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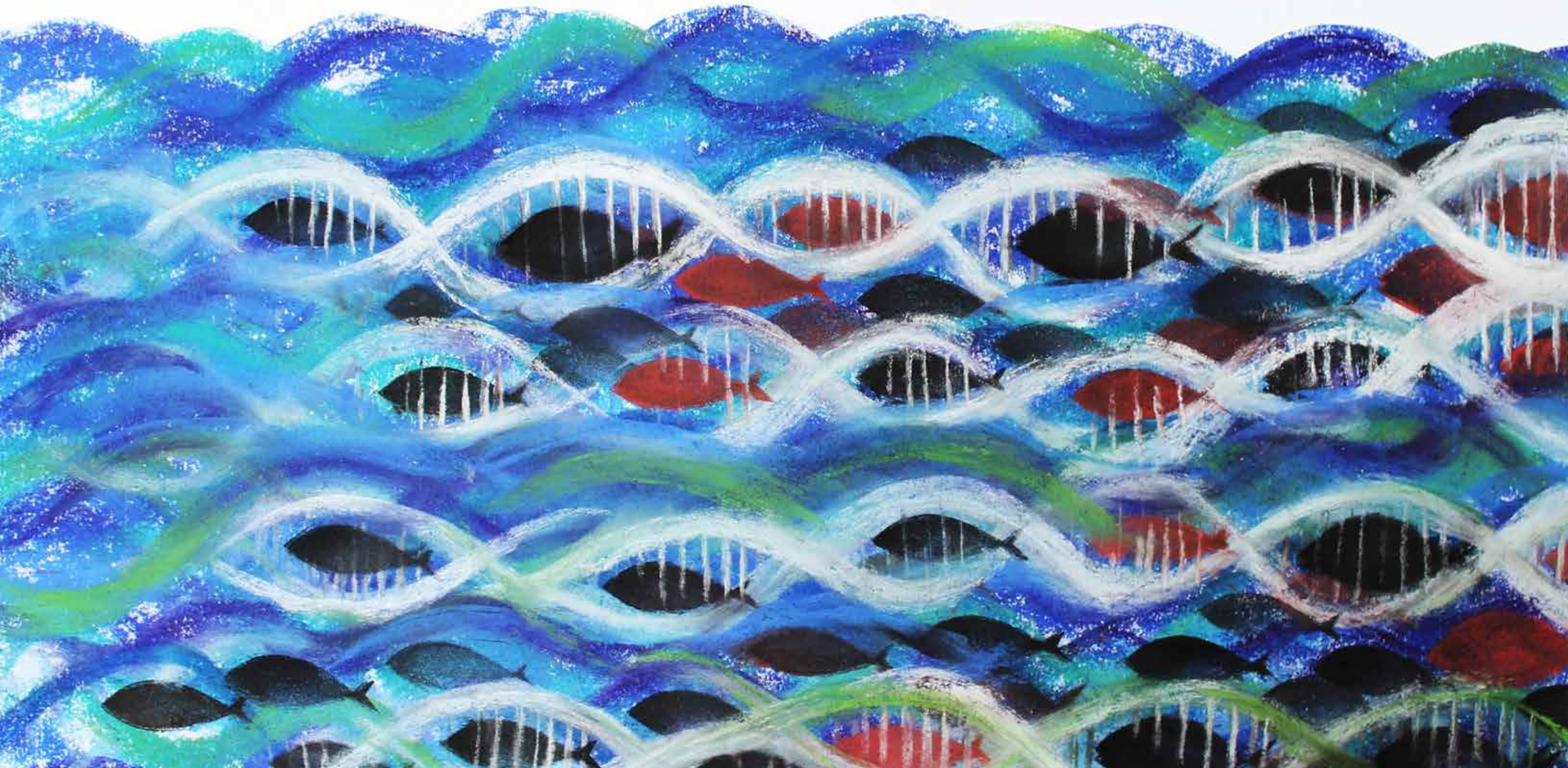

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Cover art by Priya Sebastian

Eclipsed by the terrestrial sphere in more ways than one, marine spaces remain poorly understood despite the huge pressures they face. In this issue, we feature two very different, but not mutually exclusive, approaches to conservation in the marine realm. We bring together a collection of articles that explore contemporary scientific and conservation concerns. Demian Willette elaborates the role of science in conservation, specifically molecular tools such as DNA analysis. In their project in the Philippines, DNA sequences are used to delineate stocks and identify new species of sardines. Drawing on research conducted on 42 coastal communities spread across the Indo Pacific, Joshua Cinner opines that although there may not be a silver bullet solution for the world's fishery problems, given the right set of conditions, local communities can indeed manage their resources in a sustainable manner. We also highlight Barbara Block's research on marine predators. In conversation with Janaki Lenin, Block unravels the mysteries surrounding the movements of sharks and tuna, and the projects that enable a better understanding of their conservation. Through a series of a breathtaking images, Tasneem Khan and Umeed Mistry explore the problems and prospects for sharks and the complexity surrounding these iconic predators. And finally, Rohan Arthur tells us the story of the fish that may have saved reefs in the Lakshadweep Islands.

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Shark in peril!

Sharks in the ocean are akin to tigers in the forest. They are apex predators at the top of a complicated food pyramid. Removing the apex predator from any ecosystem creates a top-down trickle effect of imbalances in species populations, which can eventually lead to the collapse of the entire system.

The problems with shark conservation are complex, spanning ecological, political, economic and social arenas. These are not charismatic poster-child animals. Instead, the media has successfully, albeit inaccurately, painted them as sharp-toothed, large-mouthed, stealthy killing machines on the lookout for the next human that comes surfing, diving or swimming by. Furthermore, sharks inhabit a world that is further removed from our own than other creatures that have captured the spotlight of conservation. If the well-known and well-loved tiger cannot garner much by way of conservation efforts and results, what hope does the shark have—living in vast bodies of water that most of us have little connection to?

These iconic predators, keystone species of marine systems, are now facing severe threats to their very existence. A glimpse into the precarious state of sharks in the wild reveals two serious flaws - one, in the public perception and awareness of sharks and their alarmingly dwindling populations, and two, in the international management and policy of shark fisheries.

Tasneem Khan

One hundred million sharks are killed every year, decimating their populations by up to 90% globally, and India is currently believed to be one of the largest exporter of shark fins in the world. Most of these sharks cater to the seafood and cosmetic industries.

The niche consumer market for shark-fin soup has resulted in a massive increase in global shark-finning practice, and is driven by users that seem willing to pay increasing amounts of money for this relatively bland, "status-symbol" meal. Consequently, fishermen that have the opportunity to harvest sharks fins have hit a jackpot that they will take full advantage of, sometimes even illegally. This scenario, in many ways, illustrates Berk's Law – "The threat of damage to or depletion of an uncontrolled common resource increases its value and stimulates competition among free individuals to harvest it all the faster, regardless of the future" – Habitat of Grace.

Sumer Verma


Umeed Mistry

In the cosmetic industry, shark oil is used in creams and moisturisers as an anti-wrinkle ingredient. In a world increasingly obsessed with appearance and eternal youthfulness, the demand for products that promise to reduce ageing is skyrocketing. In both instances, petty indulgences are driving a wilful destruction of the earth's vital marine ecosystems.

Even today, biological information available on sharks is scarce. While human demand continues to push this group of animals closer to the tipping point of survival, scientists are continuously describing new species. Ironically, these species are often 'discovered' by the very fishermen whose livelihoods depend on the consumer market. Trawlers are continuously hauling up deep-water species and there is no way of knowing whether our discovery of them coincides with their extinction. In some cases, we have probably lost the opportunity to better understand these enigmatic creatures.


Umeed Mistry


Sumer Verma

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Sumer Verma

Gillnet fishing impacts seabird populations

Bycatch-susceptible diving birds suffer, while surface-feeders thrive

Fishing gear causes the deaths of many non-target species ("bycatch") each year. While conservationists assume that these mortality rates lead to decreases of entire populations of impacted animals, data deficiencies have made it difficult to study this directly—until now, that is.

By taking advantage of a United Nations moratorium on high seas driftnet fishing, a group of Canadian conservationists has been able to assess the effects of gillnets on north Atlantic seabird populations. The research team obtained data on fishing effort both before and after the ban, which was initiated in 1992. This allowed them to calculate fishing effort throughout their study area over the past twenty years. This information was then related to census population data collected for both diving seabirds (common murres, razorbills, Atlantic puffins, northern gannets) and surface-feeding seabirds (herring gulls, great black-backed gulls, and black-legged kittiwakes) nesting in nearby seabird ecological reserves.

