IDENTIFYING CONSERVATION NEEDS IN INDIA'S OFFSHORE WATERS

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EXECUTIVE SUMMARY

The need to protect and sustainably manage the oceans is urgent. At the Rio+20 global summit on sustainable development, which took place in June 2012, the international community pledged to redouble efforts for conservation and restoration of the seas. India now has the opportunity to show the world its own commitment to ocean protection when it hosts the 2012 meeting of the Convention on Biological Diversity (CBD) in Hyderabad. With dire threats facing the oceans, now is the time for India to act to meet its marine conservation commitments and show real leadership.

This report examines the state of knowledge of ecological and biological aspects of India's Exclusive Economic Zone (EEZ), the more than two million square kilometers of ocean for which India has economic rights and environmental responsibilities. The report contains a series of maps that plot publicly available data on measures of ocean chemistry, biodiversity, human impact and more. This report therefore provides the essential information intended to stimulate a debate as to which key areas warrant protection as marine reserves and what broader management strategies are required to adequately conserve India's valuable biodiversity and natural resources.

India has a great opportunity to make a serious commitment to protecting its wealth of biodiversity and resources before they are wiped out by unsustainable use.

Sound science and spatial data are necessary for the designation of protected areas and the design of oceans management. India can be thankful for its numerous institutions that collect data on fisheries management, oceanography and marine ecology. Yet there are significant gaps in their research, and institutional barriers to their collaboration exist. The data presented are only a starting point.

Taken as a whole, the maps contained in this report suggest a number of important areas within the Indian EEZ that deserve attention for their biological or ecological significance: the Gulfs of Kachchh, Khambat and Mannar; Palk Bay and waters off the Sundarbans; large fishing grounds such as the Wadge Bank and small biodiverse areas such as Angria Bank; potentially unique seamount ecosystems in the Laccadive Sea; and possible migration paths of already protected marine mammals and sea turtles beyond the continental shelf.

The maps also point to the need for more nuanced, spatial and temporal regulations that recognize changing biological and oceanic phenomena such as upwellings, seasonal chemical variations and large, dynamic fisheries. At the same time, more spatially explicit data are needed to understand how the populations of many marine species and ecosystems are changing. Finally, human impact on our critical ecosystems deserves serious study.

As this report outlines, India has a great opportunity to make a serious commitment to protecting its wealth of biodiversity and resources before they are wiped out by unsustainable use. To do this, high-level policy makers — including those within the ministries of Environment and Forests, Agriculture and Earth Sciences, as well as the Planning Commission itself — must work in earnest to collect the science necessary to enable the effective conservation of India's precious marine environment. With the necessary scientific information in hand, they must then consult with communities, civil society and industry to ensure that effective but equitable measures are put in place.

The oceans need protecting. Across the world, ocean ecosystems are reaching tipping points and fisheries are collapsing; India has an opportunity to safeguard its oceans before it is too late. The upcoming CBD conference provides an excellent opportunity for India to make clear its intentions to commence a comprehensive process to identify and protect key areas within its own EEZ.

Corals. Andaman Sea.

A NEED TO PROTECT

Ocean management and conservation have become crucial goals for nations across the globe. The global oceans — Homer's "wine-dark seas" — remain one of the least understood areas of the planet, but we can no longer afford to treat them solely as edges on the map, the domains of fisherfolk and sea captains. Numerous governments, scholars, NGOs and communities have all declared the urgent need to protect the oceans, not only for the wondrous marine biodiversity they contain but also for the crucial natural resources and ecosystem services they provide. Healthy oceans maintain the livelihoods and lives of tens of millions of people around the globe. Indeed, they are necessary for the health of the planet as a whole.

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In June 2012 at the U.N. Conference on Sustainable Development in Rio de Janeiro — commonly known as Rio+20 — the world's governments clearly recommitted to the goal of protecting the ocean; in particular, the need to "protect, and restore, the health, productivity and resilience of oceans and marine ecosystems, and to maintain their biodiversity, enabling their conservation and sustainable use for present and future generations" was underscored (UNCSD 2012).

Inherent in this declaration is a recognition that we need to abandon our false notion that the seas are a limitless resource. Though scientists have been warning us for years and even the smallest fisher has witnessed detrimental changes at the local level, governments and institutional authorities have been very slow to respond to the oceans crisis. In addition, governments have a woeful track record of meeting international environmental targets. For example, under the U.N. Convention on Biological Diversity (CBD) governments committed to implement a global network of marine protected areas (MPAs) by 2012. Yet estimated MPA coverage today is a meager 1.6 percent (MPA News 2012), substantially short of the current CBD "Aichi Target" of 10 percent MPA coverage globally by 2020 (CBD 2012a).

Rio+20 stressed the importance of MPAs, as a tool for conservation of biological diversity and sustainable use of natural environments; India and other countries will need to act and act quickly if they are to meet their commitments under the CBD. Yet it is worth noting here that 70 percent of global oceans lie beyond state jurisdiction; national efforts must extend into international action to establish legal mechanisms to protect the high seas. World's leaders at Rio+20 committed to address, on an urgent basis, the issue of the conservation and sustainable use of high seas marine biodiversity and to take a decision on the development of an international instrument under the U.N. Convention on the Law of the Sea (UNCLOS) before the end of the 69th Session of the U.N. General Assembly in 2014. This is the best way for nations to meet their own commitments to global marine conservation.

Redirected political will is not the only necessary ingredient to achieving these

The giant moray (Gymnothorax javanicus) in the reefs in the Indian EEZ.

international goals and establishing networks of MPAs and marine reserves. Robust science on ocean biogeochemical properties, biodiversity and human interaction is essential for identifying areas in need of protection. Without such spatial, temporal and up-to-date information, ocean conservation measures are not likely to meet set objectives.

This report aims to advance the dialogue about the state and extent of knowledge of the areas found within the Indian Exclusive Economic Zone (EEZ), the waters up to 200-nautical miles from India's coastline over which India has sovereign economic rights to marine resources and conservation responsibility for the marine environment. Not surprisingly, much more is known about "territorial waters" within 12 nautical miles of shore, where most humans interact with the ocean. While near shore waters are certainly under duress, this report focuses primarily on the more expansive, deeper off shore waters within India's EEZ.

This report is written primarily from the perspective of a policy scholar, combining the results of an extensive literature review with basic analysis and synthesis of the scientific data. It is intended to help bridge the gap between those that have the power to set conservation and management policy and those that possess the data that are needed to inform the development of these policies. The report contains a series of maps that function as an atlas of the state of knowledge of the Indian EEZ. These maps plot the publicly available data on the environmental parameters, biodiversity and anthropogenic impacts within the 2 million square kilometers of India's EEZ. The report also includes a number of key recommendations for government officials, scientists, advocates and communities.

The 11th Conference of the Parties (CoP) to the CBD will gather in October 2012 in Hyderabad, to discuss protection of our planet's biodiversity, including progress towards meeting the Aichi target on MPAs. This marks an opportunity for the hosting Indian government to make a significant contribution and set the right trajectory for the meeting by announcing the establishment of additional marine conservation areas within India's EEZ. This report intends to contribute to the identification of these important areas. The CoP also provides the opportunity for India to champion the protection of the marine biodiversity of the high seas by advocating for the negotiation of a new legal regime under UNCLOS.

Trevally. Andaman Sea. India.

CONTEXT

The world's oceans are in danger. Overfishing and destructive fishing practices have reduced some fisheries by more than 90 percent. Pollution, extractive industries and shipping degrade the world's oceans and seas. Ocean acidification and climate change pose distinct international threats. The cumulative impacts — many of them man-made — combine and amplify problem. A large body of academic literature has documented these effects and warned of an impending, global crisis (summarized in Rogers and Laffoley 2011).

For decades now, governments, communities, civil society and scholars have urged action to address mounting threats to the world's oceans, through a variety of processes. Since the 1980s, the International Union for the Conservation of Nature (IUCN) has advocated an international system of MPAs. In the 1990s, the World Bank, IUCN and the Great Barrier Reef Marine Park Authority co-published a multi-volume set of books examining marine protection and management on a global scale and offering recommendations for further protection (Kelleher, Bleakley and Wells 1995). By 1999, the IUCN had published specific, scientific guidelines for establishing marine protected areas (Kelleher 1999). In 2002, the World Summit on Sustainable Development agreed to establish 10 percent global MPA coverage by 2012. This goal was adopted as a CBD target in 2004, but in 2010 — as governments were clearly going to fail to meet the target — the deadline was pushed back to 2020.

For decades now, governments, communities, civil society and scholars have urged action to address mounting threats to the world's oceans, through a variety of processes.

Worldwide, Greenpeace is campaigning for a global network of marine reserves covering 40 percent of the world's ocean. In 2006, Greenpeace published its *Roadmap to Recovery: A Global Network of Marine Reserves*, which recommended 29 marine reserves across the high seas (Roberts, Mason and Hawkins 2006). A team of scientists, led by marine conservation biologist Callum Roberts at the University of York, collected a large variety of environmental data and used advanced computer modeling to generate a network of representative reserve areas that would cover more than 40 percent of the ocean, including part of the Bay of Bengal. The effort also relied on input from dozens of other scientists around the globe to shape the parameters of modeling and identify crucial areas independent of the model. Though the focus of the *Roadmap to Recovery* was high seas, the methodology is certainly applicable to national and subnational scales.

Four years later, Greenpeace followed up with the Emergency Oceans Rescue Plan, which also included national and regional marine reserve proposals from Chile to the South Pacific (Page 2010). The report echoed the alarm of many scientists that global ocean ecosystems are approaching a tipping point, beyond which significant degradation may be unavoidable. The report noted that while some progress had been made in granting legal protection to parts of the ocean, much work was left undone.

A few clownfish (Amphiprioninae species) with their home in a magnificent sea anemone (Heteractis magnifica) in the Indian EEZ.

MPAs are a significant tool for protecting, managing and conserving oceans but they are not the only one. Integrated coastal zone management programs are ongoing in India. Scientists have more recently advocated for "marine spatial planning," an ecosystem-based management approach to balance interests of competing ocean stakeholders and environmental protection (Ehler and Douvere 2009). Numerous multilateral agreements also provide some oceans governance, ranging from UNCLOS to treaties specific to individual fisheries. National and regional regulations — such as several recommended in this report — are also necessary and can articulate local political will and traditional expertise. An Indian example is the temporal mechanized fishing ban during monsoon periods (Vivekanandan et al. 2010).

Yet all of these measures — from the strictly off-limits marine sanctuary down to the district-level regulation on fishing nets — require scientific information. Chemical, climatological, oceanographic, ecological, biological and socioeconomic metrics are the basis of conservation, management and regulation, whatever the form. Many of these metrics were included in the modeling used by Roberts' team to recommend high seas areas for protection in Greenpeace's Roadmap to Recovery.

It is now 2012, and progress has been very slow. We urgently need a comprehensive plan that will create networks of marine reserves and oceans management regimes both within national jurisdictions and beyond. Every day that we delay brings our oceans ever closer to tipping points.

INDIA AND THE CBD

Involvement of all stakeholders — from conservationist to community to government to industry — can lead to thoughtful, balanced protection and sustainable use plans.

In 2008, the CBD adopted scientific criteria for identifying Ecologically or Biologically Significant Areas (EBSAs) and guidelines for establishing a network of protected and managed marine areas. The EBSA criteria — uniqueness or rarity; special importance for life history of species; importance for threatened, endangered or declining species and/or habitats; vulnerability, fragility, sensitivity, slow recovery; biological productivity; biological diversity; and naturalness — provide a framework for identifying ocean sites in need of protection (CBD 2008). This was a key development intended to kick start an international effort. The subsidiary body that gives the CBD scientific advice noted at its spring 2012 meeting that the scientific description of EBSAs is “an open process that should be continued to allow ongoing improvement and updating as improved scientific and technical information becomes available in each region” (CBD 2012b).

Proactive designation of EBSAs supports international commitments to precautionary protection given the reality that detailed information and data are simply not available for all the deeper spots of the ocean (Weaver and Johnson 2012). EBSA designation is a step towards developing comprehensive marine spatial planning and designing MPA networks. Involvement of all stakeholders — from conservationist to community to government to industry — can lead to thoughtful, balanced protection and sustainable use plans.

India's effort at meeting CBD targets of marine management and conservation remains a work in progress. The National Biodiversity Action Plan generated by India's Ministry of Environment and Forests declared that marine conservation needs specific attention. "Efficient management system for marine protected areas is lacking. Documentation, conservation and sustainable utilization of marine biodiversity are urgently needed" (GoI 2008: 15). For the conservation community, this is a strong, clear and welcome recognition of the challenges ahead in identifying, managing and protecting India's marine resources. The action plan goes on to note that substantial study has only been carried out on a few marine species while "important life forms such as coral reefs, sea horses, sea cucumbers, dolphins, dugongs, whales, sharks, mollusks and crustaceans have not been properly studied so far."

"Efficient management system for marine protected areas is lacking. Documentation, conservation and sustainable utilization of marine biodiversity are urgently needed"

In 2009, India submitted its fourth and most recent report to the CBD as part of a regular update on efforts to meet various national commitments. With respect to protected areas, the national report identified approximately 160,000 square kilometers spread across 659 sites (GoI 2009). This number has barely increased three years later (WII 2012). The report does not specifically identify marine protected areas, though a previous version stated that India had 31 protected areas covering marine environments (GoI 2006). Other scholars have identified as many as 38 official sites — some connected or overlapping — that give protection to marine waters (Rajagopalan 2008).

The fourth national report to the CBD does recognize serious anthropogenic threats to the ocean, including unsustainable fishing, runoff and pollution. However, with regard to marine protected areas, the report only generically suggests that more effort is needed to plan and establish new sites. India must advance this issue, including on EBSA identification or designation, particularly in the remaining weeks and months ahead of the 11th CBD COP.

A feather star (class Crinoidea) clinging to rock and reef in the Indian EEZ.

UNDERSTANDING WHAT WE DON'T KNOW

For decades in India, numerous centers and institutes — with varied and sometimes overlapping mandates in ocean research — have generated valuable data useful to understanding, preserving and managing ocean resources. The Central Marine Fisheries Institute (CMFRI) produces research based on landings data, while the Fishery Survey of India (FSI) conducts numerous fishing surveys at sea. These are just two of more than two dozen institutions under the broad ambit of the central government Ministry of Agriculture (Pillai 2011). Other central and state ministries, departments and institutes, from the National Institute of Oceanography (NIO) to the Center for Marine Living Resources and Ecology (CMLRE), perform biology research, ocean exploration, remote sensing, weather forecasting, *in situ* monitoring and more.

However, these institutes do not necessarily share their data widely and readily. In many cases, the data is not easily accessible or even available to the public. It is often held instead in student theses, academic journals and textbooks. This has led to a potentially impressive but scattered and divided body of knowledge on the Indian EEZ.

Recently, several Indian scientists suggested that known biodiversity of the Indian Ocean may be "only a fraction of what remains to be discovered…"

There are also gulfs in data that are spatially explicit and representable in cartographic terms. Though ecological and biological systems certainly do not respect lines on a map, the ability to tie information to set of coordinates or even a region is obviously important for demarcating areas for management or protection. Consider CMFRI data on catch haul from fish-landing centers (Srinath et al. 2006). The location of the where a fish is brought to shore tells us very little about where the fish was pulled from the ocean. Further stratifying by the type of gear used still only provides a rough idea of the depth zone of the catch. CMFRI has been gathering additional spatial data recently (CMFRI 2011), but more is necessary.

Biodiversity studies have focused mostly on commercial species (Venkataraman and Wafar 2005). Recently, several Indian scientists suggested that known biodiversity of the Indian Ocean may be "only a fraction of what remains to be discovered… Some obvious areas where gaps exist are continental shelves and deep seas, including seamounts. Even along the 60,000-kilometer coastline of IO (Indian Ocean) countries, there are vast stretches that have never been sampled" (Wafar et al. 2011).

In 2010, experts in ocean ecology, biology, conservation and management identified numerous research gaps, including a need for better coordination between various institutions and increased support for marine biology, ecosystem, conservation

Oriental Sweetlips. Andaman Sea. India.

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and taxonomy education (Sivakumar, Johnson, Choudhury and Mathur 2010). Their detailed list of research needs — more than 50 in total — is voluminous; examples include sea grass inventories, habitat connectivity models, fishing technology impact assessment, endemic invertebrate ecology and commercial vessel traffic studies. The report may sound like an academic wish list, but it makes clear the substantial gulfs in what is known about India's marine environment.

MAPPING METHODOLOGY

Thousands of tiny reef fish schooling
in the coastal waters of the Indian EEZ.

This mapping exercise examines the state of spatially explicit environmental, ecological and biodiversity knowledge that is readily available about the Indian EEZ. These datasets have been plotted using Geographic Information System (GIS) mapping and analysis software. The outcome of this analysis is an atlas of the Indian EEZ.

The data come from both publicly accessible Indian and international sources, including academic literature, government publications and electronic sources. In some cases, maps were recreated and approximated by hand from hardcopy publications or digital images. Data and literature citations follow each map figure on first reference. Maps are presented individually or in groups accompanied by an explanation of their relevance and most important details.

Comments were sought from dozens of scientists, scholars and advocates both in India and abroad to supplement this review and identify overlooked data sources. Visits to FSI in Mumbai as well as CMFRI, CMLRE and CIFT in Kochi aided in this effort.

The report is modeled on exercises such as the Greenpeace International *Roadmap to Recovery* and the CBD background report on the EBSA process (Ardron et al. 2009). This is by no means an exhaustive compilation. Indeed, as the previous discussion of scattered data sources indicates, to gather ever more comprehensive information would require substantial time, access and authority. Importantly, additional inputs from local communities, civil society and industry would be necessary.

INDIA'S WATERS

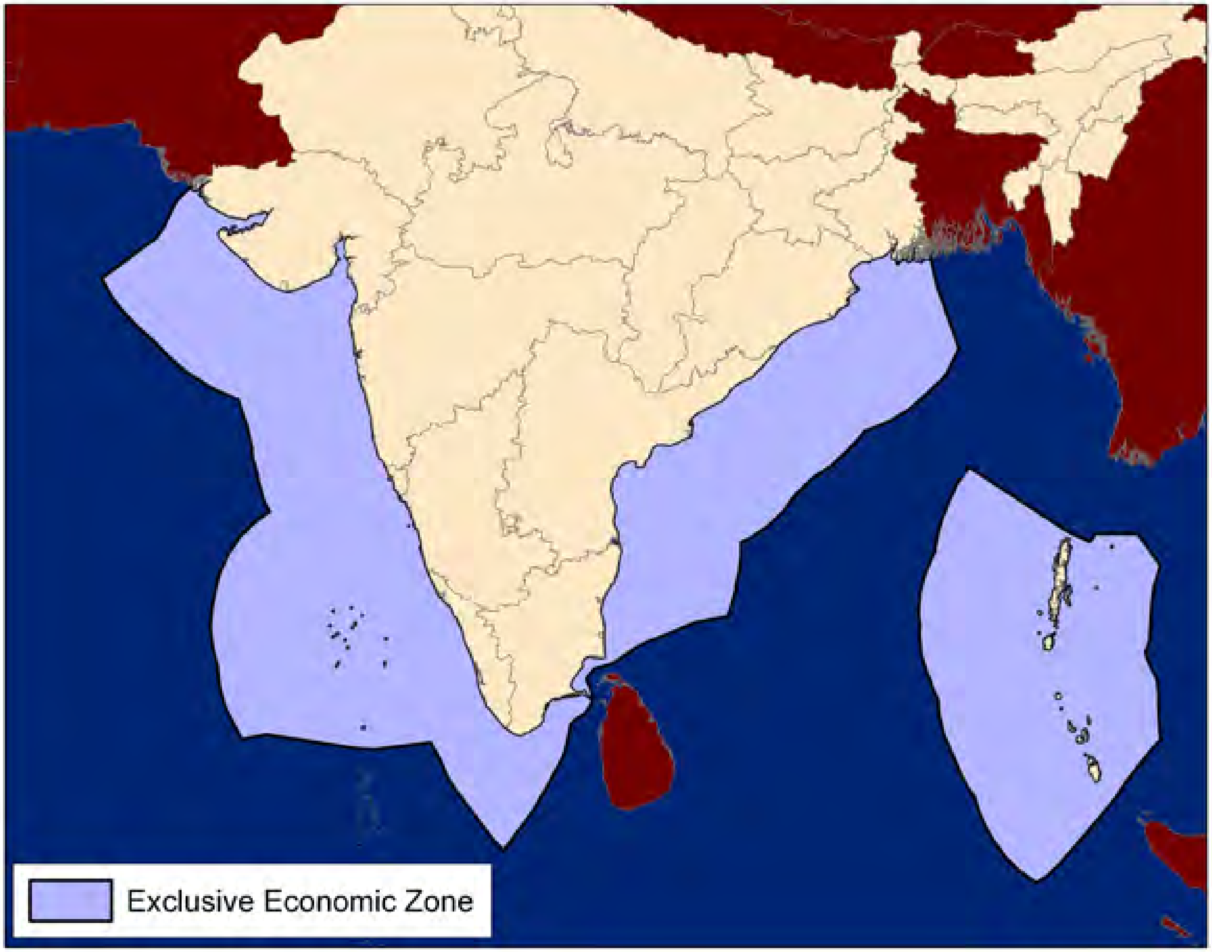


Figure 1: India's EEZ (VLIZ 2011; Hijmans et al. 2011)

The Indian EEZ encompasses slightly more than 2 million square kilometers (VLIZ 2011; see Figure 1). The mainland EEZ, which includes the Lakshadweep archipelago, covers approximately 1.6 million square kilometers of ocean. The separate EEZ surrounding the Andaman and Nicobar Islands contains another 600,000 square kilometers (SAUP 2012).

UNCLOS defines the EEZ as an area up to 200 nautical miles from a nation's shores. India's EEZ extends this far from its roughly 8,000-kilometer coastline except where it confronts other national EEZs. Within the EEZ, a nation has sovereign rights for "exploiting, exploring, conserving and managing" natural resources whether living or non-living in the water column and seabed (UNCLOS 1982: Article 56), as well as jurisdiction over marine scientific research and marine environmental protection. Along with the right to exploit comes the responsibility to properly conserve, manage and protect important ecosystems.

THE LAY OF THE SEA

Bathymetry reveals the topography of the Indian Ocean within and surrounding the EEZ. The area of the Arabian Sea within the EEZ is comparatively deeper than that of the Bay of Bengal, though the maximum depth of either is less than 5,000 meters (GEBCO 2010; see Figure 2).

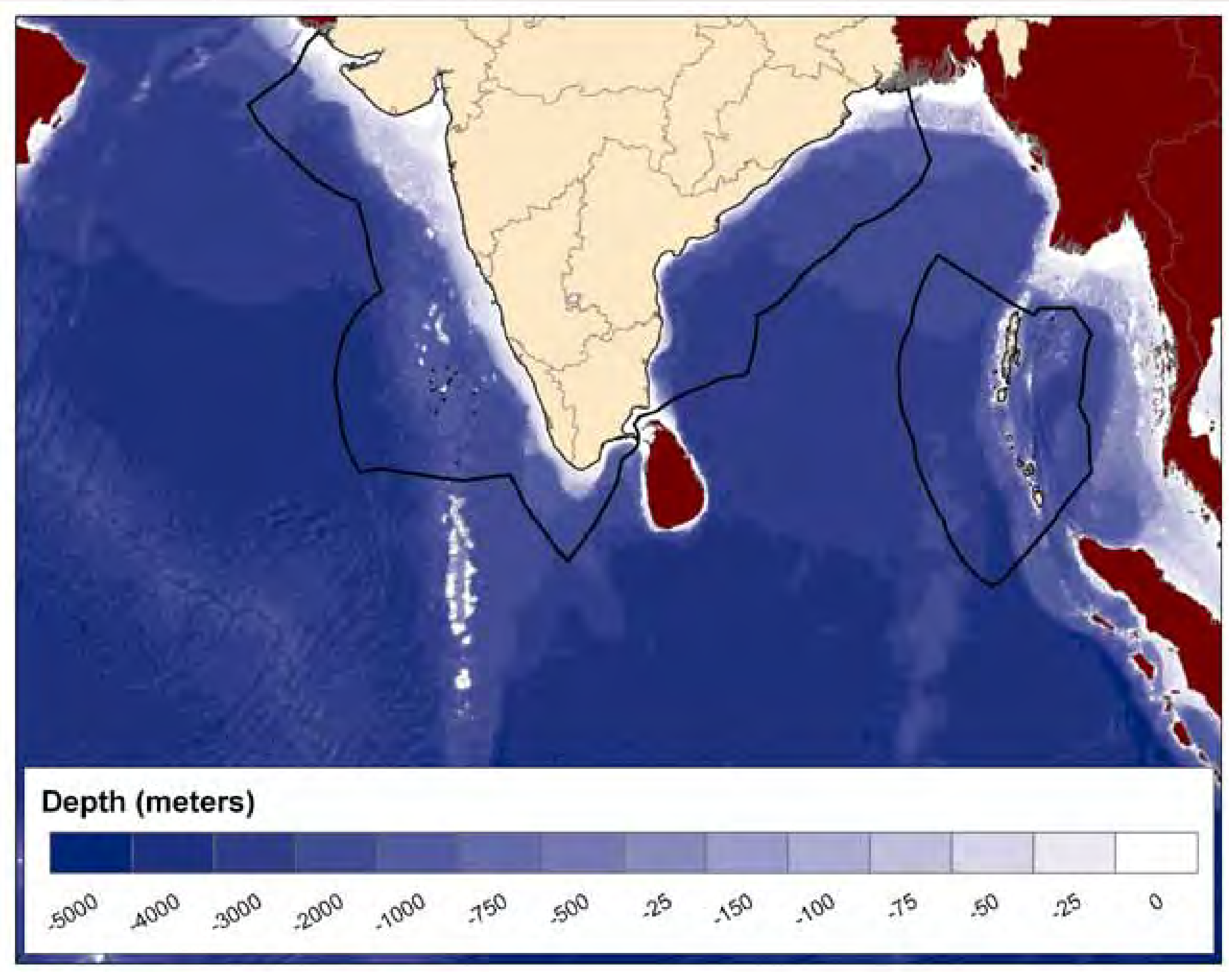


Figure 2: Indian Ocean Bathymetry (GEBCO 2010)

The continental shelf area of the mainland — the gently sloping bottom that is relatively shallow (a depth of 200 meters or less) compared to the open ocean — is approximately 380,000 square kilometers (SAUP 2012). The shelf area of the Andaman and Nicobar EEZ is less than 30,000 square kilometers. That means that more than three quarters of the EEZ lie beyond 200 meters of depth and most of that is substantially deeper. The western shelf is substantially wider than its eastern counterpart. For example, laterally from the northern coast of Maharashtra, portions of the shelf extend more than 180 nautical miles before reaching depths beyond 200 meters (see Figure 3). It is not surprising, then, that the western coast of India is relatively more productive in terms of fisheries (CMFRI 2011).

