fishing fleets. In recent years those ships have collectively hauled in an annual average of 8-16 million tons of shark. Because only 35 percent of the country's total shark catch is taken from Indian Ocean waters, however, the total annual tonnage of shark caught in all Indonesian waters (including the Pacific Ocean) probably is dramatically larger. In the long term, the unsustainable drawdown of local shark populations could throw the region's maritime food chain off balance by reducing the ecosystem services provided by these apex predators.

Exacerbating the drawdown of fish stocks in Indonesia has been the clandestine and illegal fishing done by foreign fleets in the country's territorial waters. This illicit activity is considered widespread, yet the vastness of Indonesia's maritime space makes the waters essentially impossible to patrol, aside from a few strategic areas of limited size. According to the FAO, illicit foreign fishing in 2011 cost Indonesia more than $3 billion in lost revenue. Bodies of water targeted by these fishing fleets have typically included the Sulawesi, Natuna, Aru, and Arafura Seas, as well as the Malacca Strait.

Belatedly, the government is signaling that it intends to take action to protect its domestic fishing industry, primarily because it feels that fish exports should represent a far larger portion of the nation's GDP than they currently do. In 2011, Indonesia's fisheries industry registered an export value of $3.34 billion. Vietnam's fisheries industry export value for the same time period was $5 billion, even though Vietnam's territorial waters are a fraction of the size of Indonesia's territorial waters. The Indonesian Government has taken the position that illegal foreign fishing, combined with widely underreported domestic fishing, is causing the fisheries sector to underperform economically. For that reason, it has been exploring approaches to improving data collection and protecting strategic fisheries, potentially by deploying limited maritime patrols. However, these plans are in the early stages, and their potential effectiveness is unknown.

In addition to illegal fishing and general fishery overexploitation, climate change poses another threat to Indonesia's wild fisheries. Already, notable shifts in current movement and water temperature have been documented in the waters near Australia. Local scientific experts are linking these shifts to climate change impacts and suggest that they may adversely affect local fish stocks. The Indonesian Government, for its part, has not invested substantially in climate change mitigation and adaptation efforts primarily focused on preserving maritime resources, and the operating budget for the country's Maritime Affairs and Fisheries Ministry is small. However, the threat Indonesian fisheries face as a result of climate change and overexploitation could be very serious. According to some projections, catch potentials within the Indonesian EEZ may decline more than 20 percent between 2010 and 2055.

Like other nations across the Indian Ocean littoral and the South China Sea, Indonesia has relied upon aquaculture to help mitigate the impacts of overexploitation of its wild fisheries. Aquaculture farms in the country, which are well-established, raise both animals (including various species of crab and fish) as well as plants (such as seaweed). The industry's growth in recent years has been impressive. Fish farming is now practiced by both large-scale export-oriented commercial operations and at the local level. It has provided a reliable new revenue stream for fishers in coastal communities who have grown wary of unpredictable seasonal variation in the availability of wild fish stocks. Viewed more broadly, Indonesia's aquaculture industry is now one of the world's largest, generating a harvest of several million metric tons annually, ranking the country among the top ten aquaculture producers in 2010, alongside India, Bangladesh, Thailand, and Burma. Aquaculture, combined with the harvesting of wild offshore fisheries, provides a livelihood for an estimated six million Indonesians.

This page has been intentionally left blank.

Annex E
Case Study: Philippines

DI Cartography Center/MPG
903296AI (C00197) 7-13

With a population of some 93 million people in 2010 and the highest rate of long-term population growth among South China Sea littoral states, the Philippines is one of the most populous countries in the area. According to UN projections, the population of the Philippines will reach 141 million by 2040. Approximately 1.6 million Filipinos were classified as fishers, according to 2002 census data. The majority of the current population and projected population growth is located within the many coastal zones of the Philippines, where fish consumption already constitutes a significant and growing part of local diets. According to statistics from the FAO, the average proportion of daily caloric intake that seafood represent per person has steadily increased in recent years from 58 kcal/capita/day in 2002 to 70 kcal/capita/day in 2009, compared to the world average of 33 kcal/capita/day, a figure only

surpassed in the South China Sea in that year by Cambodia at 71 kcal/capita/day and Malaysia at 102 kcal/capita/day.