Unsurprisingly, gillnet fishing activity was found to decrease sharply after the moratorium was initiated. Simultaneously, populations of diving seabirds increased, while populations of surface-feeding seabirds decreased. Diving birds are particularly susceptible to bycatch, so removal of the gillnets likely led to increased population size by reducing annual mortality rates. Surface-feeding birds, on the other hand, take advantage of discards and offal produced by fishing efforts; elimination of these treats has previously been associated with reduced breeding rates and probably drove the population decreases observed here.

The authors believe their study may be the first ever to support the idea that bycatch affects not only individuals, but entire populations. These findings may be useful in promoting future moratoria and other conservation efforts aiming to reduce bycatch.

Regular P et al. 2013. Canadian fishery closures provide a large-scale test of the impact of gillnet bycatch on seabird populations. *Biology Letters* 9(4): 2013088 (online advance publication).

Andreas Trepte

Also know as the Thin-billed Murre, the Common Murre (*Uria aalge*) is a large auk found in low-Arctic and boreal waters in the North-Atlantic and North Pacific.

Proximity to nearest fish market impacts coral reef health

Even remote reefs may be at risk if they are within boating distance of markets

Scientists have repeatedly shown that coral reefs are negatively impacted by proximity to larger and denser human populations. However, suspecting that this was not the whole story, a team of Australian researchers recently investigated whether a socioeconomic factor—proximity of each reef to the nearest market—might also influence coral reef condition.

Indeed, they found that mathematical models could more accurately predict reef fish biomass when they included data on distance to market. Because a majority of conservation policies have not taken this variable into account when pinpointing reefs that need to be protected, these findings suggest that some management efforts may be ignoring imperiled reefs. Intriguingly, biomass was noticeably larger at reefs that were more than 14 kilometres from the nearest market. This distance appears to be a threshold beyond which fishing is not sufficiently profitable to merit the time or effort.

Together, these findings suggest that reef health may be significantly influenced not just by the presence of people, but also by the social and economic characteristics of those people. This could explain why many remote reefs are in poor shape: People may not live nearby, but travel to the reefs to harvest fish that they can sell at relatively close markets.

Anyone who has read about the ivory trade knows that market activity can have devastating effects on wildlife populations. However, the authors point out that markets can also create incentives for conservation and sustainability—as showcased by the drive for eco-friendly coffee, for example. Interdisciplinary collaborations of economists, anthropologists, and conservationists will be critical for suggesting ways that 'coral reef nations' can use marked-based management to further reef conservation efforts.

Cinner JE et al. 2013. Global effects of local human population density and distance to markets on the condition of coral reef fisheries. *Conservation Biology* 27(3):453-458.

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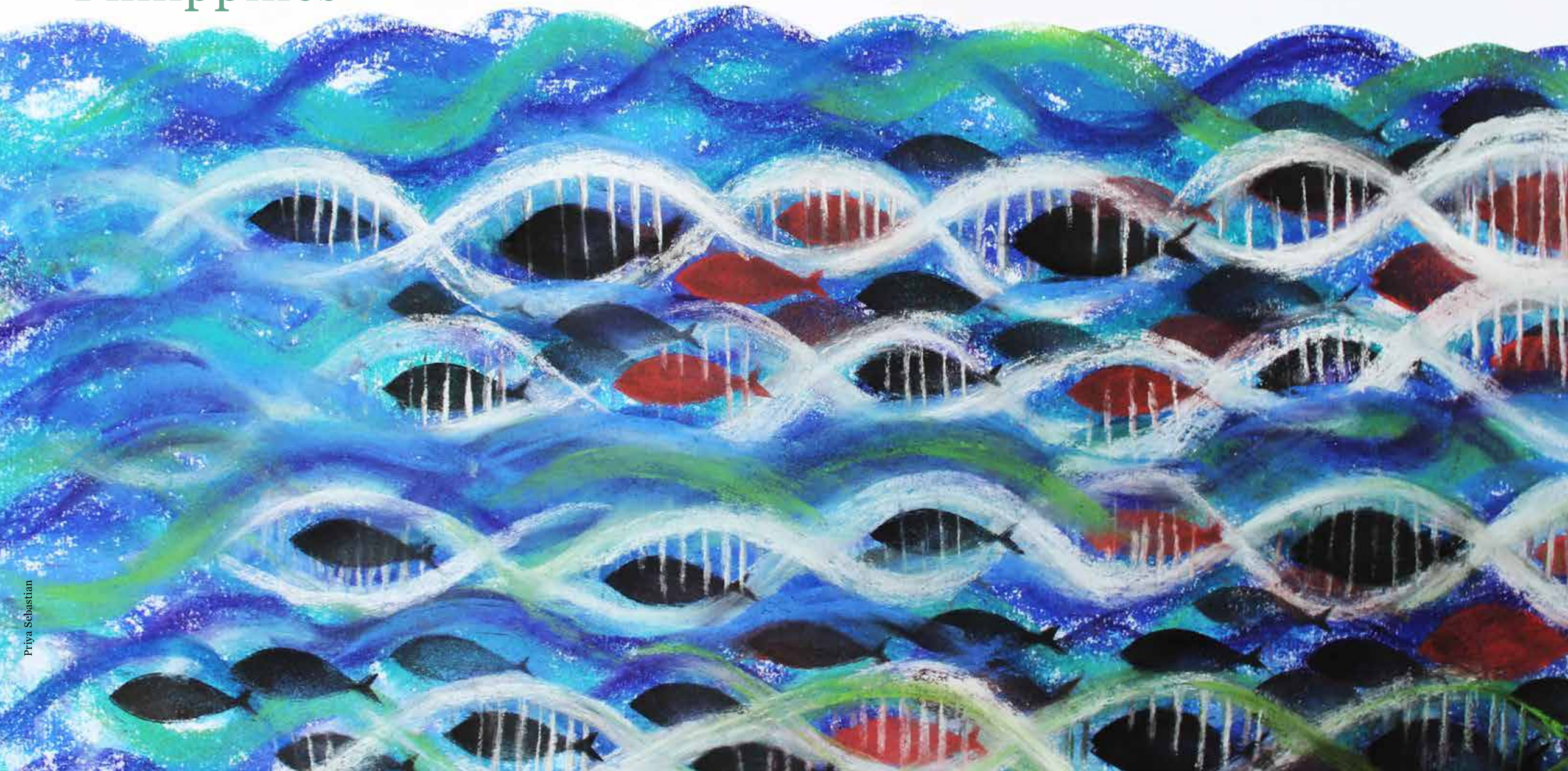
Brocken Inaglory

Coral reefs at Papua New Guinea

Increasing the conservation yield from molecular fisheries research in the Philippines

As food security moves to the forefront of national priorities in developing nations, governments are investing more in knowledge generation with the expectation that science and technology will help rescue imperiled stocks and boost agricultural yields.



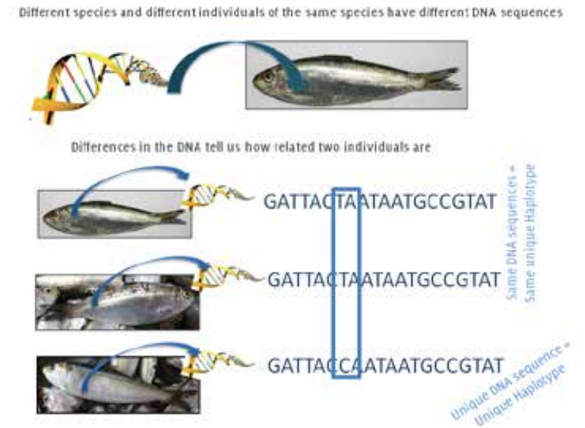
Priya Sebastian

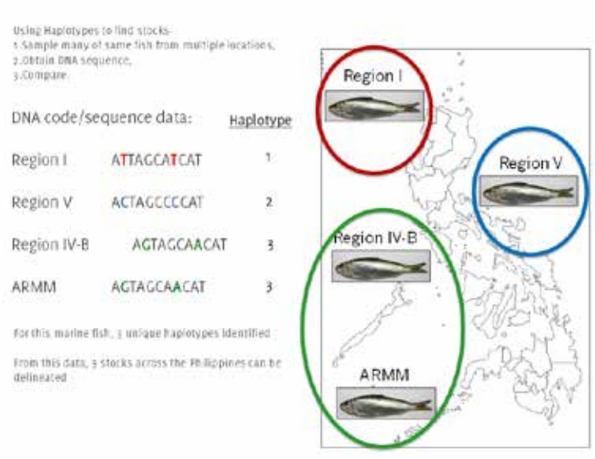
Marine fisheries are particularly troubled as wild fish landings have continued to decline since the 1980s. Although a few marine fisheries are managed sustainability (notably sockeye salmon in Alaska), the majority of the world's fish stocks are currently fully exploited, over-exploited or depleted. Further, although the broad development of aquaculture has led to a net increase in global fish production, aquaculture has done little to alleviate fishing pressure on wild stocks, and may exacerbate their vulnerability to collapse. National and regional initiatives, such as the visionary Coral Triangle Initiative, highlight the need for science-based knowledge to aid in the development of more sustainable fishery regulations and practices, and conserve centres of marine biodiversity. Yet, how exploitative fishing and conservation can successfully cooperate remains uncertain. At face value, conservation and exploitation may seem like two sides of the same coin; one aiming to safeguard marine resources, the other tasked with harvesting them. However, both are necessary. Marine resources must be exploited to feed our global population and provide livelihood for millions of people; and marine resources must be conserved to ensure that future generations can also provide for themselves and that marine food webs endure.