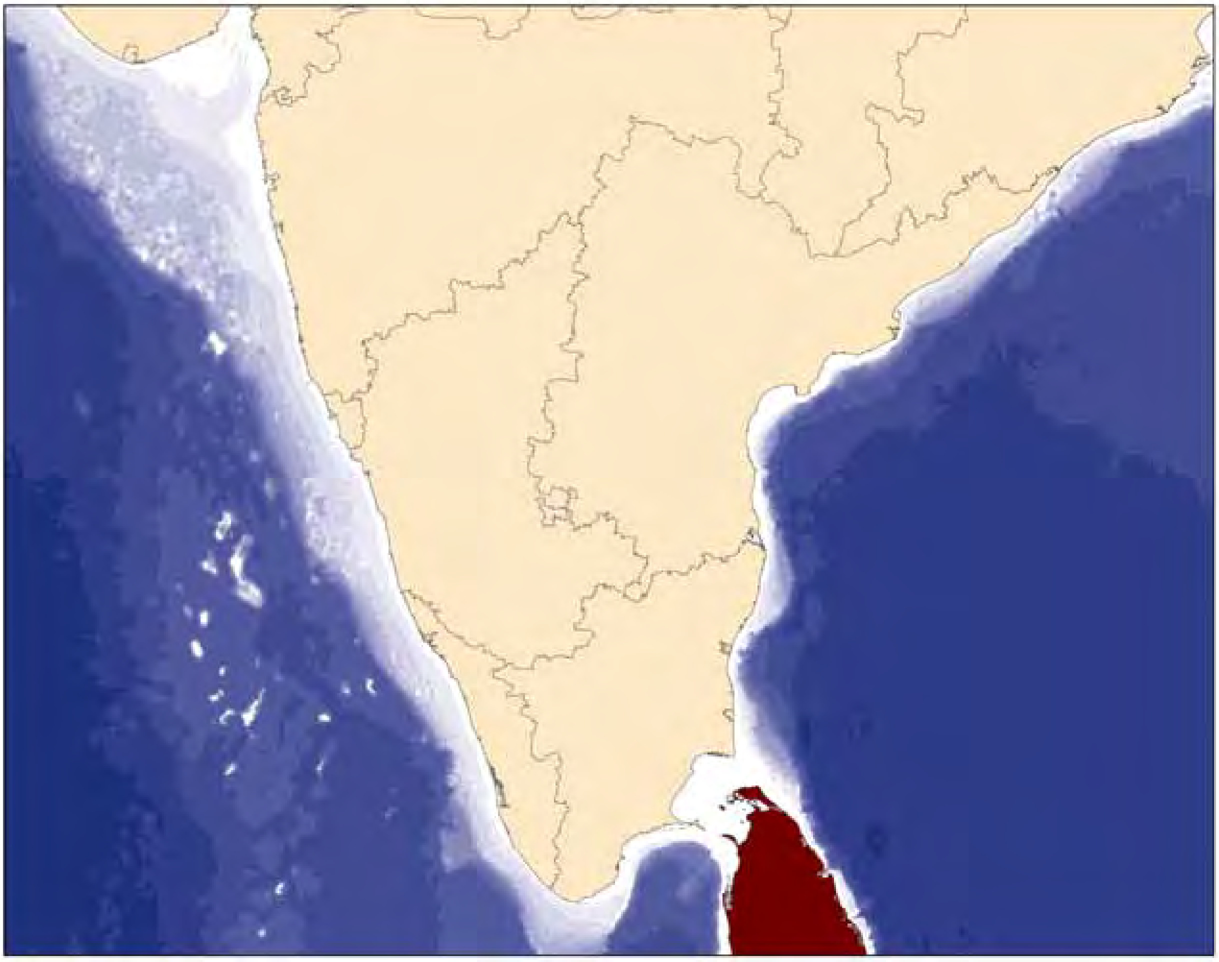


Figure 3: Indian Ocean Bathymetry (GEBCO 2010)

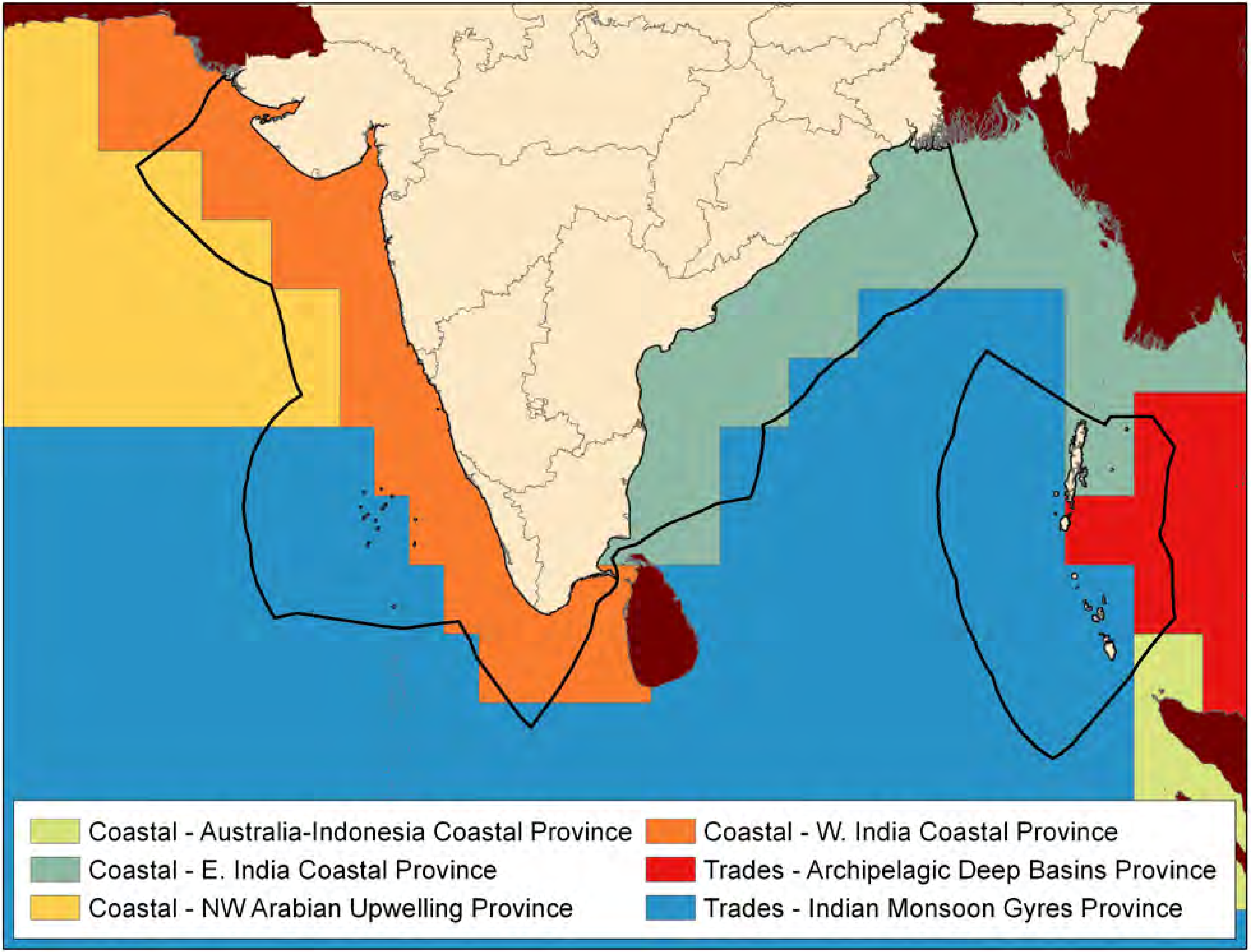
CLASSIFYING THE OCEAN

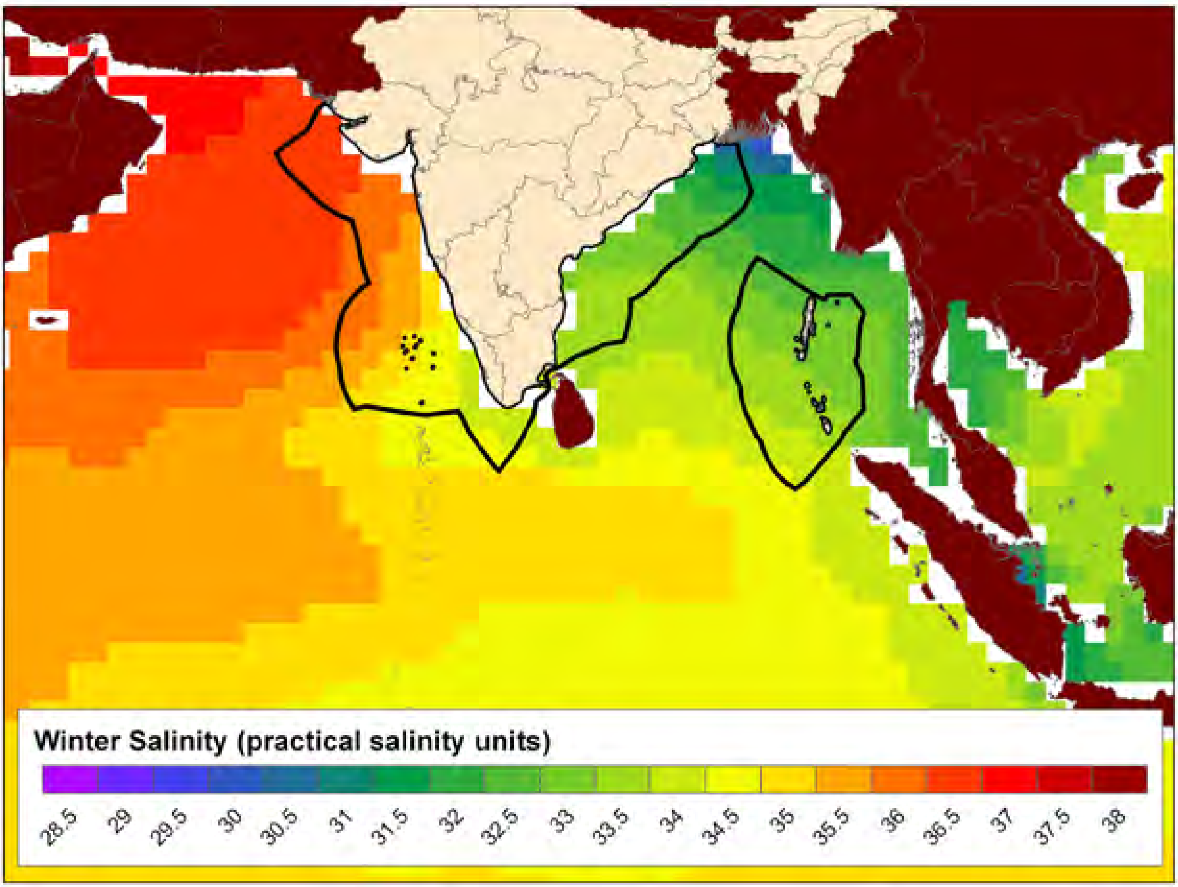
As ocean use has changed in the intervening decade and a half, new evaluations at a national scale may be needed to better define areas important for conservation.

In 1995, Alan Longhurst and other scientists began to describe the worlds oceans based on average characteristics of their plankton production, which serves as a basis for the marine food web. Longhurst and colleagues broke the ocean into a total of 57 provinces, each based on their biological and chemical properties. The result is a map of the ocean that demonstrates regional ecological variation.

India's EEZ is dominated by its two coasts but, in total, it overlaps portions of six different biogeochemical provinces (VLIZ 2009; see Figure 4). Though the boundaries shift with seasons and periods, they represent regional means of primary production. Longhurst, Sathyendranath, Platt and Caverhill (1995) also posited that their province descriptions could certainly be redefined by local conditions and changing phenomena. As ocean use has changed in the intervening decade and a half, new evaluations at a national scale may be needed to better define areas important for conservation.

Figure 4: Biogeochemical Provinces of India's EEZ (Longhurst 1995; Longhurst, Sathyendranath, Platt and Caverhill 1995; VLIZ 2009)


Coastal - Australia-Indonesia Coastal Province
Coastal - E. India Coastal Province
Coastal - NW Arabian Upwelling Province
Coastal - W. India Coastal Province
Trades - Archipelagic Deep Basins Province
Trades - Indian Monsoon Gyres Province



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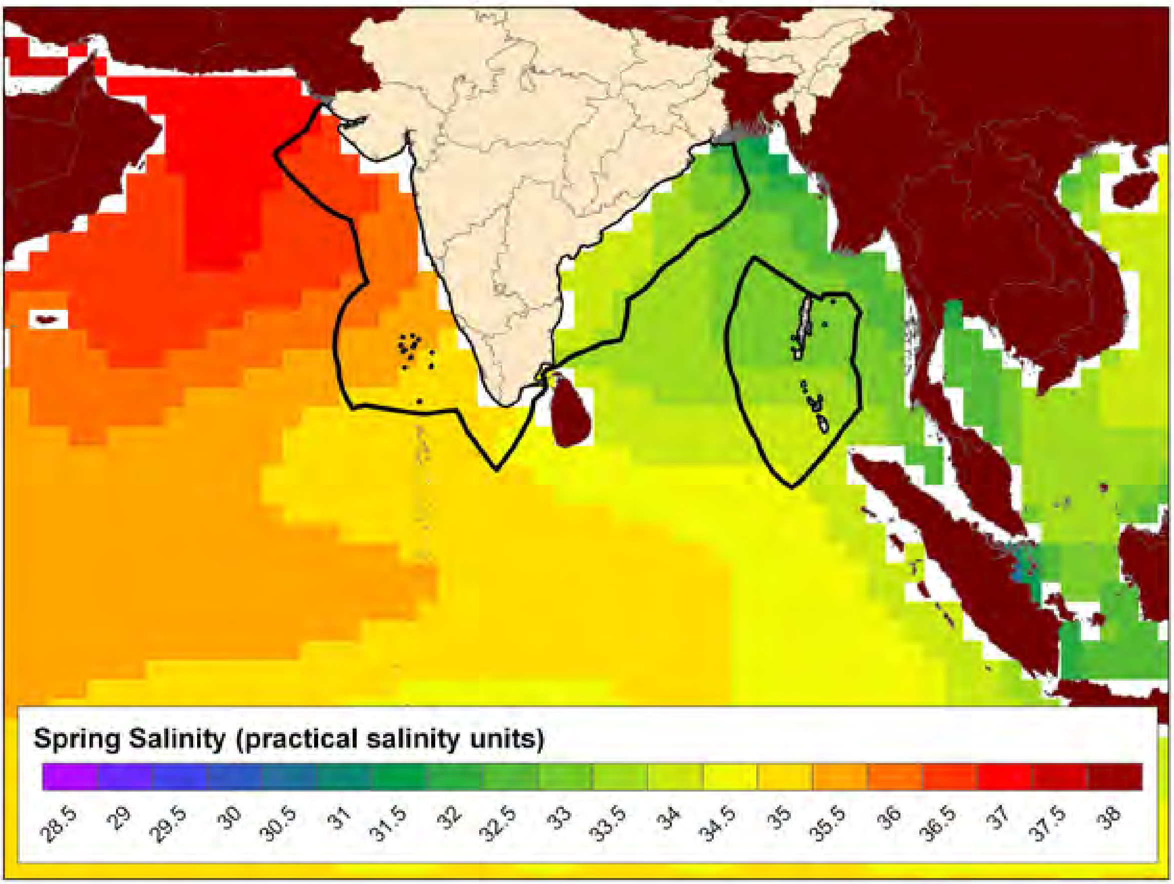


CHANGING SEASONS, CHANGING SEAS

Due to climatological forces — namely, dual monsoons — as well as geographic conditions (such as riparian discharge and topography-influenced runoff), the Indian Ocean varies substantially between the Arabian Sea and the Bay of Bengal. Indian scientists have recently augmented the temperature and salinity profiles of the World Ocean Atlas with additional observations to generate a new climatology atlas for the northern Indian Ocean (Chatterjee et al. 2012).

Indian scientists have recently augmented the temperature and salinity profiles of the World Ocean Atlas with additional observations to generate a new climatology atlas for the northern Indian Ocean.

This new atlas charts the spatial and temporal changes in both temperature and salinity of the Indian EEZ and surrounding international waters. The maps here (see Figures 5, 6, 7, 8, 9, 10, 11 and 12) are broken into three-month Levitus seasons: winter (January, February, March), spring (April, May, June), summer (July, August, September) and fall (October, November, December).

The Arabian Sea is generally saltier and cooler than the Bay of Bengal, yet this varies across seasons. Both seas warm during the spring season yet the Bay remains comparatively warm even as Arabian side cools into the summer months. The Bay of Bengal's salinity also varies substantially more than the Arabian Sea, due in part to freshwater discharge from rivers following the southwest monsoon.

Understanding the effects these variations have on ecosystems and species distributions will be useful in designing conservation and management plans, which must take into account the diverse conditions across space and time within India's EEZ.

Figures 5, 6, 7, 8, 9, 10, 11 and 12: Seasonal Temperature and Salinity of the North Indian Ocean (Chatterjee et al. 2012)

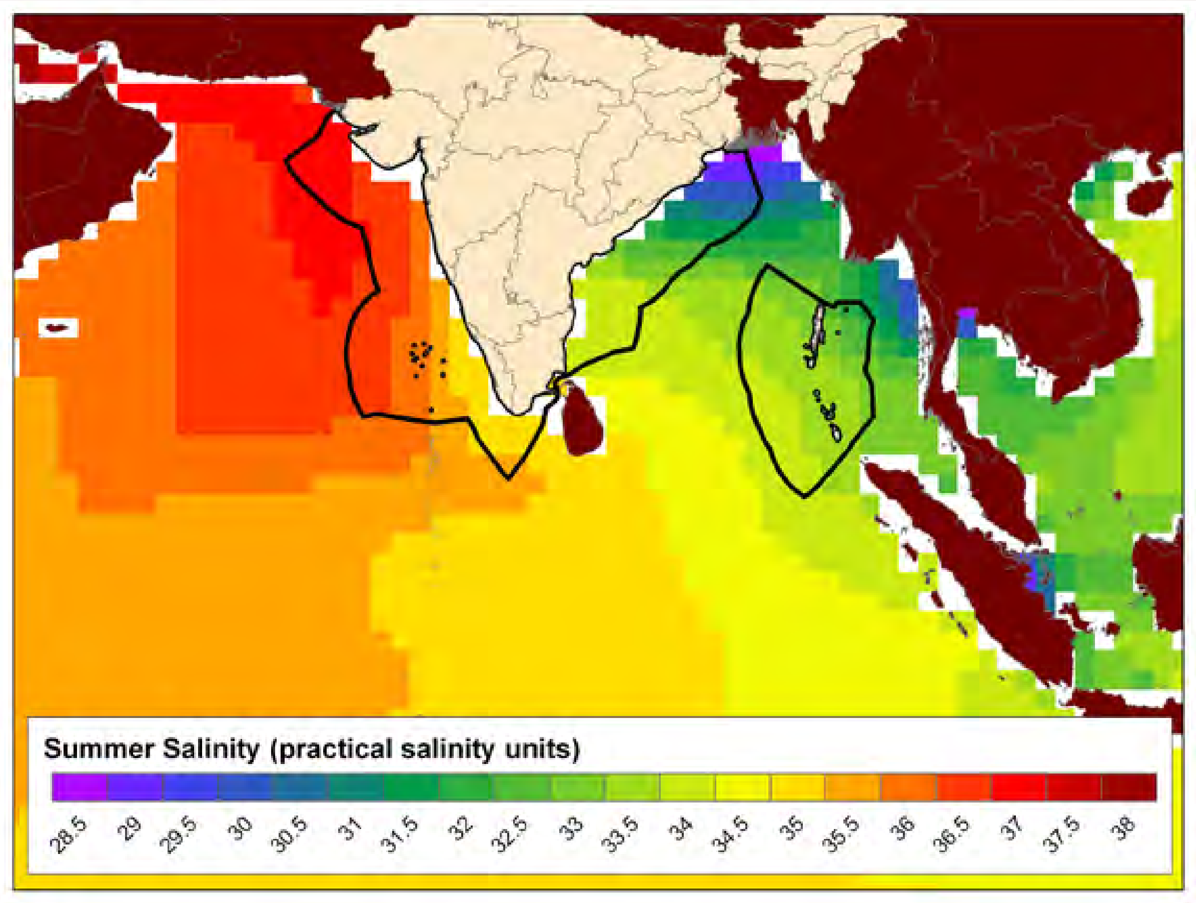
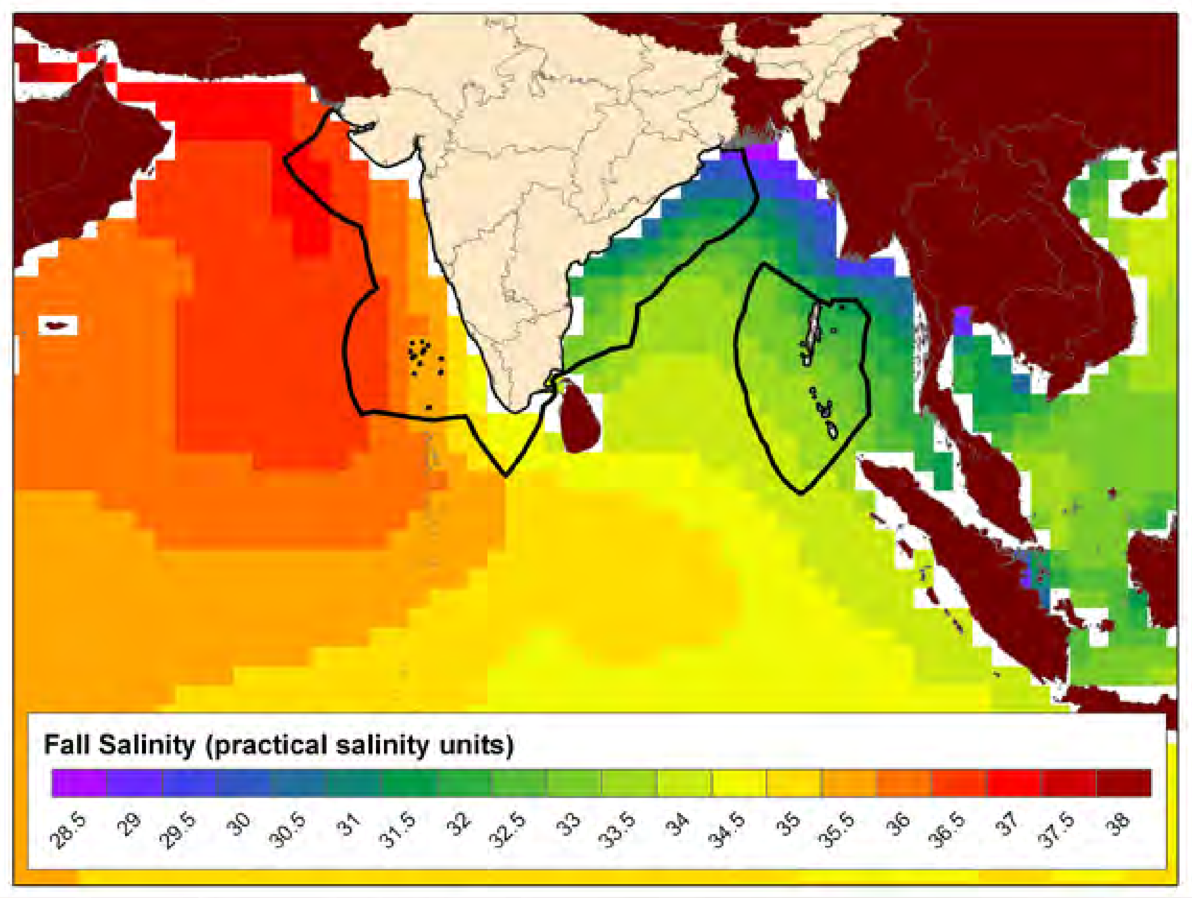
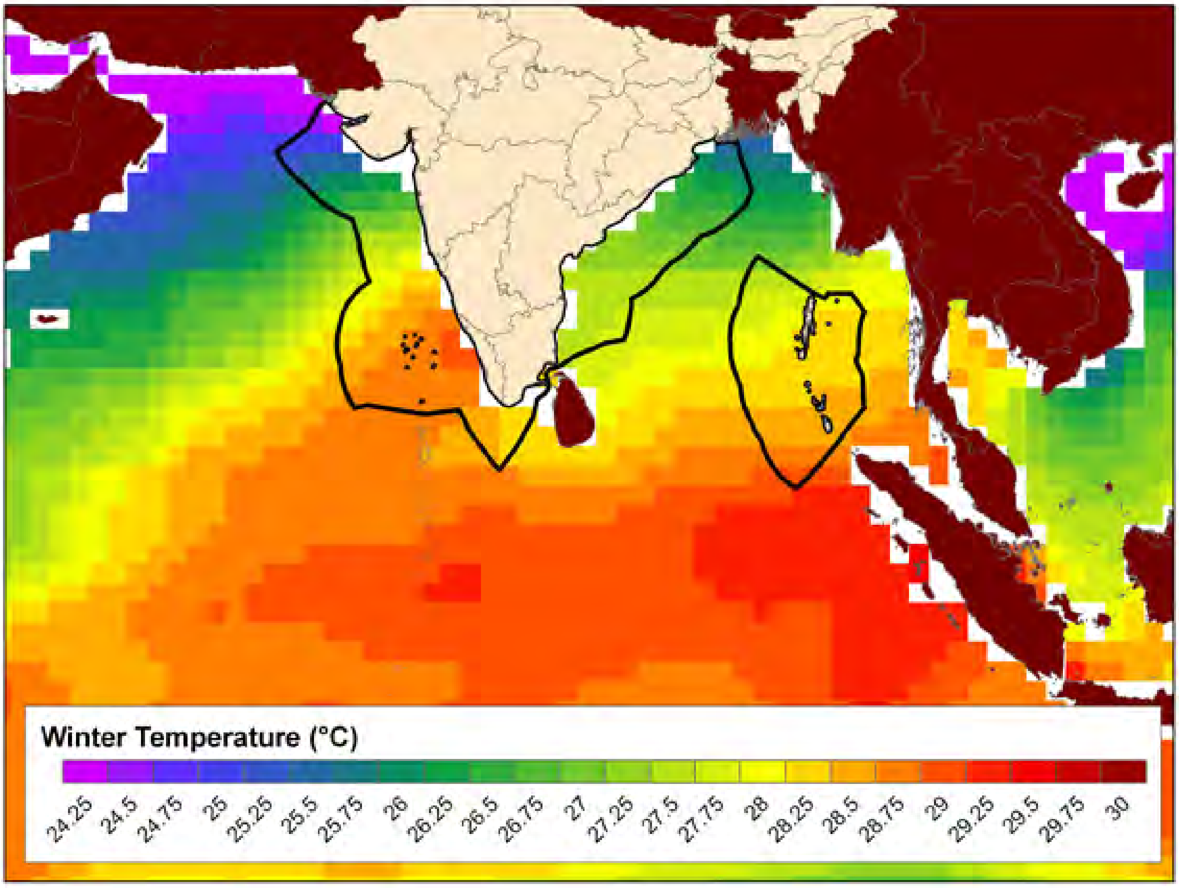