In 2010, the total volume of Philippine fisheries production (including aquatic plants) reached over 5.1 million metric tons, of which 2.6 million was capture production, a capture amount higher than any other Southeast Asian country except Indonesia (5.4 million tons) and Burma (4 million tons).

Despite the high capture level of the Philippine fishing industry, the sector plays a comparatively small part for the country's trade, having exported $569 million of fishery commodities in 2009. Of these, tuna has been the most important species for exports in the Philippines, followed by seaweeds, crabs, and shrimp. In contrast, Vietnam, with a capture production of 2.4 million metric tons in 2009, exported a much higher $4.3 billion worth of fishery commodities in the same year. A number of reasons account for this difference. Some of the major factors are the comparatively lower reliance of many of the Philippines' neighbors on seafood for food security (based on caloric intake), as well as the higher quantity and economic value of different types of aquaculture production for fish in almost every other country along the South China Sea.

Aquaculture Production of Fish in the South China Sea Littoral (2010)

Country	Quantity (Metric Tons)	Value ($1,000)
Brunei	N/A	N/A
Cambodia	N/A	N/A
China	36,734,215	59,141,915
Indonesia	2,304,828	4,894,871
Malaysia	373,151	838,544
Philippines	744,695	1,563,082
Thailand	1,286,122	2,817,138
Vietnam	2,671,800	5,150,010
Regional Total	44,114,811	74,405,560
World Total	59,872,600	119,444,278

Source: UN Food and Agriculture Organization.

Although the Philippines capture production for the archipelagic state exceeds that of several of its neighbors, data indicates that in 2006 the Philippines was surpassed by several states—China, Vietnam, Thailand, and Indonesia—in terms of production from the South China Sea. This is due at least partly to the archipelagic nature of the Philippines, giving the country a huge amount of shallow, near-shore archipelagic waters (as defined under UNCLOS) for Filipino fishers to exploit.

However, much of those Filipino archipelagic waters are overfished, leaving few areas that have not had their habitat and corresponding fish population depleted. A press release in July 2012 by Filipino Environment Secretary Ramon Paje affirmed what several research projects had shown years before: the Philippines' coral reefs have been badly damaged by destructive fishing practices and pollution.

Forty percent of the Philippines' reefs (estimated to cover 26,000 km^2, one of the highest reef areas in the world) were in poor condition, a significant increase from the 1997 figure of 27 percent from the Philippine Bureau of Fisheries and Aquatic Resources. Only 5 percent were listed as in "excellent" condition in 2012. Making matters worse is a general lack of resources to effectively manage even zones that have been designated as Marine Protected Areas.

This depletion of coastal and near-shore habitats in the Philippines has forced more and more Filipino fishers to travel farther offshore to find fish, though their often limited means makes this difficult. Of the many Filipinos who are fishers, the majority are classified as small-scale (or municipal), making fishing activities far from the shore costly, particularly with rising fuel prices. This means that many Filipino fishers are often at a profound disadvantage in the South China Sea when competing with some of the Philippines' neighbors, particularly China's massive and far more industrialized marine fishing fleet.

Much like many other countries along the South China Sea, aquaculture (inland, brackish water, and marine) provides the best scenario for sustainably increased production of fishery commodities in the Philippines, though this path is not without its own challenges. Previous attempts at expanding aquaculture in the Philippines have been inefficiently implemented, inadequately funded, and plagued with oceanographic problems. With a rapidly growing population dependent on fisheries for both food security and income, as well as depleted local waters, the Philippines will probably contribute significantly to growing pressure on the South China Sea in the future, particularly if aquaculture development does not progress.

Although aquaculture production of fish is comparatively low in the Philippines, the country is already almost unrivaled in its production of aquatic plants through aquaculture worldwide, after China and Indonesia. However, as seen below, this trade is significantly less profitable overall than fish and, much like aquaculture production of fish, focused heavily in Southeast Asia and China.

