CLIMATE RISKS TO INDIA'S HOLISTIC MARITIME SECURITY. PART 3: COLLAPSING OCEAN BIODIVERSITY

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This article constitutes the third part of an ongoing series relating to a comprehensive research-project, being undertaken by the National Maritime Foundation (NMF), on the impacts of climate change on India's holistic maritime security. The first two parts of the series, which may readily be accessed on the NMF's website, had focussed, respectively, on the adverse impacts of rising sea-levels,[1] and, intensifying extreme weather events due to climate change.[2] This third article of the series seeks to provide an overview of how the impacts of climate change and overexploitation are affecting biodiversity in the Indian Ocean and to identify at least the more serious and immediate implications for India's holistic maritime security.

The health of human civilisations is inextricably linked with the health of ecosystems. Declining biodiversity and collapsing ecosystems pose a serious threat to economies, food-security, livelihoods, and human health, globally. In May of last year (2019), in a landmark event, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), an organ of the United Nations, published its global assessment report,[3] in which it unequivocally warned that natural biodiversity was declining rapidly due to changes in land- and sea-use, the exploitation of organisms, climate change, pollution, and the introduction of invasive alien species through the discharge of ballast-water from merchant ships. In a striking conclusion, the report stated that around one million plant and animal species were now at risk of extinction, many within decades, at a rate unprecedented in human history.

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[1] Dr Pushp Bajaj, "Climate Risks to India's Holistic Maritime Security — Part 1: Rising Sea Level", National Maritime Foundation Website, 22 June 2020. "https://maritimeindia.org/climate-risks-to-indias-holistic-maritime-security-part-1-rising-sea-leve l/

[2] Dr Pushp Bajaj, "Climate Risks to India's Holistic Maritime Security —Part 2: Intensifying Extreme Weather", National Maritime Foundation Website, 23 July 2020, https://maritimeindia.org/climate-risks-to-indias-holistic-maritime-security-part-2/

[3] Sandra Diaz et al, "The global assessment report on Biodiversity and Ecosystem Services", *Paris: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019*, https://doi.org/10.5281/zenodo.3553579

Nowhere are the impacts of climate change more apparent than in the ocean. Carbon dioxide concentration in the atmosphere has been increasing at an alarming rate since the industrial revolution (whose year of occurrence is taken to be 1850). According to scientific estimates, nearly a third of all human-caused emissions of carbon dioxide have been absorbed by the oceans, which has, inevitably, led to increased acidity of ocean water. The pH (a measure of acidity, wherein a lower pH value corresponds to higher acidity) of surface ocean-water has been declining steadily since the late 1980s, at a rate of 0.017-0.027 units per decade.[4] The oceans have also absorbed around 90 per cent of the excess heat generated by the increasing concentration of greenhouse gases in the atmosphere, leading to significant warming of the global ocean. In the Indian Ocean, sea surface temperature (SST) has increased, on the average, by 1.0° C during the period from 1951 to 2015, which is much higher than the global average SST rise of 0.7° in the same period.[5] Increasing ocean temperatures are, in turn, leading to a loss of oxygen in some parts of the ocean, as warmer temperatures reduce the solubility of oxygen in seawater, creating new 'dead zones' and expanding existing ones. This combination, of ocean acidification, rising temperatures, and deoxygenation, is causing major disruptions to marine life, and destabilising entire ecosystems.

Marine Life Bears the Brunt of Climate Change

Significant changes have been observed in marine species due to the ongoing physical and chemical transformation of the oceans. From microscopic phytoplankton and small pelagic fish, all the way to multi-tonne whales, all ocean inhabitants are bearing the brunt of climate change. In contrast to land animals, most marine species are highly sensitive to temperature changes and can only survive in a very narrow range of optimum temperatures.[6] Consequently, with increasing temperatures, many species are moving either to higher latitudes or deeper waters in order to avoid the rising heat. Changes have also been observed in biological functions such as, metabolism, growth, reproduction.[7]

At the very bottom of the marine food-chain are tiny organisms called phytoplankton. They sustain not only the millions of marine species but also all land-based animals, as they are the primary

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[4] Nathaniel L Bindoff et al, "Changing Ocean, Marine Ecosystems, and Dependent Communities", in *IPCC Special Report on the Ocean and the Cryosphere in a Changing Climate*, eds Hans-Otto Pörtner et al, (In Press, 2019). https://www.ipcc.ch/srocc/chapter/chapter-5/