Figure 7 (above) *and* **Figure 8** (below)





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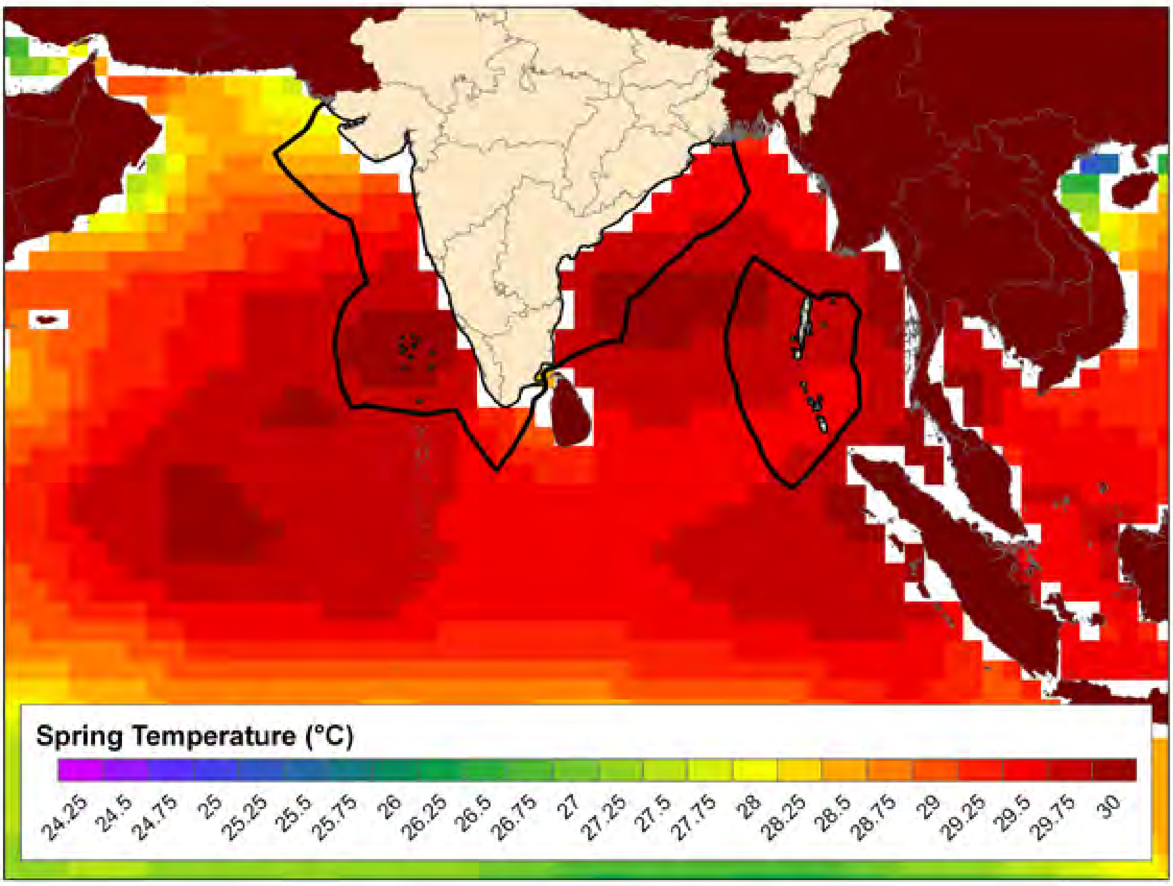

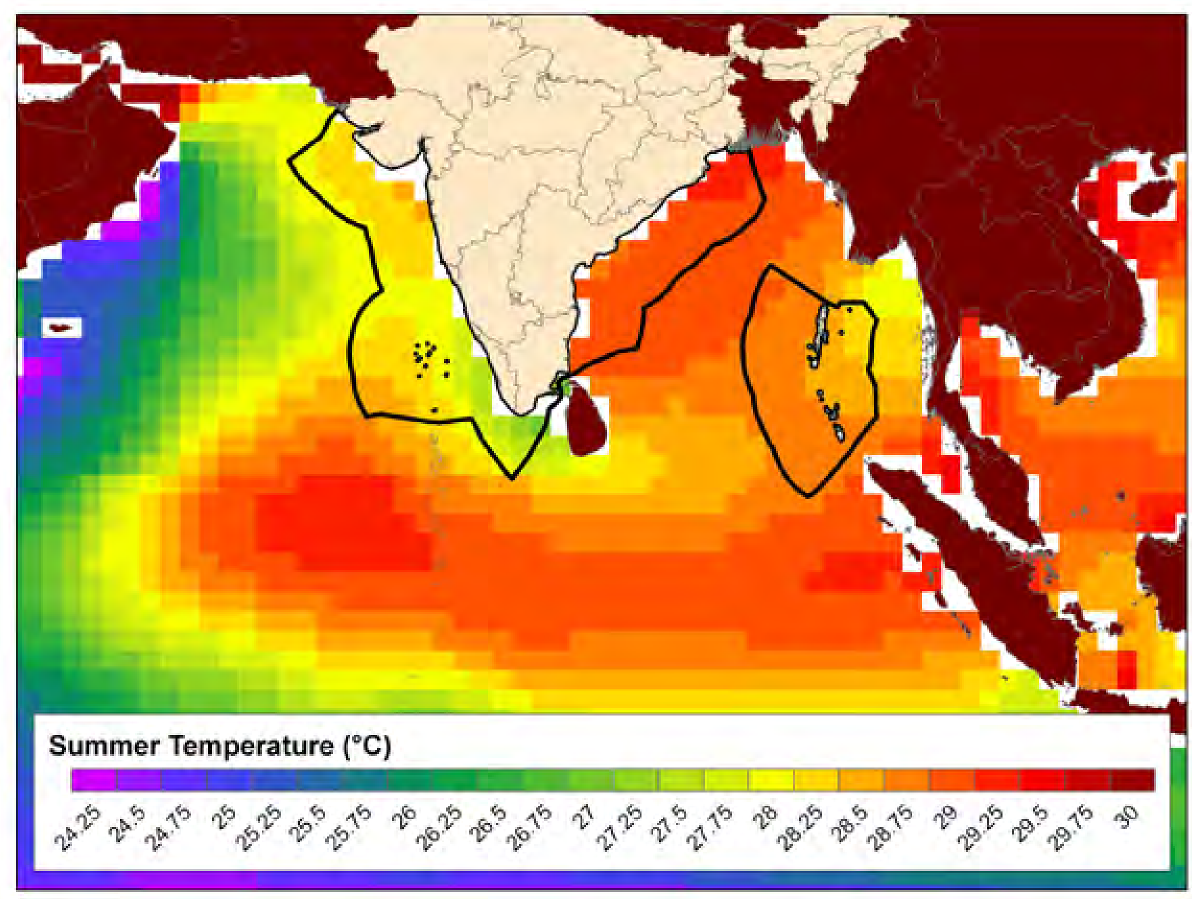

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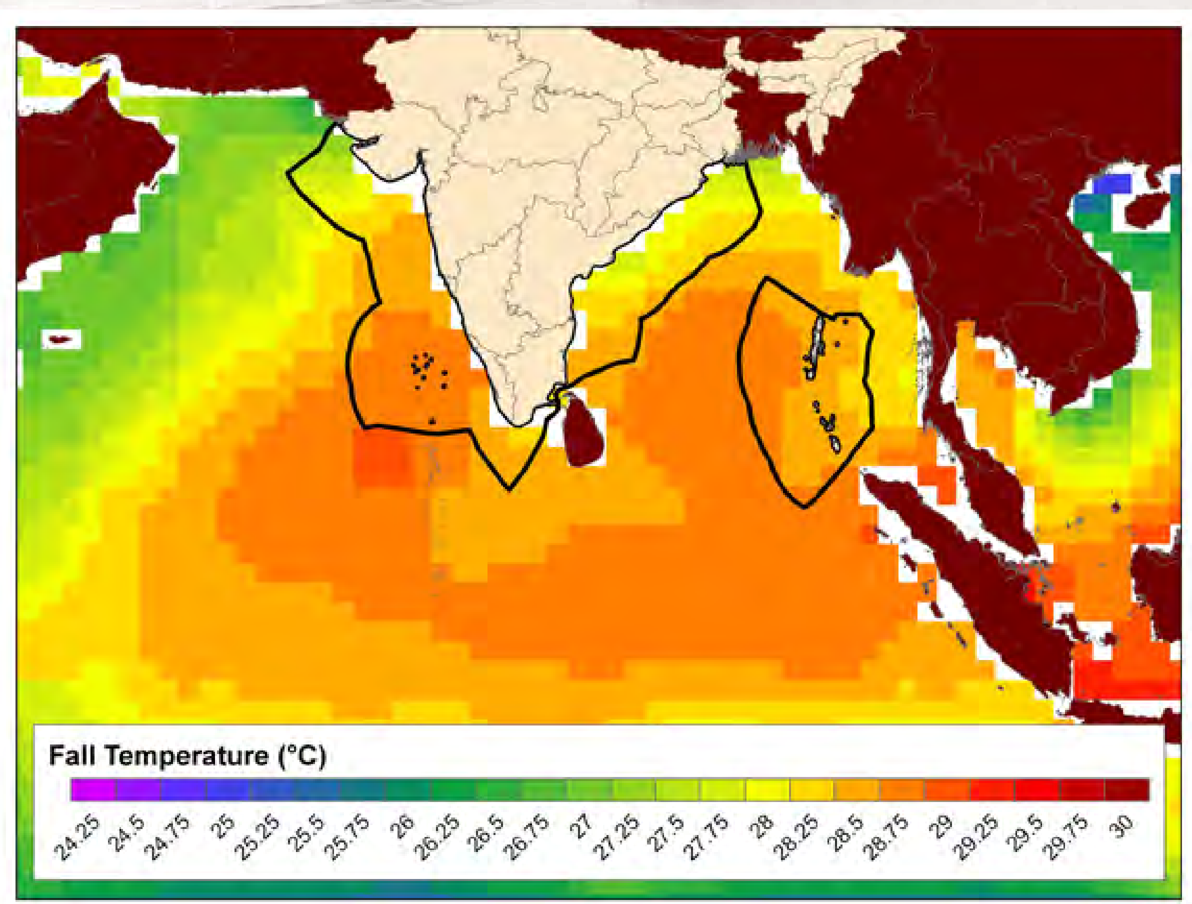


THE FOUNDATIONS OF OCEAN LIFE

Though fish, whales and turtles are perhaps the most recognizable sea creatures, the basis for the food web that sustains marine biodiversity are the microscopic masses of phytoplankton that harness sunlight to fix carbon dioxide into organic material. This “primary production” by phytoplankton places them in the lowest, most fundamental ocean food tropic level.

As a key ingredient for biological productivity, phytoplankton are important to fisheries and conservation planning. Basic seasonal data from satellites demonstrate substantial variation in primary production levels (Behrenfeld and Falkowski 1997; Oregon State University 2008).

Average June productivity (see Figure 13) is highest along the western coast of India. Productivity is markedly lower along the eastern coast with the

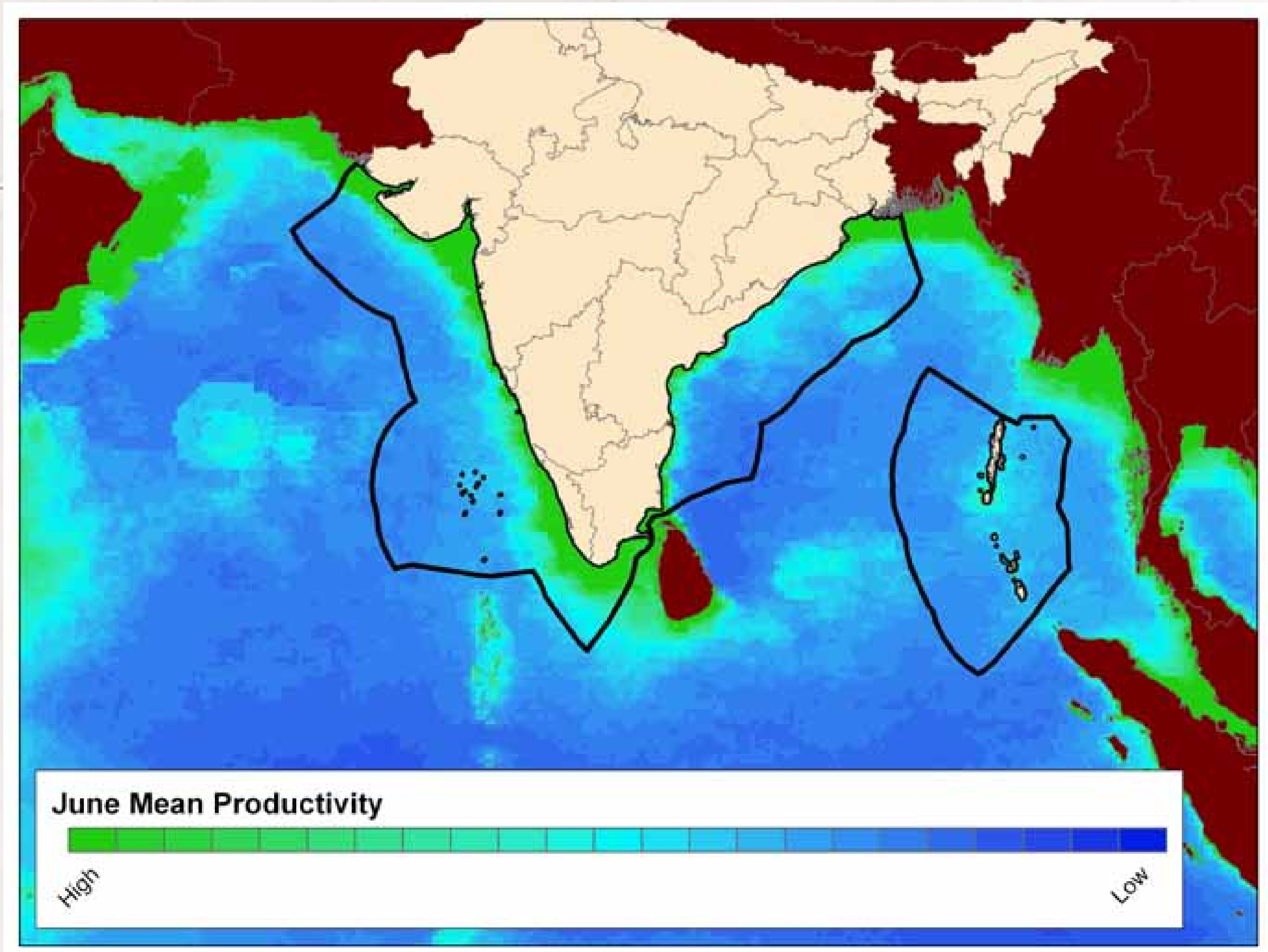


Figure 13: Mean Sea Surface Productivity, 2003-2007 (Behrenfeld and Falkowski 1997; Oregon State University 2008; UNEP-WCMC 2012)

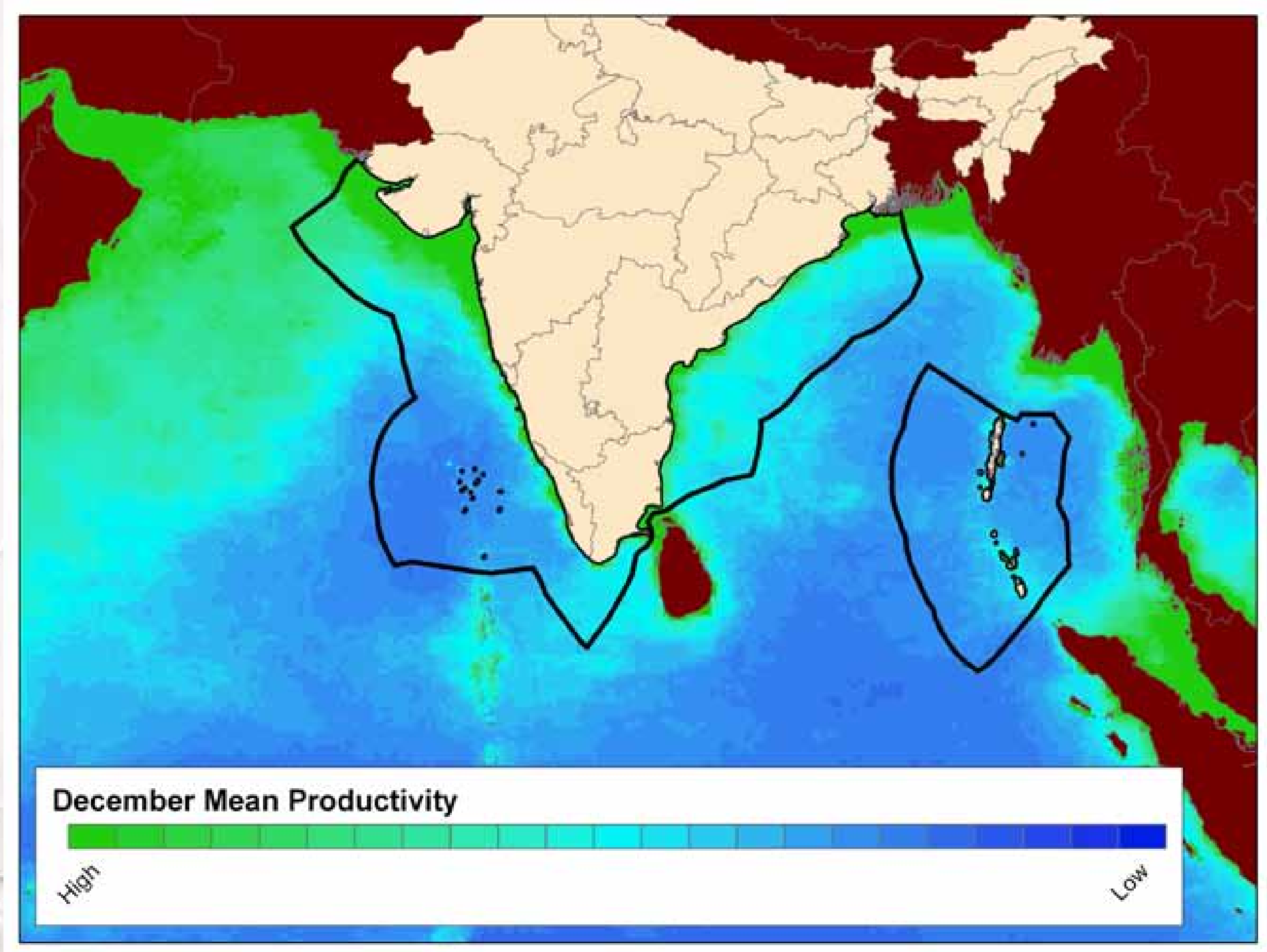


Figure 14: Mean Sea Surface Productivity, 2003-2007 (Behrenfeld and Falkowski 1997; Oregon State University 2008; UNEP-WCMC 2012)

exception of the area around the Sundarbans. Productivity is also particularly strong surrounding the southern tip of the India over the Wadge Bank and beyond the continental shelf. Primary productivity lessens along much of the western coast by December (see Figure 14), except for the northern latitudes off Gujarat and Maharashtra where it strengthens. Productivity is also slightly higher in the Bay of Bengal.

Primary production is substantially influenced by complex, seasonal upwelling currents, which pull cold, dense, nutrient rich waters to the surface from the deeper ocean. This phenomenon is largely driven by variation in surface wind stress (Xie and Hsieh 1995; Wong, Xie and Hsieh 2007; see Figures 15 and 16). In the Indian Ocean, upwellings roughly follow a seasonal pattern with the dual monsoon cycle. As these nutrient rich waters rise, they support higher levels of primary production, which filters up the food chain to support fisheries.

The strength and location of the upwelling varies with the monsoon. During the southwest monsoon, upwellings affect much of the coastline of mainland India, peaking approximately in July or August. During the northeast monsoon, a mild downwelling is observed at the southern tip of India and along the eastern coast while the western side of the peninsula experiences a second upwelling peak in winter.

These upwellings are also influenced by local conditions ranging from run-off to wind-altering terrestrial topography. Spatial modeling and species observations can help further understand upwelling effects on the ecology of regions. Understanding the where and what of upwelling contributions to the marine food web can help design appropriate ocean management and conservation plans.