Aquaculture Production of Aquatic Plants in the South China Sea Littoral (2010)

Country	Quantity (Metric Tons)	Value ($1,000)
Brunei	N/A	N/A
Cambodia	N/A	N/A
China	11,092,270	2,533,196
Indonesia	3,915,017	1,268,367
Malaysia	207,892	17,444
Philippines	1,801,272	256,715
Thailand	N/A	N/A
Vietnam	35,000	17,500
Regional Total	17,051,451	4,903,222
World Total	19,007,053	5,651,167

Source: UN Food and Agriculture Organization.

The Philippines generally lacks dedicated fisheries agreements, such as agreements to establish catch levels, sustainable practices, and patrols, with most of its neighbors. The absence of agreements is a significant hurdle impeding sustainable fisheries management for countries bordering the South China Sea and surrounding waters. The Philippines has a bilateral agreement with Papua New Guinea based on fisheries, but in many respects the agreement mirrors the basics of SEAFDEC's mission: namely, research and technology transfers in the pursuit of fisheries development. Although the essence of this agreement is positive, a general lack of reliable data plagues many of the waters in that region. This multilateral agreement directed at shared management of shared fishery resources has not experienced significant progress. Several regional agreements and bodies, such as the Regional Plan of Action (RPOA), are dedicated to reversing this deficiency.

The RPOA, created in 2007 and endorsed by 11 regional countries, is a voluntary measure that attempts to promote efforts to tackle illegal, unregulated, and unreported fishing in the region. The RPOA also is designed to facilitate participation in other existing international agreements such as UNCLOS and the FAO Code of Conduct for Responsible Fisheries, and use existing regional organizations to attempt to coordinate policy. Almost every country bordering the South China Sea, with the exception of China, has endorsed the plan.

The Philippines has made progress in signing one important international agreement. Unlike most Southeast Asian countries, the Philippines (along with China) is a signatory to the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific, which came into force on June 19, 2004. Vietnam, Indonesia, and Thailand are cooperating nonmembers of the Western and Central Pacific Fisheries Commission created by the Convention. The purpose of this agreement is to address long-term sustainability of fish stocks that straddle the waters of several states, as well as the high seas where no country has economic jurisdiction. Although this was a promising development, more needs to be done to address overfishing, rising use of destructive fishing practices as fishing becomes more difficult, and a deficiency in enforcement capability of regulations designed to counteract these trends.

Annex F
Case Study: China

DI Cartography Center/MPG
903297AI (G01977) 7-13

The Role of Fisheries in China

The Chinese Government has long recognized the importance of fisheries to food security and the economy, and has spent decades of dedicated development to boost China's fishing and aquaculture industries. As a result, China has become the world's top producer and exporter of fisheries products, both in terms of wild catch and aquaculture. In 2010, China accounted for 35.1 percent of global fisheries production with a combined 52 million metric tons, 36.7 million of which came solely from aquaculture, which accounted for 61.4 percent of the world's total. In the South China Sea, China is the dominant producer of marine catch, followed by Vietnam, Indonesia, Thailand, and the Philippines.

The fishing industry plays a major role within China's agricultural sector (comprising nearly 10 percent of agriculture), particularly in the realm of exports. Over 13 million Chinese are employed in the fishery industry. Fisheries exports have been the largest portion of agricultural export, coming in at $10.2 billion in 2009, making it also the largest exporter of fishery commodities in the world. Subsequently, the fishery and aquatic industry is significant in the Chinese economy, particularly along the coastal regions. Hainan, Guangdong, and Fujian provinces in China have the greatest focus in their fishing industry on the South China Sea. Guangdong in particular is among the most populous Chinese provinces with one of the highest growth rates, which will contribute to further pressure on the South China Sea in the future.

Seafood contributed approximately 7.5 grams of protein per capita per day in 2009, a number that remained static from 2008. Coastal provinces depend far more on seafood than most areas of the interior. However, the source of production for the fishing industry has shifted dramatically since the early 1980s. According to the China Fishery Statistic Yearbook 2011, catch from marine sources constituted over two-thirds of the fishing industry compared to the 26 percent from aquaculture of the early 1980s. By 2010, that number had reversed dramatically, with marine catch representing less than one-quarter of China's fishing industry, compared to 71.3 percent from aquaculture, with the remainder coming from inland fisheries.