[5] R Krishnan et al, "Assessment of Climate Change Over the Indian Region" Ministry of Earth Sciences, Government of India, 2020, https://www.springer.com/gp/book/9789811543265

[6] Malin L Pinsky, "Greater Vulnerability of Warming of Marine versus Terrestrial Ectotherms", *Nature* 569 (2019), 108-111, https://www.nature.com/articles/s41586-019-1132-4

[7] Hans O Pörtner and Julian Gutt, "Impacts of Climate Variability and Change on (Marine) Animals: Physiological Underpinnings and Evolutionary Consequences", *Integrative and Comparative Biology* 56, No 1 (2016), 31-44. https://academic.oup.com/icb/article/56/1/31/2363254

producers of oxygen on the planet. Phytoplankton are microscopic marine plants that take-up carbon dioxide and utilise sunlight to generate oxygen (and carbohydrates), through photosynthesis, amounting to as much as 80 per cent of the total atmospheric oxygen.[8] One of the largest growths of phytoplankton (also called 'phytoplankton blooms') occurs in the western Indian Ocean.[9] Recent studies show that rising temperatures are leading to a decrease in phytoplankton populations. As the surface water is warming up rapidly, the temperature difference between surface and deep waters is increasing, resulting in enhanced ocean stratification, which prevents the mixing of water and, in turn, nutrients in the ocean. This mixing of nutrients is essential for phytoplankton blooms. The more the stratification and the less the mixing, the less the phytoplankton. According to a recent estimate based on long-term records, phytoplankton numbers decreased by 20 per cent in the western Indian Ocean over the past six decades.[10] The decline in phytoplankton has a ripple effect all across the marine food web, particularly for the species that rely upon it as a primary food-source, adding to the growing stresses from ocean acidification, rising temperatures, and deoxygenation.

In addition to primary productivity, the health of several marine ecosystems that provide critical habitats to marine species is also declining due to the adverse impact of climate change. Coral reefs that provide habitat to nearly a quarter of all marine life are arguably the most vulnerable ecosystem and face a high risk of disappearing completely from the world's oceans, perhaps as soon as the end of the present century.[11] During marine heatwaves, corals experience a phenomenon called 'bleaching'. They expel the microscopic algae, that live within them symbiotically, and which provide the corals with nutrition (and colouration). Without the algae, the corals cannot survive. Bleaching is a common natural phenomenon and corals typically recover completely as the algae return when temperatures cool down. However, due to relentlessly rising ocean temperatures, bleaching events are becoming longer and occurring more frequently, not allowing enough time for corals to recover completely. The devastating impacts of climate change on the world's largest coral ecosystem called the Great Barrier Reef came under the spotlight of global media following the consecutive months-long marine heatwaves in 2015-2016 and 2016-2017 that wiped out nearly 50 per cent of the reef. Indian coral reefs have experienced similar widespread bleaching events in recent decades, but these have largely gone unnoticed in the Indian and global public discourse. According to a 2009 study, "*bleaching would become an annual or biannual event for almost all reef regions along*

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[8] Sarah Witman, "World's Biggest Oxygen Producers Living in Swirling Ocean Waters", *Eos*, 13 September 2017. https://eos.org/research-spotlights/worlds-biggest-oxygen-producers-living-in-swirling-ocean-waters

[9] Syed Naqvi et al, "The Arabian Sea, in Biogeochemistry", eds. K. Black and G. Shimmield (Blackwell, Oxford, UK, 2003)

[10] Mathew Koll Roxy, "A reduction in marine primary productivity driven by rapid warming over the tropical Indian Ocean", *Geophysical Research Letters* 43, No 2 (2015), 826-833, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015GL066979

[11] Jordan Davidson, "Coral Reefs could be Completely Lost to the Climate Crisis by 2100, New Study Finds", *EcoWatch*, 20 February 2020, https://www.ecowatch.com/coral-reefs-climate-crisis-predictions-2645201373.html

the Indian coast in the next 30-50 years".[12] Moreover, the impacts of bleaching are and will continue to be amplified by increasing ocean acidity, which hinders the growth and degrades the structural integrity of the coral exoskeleton.