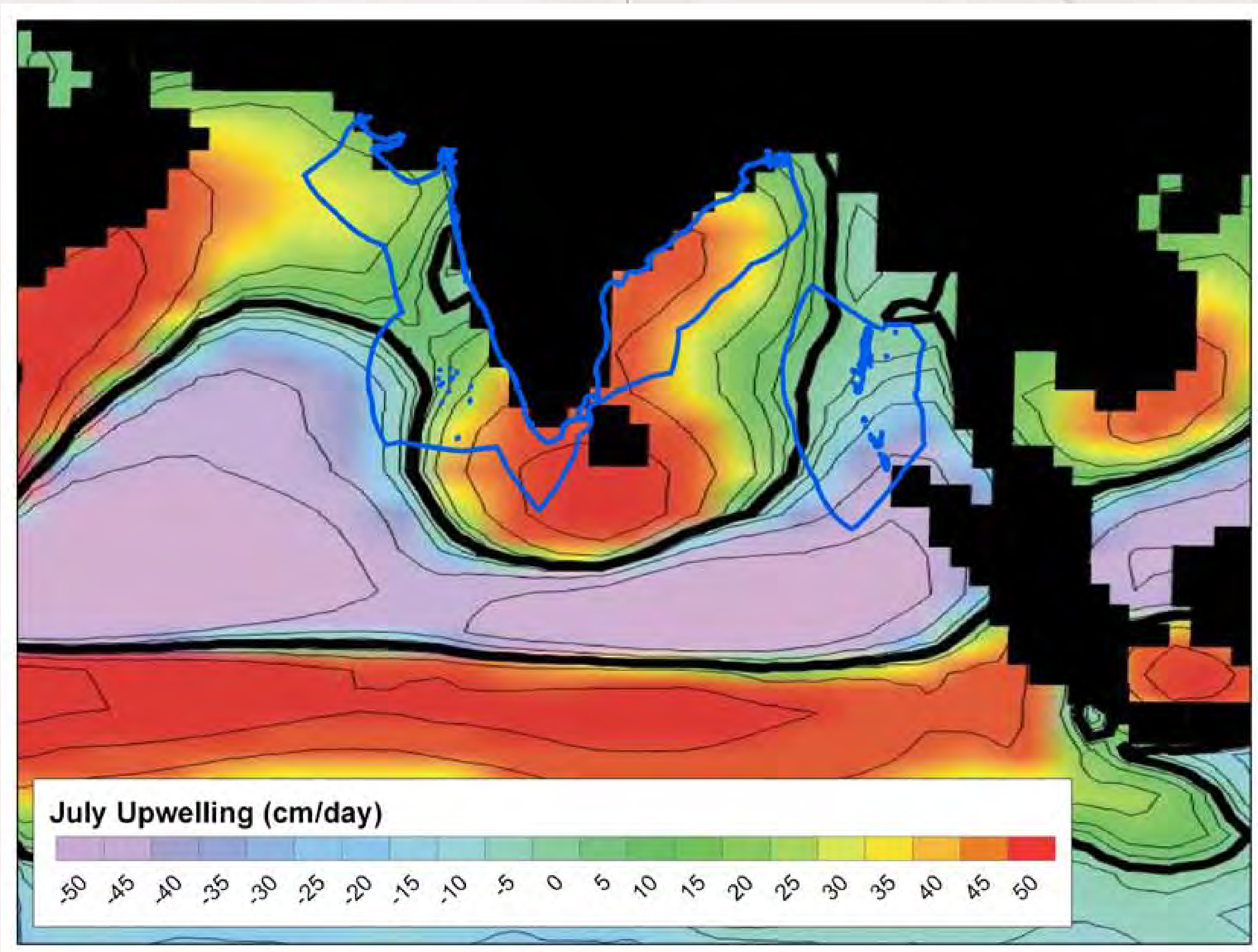


Figure 15: Seasonal Wind-Induced Upwelling (Approximated from Xie and Hsieh 1995; Wong, Xie and Hsieh 2007)

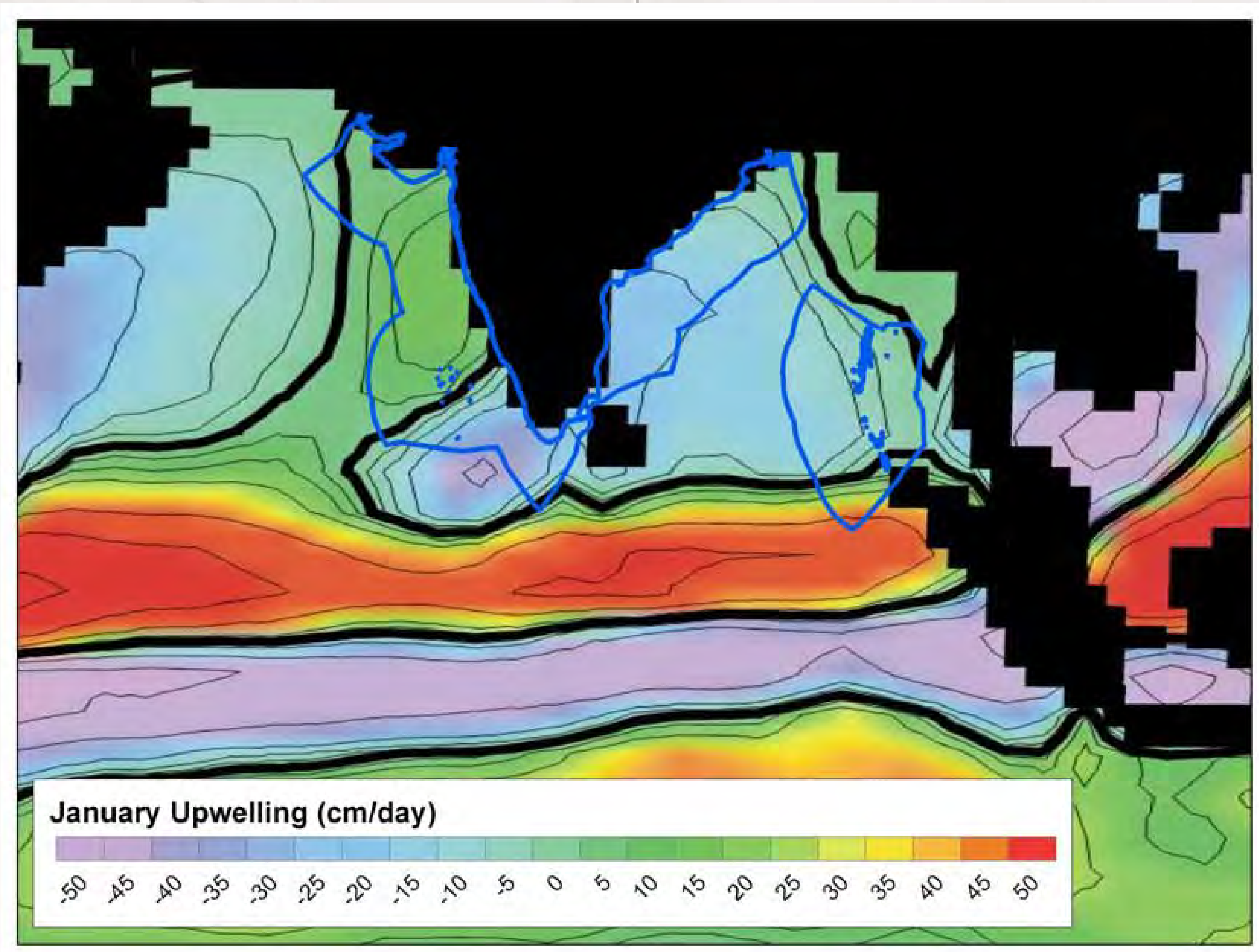


Figure 16: Seasonal Wind-Induced Upwelling (Approximated from Xie and Hsieh 1995; Wong, Xie and Hsieh 2007)

OCEAN HABITATS

Coral reefs may be the most iconic marine habitats, recognized as crucial areas for conservation. They are biodiversity storehouses. They support fisheries and provide crucial ecosystem services. They generate tourism revenue.

Yet reef systems in the Indian EEZ are primarily coastal and make up only a small portion of marine habitats. Other habitats are less understood or considered, but deserve equal attention. This report, being focused away from shore areas, considers other marine habitats and sources of marine biodiversity.

India's southeastern coast, in particular, is blessed with concentrations of seagrasses that deserve spatial study as they are at risk from human activities such as dredging.

The seas also have considerable topographic variation known to support vibrant ecosystems, including but not limited to coral. Benthic, or bottom, complexity is one indicator of potential species richness that lends itself to spatial representation (Ardron 2002). Rougher areas of the sea floor — nooks, crannies, holes, trenches, ravines and niches — can provide shelter and habitat variation for species. Computer analysis tools can calculate terrain roughness from topographic data using a so-called Vector Ruggedness Measure (Sappington, Longshore and Thompson 2007).

Applying this tool to Indian Ocean bathymetry shows considerable complexity across the continental shelf of India (see Figure 17). Areas of particular complexity include the Gulf of Kachchh and the wider Gulf of Khambat (see Figure 18), as well as the Wadge Bank, Gulf of Mannar and Palk Bay off the coast of Tamil Nadu (see Figure 19). These areas, along with the fringing shelves of India's island chains certainly deserve regional attention on account of their likely habitat and species diversity.

Seagrass beds also support biodiversity, including species such as the dugong, which are under threat. India's southeastern coast, in particular, is blessed with concentrations of seagrasses that deserve spatial study as they are at risk from human activities such as dredging (Sivakumar, Johnson, Choudhury and Mathur 2010). The World Atlas of Seagrasses (Green and Short 2003) has estimated global seagrass richness, which is the potential range of individual seagrass species. This is different from observed occurrence data, which are limited by sampling. Plots of seagrass richness demonstrate high potential for seagrasses in the areas around the Gulf of Mannar and Palk Bay off Tamil Nadu (see Figure 20).

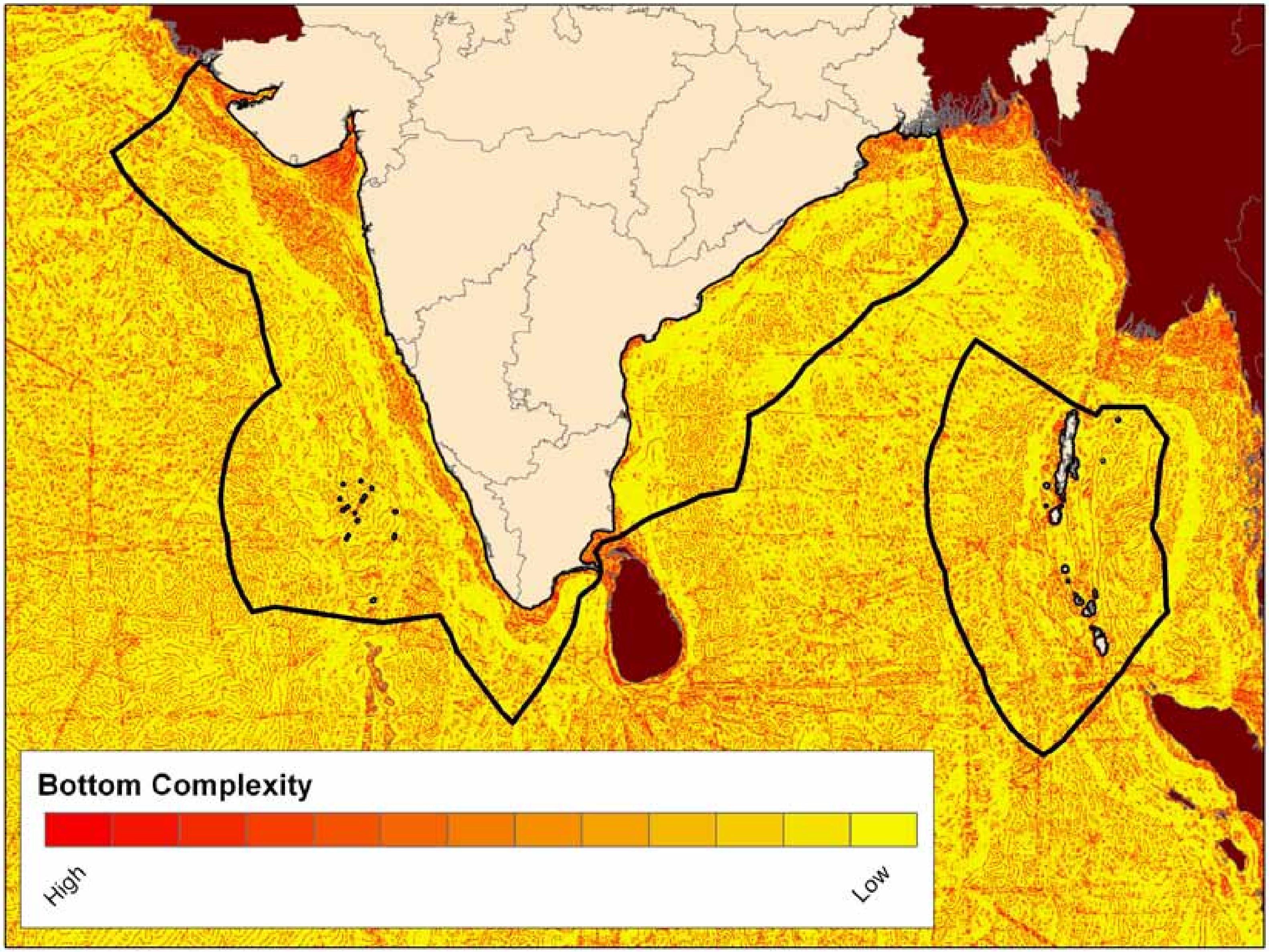


Figure 17: Vector Ruggedness in the Indian EEZ (Calculations based on Ardron 2002; Sappington, Longshore and Thompson 2007)

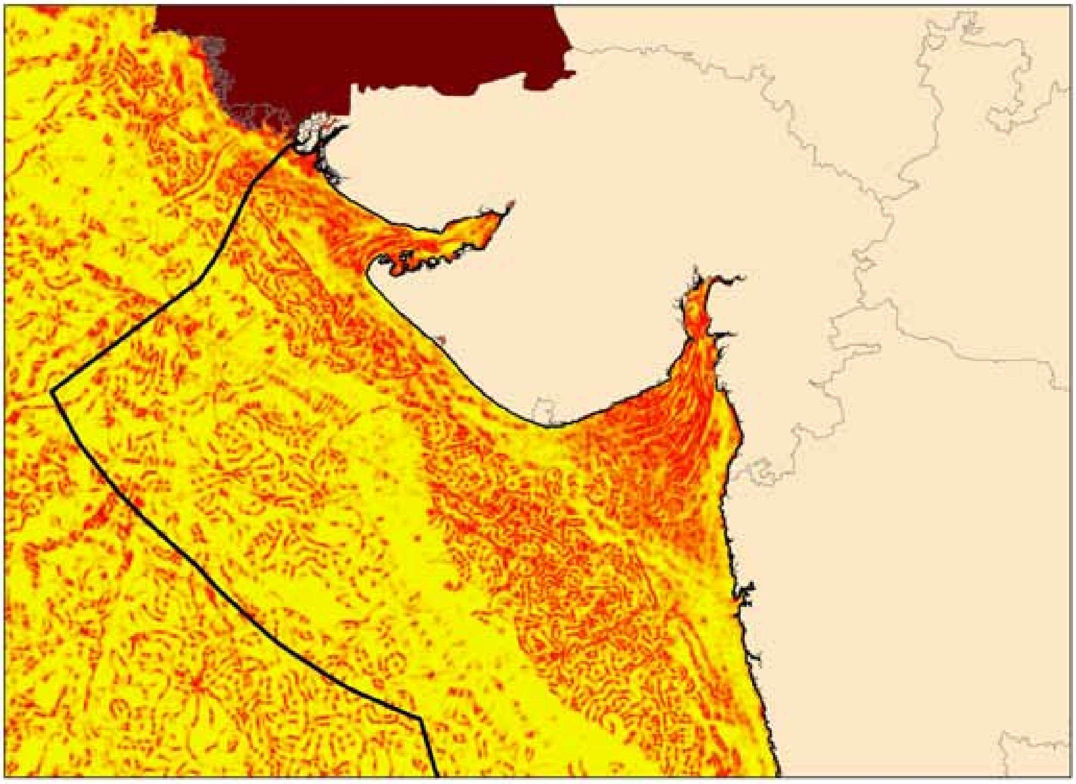
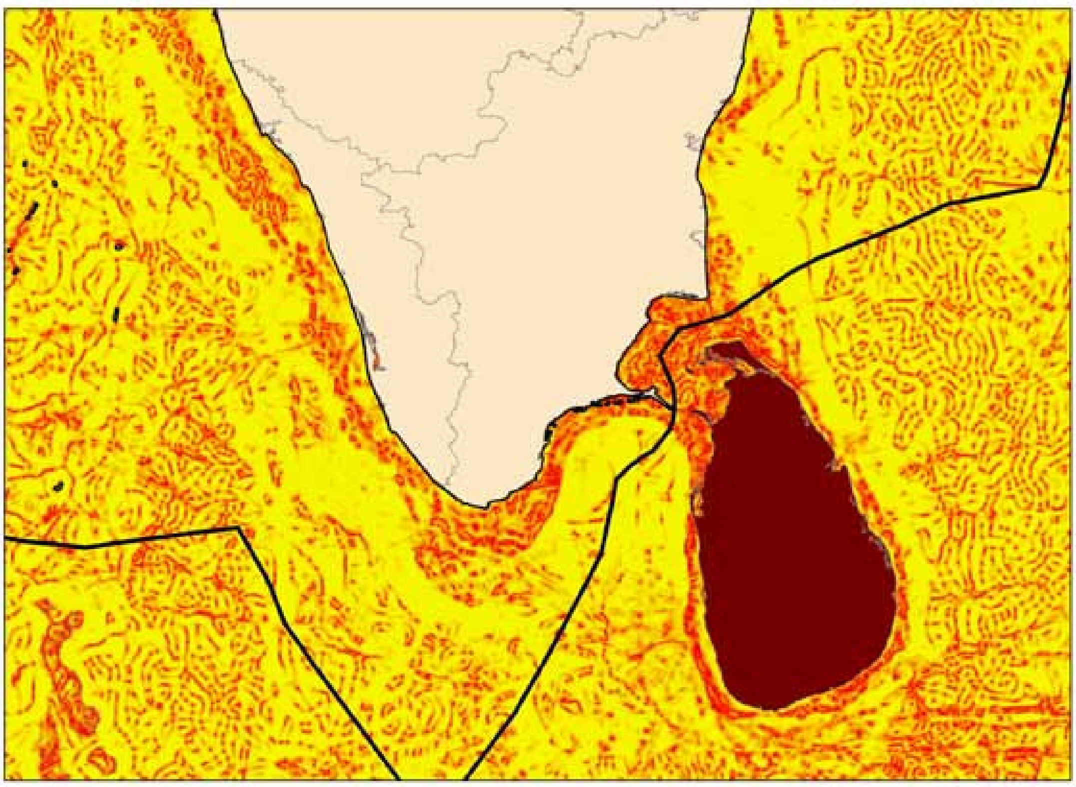


Figure 18 (above) and **19** (below): Vector Ruggedness in the Indian EEZ (Calculations based on Ardron 2002; Sappington, Longshore and Thompson 2007)



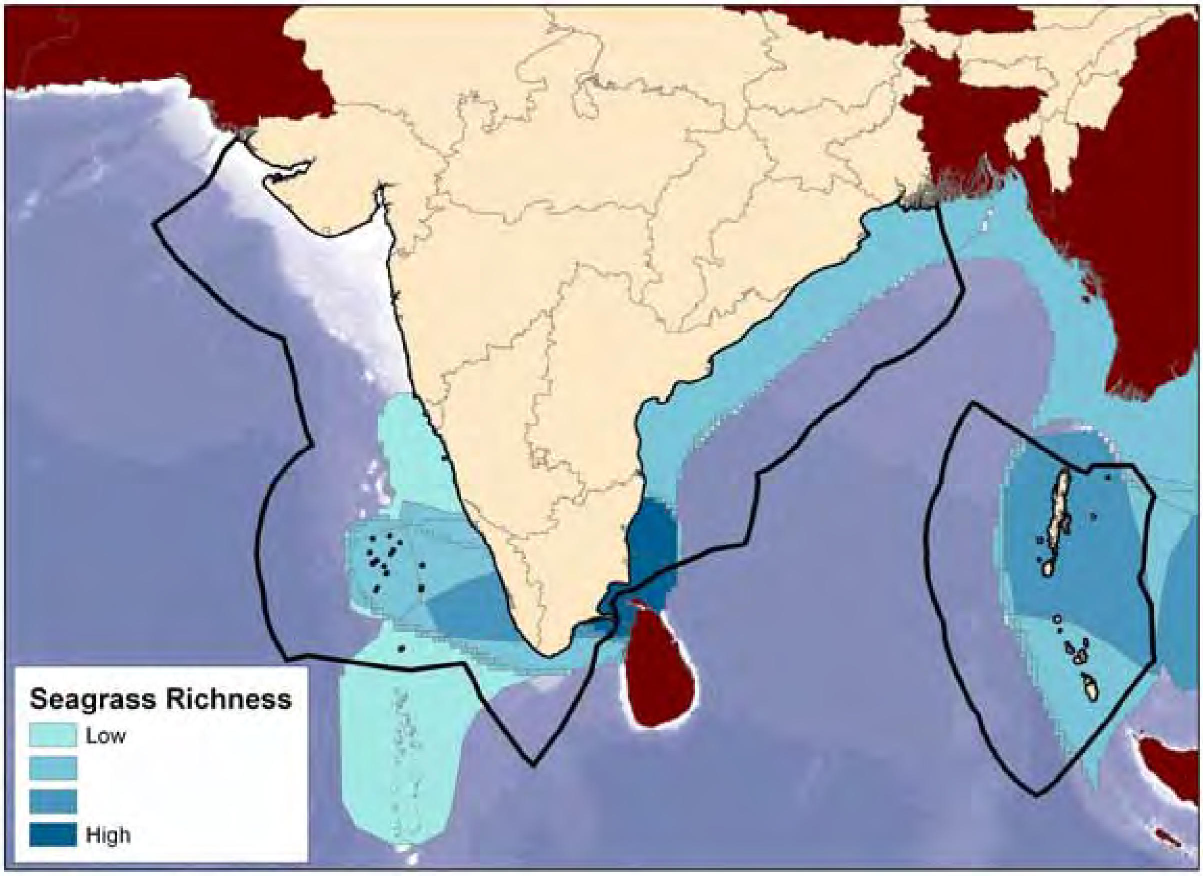


Figure 20: Seagrass Species Distributions (Green and Short 2003; UNEP-WCMC 2012).

Underwater geological formations also have great potential to harbor biodiversity. Of particular importance for conservation and ecology are seamounts. These undersea mountains rise from the sea floor yet do not break the surface; they act like submerged islands and can be aggregation points of biodiversity. Seamount ecology remains a new field of science, but much research so far demonstrates that these somewhat mysterious underwater features represent potentially unique ecosystems that are under threat from fishing and mining industries (Morato and Pauly 2004). For example, due to the mountainous shape of their habitat, some seamount invertebrates have adapted bushy structures for filter-feeding which makes them particularly vulnerable to fishing and mechanical damage (Stocks 2004).

Out of more than 10,000 seamounts identified worldwide, several dozen sit within the Indian EEZ, mostly rising from the floor of the Laccadive Sea (Wessel, Sandwell and Kim 2010; see Figure 21). Yet few have been studied in detail. Iyer, Das, Kalangutkar and Mehta (2012) report the known characteristics of less than 20 seamounts within the Indian EEZ, but they see this as an opportunity for further marine and geological studies. A precautionary approach to conservation suggests that study and protection are urgently needed before these diverse and vulnerable resources are destroyed in a rush to exploit the deep ocean.

Along the western coast of India, scientists have identified other potential hotspots of biodiversity far offshore where a number of shallow banks rise near the surface of the ocean. Scientists conducting some basic biological surveys have found substantial life yet detailed studies do not exist. These known submerged banks (see Figure 22) — five in total off the coast of Maharashtra and Karnataka — may be only a few of many that remain unknown.

Angria Bank, almost 65 nautical miles west of southern Maharashtra, has been known for decades as an important fish spawning ground (Silas 1985). More recently, marine scientists have surveyed the bank and found high biodiversity — from coral reef to large sharks — spread across some 350 square kilometers (GEF 2011). Sarang Kulkarni, a scientist at the Science and Technology Park at the University of Pune plans more study, and the Wildlife Institute of India has recommended Angria Bank's inclusion in a network of protected areas (Choudhury, Sivakumar

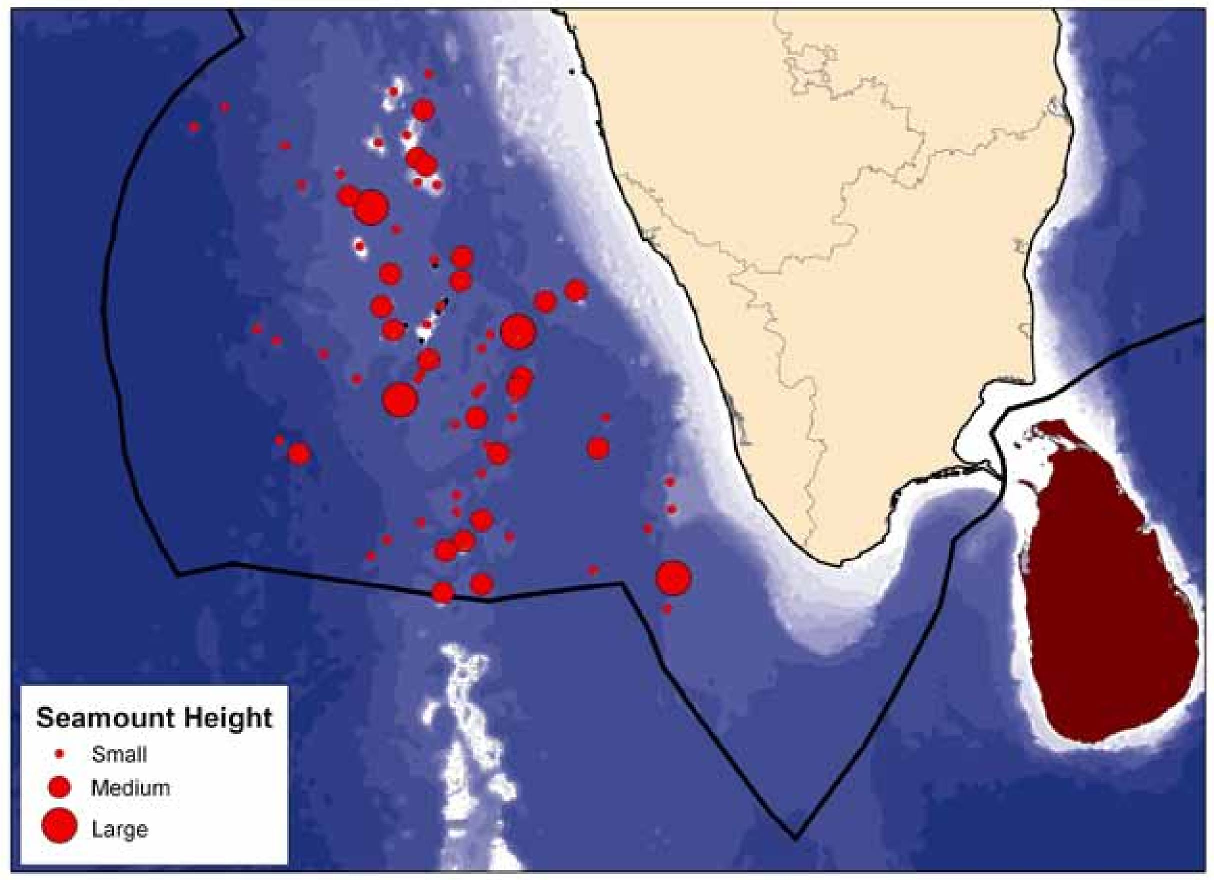


Figure 21: Seamounts of the Indian EEZ (Wessel, Sandwell and Kim 2010)

and Saravanan 2011).