In the future, China is likely to continue to expand its reliance on aquaculture to meet its fish demands, particularly as levels of income continue to rise. China's population is expected to peak and begin to fall sometime in the medium term. At present, however, it almost certainly will continue to rise, with a high amount of China's growth and continuing population migration being concentrated on coastal provinces and urban areas.

China's Fishery Law and Fisheries Development

China adopted its fishery law in 1986, several years after Beijing began its economic liberalization. Though the fishery law has experienced revisions in years after (in particular a "Zero Growth" policy in 1998 designed to limit the effect of overfishing on marine catch), the basic idea has remained the same:

> *"…enhancing the protection, increase, development and reasonable utilization of fishery resources, developing artificial cultivation, protecting fishery workers' lawful rights and interests and boosting fishery production…"*

This law reflected a desire within China to promote fisheries development to meet food needs, a goal that was largely achieved. By the end of the 1970s, China's fishery production was just over 5 million metric tons a year. It has expanded to over 50 million tons since. However, the cost of this growth has been a rapid depletion of the coastal zones around China of its fish stocks for a number of reasons.

Depletion is the result of overfishing caused by the expansion of the industry,[7] illegal, unregulated, and unreported fishing, and the steady increase in efficiency of the Chinese marine fishing fleet. Though China has made efforts to reduce the size of its fishing fleet, these efforts have been relatively ineffective due to a lack of incentive among local fishermen and governments. The result has been an expansion of fishing operations farther and farther from China's coast—as far away as Africa or South America. The unfortunate side effect of this has been to bring Chinese fishers into conflict with foreign fishers and enforcement agencies, often violently, and particularly within the contested South China Sea.

[7] The Chinese fishing fleet numbers just under 300,000 vessels in 2010.

Cooperative Fishery Agreements

China has several fishery management agreements with regional neighbors, indicating a desire to effectively manage marine fisheries, though unfortunately most of these agreements are not with China's neighbors along the South China Sea. In particular, China has cooperative agreements with South Korea, Japan, and Vietnam. The Japanese agreement came into effect in 2000, the Korean agreement in 2001, and the Vietnamese agreement in 2004. The major focus of these agreements is to proclaim rights to fisheries resources within their own EEZ, establish rules for nationals from one state fishing in the EEZ of another, and create agreements on managing shared stocks.

The Vietnamese agreement is limited to the Gulf of Tonkin, but it sets a useful precedent that could be expanded to the South China Sea. The agreement includes the establishment of a common fishing zone and a transitory fishing zone to preserve fishing stocks that straddle their respective EEZs and to facilitate the establishment of the newly delimited national borders. The primary purpose of the transitory zone was to ease the displacement of fishers who could no longer fish in newly created zones belonging to the opposing state. The common fishing zone was created with joint management in mind. Enforcement agencies of each state are responsible for monitoring the activities of fishers from both states in their respective zones. The allocated catch within that zone, which is determined yearly by the commission created by the agreement, is harvested on an equitable basis.

These fishery agreements have not been without dispute, and in several cases have not prevented diplomatic tensions from flaring up (for example, in the case of a Chinese fishing boat captain fatally stabbing a South Korean coastguardman and seriously injuring another in 2011), but in each case they present a useful starting point for cooperative fisheries management based on the mutual interest of both parties in sustaining fish stocks. However, there are doubts that the level of enforcement of these agreements is sufficient to prevent further overfishing due to a lack of resources and coordination in national fishery administrations. Southeast Asian enforcement agencies are generally underfunded, and in many cases the relationship between China's many coastal fishery administration agencies is better characterized as competitive rather than cooperative. This means that, although China has the best equipped fishery agencies among South China Sea states, they cannot prevent illegal fishing.