Another critical coastal ecosystem in India that is under threat from climate change is the Sundarbans, the largest mangrove forest on the planet. Mangroves are tropical plants that grow at the land-sea boundary. In addition to providing a native habitat to myriad land-based animals (perhaps the most famous being the Bengal Tiger) and bird species, mangroves provide an equally critical habitat to a variety of marine species as well. The Sundarbans, for instance, support nearly 400 fish species, with many species using them as nursery grounds. The mangroves of the Sundarbans also act as the primary line of defence against tropical storms and floods. Increasing temperatures, sea-level rise, coastal flooding, and increasingly frequent cyclonic storms, due to climate change, pose a major threat to this crucial ecosystem. While mangroves are resilient to seawater to some extent, seawater is now intruding for longer durations and encroaching into areas that it did not earlier reach. Excess salinity-levels in the soil can hinder plant growth and damage the ecosystem and, in turn, adversely impact the biodiversity in the region.[13]

At the individual level, species are responding in a number of different ways in order to adapt to the changes in the oceans, with some doing better than others. The most common responses include horizontal and vertical movement, changes in the time of spawning, changes in growth rate, reduction in size, and reduction in number of eggs, amongst a host of others. For instance, Hilsa, which is a highly migratory fish and found in large numbers in Upper Bay of Bengal (largely because of the riverine systems in the Sundarbans), is changing its migratory routes and spawning grounds. Studies show that its fertility rates are declining and populations are gradually moving from inland to marine water, due to human exploitation, climate change, increased siltation, etc.[14] Not all species are adversely impacted by rising ocean temperatures, however, and some

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[12] Vivekanandan E, M Hussain Ali, B Jasper and M Rajagopalan, "Vulnerability of Corals to Warming of the Indian Seas: A Projection for the 21st Century", *Current Science* 97, No 11 (2009), 1654-1658, https://www.jstor.org/stable/24107307?seq=1

[13] Chime Youdon, "Climate Change Impact on Mangrove Ecosystems in India's Coastal Regions", National Maritime Foundation Website, 12 October 2020, https://maritimeindia.org/climate-change-impact-on-mangrove-ecosystems-in-indias-coastal-regions/

Also see:

"The Sundarbans and Climate Change", Fact Sheet, Convention on the Conservation of Migratory Species of Wild Animals and United Nations Environment Programme, https://www.cms.int/sites/default/files/publication/fact_sheet_sundarbans_climate_change.pdf

[14] M. Shohidullah Miah, "Climate and Anthropogenic Factors Changing Spawning Pattern and Production Zone of Hilsa Fishery in the Bay of Bengal", *Weather and Climate Extremes* 7, March 2015, 109-115, https://www.sciencedirect.com/science/article/pii/S2212094715000031

species, particularly tropical (warm water) fish, are actually gaining new territories and expanding into previously inhospitable (colder) waters.[15]

The chances of a species surviving the dramatic changes in the oceans will depend on how efficiently and how quickly it can adapt. Naturally, those species that are not able to keep up will perish, while the ones that are able to adapt will thrive, albeit with altered distributions and behaviour. Arguably, small-sized (low value) fish with high turnover numbers will enjoy better odds of survival compared to large-sized (high value) fish that are already threatened by overfishing. Taken in aggregate, the aforementioned changes indicate that there may be a grand reorganisation of the marine food-web in the offing, resulting in changes in the structure and function of marine ecosystems, with huge socio-economic consequences. Indeed, some studies have shown that the trophic level (position in the food chain) of fish has been decreasing since the 1950s, with small pelagics increasing in abundance and large pelagics declining at steady rates.[16]

Consequences for India's Economic and Food Security

The fisheries (including aquaculture) industry, which forms a major part of India's economy, is inherently dependent on the health of marine and coastal ecosystems and marine species. In 2014, India's total marine fish catch was approximately 3.59 million tonnes, valued at nearly 5.6 billion USD. Together with fish produce from aquaculture practices, India exported fish worth 5 billion USD in 2014.[17] According to the National Fisheries Development Board of the Ministry of Fisheries, Animal Husbandry and Dairying, the fisheries and aquaculture industry employs around 14 million people. Around 30 per cent of India's total population lives in coastal areas and relies heavily on the fisheries industry as an important food source. Therefore, any significant losses in marine ecosystems and fish populations will inevitably impact India's economic and food security.