This challenge has yet to be solved, but we are striding forward. Here, I describe how an investment in scientific research for the exploitation of a fishery produced valuable and unexpected data for the conservation of that fishery. Mandated by the Philippine administration to be the research arm of the Bureau of Fisheries and Aquatic Resources, the National Fisheries Research and Development Institute (NFRDI) has been the principle source of government-supported scientific data for the development and management of the country's fisheries since 2001. Since its origin, the Institute has primarily utilised labor-intensive field measurements to obtain stock assessment metrics of growth, abundance and mortality rates of highly-valued commodity species. Although well-established and important in providing a snapshot of fish population parameters (such as Total Available Catch), these metrics are limited to quantifying phenotypic patterns (physical attributes or phenotypes). They provide little insight for delineating stock boundaries, quantifying migration rates and identifying corridors and barriers to gene flow. Rather, to effectively describe these metrics, researchers required tools that profiled the genotypic features (genetic attributes or genotypes) of the fish populations; they use population genetics.

Genotypic data has several advantages over phenotypic data; in particular that genetic data shows patterns and traits that may not be expressed in the phenotype, in other words, features that are not visible. For this reason, genotypic data is a powerful tool in species identification, especially in specimens that are difficult to distinguish by appearance.

A population is a group of organisms living in the same geographic area that can potentially interbreed. Population genetics, furthermore, is the study of the genetic variation in a population and how it changes in response to environmental and evolutionary forces. Whereas phenotypes can be quantified by examining the physical features of an organism, genotypes are obtained from an organism's genetic features. One way to obtain this data is through DNA sequencing. Genotypic data has several advantages over phenotypic data; in particular that genetic data shows patterns and traits that may not be expressed in the phenotype, in other words, features that are not visible. For this reason, genotypic data is a powerful tool in species identification, especially in specimens that are difficult to distinguish by appearance. Further, this data can used to determine from which population an individual originated, the parentage and kinship of individuals in a population, and the relatedness among populations distributed over a geographic region. These uses are applicable to marine fisheries management, particularly for demarcating the geographic limits or boundaries of a fish population (delineating stock boundaries), and for locating pathways or corridors where genes are transferred among populations via migration (gene flow).





Demian A Willette

The emergence of a wide range and inexpensive suite of molecular genetics tools over the past two decades has since made genotypic studies commonplace, even on the modest budget of research laboratories in developing nations. The formation of NFRDI's molecular genetics laboratory signified a stride forward for fisheries research in the Philippines. In recent years, NFRDI has become the leading government laboratory utilising molecular genetics explicitly for fisheries research, and overall, one of the nation's most productive sources for scholarly, peer-reviewed molecular genetics publications.

Tuna, mackerel, scad and sardines are the primary targets of capture-fisheries of the Philippines and across much of South East Asia. Of these, sardines are the cheapest and most accessible source of animal protein in the Philippines and provide billions of pesos in domestic economic revenue. Molecular genetic research on this taxon was limited to just a handful of studies on a rare and endemic freshwater species prior to 2010. At that point, a new collaboration focusing on sardine research was forged between NFRDI and the Old Dominion University (United States). By design, NFRDI would host an Old Dominion University scientist for two years who would mentor the Institute's junior scientists and together generate molecular data on sardines. The research aim was to delineate sardine stock boundaries, following which the data would be transferred to a policy-making body actively in the process of forming national sardine policy. In short, this objective was met and culminated in several data-supported recommendations made to policy makers. Subsequently, one recommendation was incorporated into an administrative order instituting a closed season for sardine fishing in southern Philippine waters. This involved a correction to the taxonomic nomenclature of the most abundant sardine species (*Sardinella lemuru*) that had persisted for nearly a century, an important amendment given regulations are species-specific. Although the incorporated recommendation was modest in scope, it signified a discrete example of molecular genetics data being applied to the development of marine

fishery policy in a developing nation.

More exciting from a conservation perspective were, however, the unanticipated discoveries that shed new light on the biodiversity of this valued fishery. In addition to the previously mentioned taxonomic correction of the most common Philippine sardine, we identified the presence of a sardine previously unknown to the archipelago. *Sardinella hualiensis*, the Taiwanese sardinella, as its name indicates, is native to Taiwan and mainland China. This is a particularly fascinating discovery when considering the sea-surface temperature regimes of these areas; Philippine waters are tropical, Taiwanese waters are temperate to sub-tropical. In other words, the water where the sardine is "from" is cooler; yet repeated field and molecular assessments confirm its presence in the Philippines. Could the range extension of a northern-latitude, cool water species be in some way related to global climate change, or has the Taiwanese sardinella long been present in the Philippines and just has gone unnoticed? Given the difficulty in taxonomic identification of sardines, the latter is plausible. Since 1908, the number of Philippine sardinella species cited in scientific publications has ranged from three to eleven. Using a combination of robust morphological and genetic metrics on specimens from across the Philippines, we at the NFRDI lab have confirmed the presence of six *Sardinella*, including the Taiwanese sardinella.

Further, we have been able to quantify the genetic diversity of these sardines in relation to their geographic distribution across the archipelago—their phylogeographic pattern. Paralleling the region's extraordinary level of marine biodiversity (the Philippines is at the apex of the Coral Triangle, the world's epicenter of marine biodiversity), several of the sardine species show high degrees of genetic diversity, including exceedingly high diversity in one species that it is arguable a cryptic species complex. Cryptic species are morphologically identical (or at least highly similar) but genetically distinguishable sister species evolving from a common ancestor. Cryptic species are common in marine environments with a number of examples in corals, fish, and invertebrates. Their accurate distinction is often only revealed through molecular genetic studies and intuitively, can aid in improved delineation of interbreeding stocks.

Demian A Willette

Sardines at Navotas, Philippines

The Coral Triangle is the world's centre for marine biodiversity. This triangular geographic area, including all or portions of the countries of Indonesia, Malaysia, the Philippines, Brunei, Timor L'Este, Papua New Guinea and the Solomon Islands, covers approximately six million square kilometres of sea. In addition to its geometric contour, the region receives its name from the over 550 species of corals that occur here; the highest concentration of coral species anywhere in the seas.

Beyond supporting 76% of the world's coral species, the Coral Triangle is home to nearly all of the world's mangrove forests, more than half of all coral reefs, the globe's highest diversity of seagrass species, and a third of coral fish species, among other exemplary statistics. The Coral Triangle is also home to a growing human population of over 374 million people, one-third of whom depend on marine resources for their livelihood. Resultantly, not only is the Coral Triangle a hotspot for marine biodiversity, but it is also a hotspot for marine calamity. Threats include overfishing, destructive fishing techniques, pollution, ocean acidification, increased sea-surface temperature, and sea-level rise; the latter three products of global climate change. As the threats to marine biodiversity mount in the Coral Triangle, so are the efforts by marine scientists and resource managers towards reducing the effect of these impacts and in working diligently to better understand the region's extraordinary biodiversity before more is lost.

Lastly, in a survey of sardine species sold in metropolitan Manila fish markets, we documented the frequent availability of the freshwater sardinella *Sardinella tawilis*. Endemic to a single freshwater lake in the Philippines and revered as a culinary delicacy, this sardine's population is currently declining under increased pressure from fishing, invasive species and aquaculture development of the lake. Upon gathering molecular data, we were surprised to discover that none of the market-sold fish were actually the freshwater sardinella as advertised, but rather one of several marine sardinella species. Markets were advertising and selling marine sardines as the freshwater species (the latter fetches a higher price), and consumers were unaware of the switch until our discovery through the use of molecular methods. Note that distinguishing sardinella species is difficult by even a trained scientist and it is unclear where in the supply chain marine fish were being substituted for the freshwater species. This, however, presents an interesting conservation situation—because marine sardines were being sold as the freshwater sardines, the market demand for the actual freshwater sardine is lower and may relieve fishing pressure on an already declining stock. However, molecular evidence shows consumers are being misled.

In science, we are often intensely focused on the discrete objectives of a project, understandably so since they are what research funds have been allocated to. However, if we are rigorous in our investigation and allow the data to lead the discussion, the project not only yields the target information, but could also uncover unanticipated, yet welcome results. Results that are of particular value as we work to find an enduring balance between the exploitation and conservation of our marine resources.