Other sunken banks off the coast of Karnataka, though studied less, have been compared to Angria Bank (Ambiye and Untawale 1992; Rao, Kodagali, Ramprasad and Nair 1993). Even basic surveys may reveal biodiversity worth protecting.

Figure 22: Submerged Banks of the Western Coast. Source: (Silas 1985; Ambiye and Untawale 1992; Rao, Kodagali, Ramprasad and Nair 1993)

AN OCEAN OF DIVERSITY

Efforts to collect decades of surveys of global ocean biodiversity have progressed in recent years with the development of the Ocean Biogeographic Information System (OBIS) now under the auspices of the Intergovernmental Oceanographic Commission. At present, the OBIS system has 32.7 million records in nearly 1,100 datasets. More than 25.5 million records have been identified to species or infraspecies level. This collection represents more than 145,000 species observed worldwide (IOC 2012a).

From these records, scientists have generated summary maps, which are useful in examining spatial biodiversity patterns (IOC 2012b). Generally speaking, these summaries use technical formulas to overcome spatial biases in sampling to predict species diversity. A popular method, the Shannon Index, shows predicted marine biodiversity of the Indian EEZ and nearby waters (see Figure 23).

This biodiversity mapping places much India's biodiversity close to the shelf, as is the case for much of the world's oceans. Notable spots of diversity are areas such as Palk Bay, the Gulf of Mannar, much of the Gujarat Coast and the limited shelf areas surrounding the Andaman and Nicobar Islands. This however is only a preliminary analysis of probable hotspots. Scientists and policy makers interested in conservation and resource management should work together to design more robust analysis of diversity hotspots and important species and ecosystems using OBIS records.

However, the value in such data remains dependent on sampling, which is far from exhaustive, particularly in the Indian EEZ. Though the OBIS database as a whole has more than 30 million records, the primary Indian data set — the IndOBIS catalogue currently loaded in OBIS — has fewer than 50,000 records in the Indian Ocean and only slightly more than 19,000 within the EEZ. This results in a heavy spatial bias in sampling (IOC 2012c; see Figure 24). Diversity analyses,whether the Shannon Index or another, require more records and sampling effort. Conversations with senior scientists at some of India's government institutions reveal honest recognition of this problem, but availability of dedicated resources remains a constraint.

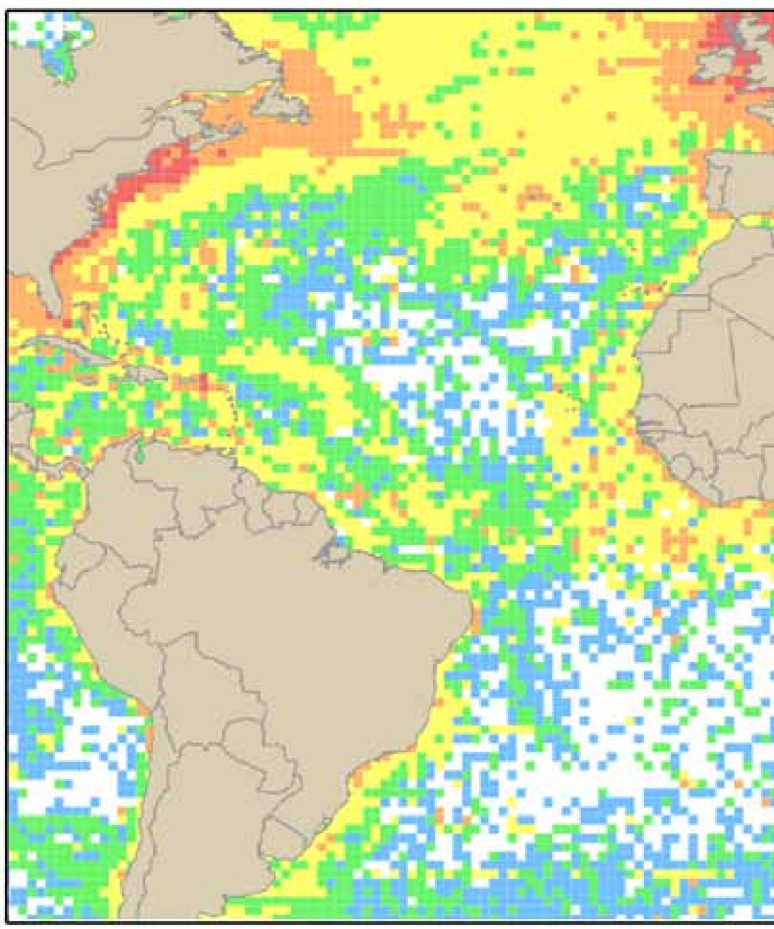
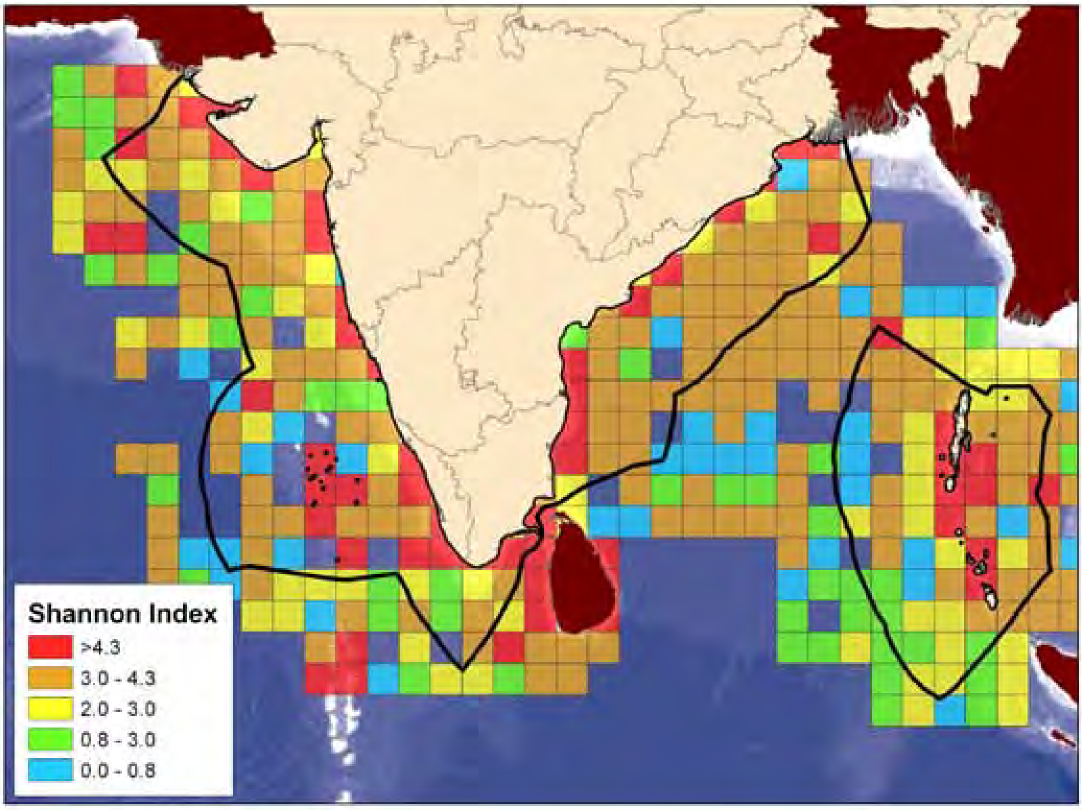
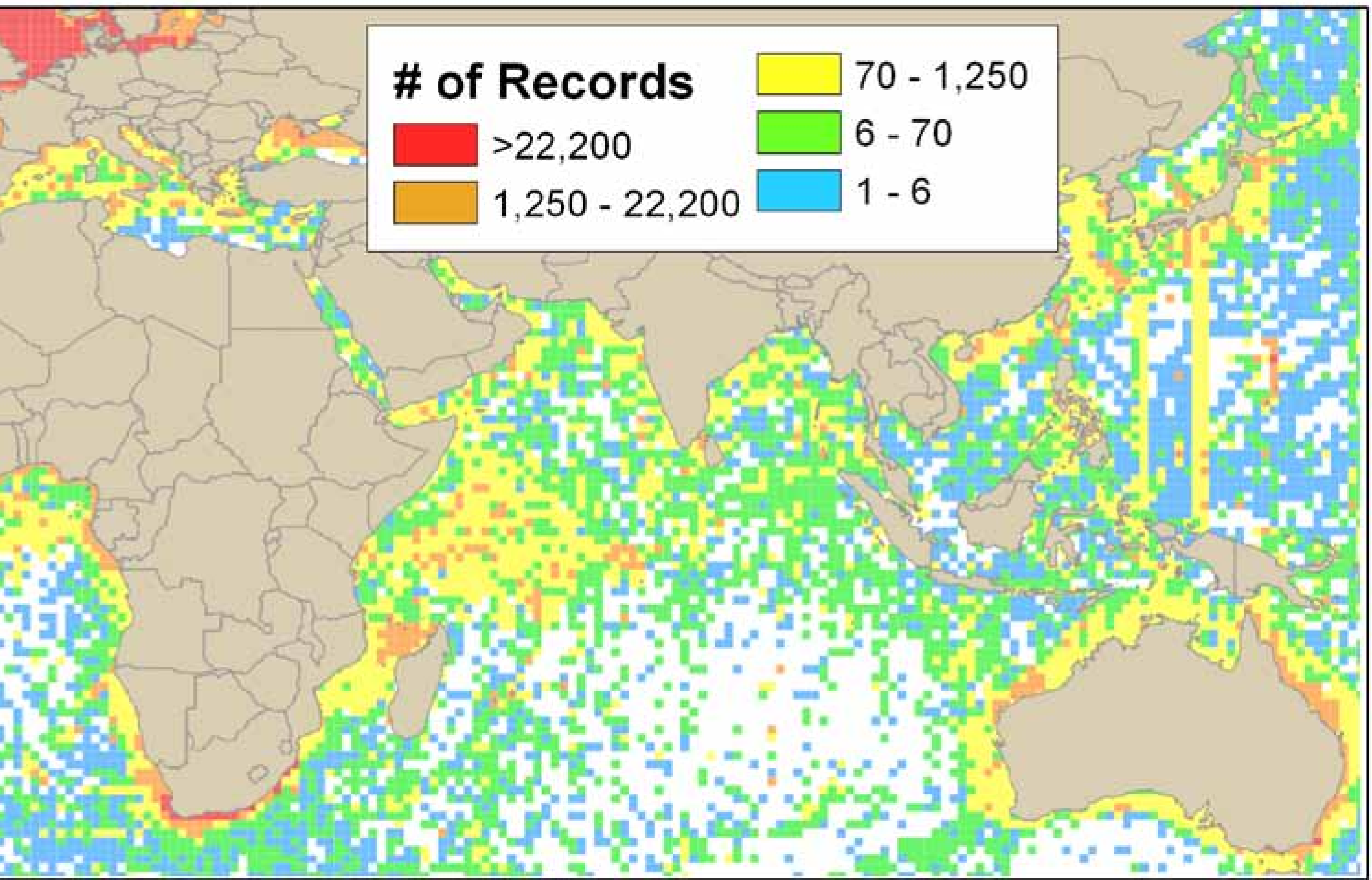


Figure 23 (top right): Biodiversity of the Indian EEZ and Surrounding Waters (IOC 2012b)

Figure 24 (bottom right): Number of Records of Ocean Biodiversity in the OBIS Database (IOC 2012c)


Shannon Index
>4.3
3.0 - 4.3
2.0 - 3.0
0.8 - 3.0
0.0 - 0.8


# of Records
>22,200
1,250 - 22,200
70 - 1,250
6 - 70
1 - 6

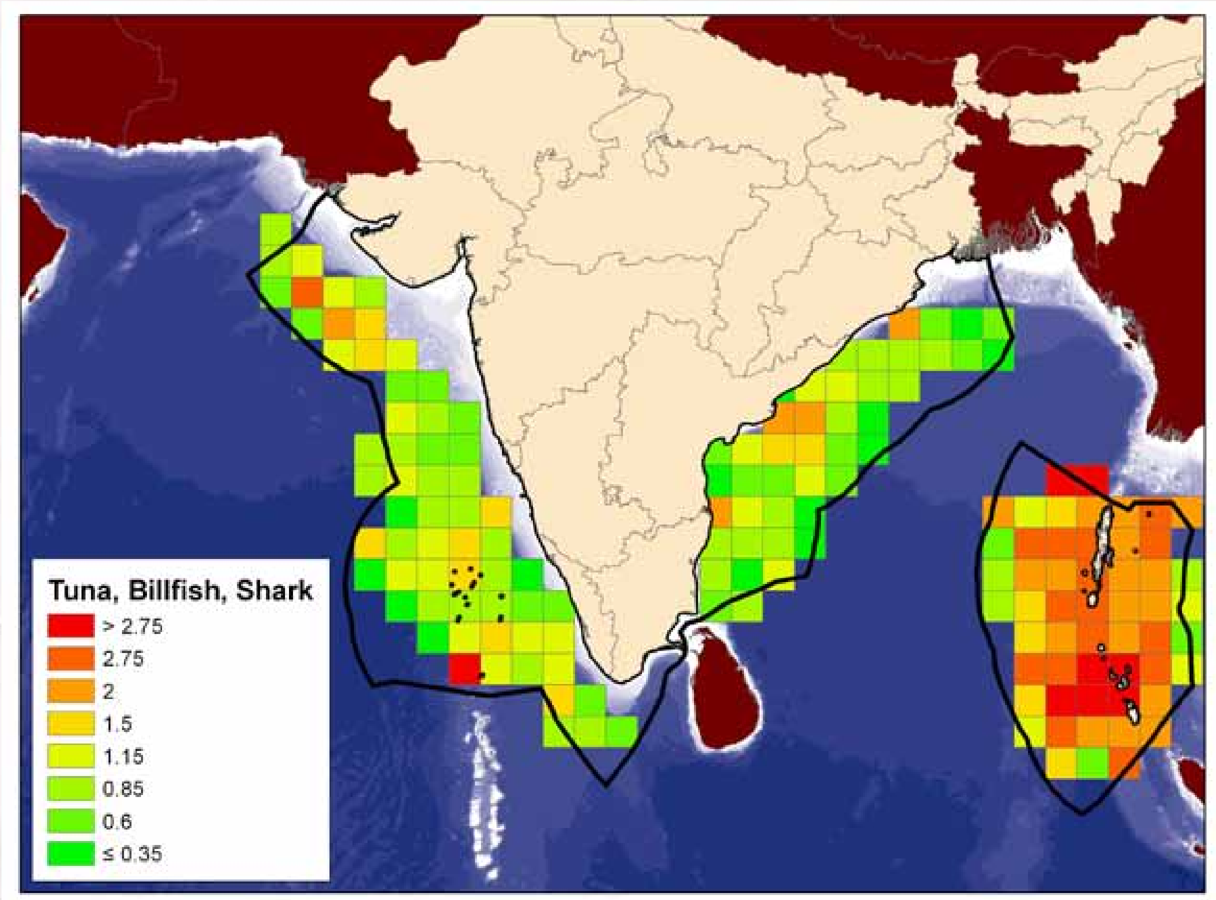
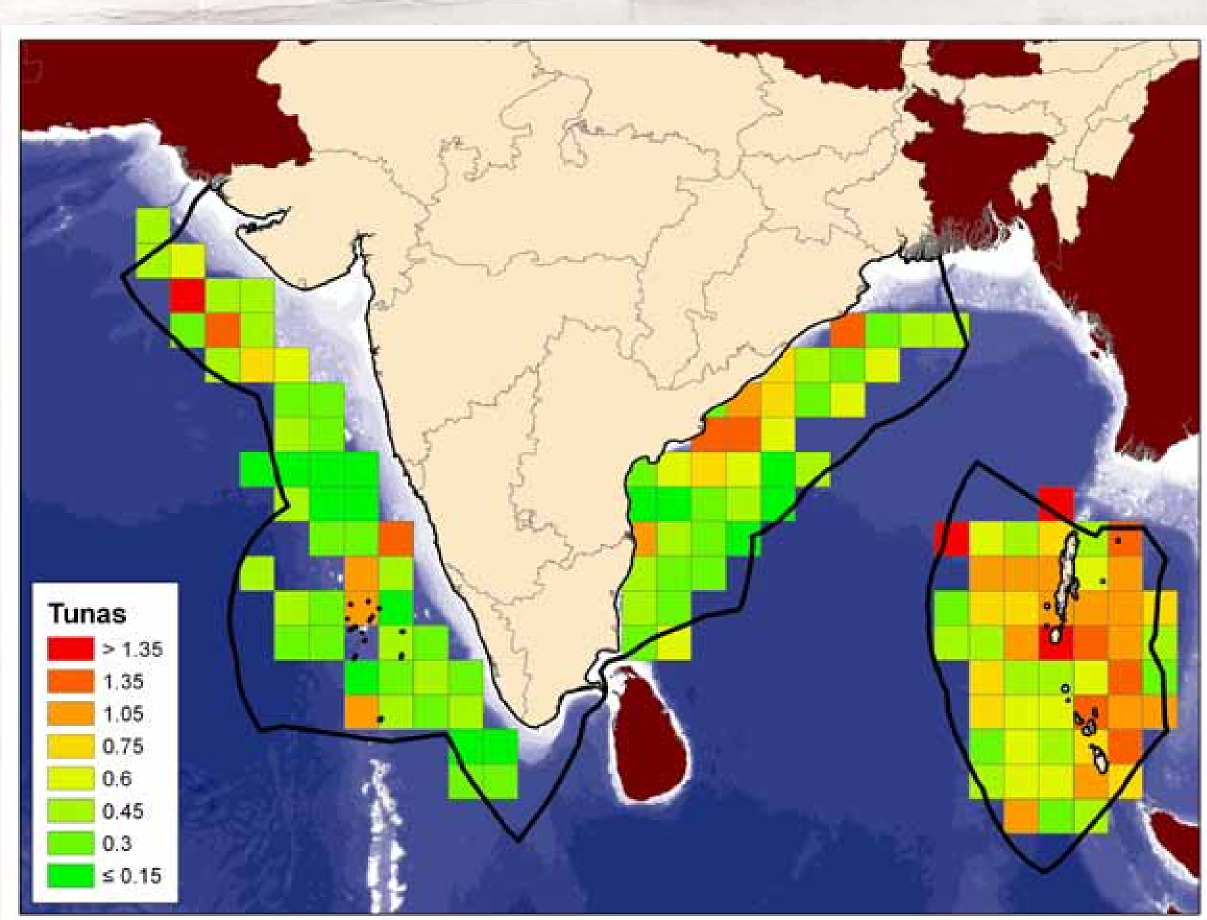


Figure **25** (above) and **26** (below)



HOW MANY FISH IN THE SEA?

The majority of biodiversity research in India has been focused on commercial species and products rather than on ecosystems (Sivakumar, Johnson, Choudhury and Mathur 2010). Nonetheless, some fisheries data are indicative of wider trends in biodiversity and the protection of important commercial species can result in protection of cohabitating species. Research suggests that Indian fisheries at the moment are "beset by problems of over capitalization, over capacity, increased operational expenses and reduced catch rates" (Pillai and Ganga 2010: 34). So far, these problems have been mitigated or masked by bumper catches of forage fish such as the prolific Indian oil sardine and high prices for ocean produce. Other scientists have suggested that India is "fishing down marine food webs" by increasingly catching fish from lower trophic levels as larger fish stocks are depleted (Bhathal and Pauly 2008). Greenpeace India's own work in this regard has argued strenuously that Indian fisheries need careful conservation and management to avoid collapse (Fernandes and Gopal 2012). A number of species have already been identified as fully exploited or even over exploited (Pillai 2011).

Research suggests that Indian fisheries at the moment are "beset by problems of over capitalization, over capacity, increased operational expenses and reduced catch rates"

FSI oceanic survey data — from assessments of coastal demersal stocks to atlases of large pelagic predators — can help determine species abundance. FSI's historical database contains thousands of species catch records, geo-referenced and stratified by gear type, sea condition, bottom complexity and other variables. Such data could be highly relevant in designing plans for management and protection.

Unfortunately, the database is not publicly available, but some FSI publications contain useful information for exploring fishery resources of the Indian EEZ. Of particular interest are multi-year longline surveys of large pelagic predators that sit near the top of oceanic food chains (John and Somvanshi 2000; Somvanshi, Varghese, S. and Varghese S. P. 2008; see Figures 25, 26, 27 and 28). These warrant protection measures both for their contribution to commercial fisheries and because they live longer and reproduce more slowly than smaller fish in lower trophic levels. However, these data lack a temporal dimension and are quickly outdated as Indian fisheries intensify.

Differentiation by catch shows that tuna (and in particular yellowfin) is an abundant species throughout the EEZ, as are various billfishes. Older shark hooking rates are also substantially higher in the Andaman and Nicobar Islands but that may have changed in recent years.

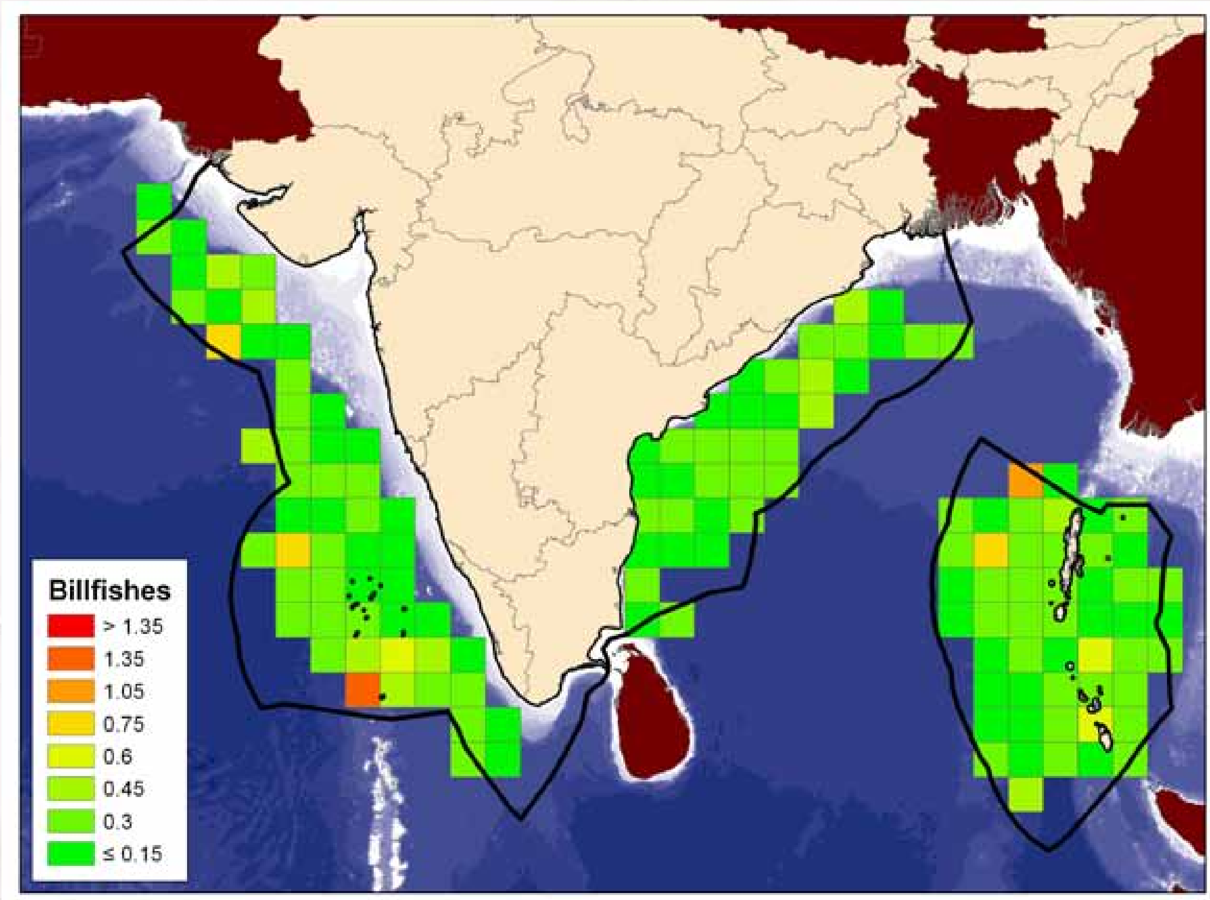
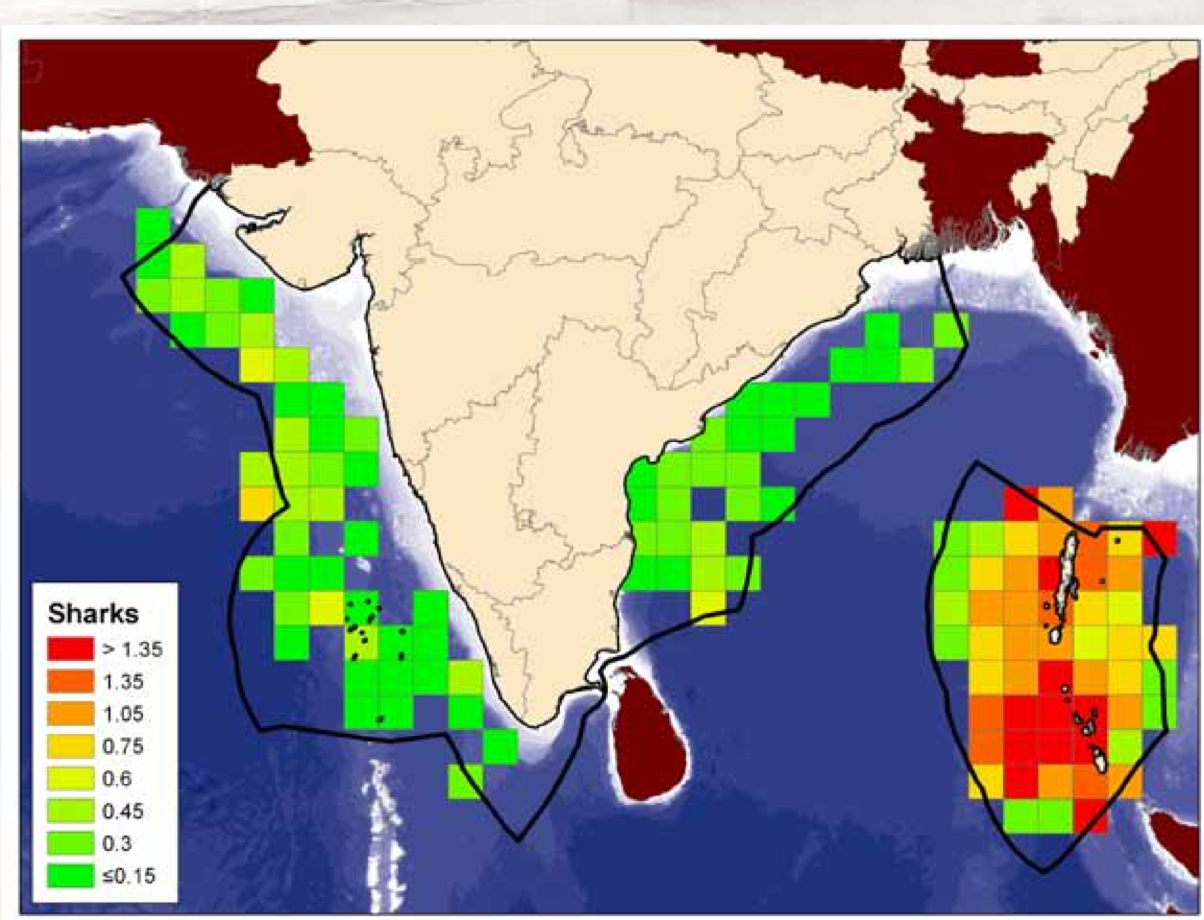