Of course, declining fish populations due to die-offs in extreme events and/or reduced reproduction rates, are not the sole concern. India's legal access and right to exploit marine fisheries is limited to its own maritime zones (specifically the Exclusive Economic Zone). However, as marine species continue to move, they may cross India's EEZ and move into the 'high seas', or worse, into another

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[15] Bimal Mohanty et al, "The Impact of Climate Change on Marine and Inland Fisheries and Aquaculture in India", in *Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis*, eds Bruce F. Phillips and Mónica Pérez-Ramirez (Wiley-Blackwell, 2017).

[16] Elayaperumal Vivekanandan et al, "Fishing the Marine Food Web along the Indian Coast", *Fisheries Research* 72, No 2-3 (2005), 241-252. https://www.sciencedirect.com/science/article/abs/pii/S0165783604002498
Also See:
Elayaperumal Vivekanandan and Periyadan Krishnakumar, "Spatial and Temporal Differences in the Coastal Fisheries along the East Coast of India", *Indian Journal of Marine Sciences* 39 (2010), 380-387.
http://nopr.niscair.res.in/handle/123456789/10674

[17] Bharathiamma Meenakumari and A Gopalakrishnan, "UN Global Marine Assessment – Food Security-India", Central Marine Fisheries Research Institute, India, 2014, http://www.cmfri.org.in/uploads/files/CMFRI2014_UN_Report.pdf

nation's EEZ. Such relocations of populations are equally detrimental to Indian fisheries and will inevitably lead to geopolitical complications as well — not only for India but also for nations within the Indian Ocean Region as a whole. There have been several examples of international disputes over fish stocks, in recent history. Most notably, in 2007, a conflict erupted over stocks of the northeast Atlantic mackerel, which had shifted from waters managed by the European Union, Norway and Faroe Islands, into Icelandic and Greenland waters, leading to the so-called "mackerel war".[18] Increased competition and lack of a decisive agreement between the stakeholders eventually led to the available stock being overfished. Given the enhanced competition for fishing grounds and depleted fish stocks in almost all fishing areas, climate-change driven geographic shifts of marine species will make such conflicts more likely, as the future unfolds. According to a recent estimate, as much as 35 per cent of the global EEZs could receive new transboundary stocks by 2100 if climate change continues unabated.[19]

In the economic context, marine and coastal tourism (often clubbed together and referred-to as 'ocean tourism') industry, which accounts for nearly 26 per cent of the total global ocean economy,[20] will also be impacted by declining ocean biodiversity. Ocean tourism is a source of livelihood for millions of people in developing coastal nations. Within that, coral reef tourism is a major component, including activities such as diving, recreational fishing, and snorkelling.[21] The deteriorating state of coral reef ecosystems worldwide will have a direct impact on this sector. India under its *Swadesh Darshan* scheme is promoting coastal tourism under its theme-based circuits.[22] It has selected six states, and two union territories, namely, Puducherry and Andaman & Nicobar Islands, of which the latter has one of the major coral reef formations in India. The conservation and protection of ocean biodiversity is, therefore, essential to safeguard the economic benefits of coastal tourism as well.

Protecting and Preserving Ocean Biodiversity

In India, climate-change mitigation and adaptation is largely restricted to a top-down approach. It encompasses the national policy at the Centre and sub-national policies formulated by the respective

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[18] Jessica Spijkers and Wiebren J. Boonstra, "Environmental Change and Social Conflict: The Northeast Atlantic Mackerel Dispute", *Regional Environmental Change* 17 (2017), 1835-1851, https://link.springer.com/article/10.1007/s10113-017-1150-4

[19] Malin L Pinsky et al, "Preparing Ocean Governance for Species on the Move", *Science* 360, No 6394 (2018), 1189-1191, https://science.sciencemag.org/content/360/6394/1189.full

[20] OECD, "The Ocean Economy in 2030", Paris: OECD Publishing, 2016), https://dx.doi.org/10.1787/9789264251724-en

[21] *Ibid*

[22] "Tourism Circuits: Coastal", Ministry of Tourism, Government of India. http://swadeshdarshan.gov.in/index.php?Theme/themeDetail/1

state governments. The National Action Plan on Climate Change (NAPCC) adopted by the Government of India in 2008 gave a formidable thrust towards India's climate change mitigation initiatives. The policy was largely based on India's internal challenges and efforts to tackle climate change, but it also implicitly encompassed India's international commitments to the United Nations Framework Convention on Climate Change (UNFCCC) and its provisions.[23] It is a long-term policy consisting of eight 'national missions', which represent the core of the NAPCC. These are the 'National Solar Mission', the 'National Mission for Enhanced Energy Efficiency', the 'National Water Mission', the 'National Mission for Green India', the 'National Mission on Sustainable Habitat', the 'National Mission for Sustaining the Himalayan Ecosystem', and, the 'National Mission on Strategic Knowledge for Climate Change'.