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Making co-management work

Some 200 million around the world people depend on fisheries for some part of their livelihoods. An overwhelming proportion of these are in developing countries, where the capacity of national governments to effectively manage fisheries is low. As a result of this weak governance, overfishing is rampant and threatens marine ecosystems and the people that depend on them.

Priya Sebastian

In 2006, I launched an ambitious research project that sought to better our understanding of whether and how communities can locally manage fisheries in ways that sustain marine ecosystems and local livelihoods. For several years, my research team and I travelled across the Indo-Pacific visiting 42 coastal communities throughout Kenya, Tanzania, Madagascar, Indonesia, and Papua New Guinea. Our results showed that under the right conditions, local people can sustainably manage their resources in ways that improve human wellbeing. Since so much of the headlines about fisheries are doom-and-gloom, our success story is worth sharing.

COLLABORATIVE MANAGEMENT ON THE RISE

Many governments, conservation organisations, and donors are engaging natural resource users in collaborative arrangements to deliver better outcomes for both people and the ecosystems they depend on. This is frequently called "co-management" and is a process that provides local people with greater participation in decisions about natural resources.

An example is the Beach Management Units (BMUs) introduced in Kenya during the past six years, which have allowed stakeholders to develop and enforce local rules. These rules are expected to improve the management of a fishery that has historically suffered from weak management and enforcement. Such arrangements aim to make management more reflective of local conditions and more legitimate in the eyes of stakeholders, thereby increasing the incentives for people to comply with the rules of their own accord. In Kenya, the introduction of co-management was initially met with some skepticism, but results from our survey of resource users in eight of the 33 pilot sites reveal that less than 3% of respondents think that co-management is bad for them.

One of the most exciting and unexpected results from the Kenyan co-management legislation has been a proliferation of small community-based reserves. There has been considerable opposition to government controlled marine reserves in Kenya. Indeed, attempts by the government to establish a marine reserve in the southern coast of Kenya was met with protests and subsequently abandoned. A key difference is that proceeds from tourist fees to dive or snorkel in government marine parks used to go to government coffers, but with the new BMU legislation, communities can now design and implement their own fee system that they can collect and keep. Now that the decision-making power, and benefits, remain local, 18 communities have now established community-based reserves (locally referred to as *tengefu*, the Swahili word for "set aside").

Such arrangements aim to make management more reflective of local conditions and more legitimate in the eyes of stakeholders, thereby increasing the incentives for people to comply with the rules of their own accord.

Joshua Cinner

Reef fishing in Kenya

A map of our study sites across the Indo-Pacific. At each village, we gathered information on the status of the local fishery, people's socioeconomic conditions, and the types of rules people developed to manage their resources.

Similar movements toward fisheries co-management are afoot throughout the world. In the western Indian Ocean, Madagascar and Tanzania have developed similar initiatives. In places like Papua New Guinea, local customary laws are often used to manage local fisheries. Yet the forces of globalisation are breaking down these traditional institutions, so some communities are looking toward governments and civil society to develop new co-management partnerships. Communities and scientists are working together to develop conservation programmes based on local traditions that are meeting community needs. For example, contemporary science and mapping is being combined with local knowledge to determine where management areas should be placed. Results form these types of hybrid management initiatives are promising: we are seeing tangible conservation benefits of 2 times the biomass of fish inside periodically harvested areas. Scientists, managers and policy makers are looking at ways to better understand the human dimensions of coral reef ecosystems and learn how to scale-up these local successes.

SOME GOOD NEWS

Sustaining fisheries

We found that 2/3 of co-managed fisheries were sustainably managed. Although not perfect, it was certainly better than the fisheries that lacked local management—only 1/3 of those were regarded as sustainable.

High compliance

Getting people to comply with restrictions on resource use is a continual challenge for many fisheries management and marine conservation initiatives. We found that 88% of co-managed fisheries were mostly or fully complied with.

Making co-management work for people's livelihoods

Across the Indo-Pacific, the majority (54%) of people we surveyed felt that co-management was

positive for their livelihoods, while only 9% felt that it was bad for them.

WHEN DOES CO-MANAGEMENT WORK BEST? SETTING THE STAGE FOR SUCCESS

Our study found that, overall, co-management was largely positive for people and marine ecosystems. Nevertheless, there were also cases when co-management facilitated overexploitation, resulted in poor compliance, and made people worse off. We found that successful co-management has socio-economic, institutional, and contextual attributes.

There is no silver bullet for the problems facing the world's fisheries, but co-management arrangements that reflect local conditions can help to sustain fisheries and the people that depend on them, even where poverty is pervasive and national governance weak.

Socioeconomic characteristics of resource users

People may avoid being involved in management if they do not have the time and resources and do not understand that human activities can impact the condition of marine ecosystems. The main socioeconomic considerations include:

• Poverty- People may have difficulty making the short-term sacrifices that are required to engage in co-management if they are struggling to meet their basic requirements.

• Knowledge about how humans impact marine ecosystems- People may be unwilling to restrain their use of resources because they do not see a connection between human activities (such as fishing) and the condition of the resource or ecosystems.

Kenyan fishers using a gill net on the reef flat

• Dependence on resources- People heavily dependent on fishing often find it difficult to find time to engage in other livelihood activities. On the other hand, when people are heavily dependent on fishing, they are more likely to have an incentive to cooperate and solve problems.

• Social capital and trust- People need to trust each other and their leaders if they are going to work cooperatively towards solving fisheries problems.

Getting the institutions 'right'

Local institutions that are well organised and functioning are a critical ingredient of making co-management work. Specific institutional characteristics, known as design principles, help to promote cooperation among people. These design principles include:

• Clearly defined boundaries and membership, which helps people understand where and to whom the rules apply and who gets to make them.

• Active participation, which can be facilitated through forums that encourage users to actively participate in management, particularly in decision-making processes.

• Transparent monitoring and leadership, which provide the reassurances necessary for people to invest in co-management.

• Graduated sanctions, which are punishments that increase with the frequency and severity of infringements. For example, the first time a rule is broken, the person gets a warning, a fine is given the second time and lastly the person is jailed. These help to create a sense of learning and fairness about the rules.

The local context

Conditions that can either encourage or discourage people from participating in co-management include:

• Population size- Small groups of people are more likely to coordinate and build the trust necessary to work together to solve problems.

• Markets- Temptations for people to break co-management rules are created by easy access to markets for their marine products. Co-management organisations can, however, harness markets and add value to products. This can create powerful incentives for people to participate in and comply with co-management, when done effectively.

THE DOWN SIDE

Of course, people have raised a number of important critiques about co-management. In some cases, national governments simply put the costs of managing fisheries on local communities who can ill afford it and lack the capacity to implement it.

My study found that, although co-management helps to put decision-making power in local people's hands, it does not always do so equitably. Indeed, co-management has the potential to decrease social equity by creating opportunities for local 'elites' who control resources to coopt the process and capture the majority of the benefits. For example, in Kenya, to ensure that BMU leaders understood the rules, regulations, and responsibilities, the BMU legislation required that chairmen have at least six years of education. Yet in some communities, there were no fishers with this basic level of qualification, meaning that people who were not involved in the fishery were in charge of fisheries co-management.

CONCLUSIONS

There is no silver bullet for the problems facing the world's fisheries, but co-management arrangements that reflect local conditions can help to sustain fisheries and the people that depend on them, even where poverty is pervasive and national governance weak. The likelihood of co-management becoming successful is, however, higher when specific institutional, socioeconomic, and contextual conditions are in place. Communities, donors, and managers can facilitate desirable co-management outcomes by implementing locally-appropriate strategies to address these critical conditions.

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Pencil Sauce

Barbara Block

Barbara Block is Professor of Marine Biology at Stanford University, USA. Over the course of the last decade, she has mapped the seasonal movements of predators in the Pacific and Atlantic Oceans. Her work has lifted the veil of opacity from the oceans: we now see migratory pathways, feeding and spawning grounds, and homecoming gatherings. Although marine animals seemingly have the freedom to go anywhere on earth, Barbara's work highlights they are creatures of routine, following the same route to arrive at the same spot at the same time every year.

Barbara won the Rolex Award for Enterprise in 2012 for using technology to monitor oceanic hotspots, and enabling the public to build a rapport with the animals of the deep. Since oceans are huge expanses, we think we can take as much as we want and there will always be more. In this interview she talks to Janaki Lenin about why we should conserve bluefin tuna and sharks, and the challenges of changing people's opinions.

JL: Why should we be concerned about tunas?

BB: Giant tuna, such as bluefin tuna, have a commodity value where a single tuna can sell for tens of thousands of dollars. When wildlife has a high value, it is hard to stop commerce or trade in the species. This is the case for bluefin tuna which is the most sought after member of the tuna family. Bluefin tunas (three species) are in a high-class, luxury market. The rest of the tunas, which includes species such as skipjack and yellowfin tunas, primarily goes into cans. For these species, there is often a bycatch of non-target species such as turtles and sharks. Instead of the target species, the net actually captures top predators in the ecosystem.