Prospects for Future Chinese Fisheries Cooperation in the South China Sea

China's pursuit of fisheries management agreements with its neighbors in recent years is a clear indicator that the Chinese Government is aware of the need to manage its marine resources in a sustainable fashion and has been actively pursuing that goal. This desire overlaps with the similar interests of all of China's South China Sea neighbors, all of whom have a high level of reliance on fish for their population's diets. **However, the South China Sea maritime disputes have presented an impediment to cooperation on this matter, particularly with China. China's recent assertiveness and growing economic and military power has unsettled many of its neighbors.**

The nature of Chinese claims (specifically its "nine-dashed line"[8]) are directly at odds with the United Nations Convention on the Law of the Sea (UNCLOS), the prevailing international law regime. This makes the South China Sea disputes difficult to resolve, unlike China's maritime disputes with South Korea and Japan, which are comparatively reconcilable with UNCLOS in terms of claims. Although UNCLOS provides relatively clear limits on the range of maritime borders, China has often treated the near-entirety of the South China Sea as territorial waters and has refused to back down from this position.

Fisheries cooperation has been noted by several observers as a possible method for reducing tensions in the South China Sea, but this will likely require an agreement to disagree on ownership of territory and maritime boundaries in order to establish a joint management regime. The basic idea of the common fishing zone, as seen in the Gulf of Tonkin agreement, could set a useful framework for such an agreement if the states along the South China Sea can agree on relative levels of catch allocated to each state in the sea. This will also likely require a higher degree of trust of China's fishery administrations to participate in policing any common fishing zone by Southeast Asian states than currently exists. China's marine surveillance ships have been a near-constant feature in recent flareups of the South China Sea dispute.

Still, the desire to create sustainable practices within each state remains important. Although China's annual fishing ban in the South China Sea was protested as illegal by the Philippines because it overlapped with the Philippines' EEZ, Manila still approved of the ban and issued its own overlapping ban. The capacity for further fisheries cooperation exists in the South China Sea. It remains to be seen whether such agreements will be formulated in time to prevent future even more harmful consequences from overfishing and destructive fishing techniques, which already are harming the region.

[8] "Nine-dashed line" refers to the demarcation line used by both the governments of the People's Republic of China and the Republic of China (Taiwan) for their claim in the South China Sea, an area including the Paracel Islands (occupied by China but claimed by Vietnam) and Spratly Islands disputed by the Philippines, China, Brunei, Malaysia, Taiwan, and Vietnam, who each either claim all or part of the Spratlys, which are believed to sit on vast mineral resources, including oil. According to Chinese sources the line first appeared in February 1948 as an 11 dotted U-shape line in a map appearing in a private publication in the Republic of China.

Annex G
Case Study: Vietnam

Marine capture fisheries and aquaculture are highly important to Vietnam's economy, exports, food security, and livelihoods. Vietnam has some 3,440 km of coastline and a continental shelf of approximately 700,000 square km, and four main areas of fishing activity: the Gulf of Tonkin, which it shares with China; central Vietnam; southeastern Vietnam; and southwestern Vietnam, which is part of the Gulf of Thailand and shared with Cambodia and Thailand. The highest catches come from the central and southeast Vietnam, with 75 percent of the total marine catch coming from the Mekong Delta.

In addition, Vietnam and its neighbors have one of the world's highest dependencies on freshwater capture fishing for protein. FAO statistics show that for the four Lower Mekong countries as a whole—Cambodia, Laos, Thailand, and Vietnam—freshwater capture fisheries provide on average about 48 grams of freshwater fish per capita per day and contribute protein between 1.5 (Thailand) and 5.4 (Cambodia) times the world average. The Mekong River Commission (MRC) estimates that

these freshwater fish from Thailand and Cambodia provide respectively 2.2 to 8.6 times the world average for protein.

Fish of all types, both freshwater and marine, constitute an average about 34 percent of total animal protein in Vietnamese diets and 11 percent of total protein, but the proportions are much higher in the Vietnam Delta. Coastal communities throughout the country depend greatly on capture fishing for their food and livelihoods, with aquaculture almost matching rice as the most valuable export of the Mekong Delta.