Each of these missions contains a number of subordinate missions/policies within them, such as the *Swachh Bharat* Mission which falls under the 'National Mission on Sustainable Habitat'. The NAPCC thus invokes the participation of India's civil society at large and encourages public-private partnerships (PPP) in order to achieve key climate-goals. It is important to note that as of now, the NAPCC does not include a dedicated 'mission' for the protection and conservation of the oceans. As established through the foregoing paragraphs, there is an urgent need to create a targeted national-level policy to protect marine ecosystems and species for sustained economic and food security.

Promisingly, the Ministry of Earth Sciences (MoES), in its thirteenth report of the Committee on Estimates (2018-2019), acknowledged the need for a 'ninth' mission to be added to the NAPCC. The MoES has proposed 'National Coastal Mission' to be included within the NAPCC, which will address climate-change threats to coastal zones, mangroves, corals and sea water intrusion into fresh-water systems.[24] However, in order to be comprehensive, this mission must also cover deep-sea systems, pelagic ecosystems, and, indeed, the entire ocean ecosystem. Moreover, participation of individual states and local governments in addressing the challenges to ocean biodiversity is crucial to bring about any meaningful and tangible change.

In this context, the states of Odisha and Maharashtra are key players, largely due to their rich biodiversity, which is facing extreme pressure in supporting the livelihood of millions of the citizens of these two states. Their long coastlines are categorised by the Coastal Vulnerability Atlas of India

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[23] Shyam Saran, "India's Climate Change Policy: Towards a Better Future", Ministry of External Affairs, Government of India, 08 November 2019, https://mea.gov.in/articles-in-indian-media.htm?dtl/32018/Indias_Climate_Change_Policy_Towards_a_Better_Future

[24] Ministry of Environment, Forest and Climate Change, "Performance of the National Action Plan on Climate Change" (NAPCC), Committee on Estimates (2018-2019), 13 December 2018, http://164.100.47.193/lsscommittee/Estimates/16_Estimates_30.pdf

as being highly vulnerable to climate change.[25] Ocean biodiversity is collapsing particularly sharply in the state of Odisha. One of the key indicators is the decline of dolphins which is a 'keystone species'[26] essential to the marine ecosystem in the region. According to the state's annual census of dolphins in 2019, the total dolphin population has experienced a significant decline, with numbers dropping from 469 in 2018 to 259 in 2019.[27] This 45 per cent drop in the numbers is indicative of the overall decline in ocean biodiversity in Odisha, threatening the entire marine food chain. According to the Coastal Vulnerability Index (CVI) formulated by the Indian National Centre for Ocean Information Services (INCOIS), a total of 407 km of the coastal area of Odisha comes under 'medium' and 'high' vulnerability categories.[28]

It must be admitted that the state government of Odisha is, indeed, alive to the precariousness of its situation and is actively pursuing measures to address the declining ocean biodiversity. Yet, all such measures must accommodate the impacts on coastal communities. For instance, in protecting the turtle congregation area in Odisha, the livelihood of thousands of marine fishermen will be affected due to the ban on fishing within 20 kilometres of a sanctuary such as the Bhitarkanika National Park.[29] To its credit, the Odisha government has provided 'marine cards' to the affected fishermen families as compensation, under which 25 kg of rice is provided at a nominal cost of just one rupee per kilogramme, every month.[30] This initiative was a part of the Integrated Coastal Zone Management Programme (ICZMP) funded by the World Bank. This highlights the need for 'holistic' conservation strategies, which share equitable benefits among the community and ecosystem.