JL: You were part of the 10-year-long census of Marine Life program which sounds astounding in its ambition. Could you tell me more about it?

BB: We tagged 4800 animals, about 75 scientists from many nations working together. We took on the Pacific Ocean, the largest ocean, and asked, "Could we learn how it works from the top predators?" We started with arrows on a map. Do the white sharks go this way? Do the blue whales go that way? Do the tunas go this way? We did a lot of testing of existing and new electronic tag technology. Together as a multinational coalition, we did almost the impossible. We got a glimpse for ten years of how the Pacific Ocean worked. What we discovered was there was a pulsatile movement of the animals according to seasons. Animals you thought would wander everywhere were basically going away and coming home, going away and coming home. The northeast Pacific, which is about the size of the Atlantic Ocean, from Hawaii to coastal California, basically had a repertoire of seasons that the fish and animals were following. None of us had known that. So we learned it was a finely-tuned periodicity much as you'd expect on the plains of Africa in which animals were going through large migrations on a seasonal scale.

JL: You also did a Tag-a-Giant campaign. It's amazing you managed to tag a thousand animals. How do you process data like that?

BB: We've had a lot of experience handling tags, animals and the large data sets that are generated. In the case of Tag-a-Giant, that's my favourite project. That's the project I started with. I was a youngster when we first put computers into tunas in the North Atlantic. We decided early on to put tags internally into the tuna, and have a long stalk that sampled the environment come out of it. The idea was we let the tunas go with tags that said, "We'll pay you a US $ 1000 if you return our recorder." Sure enough, 24% of them came back in the Atlantic. We put out about 700 of those tags, but we also put out pop-up satellite tags which didn't need a fisherman to intervene. And those we got back at 80% level. So together now, we have in the Atlantic, over 30,000 days in the life of tuna. Imagine if we did this to humans, we would find that we have places where we gather at restaurants, foraging stops. A Londoner and an American can be in the same place, say in New York. It's the same with tuna.

We found out where are the lunch stops are that many of the animals come to versus where are the lunch stops that are only one side might come to. We found the tunas were mixing across the ocean but separating back to their spawning grounds.

TAG a Giant

Barbara tagging tunas in North Carolina

JL: When people see the tuna at the Monterey Aquarium, what do you want them to think about the tuna fishing industry? What do you want them to take away from this experience?

BB: I think we have to stop thinking that tuna are just food on our table. We wouldn't go into Africa and eat the lions, zebras and elephants, in most cases. We are basically doing that in the ocean. We are not looking at wildlife in the ocean as anything but food, and we could leave to our children an ocean without these animals. We have to learn to live sustainably, and potentially raise herbivorous fish that are much more productive; not carnivores, but herbivores that could feed many people.

JL: How would you protect something that is so valuable? Just looking at the price of tuna, one appears to be so much more expensive than a tiger.

BB: I think it's hard. Aquaculture to some extent is going to help save the day. Around the globe, there are many projects that are trying to raise tuna. Japan has taken a spectacular lead on the technology, Australia has got an on-land facility. There's probably 10 facilities being built – one in Taiwan, a couple in Spain, Greece, Israel. It's like producing gold, if you can do it. I believe there'll be some breakthroughs there. I'm not saying I'm for farming tuna. If a portion of the market could be met through that type of activity, and done sustainably with good science and sustainable feeds, then it would take the pressure off the wild stocks.

I think if the wild stocks are managed correctly, the tuna can be fished sustainably. But it's a cocaine-of-the-sea type of problem where many people want it and no one's paying attention to the rules. Pirated tuna is a really big problem. I dream of a new technology. What if we could barcode every tuna that's landed and keep track of them. What if we could barcode every live elephant, or every live bluefin tuna left on earth so you really could keep track of them. So my dream is really to make a tag, a carcass tag that allows us to keep track of fishery in a more accurate manner from point of landing to market, so we don't have any pirating.

We are not looking at wildlife in the ocean as anything but food, and we could leave to our children an ocean without these animals. We have to learn to live sustainably, and potentially raise fish that are much more productive; not carnivores, but herbivores that could feed many people.

Monterey Bay Aquarium/ Randy Wilder

Blue fin tuna

JL: At the 2010 CITES meeting, there was a call for banning bluefin tuna fishing. Some were calling it a point of no return if the voting failed. The voting did fail. Where are we today?

BB: In the Atlantic, there is a complex population structure of the Atlantic bluefin tuna that is emerging with genetics. Our lab and many others are doing this work. What's coming out from this work is that the population near America is much more threatened than the population on the eastern side of the basin, the Mediterranean population. The tagging and genetics show that because the European tuna come over to our waters, they help protect our tuna. If our US or Canadian fishermen catch one of their fish, they don't kill one of our fish. So we have this complex set of dynamics going on that are critical to capture in the models being used to manage the fishery. The European fish are thought to reproduce quicker, faster, potentially they have a larger and stronger population. Whereas our population that breed off US shores in the Gulf of Mexico of North America is the weak population: the animals take longer to mature, and reach larger body size at maturity. These bluefins are the giants of the ocean, the largest tuna in the sea. Our North American population is extremely low and the eastern Mediterranean population is larger, potentially rebounding quicker (due to lower age to mature), but we're still not sure. Some say they are coming back after a short letup in fisheries take. The models being run by ICCAT [International Commission for the Conservation of Atlantic Tunas] don't really reflect


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the true biology of these populations. Until they do, I would be cautionary. They don't have enough robust analysis of the mixing of populations, which population is which that you are modeling, and until we get there, it would be premature to say the tunas have recovered.

Furthermore, your question refers to the western bluefin population that's spawning in the Gulf of Mexico. That is what should be discussed in those contexts, but unfortunately people say 'bluefin tuna' which is a whole species that doesn't require an endangered species status. It's a very complex problem. It raises the big question: in the ocean, what is an endangered marine species? When are there not enough parents to make the next generation? That's a tough question. That's the limit of our knowledge right now. What happens when you get down to the last few giant bluefin tuna? In our case, there could be larval cascades going on. In the old days, there may have been tens of thousands of bluefins spawning at once who made lots of bluefin babies and their burst of reproduction meant they were the dominant tuna. Now, a lot of the times they get many more of the smaller tuna eggs, the blackfin, and at the same time they get bluefin. There's a potential that they are eating the bluefin at this point.

JL: Does the fishing community see what you are doing as helping the long-term survival of their industry, or do they see you as an adversary?

BB: I think we've come a long way with our fishermen especially in America. They respect us for the high content of the information we have put on the table. We are advocates for the fish, but we are also not going after closing fisheries. We think of sustainable fisheries. I'd like to see us protect, for example, the spawning areas immediately. It's a case where longlines get set for a different tuna species called the yellowfin tuna, and the bycatch is bluefin that is protected by law. Currently, we wouldn't outright close the boundaries and say, "Don't fish here." So we try to look for solutions that are practical for the people we are working with, and I think that builds respect rather than adversity between the two groups.

JL: Both the main species—sharks and tuna—are going to East Asian consumers. Shark fins go to China and tuna goes to Japan. So shouldn't we be working with those economies?

BB: Sushi has become a fad around the world that it's really amazing. In our grocery stores in America, we didn't have tuna when I grew up. But now there's tuna as a healthy snack. Same thing around almost all cultures. Eating raw fish has been passed from Japan to everyone. So there's a global tuna pressure. Then canned tuna is very popular in America. I think to solve the problem we need to begin to think about what is it we want with our oceans. Do we want an ocean devoid of tunas? Or do we want an ocean that is managed correctly? So we can probably have healthy fisheries if we just had healthy management. That's all we are saying.

What we see as marine conservationists is the need for building protected areas in the sea. And there are some places like the California coast that might be a National Park, like Yellowstone, in North America. Places deemed unique in our oceans, rich in biodiversity should obtain World Heritage Site designations. The Great Barrier Reef is one such place but we need more.

When I first moved to California 20 years ago, I had no idea when I looked out my office window, what a special place it is. And now after all this tagging, we've learned, "My God, we might be living in a hotspot in the sea." We had animals coming from Indonesia, we had animals coming from Japan, we had animals coming from New Zealand. Many marine predators come to Monterey for a part of the year, and it's exciting to see that this is the most spectacular place and nobody knows it's there. And that's my challenge. How do you make the seas transparent?

Do we want an ocean devoid of tunas? Or do we want an ocean that is managed correctly? So we can probably have healthy fisheries if we just had healthy management. That's all we are saying.

JL: What do you think should be the strategy at the coming Bangkok meeting? Even if it's sustainability that you are talking, not outright banning. How do you set quotas? It's all a question of bargaining and Japan is going to veto anything.