Figure 27 (above) and **28** (below)



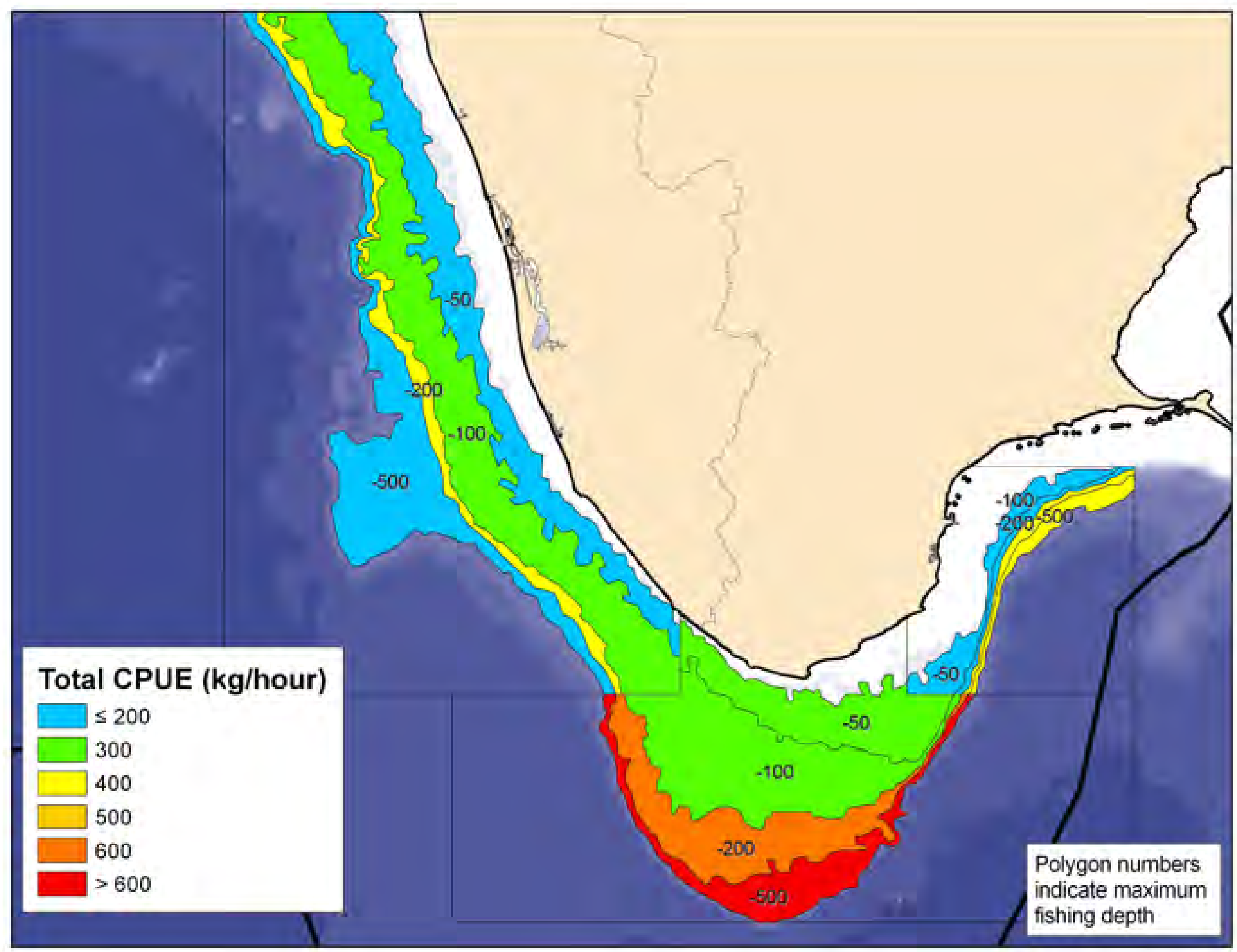


Figure 29

Of course, large pelagic predators are not the only resource important to Indian fisheries, which vary by region and depth. Even though scientists have identified many important region-, gear- and species-specific fisheries, spatially explicit data are scattered, missing or largely unavailable in digital formats. However, hardcopy publications from FSI do provide information on other fisheries resources in the Indian EEZ. One example, though outdated, examines demersal fisheries off the southwest coast as well as the Wadge Bank and Gulf of Mannar (Ninan, Sivaji, Jagannadh and Ramalingam 1992). Digitized depth charts allow for basic analysis of catch per unit of effort (see Figures 29, 30 and 31). This can help identify species abundance and compare important fisheries for monitoring and possible regulation. The deeper edges of Wadge Bank — the ranges from 100 to 200 meters and from 200 to 500 meters — are the most productive in this region as surveyed by fish and shrimp trawls. Threadfin breams are important fishes in the 50 to 200 meter range, particularly on the Bank and the west coast. Crabs are also an important resource in the region, primarily at depths between 100 and 200 meters.

A clear caution must be made: These data are likely out of date. More recent data at this regional scale — which might paint a different picture — is not publicly available.

Figures 25, 26, 27 and 28
Hooking Rates from FSI Longline Fishing Surveys; mainland 2005 to 2007, Andaman and Nicobar 1989 to 1998 (John and Somvanshi 2000; Somvanshi, Varghese, S. and Varghese S. P. 2008)

Figures 29, 30 and 31
Species abundance (CPUE) from trawl surveys of the southwest coast, Wadge Bank and the Gulf of Mannar (Ninan, Sivaji, Jagannadh and Ramalingam 1992)

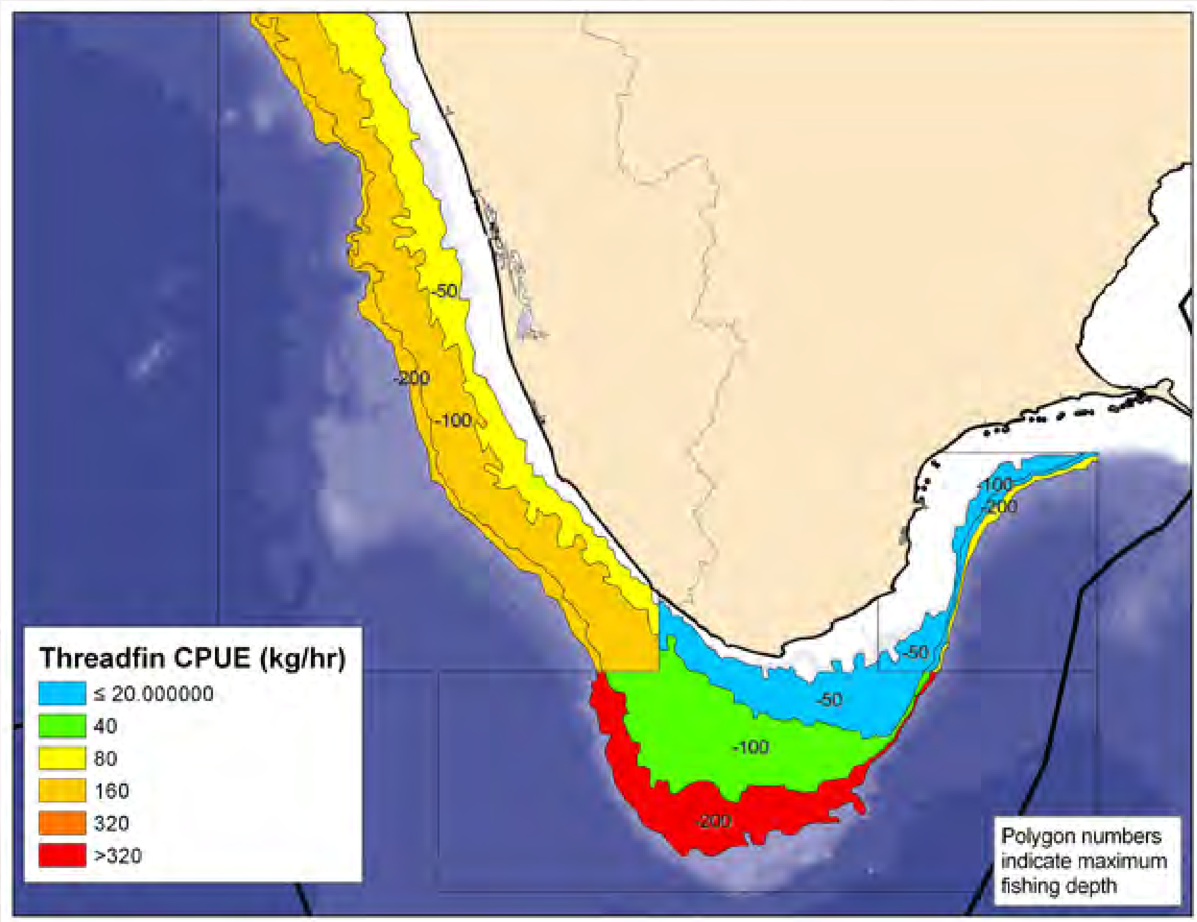
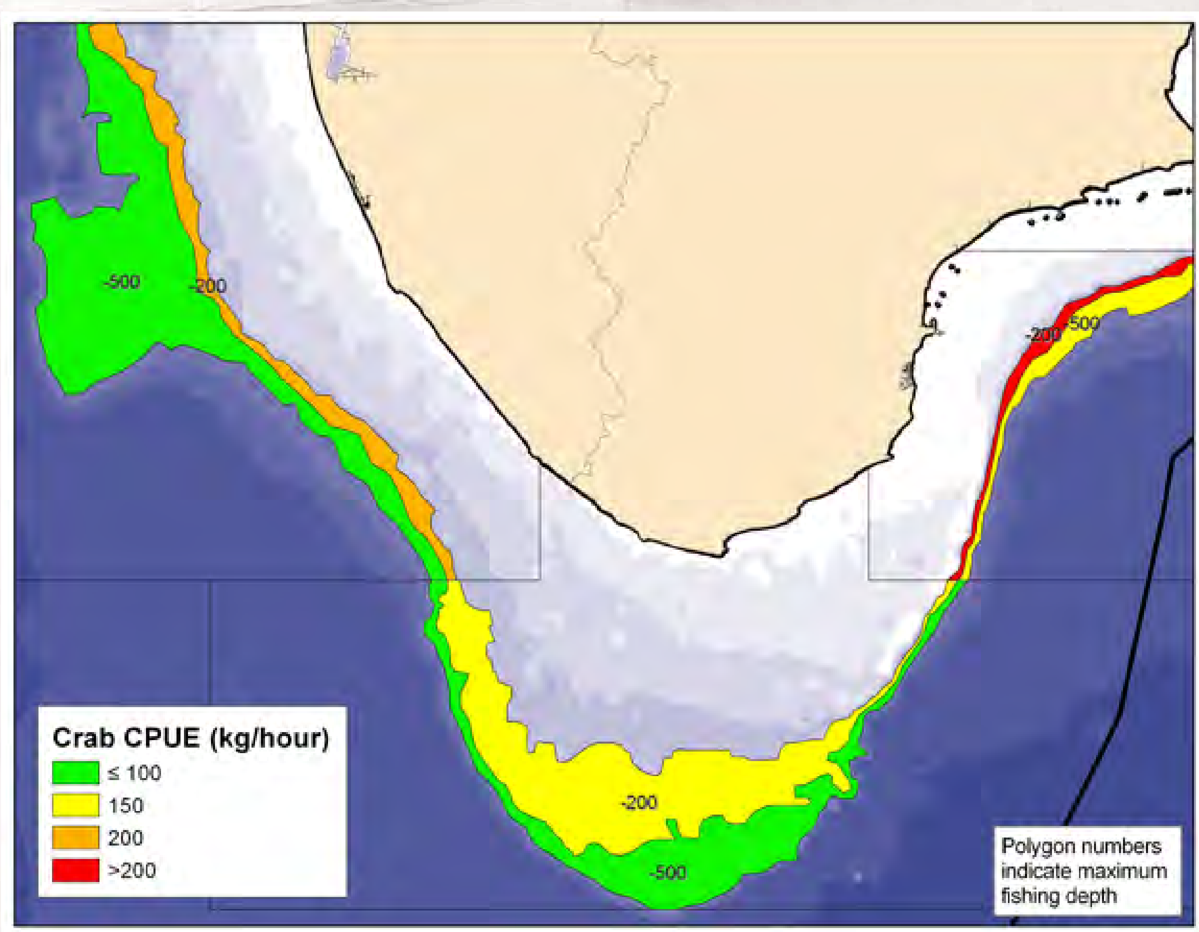


Figure 30 (above) and **31** (below)



Blue Striped Snapper. Andaman Sea.

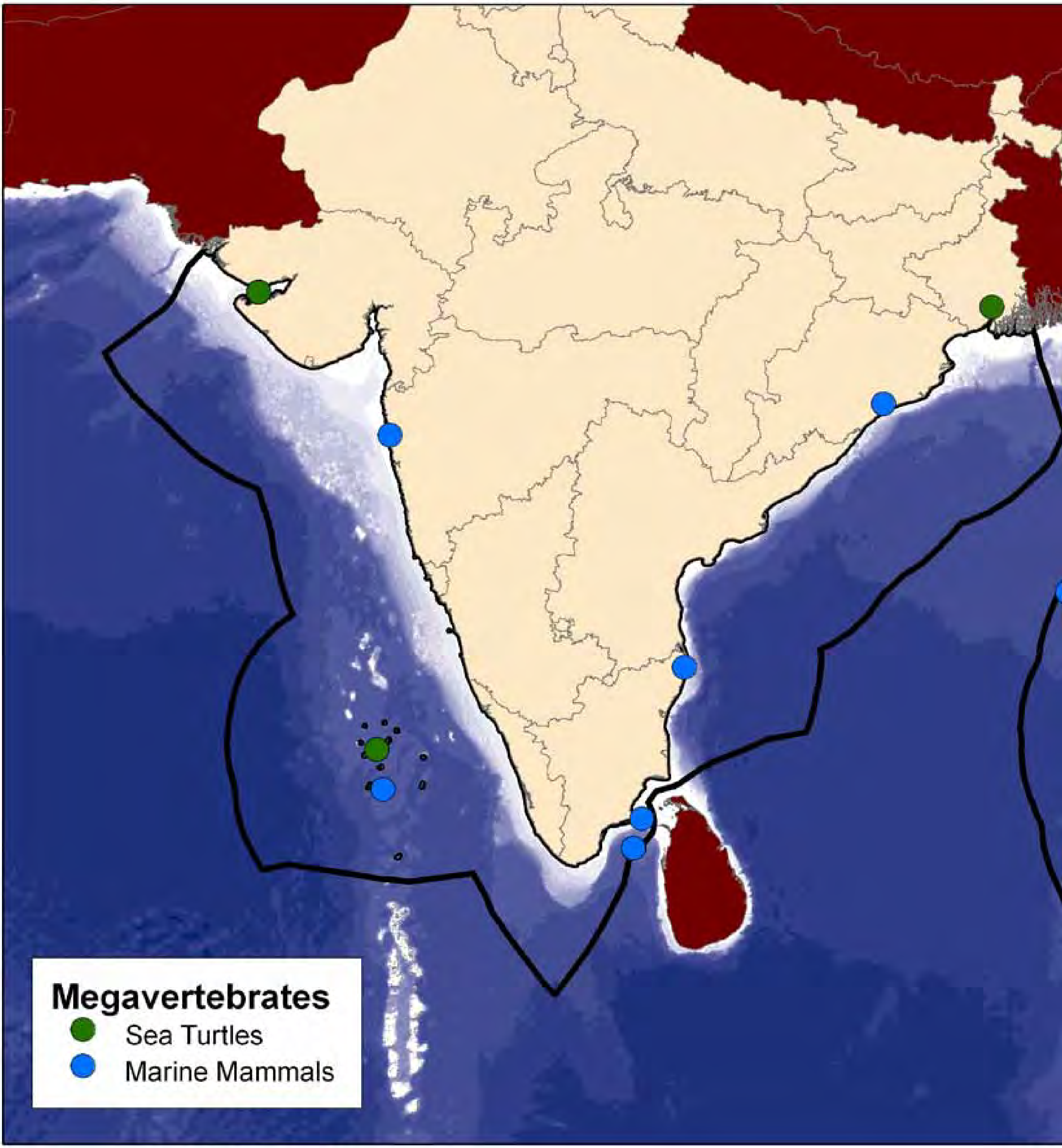
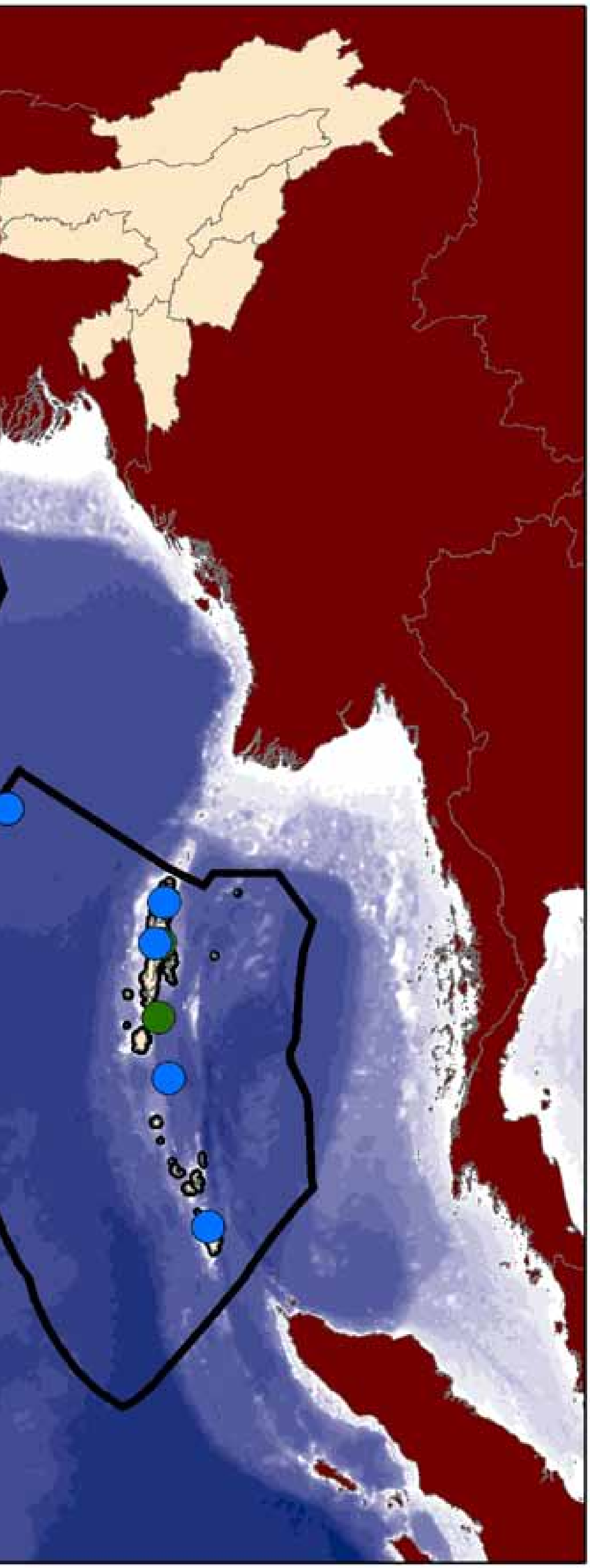


Figure 32: IndOBIS Megavertebrate Records (Chavan and Achuthankutty 2011)



CHARISMATIC CREATURES

The endangered blue whale – the largest animal believed to ever exist – and the vulnerable sperm whale both are known in Indian waters.

Charismatic megafauna such as dolphins, whales and turtles frequently merit significant attention in discussions of marine protection and management. They occupy important ecological niches and face recognized threats to their conservation. The endangered blue whale — the largest animal believed to ever exist — and the vulnerable sperm whale both are known in Indian waters. Five of the seven worldwide species of sea turtle are found in India; all are considered by the IUCN to be vulnerable, endangered or critically endangered (IUCN 2012). Worth noting: The Indian Wildlife Protection Act of 1972 grants protection to sea turtles as well as marine mammals.

Yet plotting the distribution of these large vertebrates is difficult given the paucity of recorded observations, particularly within the Indian Ocean. IndOBIS, the primary OBIS dataset for the Indian EEZ, contains a total of 51 point-occurrence records of marine mammals and sea turtles (Chavan and Achuthankutty 2011; see Figure 32), some of them with suspect or generalized observation coordinates.

Other data are necessary to complete the picture. Indian researchers in a four-year study made 473 sightings of mammal groupings within the EEZ and surrounding Indian Ocean. Of these, only 26 percent of sightings were identified to genus or species (Afsal et al. 2008; see Figure 33 for an approximated sample). Unfortunately, distribution predictions based on such survey data are likely to result in a misrepresentation of actual species occurrence.

More recently, a group of scientists created an alternative prediction technique combining expert knowledge with quantitative environmental parameters (Kaschner et al. 2011). This “relative environmental suitability” (RES) model compared the environmental tolerance of species to spatially explicit environmental data known

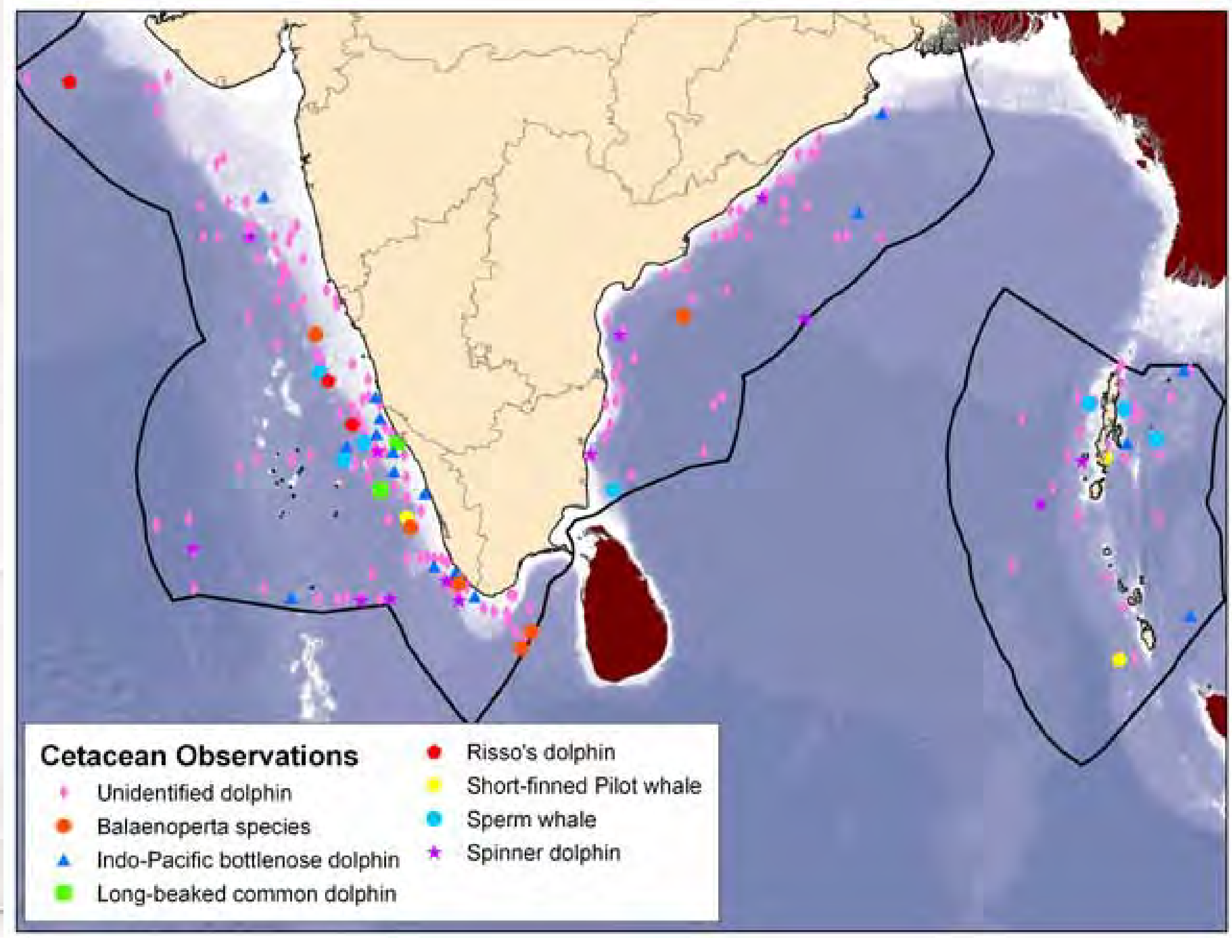


Figure 33: Cetacean Observations of the Indian EEZ (Afsal et al. 2008)

to determine — directly or indirectly — mammal distribution, such as bathymetry or sea surface temperature. The model scored half-degree grid cells globally for how well their environmental parameters match individual species' habitat preferences. The scientists used observational data from dedicated marine mammal surveys to validate the RES scores and establish model fit. Based on the validation analysis, the resulting species richness maps likely correspond to core habitats rather than total possible ranges (see Figure 34).