In the case of Maharashtra, the 750-kilometre length of the state's coastline hosts a variety of fisheries, mangroves, salt marshes, and corals. Maharashtra's ocean biodiversity and its vulnerability

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[25] United Nations Development Programme (UNDP), "Enhancing Climate Resilience of India's Coastal Communities", Green Climate Fund, https://www.undp.org/content/dam/india/docs/EnE/GCF-coastal%20communities-Brochure-Revised.pdf

[26] John N Thomson, "Keystone Species", Encyclopaedia Britannica, https://www.britannica.com/science/keystone-species

[27] Ashish Senapati, "Dolphin Numbers have Shrunk in Odisha, Reveals Census", *Down to Earth*, 14 February 2019. https://www.downtoearth.org.in/news/wildlife-biodiversity/dolphin-numbers-have-shrunk-in-odisha-reveals-census-63244

[28] Forest and Environment Department, "Odisha Climate Change Action Plan", Government of Odisha, 2018, http://climatechangecellodisha.org/pdf/State%20Action%20Plan%20on%20Climate%20Change%202018-23.pdf

[29] R Ramesh, "National Assessment of Shoreline Change", Ministry of Environment and Forest, 26 April 2011. http://www.ncscm.res.in/cms/more/pdf/ncscm-publications/orissa_final.pdf

[30] Subhashree Banarjee, "The Tragedy of Fishing Communities: A Story from Vetka Village, Odisha", Economic & Political Weekly 52, No 41 (2017). https://www.epw.in/engage/article/tragedy-fishing-communities-story-vetka-village-odisha

are inextricably linked with India's overall food security. In terms of fish species diversity, Maharashtra ranks third among Indian coastal states.[31] In this regard, the State Action Plan for Climate Change (SAPCC) of Maharashtra calls for a regional model in assessing the implications of climate change, such as the dispersal, spatial, and temporal patterns of various fish species. The present data used to estimate how climate change or environmental factors affect fisheries is collected from external sources within temperate regions.[32] For a more accurate assessment, there is a clear need for specific data in respect of tropical fish, so as to understand how they are affected, and in order to consequently formulate effective state- and national-level policies. Considering this, a bottom-up approach, through strong public participation, including back and forth dissemination of information and constructive feedback, will be an excellent guide for the decision makers to construct future strategies.[33]

Along these very lines, the UN Food and Agriculture Organisation (FAO) recommends a stepwise process involving identification, planning, and effective resilience through Early Warning Systems (EWS) and local efforts. This is shown schematically in Figure 1.[34]

[31] TV Sathianandan, "CMFRI Data Collection System for Marine Fish Landing Estimation", Central Marine Fisheries Resource Institute (CMFRI).
http://www.dahd.nic.in/sites/default/filess/CMFRI%20Data%20Collection%20System%20for%20Marine%20Fish%20Landings_0.pdf

[32] "Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change", (MSAAPC), The Energy and Resources Institute, 2014,
https://www.teriin.org/projects/nutrition-security/files/Maharashtra-CC-Report.pdf

[33] Ana Ferreira et al, "Bottom up Management Approach to Coastal Marine Protected Areas in Portugal", Ocean and Coastal Management, 118, Part B, 2015, 275-281.
https://www.sciencedirect.com/science/article/abs/pii/S0964569115001234

[34] Manuel Barange et al, "Impacts of Climate Change on Fisheries and Aquaculture", FAO Fisheries and Aquaculture Technical Paper 2018, 627, http://www.fao.org/3/i9705en/i9705en.pdf