BB: Yeah, I know it's really tough. What's happened is that the green groups have gotten better at understanding the game and how it's played. Japan is an economic force that is trying to get votes to help sustain its way of life. It's a country that requires lots of tuna. I take hope in the fact that everyone is trying to solve the tuna aquaculture problem. And even I get bitten by that bug. We've raised tunas for 20 years and I can't think of anything more fun than trying to raise, in our case, bluefin or yellowfin. Bluefin is very difficult to do. But Japan's solved it and so has Australia; Spain's trying to solve it. And I do think there'll be a day not too long from now, 20 years from now, when a lot of the meat will be coming from these facilities.

JL: Would such an operation be economically feasible?

Shark Net is a mobile application that is downloadable free from iTunes that allows the user to keep track of individual white sharks off the coast of California.

Powered by wave energy, the Glider is a floating robot that rides the waves between California and Hawaii, while trawling a listening device seven metres underwater. Should a shark with a tag embedded in it swim within 300 metres range of the robot, the latter picks up the signal and transmits the data through a satellite link. Besides the Glider, a network of fixed listening buoys with underwater microphones located at congregation sites also pick up information from tagged sharks.

The data from the Glider and the listening buoys is used by Barbara Block and her team to monitor the predators. For people with no scientific background, Shark Net presents the same data in an easily understandable form. Each shark has a name and profile with high-definition videos, and details of its comings and goings. When the signal of a shark gets picked up by one of the listening devices, within minutes the user gets an alert. Hopefully, over time enough people will develop an interest in the individual lives of these animals to care more about their future.


Tagging of Pacific predators

Long-lasting tags for sharks and tuna which can communicate to mobile and fixed listening stations.

Rolex Awards/ Bart Michiels

BB: I think it's economically feasible and I think just like salmon, which 25 years ago was wild caught, is almost entirely produced through aquaculture. The challenge will be: Can we do aquaculture scientifically correctly? Which means that you've got to develop the feeds; you've got to make the feed out of something that is not competing with human protein. It's very difficult and I recognise that. We dream of fish that eat soy grown on our farms in the plains, and then are potentially genetically selected like plants. Or, the other idea is raising fish on algae with the right essential oils. You feed little cubes like brownies to your tunas. At Monterey, we feed a snack to tunas that's just like a green brownie, and it's just seaweed with the right vitamins in it.

JL: What about sharks? We've talked a lot about tuna.

BB: The problem with sharks is that they reproduce in a manner very similar to us. They use internal fertilization and have a small number of pups per year, a reproductive style that has allowed them to be successful in the oceans for millions of years.

We always hear about shark-finning, but people are eating the meat of some sharks, not all sharks. Humans are taking sharks at a level that really defies imagination. It just makes me wonder how could there be all these sharks in the ocean. The level of landing of sharks is stripping shark populations globally. They cannot handle the kind of fishing that was set up originally for tunas and other bony fishes.

As tuna populations become smaller, the longlines and other gear target sharks by mistake. That was initially problematic for the fishermen, but now they are directed towards the sharks. Out there in the open ocean where people fished, initially sharks weren't brought in, but now they are brought in. They are brought in for their fins, they are brought in for certain parts of their meat, and that is happening everywhere you go in the ocean. It's really tragic because sharks cannot keep up with that pace. So there are places we go where we don't even see sharks anymore.

What's interesting about that is we don't understand what a shark does in a healthy ecosystem. We know they are important. We know that ocean ecosystems that are normal require top predators to maintain resilience and balance. When we remove them, we may ultimately be flipping the ecosystem to some new equilibrium that we don't even understand. It's happening everywhere

Rolex Awards/ Bart Michiels

where sharks are being removed; we are getting a new set of ecosystems. In some cases that might mean you have herbivores on the reef overnight, more algae growing because certain animals aren't there anymore, or the sharks were removing part of the ecosystem that you didn't realise what role it was playing. So we are doing these experiments everywhere and nobody really knows what the consequences are. I'm happy to say that off the California coast may be one of the places where sharks are running wild in a big way. Same in parts of Australia. It's a question of what makes it healthy versus what do you gain from a healthy ecosystem? Do you gain happiness because you have have wildness? Or do you gain something in value that's worth more? So we are actually looking for support right now to understand what does it mean to have an intact ecosystem. In general, it means more linkages, more stability, more resilience, but that's hard to translate.

JL: The trouble with making people feel a personal connection with any marine creature is the lack of a personality.

BB: That's what Shark Net is about. The Rolex award is about using new tools to bring a more personal connection to stories. I really don't know if youngsters in India, Japan, or China would have the same interest as American youngsters. They love sharks. Here, there may be a culture that fears sharks, I don't know. So how do you overcome the —what is a shark?

JL: Do sharks have personalities?

BB: An hour from where I live in San Francisco are the biggest predators, 5000 lb. white sharks, in the sea. I don't dive very much anymore in my area; I have a healthy fear, but my students all surf. I think it's great that I can go out and study the sharks in the fall, get them close to the boat, and work with them. None of them are real personalities to me; I see them as white sharks. But my students who study them quite regularly, they've got their favourites out there.

There are sharks that'll only approach the decoy one way. There're sharks that come right up. One shark called Engine comes right up to the boat and always likes to tap the engine. He keeps us on our toes.

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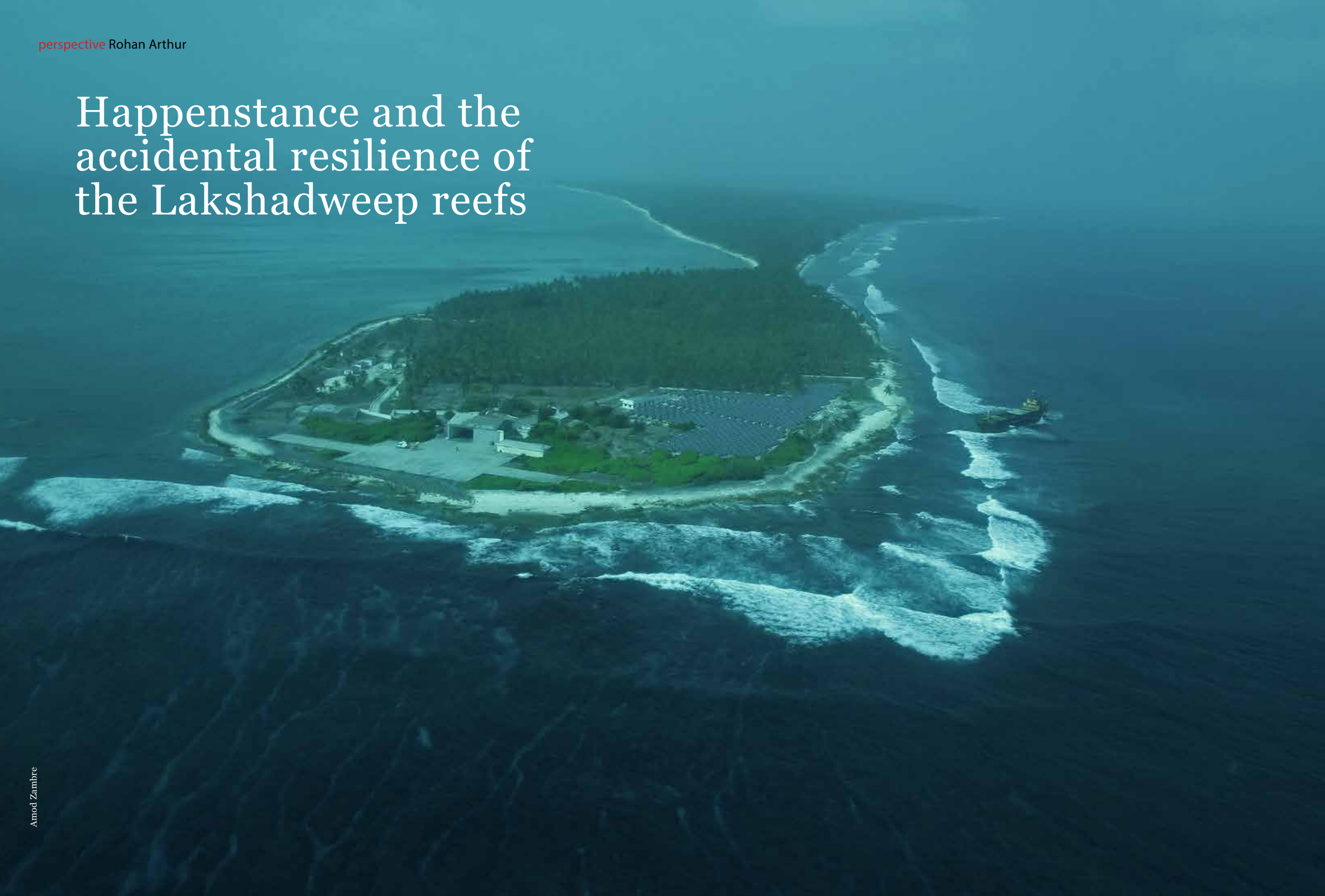
Happenstance and the accidental resilience of the Lakshadweep reefs



Amod Zambre

Diving for the first time in the Lakshadweep reefs, there was no way I could know that I would never again see them as I did then. When I returned to these waters in the summer of 1998, the reefs were already bleaching and I struggled to document the extent of the loss before the rising monsoon waves made it impossible to work. By December, many reefs were reduced to broken rubble piles, which the next few monsoons washed away. And I was certain, from case studies beginning to emerge from other parts of the tropics, that a depressingly familiar story of decline without recovery was playing itself out across the archipelago.