The model predicted fairly high marine mammal distribution throughout most of the Indian EEZ, with concentrations just beyond the continental shelf. This has implications for potential conservation or management efforts within the EEZ. This model implies that India's primary fishing grounds on the continental shelf would not necessarily be affected by efforts aimed at preserving the core habitat of marine mammals. At the same time, the growing race to extract fish beyond the shelf from deeper seas (which remain comparatively underutilized) will likely increase pressure on these prime cetacean ranges.

Future scientific and conservation research might also build upon this model looking for temporal changes in habitat distribution based on the substantial shifts in environmental parameters within the Arabian Sea and Bay of Bengal, as outlined in previous maps. In addition, the RES model applied to other species groups (Kaschner et al. 2010) needs to be evaluated with specific reference to the Indian EEZ.

Several data sources exist for mapping sea turtle habitats in India, though some are more readily available than others. Regular volumes of the *State of the World's Sea Turtles* (SWOT) reports have collected turtle nesting data globally, from more than 200 sites where animals and eggs have been observed. These data are also available as geo-referenced nesting sites (see Figure 35).

Some sites have been generalized (i.e. one point represents multiple known nesting locations). For example, though only one point is situated along the Orissa coastline according to SWOT data, this represents a series of mass nesting sites where tens of thousands of turtles gather annually.

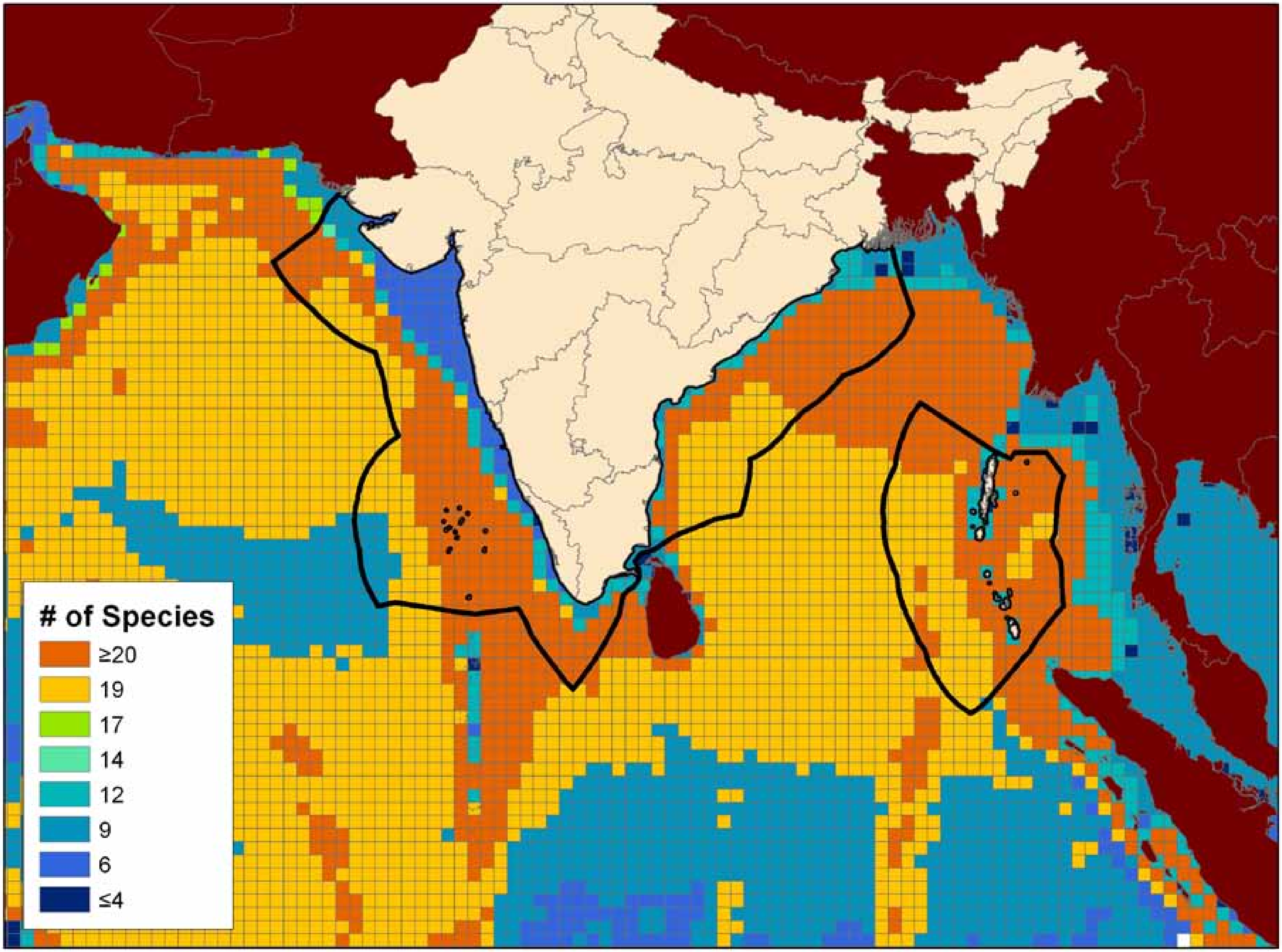


Figure 34: Predicted Marine Mammal Species Richness (Kaschner et al. 2011)

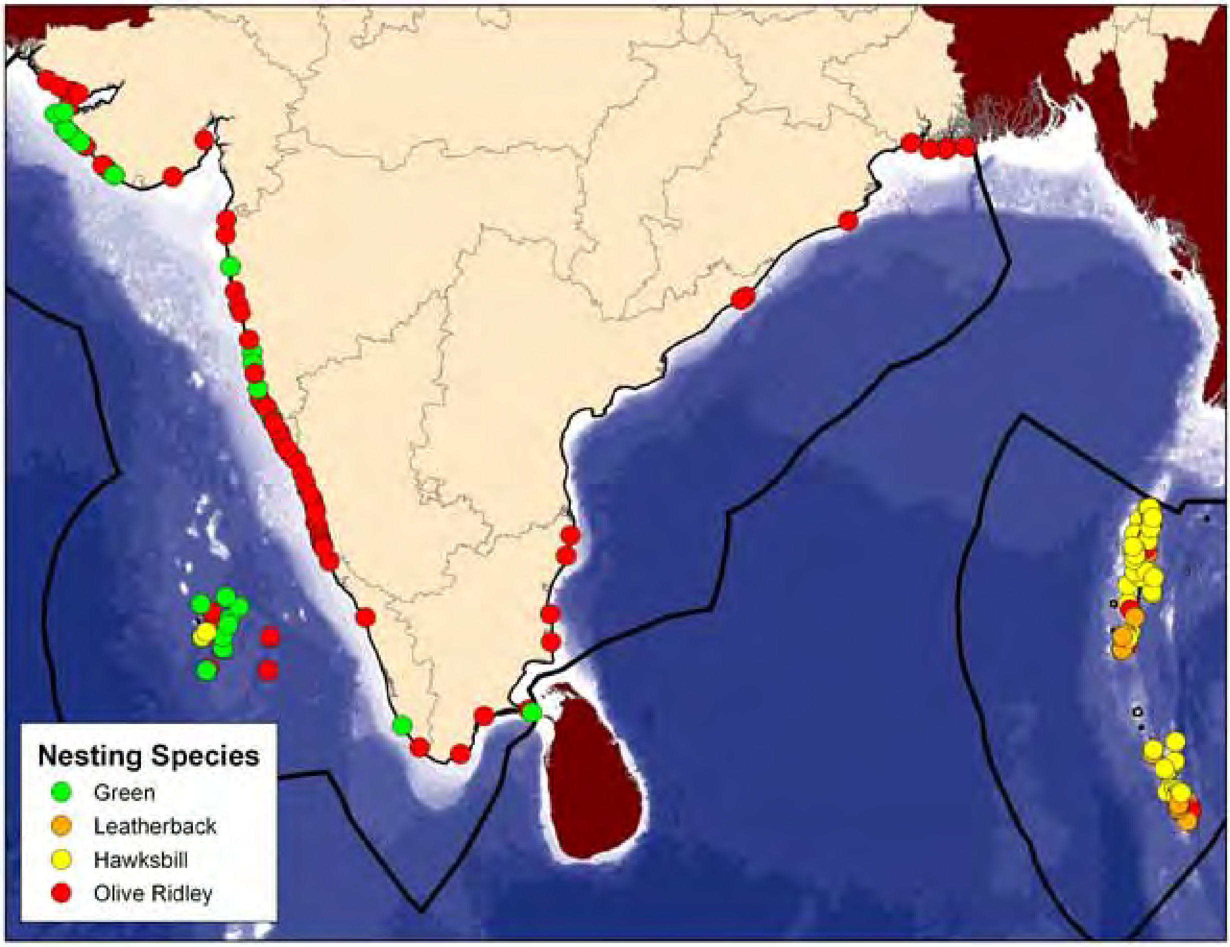


Figure 35

Nonetheless, the picture is clear: Important species, protected by Indian law and deserving of conservation attention, are found throughout Indian coastal waters where human interference — from fishing to shipping to construction — is also present. Olive Ridley nesting dominates the mainland coast though green turtle species are also present, particularly on the west coast and in Lakshadweep. India's hawksbill and leatherback populations nest primarily in the Andaman and Nicobar Islands. Loggerheads are not known to nest in India but the species is found within Indian waters and is known to nest near by in Sri Lanka (Shanker 2003).

Some state-specific or even beach-specific analyses also exist (Pandav, Choudhury and Kar, 2006; see Figure 36 for Orissa's mass nesting sites). These analyses are helpful in generating local conservation and management plans, but more comprehensive and spatially explicit time-series data are necessary to understand the permanence of nesting patterns.

While nesting data do not demonstrate the range of these species, satellites can track the migration patterns of tagged sea turtles. The Wildlife Institute of India (WII) and various NGOs have tracked numerous animals, but much of this data isn't publicly available. One tracking study of two turtles from the Tamil Nadu coast (Coyne and Godley 2005; TREE Foundation 2011) shows just how much sea turtles roam, covering vast portions of the Indian EEZ and beyond (see Figure 37). A tagged adult live Ridley turtle swam more than 2,600 nautical miles in roughly seven months. Systematic compilation of India-wide tracking data could aid conservation design and regulation, taking into account the substantial distances these animals travel.

Figure 35
Sea Turtle Nesting Sites in India (SWOT 2006-2012; Halpin et al. 2009)

Figure 36
Sea Turtle Nesting on the Coast of Orissa (Pandav, Choudhury and Kar, 2006)

Figure 37
Sea Turtle Satellite Tracks (Coyne and Godley 2005; TREE Foundation 2011)

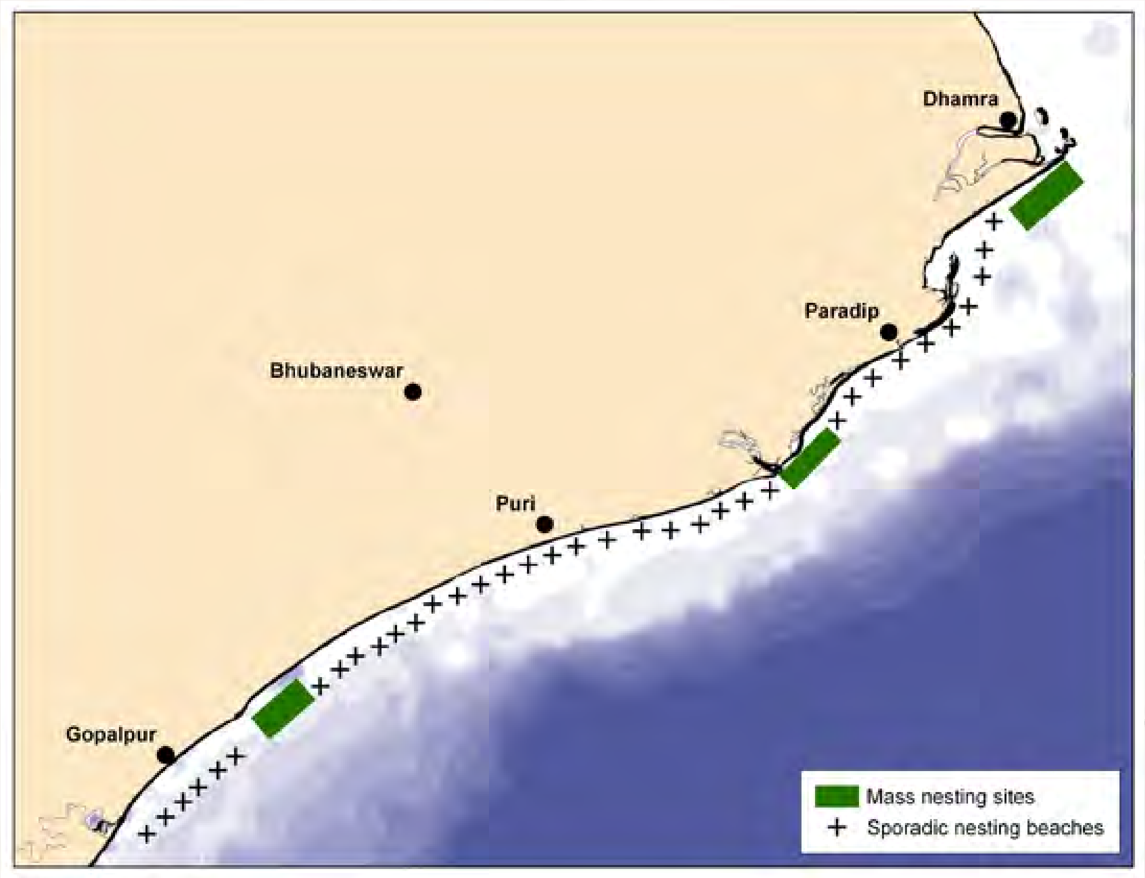
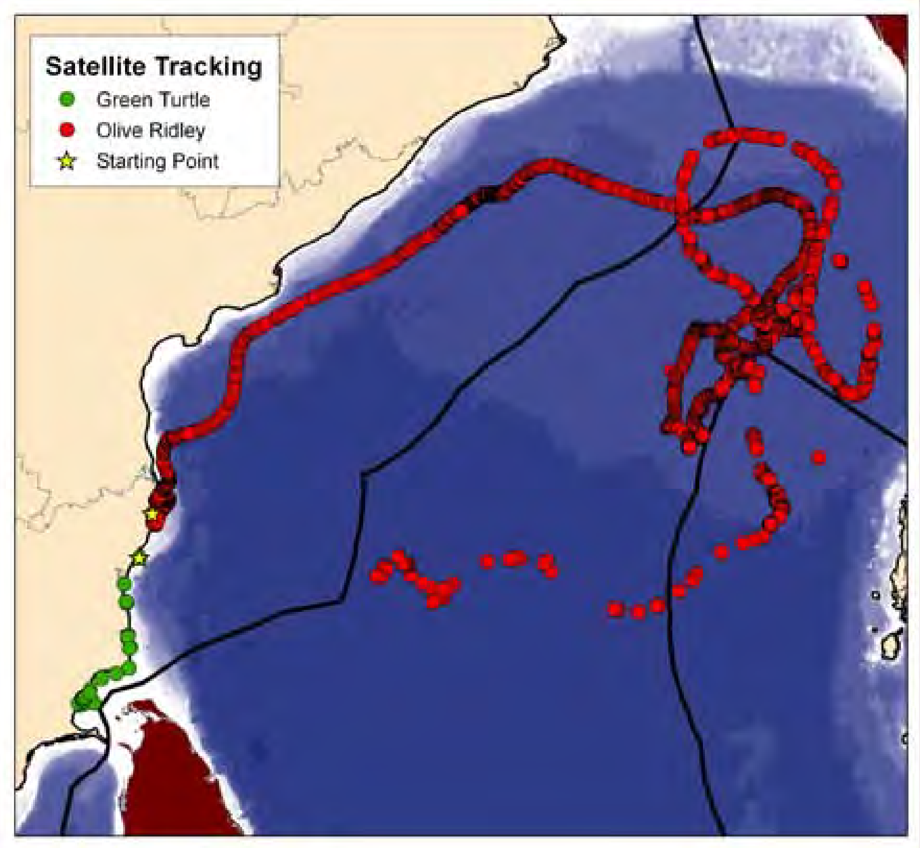


Figure 36 (above) and **Figure 37** (below)



OUR EXPANDING FOOTPRINT

Thus far, this mapping exercise has largely examined physical, environmental and biological parameters of the Indian EEZ. When the data layers are analyzed together important places for biodiversity or ecology — sites that might satisfy the EBSA criteria — are likely to emerge. While these maps would be much improved by additional and updated data, they represent an important starting point for a serious discussion as to which areas in the Indian EEZ warrant protection .

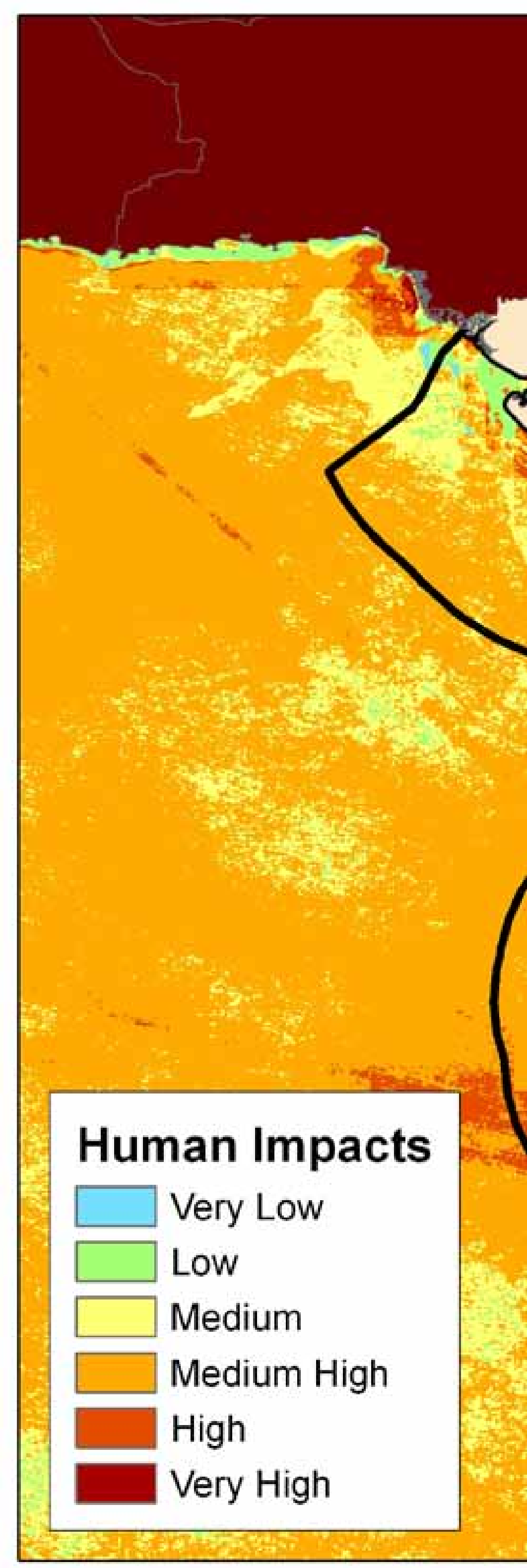
Yet they do not represent the whole picture. To properly manage or conserve, we also must understand just where humans are most affecting and altering the marine environment. The question merits a full and separate analysis; what follows is only a preliminary discussion based on a global study from a large team of international marine scientists (Halpern et al. 2008).

Team members collected global information on 17 different human activities, from various types of fishing to nutrient runoff to commercial shipping. They then mapped 20 types of ecosystems and scored them for vulnerability, on the premise that activities have disparate effects on ecosystems. Consider their example: Fertilizer runoff has a larger impact on coral reefs than on kelp forests.

Overlaying activities onto ecosystem vulnerability generated a global map of overall human impact on the marine environment, which scientists classified on a six-value scale. Forty-one percent of world oceans suffer impact categorized as medium high or worse. Impact is not surprisingly concentrated along coasts and on the continental shelf.

The mean impact within India's EEZ (see Figure 38) falls in the medium high range, which is above the global mean. Areas of the EEZ closer to shore are substantially more affected with swathes of high and very high human impact. Consideration must also be given to individual impacts, such as permanently lighted ocean structures (namely the oil rigs of the Bombay High) and commercial ship traffic. (see Figures 39 and 40).

This analysis is fast becoming old; some of the datasets reach back more than decade, and the layers of fishing impact data used are no longer available. Given the risks facing Indian fisheries (Pillai and Ganga 2010), India's economic growth in recent years and ongoing climatological change, the impacts observed here may be far more severe today.