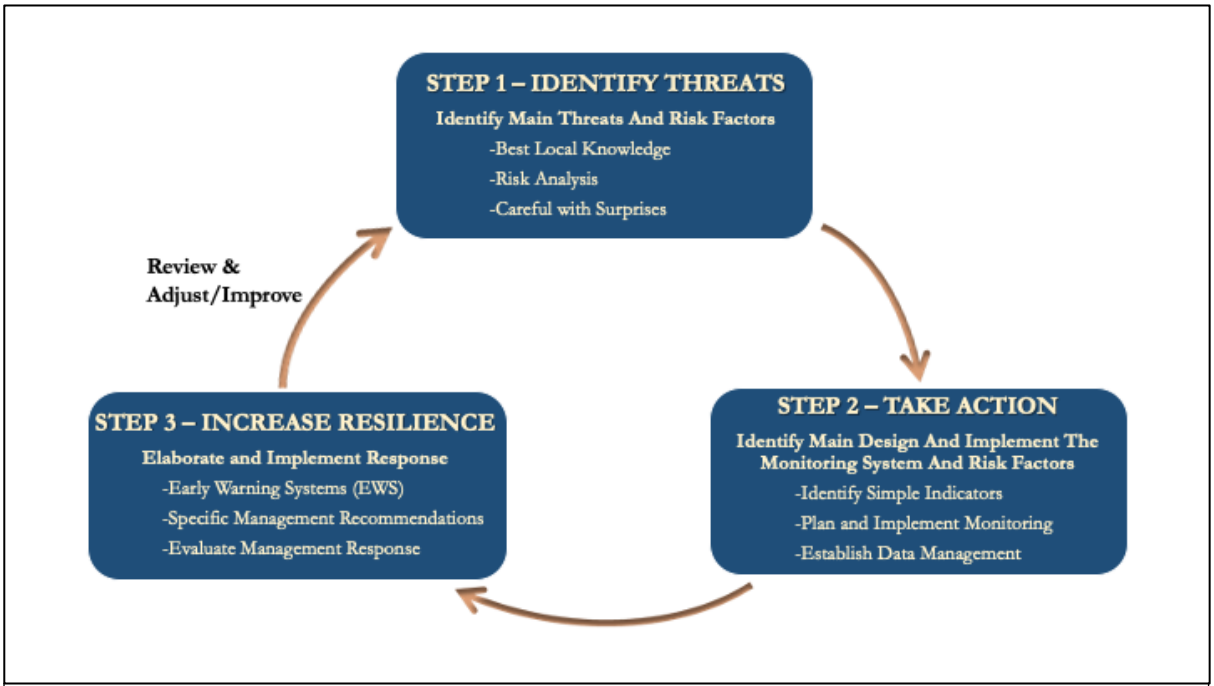

Fig 1: Schematic Representation of the Process and Steps to Implement Local Monitoring and Early Warning Systems

Source: Image adapted from Fig. 21.3 of "Impacts of climate change on fisheries and aquaculture", by Food and Agriculture Organisation (FAO) of the United Nations, http://www.fao.org/3/i9705en/i9705en.pdf

For the protection of marine and coastal biodiversity, establishing and expanding Marine Protected Areas (MPA) is an effective approach that has been recognised by the International Union for Conservation of Nature (IUCN) since 1999.[35] MPAs cover a wide array of protections from human exploitation to the maintenance of productivity and the enhancement of oceanic biomass. There are about 25 MPAs located in Peninsular India and 106 MPAs in the island territories of India. The three oldest ones — the Haliday Island Wildlife Sanctuary, the Sajnekhali Wildlife Sanctuary, and, the Lothian Island Wildlife Sanctuary — are all in the state of West Bengal and were declared protected sanctuaries way back in 1976.[36] Contemporary developments in research, and technological advancements, have enabled the adoption of innovative solutions to ocean

[35] P Laxmilatha et al, "Marine Protected Areas", Central Marine Fisheries Research Institute (CMFRI), http://eprints.cmfri.org.in/10433/1/29_Laxmilatha_1.pdf

[36] "Marine Protected Areas", ENVIS Centre on Wildlife and Protected Areas, Ministry of Environment, Forest and Climate Change, Govt of India, http://wiienvis.nic.in/Database/MPA_8098.aspx

conservation. Novel 'dynamic ocean management strategies',[37] driven by real-time data, are being explored to protect highly mobile marine species such as whales, sharks, sea turtles, sea birds, etc.[38]

Conclusion

For all that, much more needs to be done, not juts along a top-down trajectory of advocacy and action, but equally along a bottom-up one. This article is an attempt to widen the knowledge base of this critical facet of India and, indeed, of the planet itself, to lay public in India and abroad. Addressing the collapsing ocean biodiversity and its impacts on the economic and food security of India will require a dynamic and holistic approach that encompasses local/community-led efforts that are encouraged and supported by national/state level policies. Local governments should be strengthened by institutional capacity-building, capability-enhancement, and financial-support, so as to realise the national-level goals and meet India's international commitments. Moreover, any and all mitigation and adaptation policies must be directed by the best available science and utilise the latest and most effective technologies.

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[37] Rebecca Lewison et al, "Dynamic Ocean Management: Identifying the Critical Ingredients of Dynamic Approaches to Ocean Resource Management", *BioScience* 65, No 5, 2015, 486-498, https://academic.oup.com/bioscience/article/65/5/486/323837

[38] "Mobile protected areas needed to preserve ocean biodiversity", *Marine Professional*, Institute of Marine Engineering, Science and Technology, 13 February 2020. https://www.imarest.org/themarineprofessional/item/5403-mobile-marine-protected-areas-needed-to-preserve-ocean-biodiversity