It came late to me, but the Lakshadweep is a system like few others in the tropics. The atoll islands are densely populated; more than 70,000 people crowded on 10 islands, a little over 30 square kilometres, making it among the densest non-urban areas in the subcontinent. Coconuts and fishing have dominated the economy here for the last few centuries. And while none of this is particularly unique, what makes the Lakshadweep different is that despite its high fishing-dependent populations, its reefs have been relatively unfished in the last three to four decades. In the mid-1970s, the local department of fisheries began dedicated efforts to promote a pole-and-line fishery for skipjack tuna, supported with training, fuel and boat-building subsidies, as well as production and marketing schemes. This programme grew in popularity and transformed what was an artisanal reef fishery to a flourishing pelagic cottage industry that involves a large proportion of the population today. This little accident of developmental history was happy happenstance for the reefs of the Lakshadweep. Without intention or effort, the pelagic fishery serves now as an effective subsidy on reef fishing, which is no longer the main source of fish for the population. This human-dominated 'pristineness' is rare in the crowded, overfished reefs of the developing tropics. The familiar unfolding I expected in the wake of the 1998 El Niño—trophic downgrading, coral mass mortality, overgrowth of algae and reef decline—did not occur. What is emerging instead is a far more nuanced picture that shows how reefs can inherently behave when our human footprint is light.

Amod Zambre

Some coral species are better able to resist bleaching

Reefs are biogenic systems—their dominant animal and plant forms (coral and coralline algae) contribute significantly to their physical structure. What happens to these living structural elements drives the rest of the ecosystem in profound ways. Since that initial coral bleaching event in 1998, we have been returning to the Lakshadweep reefs now for the last 16 years and what our benthic data is showing is that these reefs take surprisingly divergent paths after a major disturbance.

Their capacity to resist or recover from large disturbances is critical to the buffer capacity of the Lakshadweep reefs and it creates a matrix of resilience that we are still trying to map and understand. Geography, apparently, is the key. Where the monsoon storms break heaviest on the western reefs, coral turnover is the greatest, creating environments that are wildly dynamic in the way biogenic structure changes through time. Protected from these monsoon winds, the leeward sides of reefs proceed at a much more sedate pace, more stable in their structural composition even if the coral here may have died with every successive bleaching event. These differences in benthic history ensure that the reefs of the Lakshadweep have qualitatively different behaviours, driven largely by location. Across the archipelago we are finding that the distribution of large benthic predators is influenced not so much by the complexity of the structure at a reef site, but by the history of structural change at each location. We are documenting similar trends with coral-feeding butterflyfish, and I suspect this is a pattern we will see repeated for several structure-dependent long-lived species. There are probably other critical drivers of resistance and recovery on these reefs that we do not yet know about. Getting a handle on coral recruitment rates and post-recruitment survival, as well an understanding of how higher trophic functions interact with these processes, will be essential for a more complete understanding of the mechanisms underlying this resilience matrix we are describing.

Rohan Arthur

Fisherman cleaning up his net

This programme grew in popularity and transformed what was an artisanal reef fishery to a flourishing pelagic cottage industry that involves a large proportion of the population today. This little accident of developmental history was happy happenstance for the reefs of the Lakshadweep.

This has been our narrative of the Lakshadweep over the last decade or so, and it is one that fits neatly. A reef system conferred with considerable resilience in the wake of disaster as an accidental consequence of an unrelated fisheries development. The relative absence of fishing on these reefs allows us to explore patterns and processes of ecological resistance and recovery without having to worry about the anthropogenic stressors that normally overshadow these inherent ecosystem trends. Yet the comfort of a well-told narrative comes with all the Idols of the Mind that Bacon warned against. A small shift has begun to occur in this neat storyline of happy happenstance, and I will admit that when I first stumbled on it, I almost pretended it was not happening because it did not quite fit. To be fair, the change is apparently so small that it would be easy to miss. In the Lakshadweep capital, Kavaratti, a few, still-artisanal reef fishers have begun storing their occasional catch from the reef in iceboxes. What began as a simple convenience is now a growing practice. In the village centre every evening, a few small makeshift stalls open up with fishers selling

Parrotfish catch for the day

fish by the kilo to islanders for their evening meal. It is a nascent thing, not big enough to dignify as a market, but it is signals a big change in the way the Lakshadweep relates to the reef. For the first time in the recent ecological history of the archipelago, the fish of the reef are being monetised. And while this is perhaps still a distant horizon, it is only time before international reef trade markets cotton on to the unfished spoils of the Lakshadweep reefs. From there, I am not certain how long it will be before I am narrating the same familiar tales I expected when I first saw these reefs bleach.

It was when we were conducting interviews with fishers to find out what they knew about the potential reef fish aggregations that it first struck me how tenuous the unfished resilience of these high-populated reefs actually is.

It was when we were conducting interviews with fishers to find out what they knew about the potential reef fish aggregations that it first struck me how tenuous the unfished resilience of these high-populated reefs actually is. Virtually every fisher we interviewed gave us the same response —they knew very little of the functioning of these reefs because none of their fishing experience relates to the reef. In the old days, they told us, when the reef still provided fish for the daily meal, there were fishers who knew the best times and areas to fish, which seasons they spawned in, and how these populations were influenced by current, weather, the spirits of the sea. There were also a set of customary practices that regulated fishing practices based on local almanacs, religious occasions and the condition of the sea. Three decades is enough time for this knowledge to atrophy in a population's memory and today there are few left who remember the old ways. This is a cultural loss for the community perhaps as large as the mass bleaching of coral was an ecological setback for the reefs. The real fear is that as fishers start looking back to the reef once again to supplement their diets and their incomes, they return to it without the traditional knowledge tools they governed the reef with a generation ago. In this time, the archipelago's population has more than doubled from the 32,000 inhabitants it had in 1971. It would be a sad irony that while happenstance led the fishers away from the reef back then, a similar happenstance could well work in the opposite direction,

Eastern Triangle Butterflyfish, *Chaetodon baronessa*

Surgeonfish shoal

leading the reefs down a path of rapid overharvest without the buffer of customary laws to restrain resource extraction.

The Lakshadweep reefs are on the cusp of change. Between increasing market integration, changing aspirations and fluctuating pelagic fish stocks, it is unclear if any intervention can come soon enough to hold this back. On the other hand, the low-lying atoll reefs of the Lakshadweep are perhaps the most vulnerable to the seemingly inexorable impacts of global warming, sea level rise and ocean acidification. Ensuring the resilience of the reefs and the integrity of its atoll frameworks is not a distant altruistic imperative for the archipelago; it is linked in very palpable ways to the islands' continued existence. Over the next few years, helped by the Pew Marine Fellowship and together with the fishing communities of the Lakshadweep, we are attempting to patch together what remains of these reef traditions by talking to the fishers and other community members who still remember them. It may well be a ragged palimpsest of rules and practices, beliefs and superstitions, but they may be a vital starting point to rebuild a once functioning institution of resource control. I have few certainties. I am frankly uncertain if we will succeed in documenting these vanishing traditions or if the fishing community will identify with them enough to want to adopt them again them as they move slowly back to using the reef. I am equally uncertain if it will be enough to ensure that the considerable resilience the archipelago currently has will remain intact. I am even less certain that the reefs of the Lakshadweep will ever resemble the reefs I first saw in 1996. The Lakshadweep has rewritten my comfortable narratives enough times for me not to trust them anymore. I suspect that is part of the reason that keeps me coming back here every year.

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Mangroves, reefs and reef associates in India

Towards Conservation and Management of Mangrove Ecosystems in India

Edited by JR Bhatt, DJ Macintosh, TS Nayar, CN Pandey & BP Nilaratna

ISBN-13: 978-2831712635

IUCN, India. 2011.