FAO data show Vietnam's total production of fish and fishery products averaged just over 5 million metric tons in 2010, of which capture fisheries amounted to 2.4 million tons and aquaculture accounted for 2.7 million tons. About 1.4 million tons was exported and 2.3 million tons went into the food supply. Imports were comparatively negligible at just under 0.1 million tons. The per capita supply of fish and fishery products in Vietnam averaged 27.0 kilograms per year compared to 28.6 for China, 32.9 for Thailand, 33.6 for the Philippines, and 53.6 kilograms for Malaysia.

Vietnam is one of the most vulnerable countries in terms of food security due to the overwhelming importance of the Mekong Delta to the production of freshwater fish, the role of Delta wetlands in the reproduction of marine and brackish water species, and the vulnerability of aquaculture to sea-level rise and more extreme storms from climate change. In addition, Chinese control of the Paracels, once a major fishing area, also constrains Vietnam's wild marine fish production and **reduces the opportunity for fishing livelihoods**.

China threatens Vietnam's future marine fish production. China has fast-growing marine patrol capabilities, possesses the region's largest long-distance fishing fleet, and claims maritime boundaries that penetrate deep into Vietnam's EEZs, continental shelve and valuable fishing grounds. Vietnam is responding by acquiring surface combatants, submarines, and attack aircraft; any conflict with China would come at great cost. Finding a balance in its relations with China that gives the greatest recognition of its EEZ and continental shelf may be the single most important determinant of Vietnam's future wild fish production as well as its ability to manage the sustainability of fisheries resources.

Annex H
Case Study: Climate Change Effects in the Indian Ocean and South China Sea

Coastal and marine areas are among the most vulnerable of all environments to global climate change. Projected impacts from global warming include rising sea levels, stronger tropical cyclones, larger storm surges, increasing sea surface temperatures, and—as the oceans absorb more of the carbon dioxide that human activities emit to the atmosphere—growing acidification of surface waters. Climate change will also interact with other human stressors on marine systems, such as overfishing, habitat destruction, and marine pollution, in complex patterns. Significant portions of the Indian Ocean and South China Sea already are among the most highly affected marine ecosystems on earth.

In some cases the impacts of each individual stressor may be cumulative or some effects may offset others. Interactions between still other stressors may be synergistic, exacerbating negative impacts beyond the sum of individual pressures. At present, little is known about how the ultimate effects of myriad stressors exerting overlapping pressures in concert may vary over time, between different marine ecosystems, or between species, further complicating policy efforts to manage fisheries sustainably.

Climate change will expose fisheries and fisher communities to increasing risks at sea and on shore. Along their coasts, Indian Ocean and South East Asian nations may suffer stronger storms and higher storm surges. Recent studies suggest that tropical cyclones in the region will become more intense, with likely increases in extreme high water levels and maximum wind speeds. Projected climate impacts to the Indian Ocean and South East Asian littoral especially threaten the region's growing maritime and fishing infrastructure. Cyclones and storm surges can destroy ports, docks, fishing boats and equipment, and storage and processing facilities, as well as the ponds, cages, and other installations and material necessary for coastal aquaculture. In May 2008, for example, Cyclone Nargis resulted in 27,000 fisheries workers missing or dead, destroyed over 3,000 boats, and inflicted losses of $ 24.5 billion in damages and forgone production on the country's fishing sector.

Additional climate change impacts will manifest themselves in the ocean. As humanity's emissions of greenhouse gases have grown, the oceans have absorbed increasing amounts of this added carbon dioxide from the atmosphere. Since the beginning of the Industrial Revolution in about 1760, the cumulative ocean uptake has amounted to some 25 to 30 percent of humanity's total CO_2 emissions. The absorbed carbon dioxide alters the ocean's chemistry, rendering it more acidic (measured by a lower pH value). From preindustrial levels, the surface ocean pH has already fallen by 0.1 units. If greenhouse emissions continue unabated, pH levels will tumble an additional 0.2 to 0.3 points over the 21st century, a change 30-100 times greater than those seen in the past and at a rate unprecedented in the geological record. As climate change warms global average temperatures, the oceans are also absorbing heat from the atmosphere. In the past 50 years, the oceans have soaked up some 90 percent of the supplemental heat generated by global warming, boosting surface ocean temperatures by about 0.1 degree C.