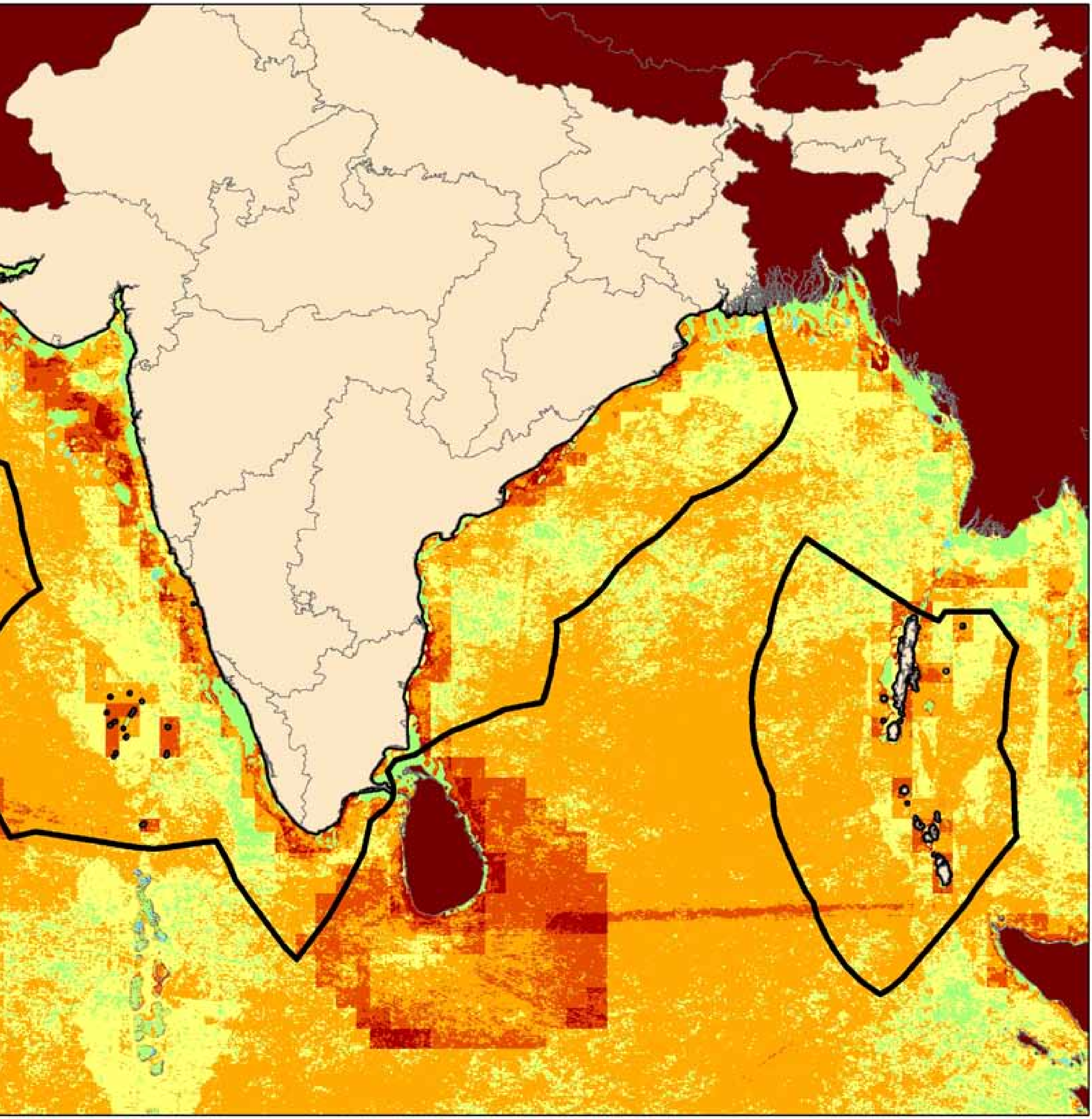


Figure 38

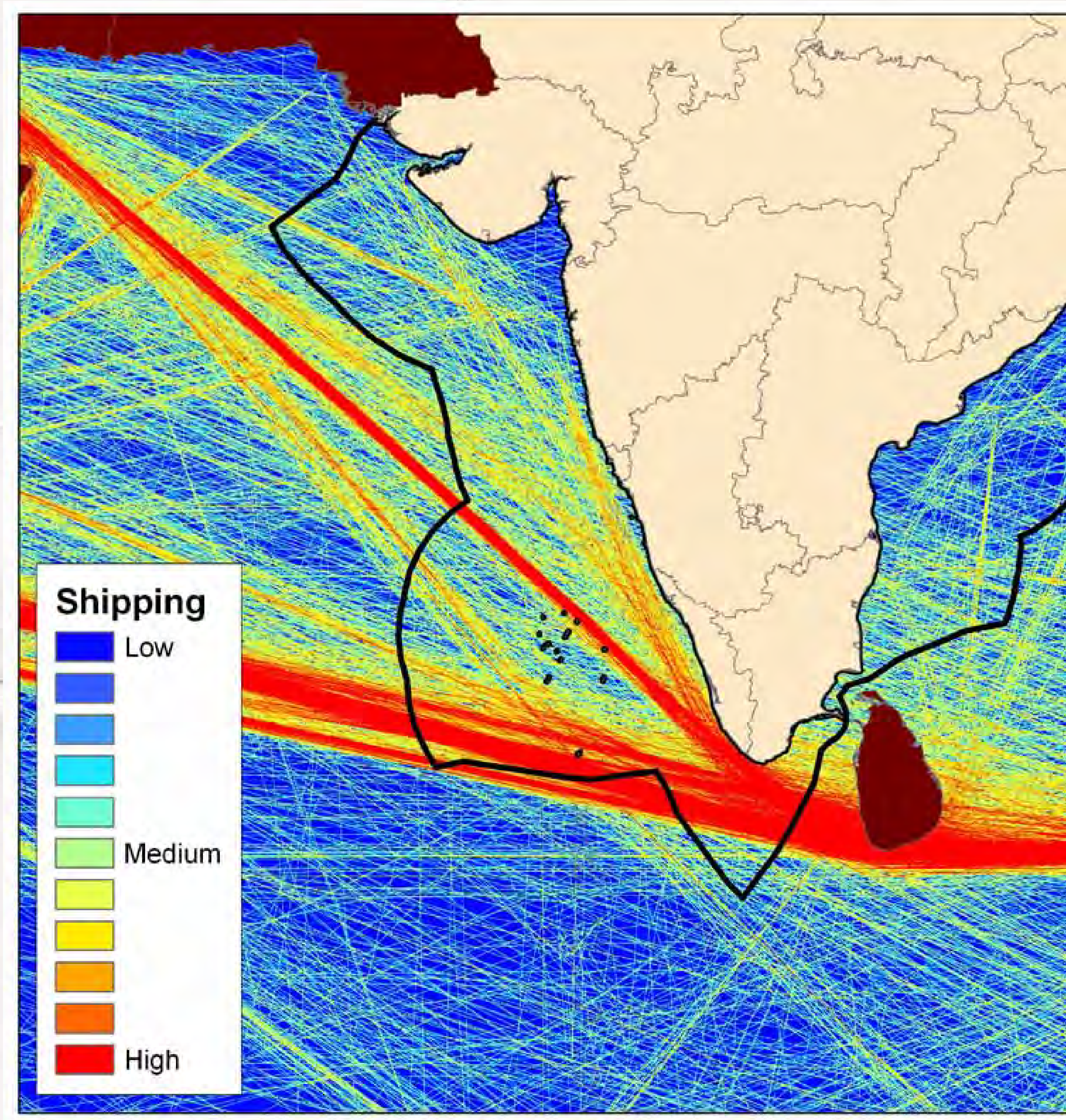
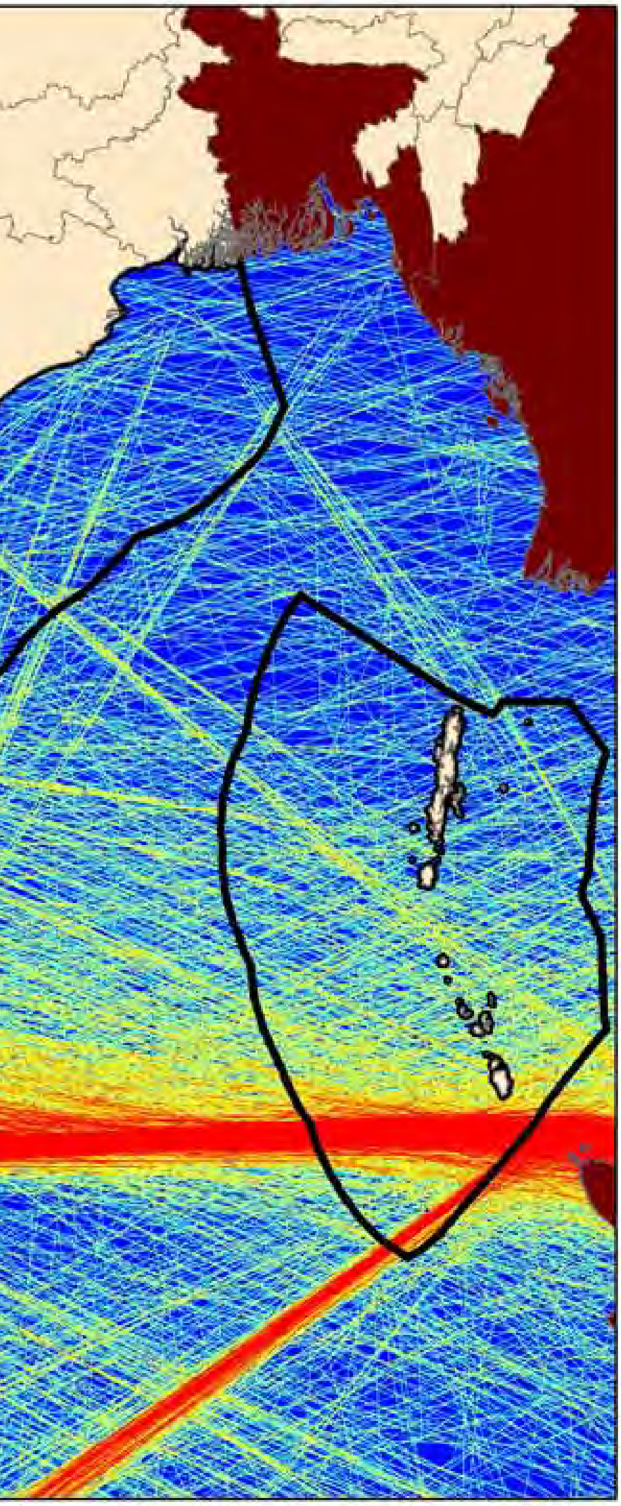


Figure 40



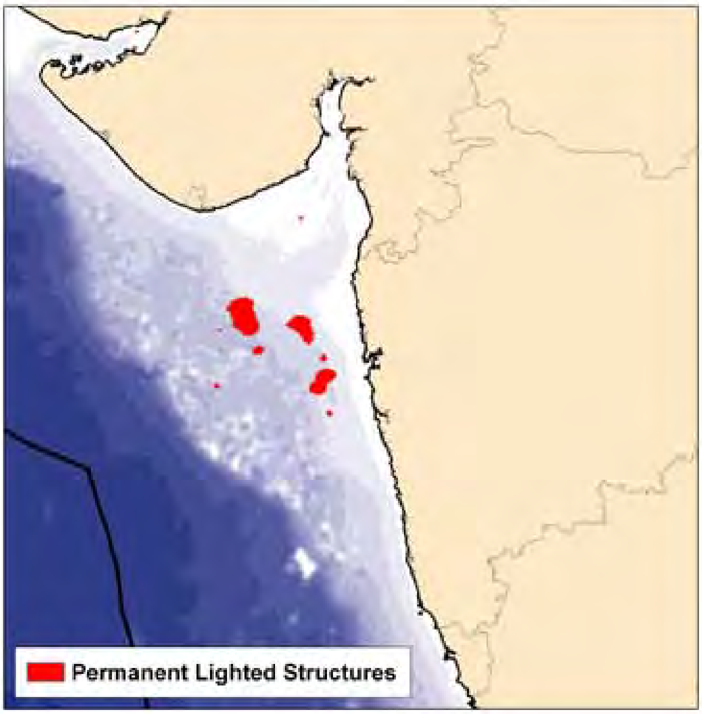


Figure 39

Figures 38, 39 and 40
Human Impacts on Marine Ecosystems
(Halpern et al. 2008)

WHAT IS PROTECTED

Though counts vary, India has as many as 38 legally protected areas — national parks, sanctuaries or reserves — that at least partially cover marine territory (Singh 2002, Rajagopalan 2008). These cover a total of less than 30,000 square kilometers of land and sea (once overlapping territory has been removed). More than two-thirds of that falls in two large biosphere reserves covering swathes of the Sundarbans and the Gulf of Mannar.

Other counts have listed fewer official MPAs, though such terminology is not a separate category in Indian law. Rajagopalan notes that the number of MPAs in India depends on how an MPA is defined.

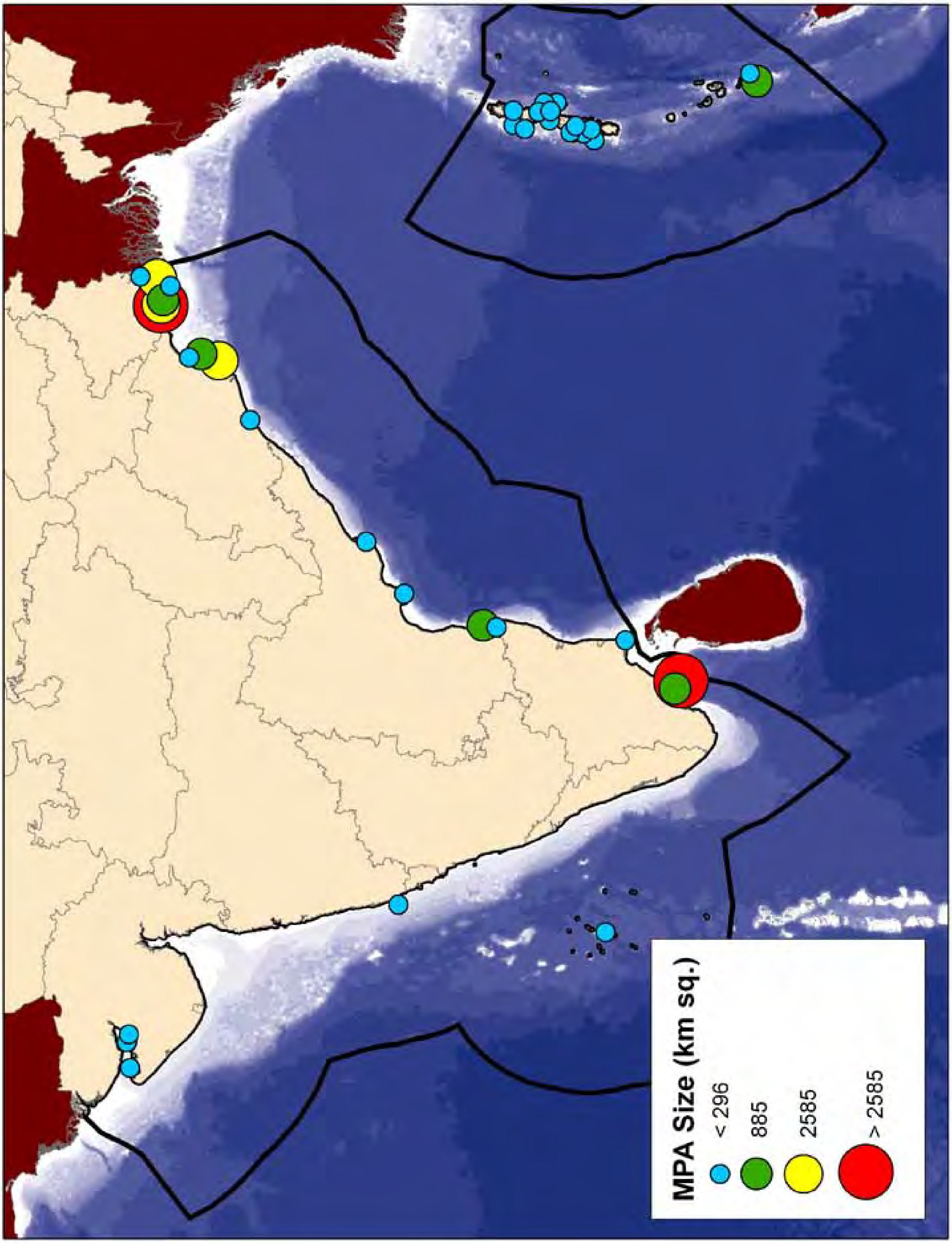
A raw count of reserves is misleading as some reserves – particularly those in the Andaman Islands – cover only small islands less than a square kilometer in size.

When these MPAs are mapped (see Figure 41), the spatial discrepancies become clear: Substantially more cover the east coast and the Andaman and Nicobar Island chain. Lakshadweep and the west coast are comparatively underrepresented. The points on the map are only symbols denoting relative size. Many reserves would hardly be visible at a national level were they drawn to scale.

Furthermore, a raw count of reserves is misleading as some reserves — particularly those in the Andaman Islands — cover only small islands less than a square kilometer in size.

No reserves cover substantial portions of deep ocean. And few can be considered the representative network of marine reserves called for repeatedly by international agreements (CBD 2008). Simply put: India's EEZ lacks significant protection or management.

Figure 41 (Facing Page): Protected Areas with Marine Environments (Singh 2002; Rajagopalan 2008)


MPA Size (km sq.)
< 296
885
2585
> 2585

THE WAY FORWARD

Communities and civil society deserve seats at the table alongside scientists, industrialists, economists and politicians.

The need to protect and sustainably manage the oceans is urgent. Ecosystem degradation can occur rapidly, and human impacts are increasing. Following the latest declaration of support for ocean conservation and management by international leaders in Rio and facing the CBD CoP in Hyderabad, India's scientific and policy communities have a significant opportunity and yet a significant challenge. Now, more than ever, the world has recognized the dire threats facing the oceans today. Now, more than ever, is the time to act.

Turtle. Andaman Sea. India.

Numerous government and academic institutions play a role in ocean protection and management in India today. There are many capable scientists and policymakers; yet, to the outsider, they appear scattered and fractured between institutional allegiances, inertias, mandates and even rivalries. Cooperation and coordination is necessary and all stakeholders must be engaged to improve the management of India's marine environment and identify areas for protection. While using the best available science is clearly very important when developing effective conservation and management measures, other inputs are absolutely necessary to ensure that the best possible and most effective system is developed. Communities and civil society deserve seats at the table alongside scientists, industrialists, economists and politicians.

The point needs to be made that very little if any traditional ecological knowledge is reflected in the official and academic data sources used for these maps. Scholars have argued for the benefits of democratization and decentralization of resource governance (Agrawal and Ribot 1999; Ribot 2002; Foti and de Silva 2010); social and political approval, downward accountability and information feedback are all likely to be bolstered when more voices are included in decision making. India's efforts at ocean protection and management must heed these words.

Given the urgency of the problem and uncertainty in terms of ongoing marine degradation, policies must incorporate the precautionary approach, lest we lose biodiversity and resources that cannot be recovered. This report has stated repeatedly that more robust science and study is required to design protection and management plans, yet that should not be an obstacle for some basic action. In pushing states to aggressively work through CBD processes, Weaver and Johnson (2012) note, "This lack of knowledge is not preventing fishing, deep-sea mining and other exploitation from expanding, however; nor should it stand in the way of designating EBSAs."

Given the urgency of the problem and uncertainty in terms of ongoing marine degradation, policies must incorporate the precautionary approach, lest we lose biodiversity and resources that annot be recovered.

A first step for India's policy elite would be to empower a multi-stakeholder working group with clear, ambitious deadlines to designate specific marine areas for further protection and management. Such a working group should be given authority to gather whatever spatially explicit information is necessary and held by government institutions, published or not. The EBSA process under the CBD is readily available as one model that could be adopted in India. Regional EBSA workshops have already demonstrated how the process can work in practice. This working group should have representatives from government, science, industry, conservation and community but it must also not be so large that it becomes an unwieldy talking shop. Defining clear objectives and time-bound outputs can prevent this. The process should take months, not years. International opinion and the upcoming CBD conference provide the rationale; India must now provide the action.

SUGGESTED TARGETS

The maps contained in this report demonstrate potential starting points for developing biodiversity conservation and ocean management within the Indian EEZ. Listed below are a number of specific sites which, from Greenpeace's initial analysis, appear as priorities for protection and likely essential components towards a future network (see Figure 42), as well as some more general suggestions regarding possible spatial or temporal regulations. It's important to note that many of these sites have multiple justifications for developing protection measures. Furthermore, many other areas not listed may equally merit protection and could deliver valuable benefits to the conservation agenda.

- Areas of high biological productivity include the Gulf of Kachchh, the Gulf of Khambat, Wadge Bank, Gulf of Mannar, Palk Bay and the extended shelf and slope beyond the Sundarbans. The productive value of these sites extends well beyond the near-shore, shallow belts up to five or 10 kilometers from shore that are the domains of traditional fishers. Protection or management beyond these traditional fishing belts may also be politically easier to implement as they would implicate alterations to fewer livelihoods.

- Early surveys of submerged banks — such as the Angria Bank off the coast of Maharashtra — indicate incredible conservation potential. Other banks along the western coast (such as Cora Divh, Bassas de Pedro and Sessostris Bank) also deserve updated study. As potential biodiversity hotspots far off shore, they represent areas that could easily be designated as marine reserves with large conservation benefits but minimal costs to present fisheries.

- Seamounts have widely been recognized as possessing unique and yet potentially at-risk habitats and communities. As such, they are prime candidates for conservation before fishing and mining interests exploit their vulnerable resources. India's seamounts are concentrated in the Laccadive Sea and represent distinct spaces for restriction of damaging activities. Considerable study is certainly needed for individual seamounts; a moratorium on extractive activities or prospecting would aid the creation of conservation and — if deemed appropriate — sustainable use plans.

- India's EEZ has wide ranges of habitat beyond already protected coral reef zones. Biogeochemical differences as well as with bottom composition diversity needs representation in planning. CBD targets for protected areas aim for representativeness; this must include spatial representation of this ecosystem and habitat diversity. Examples include the potentially rich seagrass beds of the southeast coast near Palk Bay and the Gulf of Mannar or the highly complex seafloor habitats of the Gulf of Khambat.

- Megavertebrates such as marine mammals and sea turtles deserve attention given their ecological importance, vulnerability and protected status under Indian law. Further tracking study may be needed to determine migratory patterns, but deep sea reserves and regulations are needed given data on species distribution and ranges. India's predicted marine mammal diversity lies in the EEZ beyond the shelf. Policy makers would do well to act sooner

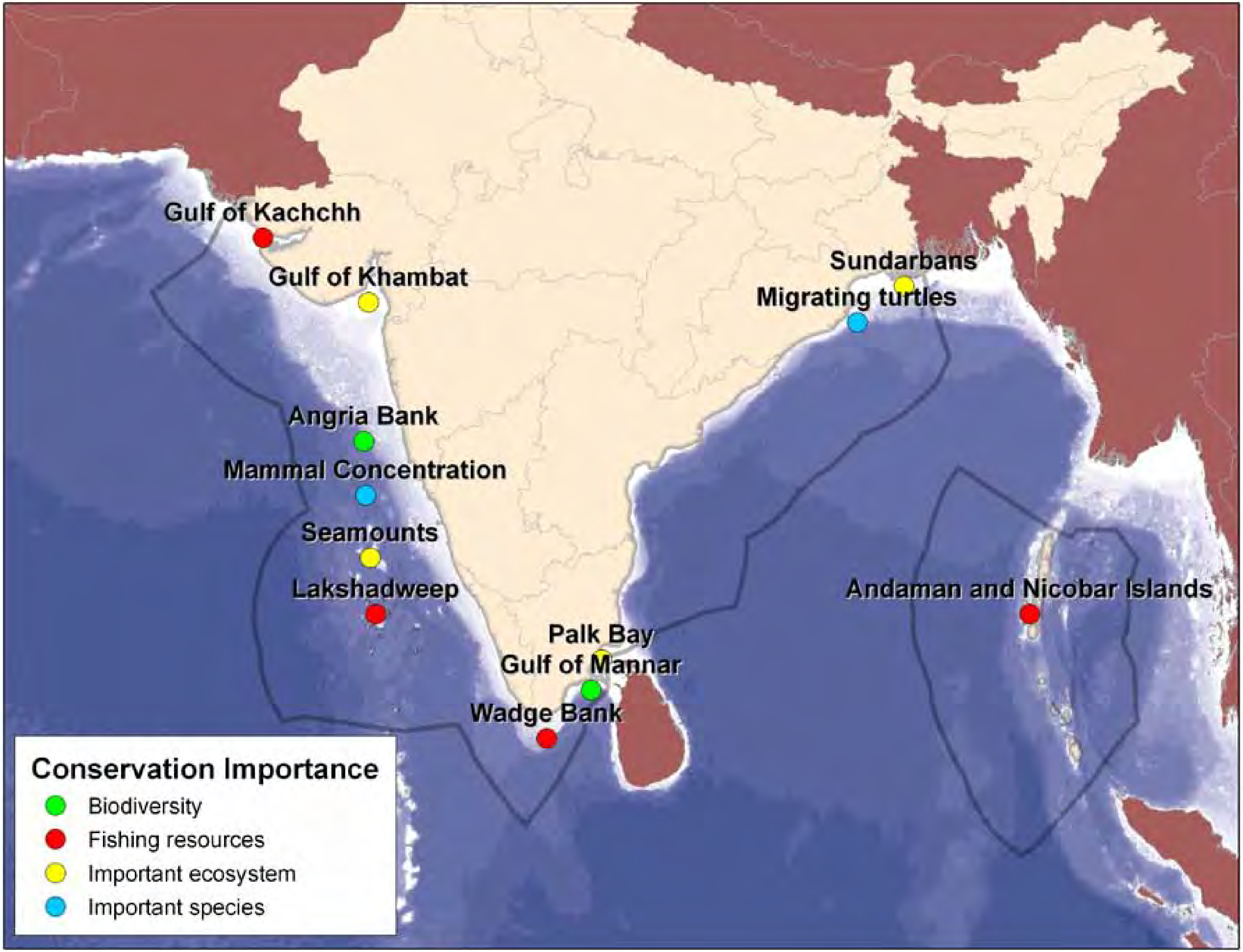


Figure 42: An Initial Selection of Key Areas in the EEZ Warranting Protection

Shoaling pelagic fish congregate by the hundreds (or sometimes thousands) above the shelfs of the Indian EEZ.

rather than later, lest new fishing interests within the deeper seas become entrenched and therefore more resistant to conservation measures. Protective areas and management plans to create safe areas and corridors for these creatures could be incorporated into plans to protect other important sites, such as seamounts in the Laccadive Sea.

- In the case of sea turtles — protected creatures with important life stages along India's coasts — some regulations may be seasonal but permanent terrestrial development plans must also be regulated. Though some current reserves protect sea turtles in specific areas (such as the Gahirmatha sanctuary in Orissa), sea turtles nest along most of India's coastline; other crucial nesting sites must be given consideration with well-planned regulations.

- Temporal phenomena such as upwellings, salinity, temperature and nutrient changes deserve consideration as these variations affect ecosystems. Upwellings contribute substantially to the food web and some mobile fish stocks such as yellowfin and skipjack tuna respond significantly to temperature changes (Anand, Kumari, Nayak and Murthy 2005).

- Fluctuating, dynamic rules should be considered. Presently, a seasonal ban on fishing by mechanized and large motorized craft (and some traditional craft) is in effect in coastal states. It is considered one of the only widely followed fisheries regulations even if it lacks nuance and has serious flaws (Vivekanandan et al. 2010). This may offer a precedent for more nuanced rules and expansion of areas under protection seasonally to conserve phenomena that affect biodiversity, productivity and spawning.

- India possesses substantial fisheries of large pelagics such as tunas, billfishes and sharks yet their status remains uncertain if not outright threatened. Oceanic tuna fisheries less than a decade ago were still considered underexploited (Anand, Kumari, Nayak and Murthy 2005) and existed in large concentrations around the Lakshadweep Islands, off the northwest coast as well as throughout the Andaman and Nicobar chain. Surveys also found high shark abundance in the EEZ surrounding the islands in the 1990s though fishing pressure on such regions has since increased. In addition, research posits that substantial amounts of fish are discarded as larger vessels push further into the EEZ on multi-day cruises in pursuit of these and other species. One scientist estimated as many as one million tons of bycatch — the equivalent of roughly one third of landed species — are discarded each year in the Indian EEZ (Pramod 2010). At the same time, as open ocean resources, they are subject to rampant extraction by large international fleets and foreign vessels with poorly regulated Indian licenses (Fernandes and Gopal 2012). Spatial protection measures together with effective enforcement may help protect important areas for these species.

- Finally, serious consideration must be given to the regional, cumulative impacts of human activity. India could consider designating temporary protected sites while vulnerability is reduced by natural recovery or science-based intervention. One area experiencing high human impact, not surprisingly, is the region of the Bombay High oil field. Other high human impact areas mapped by Halpern et al. 2008 need be studied to reveal causes of and solutions to problems.

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Shoaling fish. Andaman Sea. India.

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