Tropical coral reefs and mangroves are the world's most productive ecosystems providing several economic and ecological benefits to humankind. Coastal and marine ecosystems also stabilise the coastline and act as a sink for land-based waste. As a result, most development activities are concentrated on the coastline with profound effects on the surrounding ecosystems. We have already lost more than a quarter of these valuable ecosystems to various natural and man-made stressors in the last fifty years. Reefs and mangroves of India are no exception. Unfortunately, there is little scientific information to inform resource managers on the best management practices that can halt, if not reverse, the current extent of degradation of these two very critical coastal ecosystems of India.

Despite a glowing legacy of research on coastal and marine ecosystems that includes the first international coral reef symposium, held in January 1969 at Rameswaram, marine biological research in India is yet to evolve beyond describing patterns and conducting status surveys. This has come at the cost of understanding the underlying processes and mechanisms of ecosystem functioning, knowledge that is critical to manage and conserve our marine resources.

In 2008, the Ministry of Environment and Forests (India) in collaboration with the Mangroves for the Future (MFF) initiative, IUCN India, organised a series of national workshops. Representatives from various government and non-government organisations, institutions and departments gathered at the workshop to brainstorm about the current status of coral reefs and mangrove ecosystems in India, to understand the threats they face and to identify ways to conserve and sustainably utilise them. These workshops aimed to shape the future for coastal and marine conservation interventions in India and culminated in two edited books:

• Bhatt Bhatt, DJ Macintosh, TS Nayar, CN Pandey and BP Nilaratna (Editors). 2011. *Towards Conservation and Management of Mangrove Ecosystems in India*. IUCN India.

• Bhatt JR, JK Patterson Edward, DJ Macintosh and BP Nilaratna (Editors). 2012. *Coral reefs in India- Status, threats and conservation measures*. IUCN India.

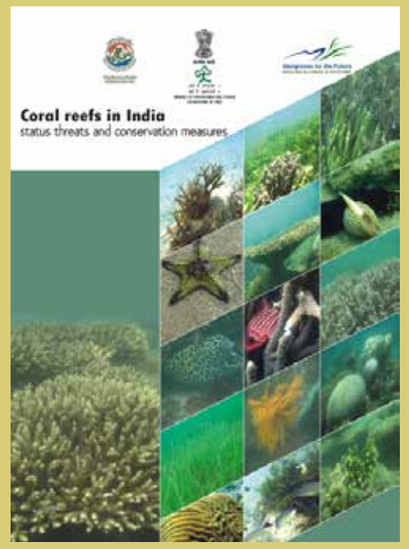
In TOWARDS CONSERVATION AND MANAGEMENT OF MANGROVE ECOSYSTEMS IN INDIA, the opening chapter by Kathiresan and Bhatt provides an introduction to mangrove ecosystems of India, their distribution, land cover, floral and faunal biodiversity and livelihood services. The chapter also outlines major knowledge gaps which need to be addressed for their conservation and management. The chapters that follow provide more detailed site-specific information on the floral and faunal diversity of mangroves, their current status, and past and ongoing conservation interventions covering the mainland states of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Gujarat and the Sundarbans from West Bengal. In addition, there is a chapter on the poorly studied and understood mangrove ecosystems of the Andaman and Nicobar Islands. Various chapters in the book provide useful information on repositories and resources, both online and printed, that will be of immense use to researchers, resource managers and any lay person interested in learning more about the mangroves of India.

A chapter on the potential impacts of climate change on the coastal and marine ecosystems of India reviews the potential ecological and economic costs of sea level rise on coastal and marine ecosystems. Nayak highlights the need for an integrated approach to managing our coastline, stressing the value of remote sensing techniques in achieving this. This essay sets the context for Bahuguna's chapter which provides a detailed review of the applications of remote sensing in developing a sound Integrated Coastal Zone Management (ICZM) plan for the coastline of India. A chapter by Ramesh and Purvaja provides a succinct summary of the core philosophy and approach underlying an integrated management approach of the coasts by highlighting the lack of trained and motivated people to practice the ICZM approach.

In a comprehensive review of the Coastal Regulation Zone (CRZ) Notification 1991, Ramesh et al. provide interesting insights into the history and evolution of the notification over two decades. They also provide a clear account of the formulation of the Island Protection Zone Notification of 2011. The final section on existing legal instruments for mangrove conservation and management will be a useful read for any one engaged in coastal and marine resource management.

Two chapters that share experiences of mangrove conservation efforts, both from Gujarat, provide useful insights on factors that ensure the success and failure of conservation projects. Both chapters highlight the need for a community based approach to mangrove management efforts in the region.

Pandey's final chapter provides recommendations that emerged from the brain-storming sessions and discussions of the workshop. About 21 detailed recommendations highlight the need for research on biological and ecological aspects, social-economic aspects and policy and governance mechanisms. The recommendations also stress the need for capacity development, including communities in conservation and restoration efforts, documenting traditional knowledge, improving institutional linkages and creating databases and knowledge repositories.



Coral reefs in India- Status, threats and conservation measures

Edited by JR Bhatt, JK Patterson Edward, DJ Macintosh & BP Nila-ratna.

ISBN: 978-2-8317-1262-8

IUCN India. 2012.

Similar to the earlier book, this book is also a compilation of various presentations made at a workshop held in late December 2008 at the Suganthi Devadason Marine Research Institute (SDMRI), Tuticorin, Tamil Nadu. Twenty six select papers presented at the workshop that fall into four broad thematic categories namely (1) Coral Status and Conservation (2) Coral Associates (3) Reproduction, recruitment and restoration and (4) Coral environment and threats, are presented in detail. With an adequate coverage of a range of issues and themes, this book is a welcome appraisal of the current status of coral reefs in India, the threats they face and ongoing conservation initiatives. There is a strong skew towards work from the Gulf of Mannar region with little information on ongoing research initiatives from the far more critical coral reefs of the Lakshadweep and the Andaman and Nicobar Islands. This indicates the need to initiate and support more research from the island ecosystems of India and to involve more institutions and organisations involved in coral reef research in these regions.

The introductory chapter by Bhatt et al. sets the right context for the book by providing information on the status and trends of Indian coral reefs, the threats and stresses they are subject to, ongoing management efforts and recommendations for better management of coral reefs in India. The three chapters that follow provide more location-specific information on the status of coral reefs from various sites including the Gulf of Mannar, Lakshadweep, Gulf of Kutch and the Andaman and Nicobar Islands. A study on the recruitment of corals in the reefs of the Gulf of Kutch is a useful attempt to understand the often overlooked demographic processes that underlie coral reef dynamics. The next chapter by Padmakumar and Chandran reviews the biodiversity of octocorals of India providing an excellent resource for interested students and researchers. Melkani then reviews the success of the Eco-Development Committees (EDCs) and women Self Help Groups (SHGs) set up by the Gulf of Mannar Biosphere Reserve Trust as part of its sustainable marine resource use programme, which has important lessons for management practitioners.

The section on coral associates begin with reviews of reef associated ecosystems including mangroves and seagrass ecosystems focusing on their current status and conservation needs. Other chapters in this section examine crustacean and marine ornamental fish resources of the Gulf of Mannar, and giant clams of the Lakshadweep Islands. Rao provides an overview of reef fish diversity in the Andaman and Nicobar Islands, with records of 720 species of reef associated fishes belonging to 90 families. Shanker et al. reconstruct the evolution of research and conservation initiatives of marine turtles in India, including a summary of threats. Two chapters dealing with single species conservation follow; the first deals with a status survey of dugongs in the Andaman and Nicobar Islands and the other deals with a community based whale shark conservation project in Gujarat.

The following section has the only chapter that deals specifically with coral reef related processes by Diraviyaraj and Patterson which provides a detailed summary of the reproductive and recruitment patterns of corals from the Gulf of Mannar. This clearly highlights a fundamental problem with Indian marine biological research—a conspicuous absence of process based studies.

A section on threats to coral reefs begins with the often overlooked issue of coral diseases. Ravindran and Raghukumar's review identifies coral disease as a potential structuring force of future reefs of India. This prediction is supported by Thinesh and Edward's study that reveals an alarming loss of live coral cover due to diseases in the Palk Bay and the Gulf of Mannar.

The final chapters review the important natural and anthropogenic threats to coral reefs, including climate change, and their impacts on the Marine National Park in the region, identifying lack of local awareness, capacity and alternate livelihood options as the main impediment to their successful management. The closing chapter by Edward and Bhatt notes the biological invasion of the coral reefs of the Gulf of Mannar and Palk Bay, an issue that has the potential to become one of the most serious threats in coming years.

Both books are landmark publications with contributions by some of the leading coastal and marine biologists and resource managers in India, providing concise syntheses of past and ongoing research and conservation initiatives in India including the islands of Lakshadweep and the Andaman and Nicobar. The books provide up-to-date information on the current status of these ecosystems, a critical assessment of existing legal frameworks and also a series of recommendations that are aimed at addressing current concerns and issues surrounding the management of coastal and marine resources in India.

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