As the global population swells from 7 billion to 9 billion by mid-century, some studies anticipate that world fish production might need to rise by half from current levels to keep pace with projected food requirements. Yet current overexploitation of most world fishing grounds coupled with emerging climate and other environmental strains on marine ecosystems cast doubt on whether the world's fisheries can readily achieve such yields sustainably even with significant management improvements.

During the coming decades, oceanic warming and acidification could significantly impact global fisheries, affecting the physiology, reproduction, and development of individual species as well as the relations between species and their habitats, food sources, competitors, predators, and pathogens. One recent study, for instance, finds that changes in ocean temperature and biogeochemical properties could substantially affect the ecophysiology of marine organisms, diminishing the average maximum body weight of ocean fishes by 14-24 percent by 2050. The largest projected shrinkage—24 percent—occurs in the Indian Ocean.

Available analyses suggest that climate change could also engender substantial shifts in catch sizes and locations by mid-century. Global maximum potential catches may witness little change ($\pm$ 1 percent), but projected potential catches in different regions vary from considerable increases to precipitous declines. In Indian Ocean fisheries, model simulations project marked increases in maximum catch potential in 2055 relative to 2005 levels in much of the Arabian Sea and East African waters. Catch potentials may plummet by 30-50 percent or more in the Red Sea, Persian Gulf, Bay of Bengal, and the high seas of the equatorial Indian Ocean. Similarly, maximum catch potentials may rise 50—100 percent in parts of the South China Sea, while falling more than 50 percent in others. For Indonesia, lying between the Indian Ocean and South China Sea, catch potentials within its EEZ are projected to slip more than 20 percent by 2055, the largest drop for any country.

Such a significant shuffle of fishing potential could dramatically alter fisheries politics across the region. Rising catch potentials in the western Indian Ocean and Arabian Sea could draw in competing fleets from Europe, China, and elsewhere. About one third of the current catch from the Bay of Bengal comes from fishing areas beyond national EEZs. This same area is projected to suffer dramatic declines in catch potential at mid-century. Falling catch potential in the open ocean could push regional and extraregional fleets to seek out new fishing grounds to make up the difference, potentially colliding with similar efforts by other fleets. Large-scale redistribution of world fish catches could risk creating both winners and losers, reverberating across the Indo-Pacific and beyond.

The food security vulnerability of any one country to climate change impacts on fisheries can be viewed as a combination of that country's fisheries catch exposure to climate impacts, the country's dependence on fish and seafood consumption as a source of available protein, and the country's adaptive capacity—expressed through GDP per capita, projected population growth, and present rates of undernourishment in the population. Evaluated on these measures, one recent analysis ranked six countries in the Indian Ocean and South China Sea regions—Comoros, Eritrea, Mozambique, Madagascar, Pakistan, and Thailand—as among the 10 most vulnerable nations worldwide to food security threats from climate impacts on fisheries.

The National Intelligence Council manages the Intelligence Community's estimative process, incorporating the best available expertise inside and outside the government. It reports to the Director of National Intelligence in his capacity as head of the US Intelligence Community and speaks authoritatively on substantive issues for the Community as a whole.

Chairman	Christopher Kojm
Vice Chairman	Joseph Gartin
Counselor; Director, Analysis and Production Staff	Mathew Burrows
Chief of Staff	Shawn Coates
Director, Strategic Futures Group	Suzanne Fry
Senior Advisor, Counterintelligence	Joseph Helman

National Intelligence Officers

Africa	Theresa Whelan
Cyber Issues	Sean Kanuck
East Asia	Paul Heer
Economic Issues	Martin O'Meara, Acting
Europe	Michael Allison, Acting
Iran	Rachel Ingber
Military Issues	J.D. Williams
The Near East	Alan Pino
North Korea	Andrew Claster
Russia and Eurasia	Eugene Rumer
Science & Technology	Lawrence Gershwin
South Asia	Robert Williams
Transnational Threats	Julie Cohen
Weapons of Mass Destruction and Proliferation	Brian Lessenberry
Western Hemisphere	Dale Avery

National Security Information

This product was approved for publication by the National Intelligence Council.

This page has been intentionally left blank.

This paper does not represent US Government views.