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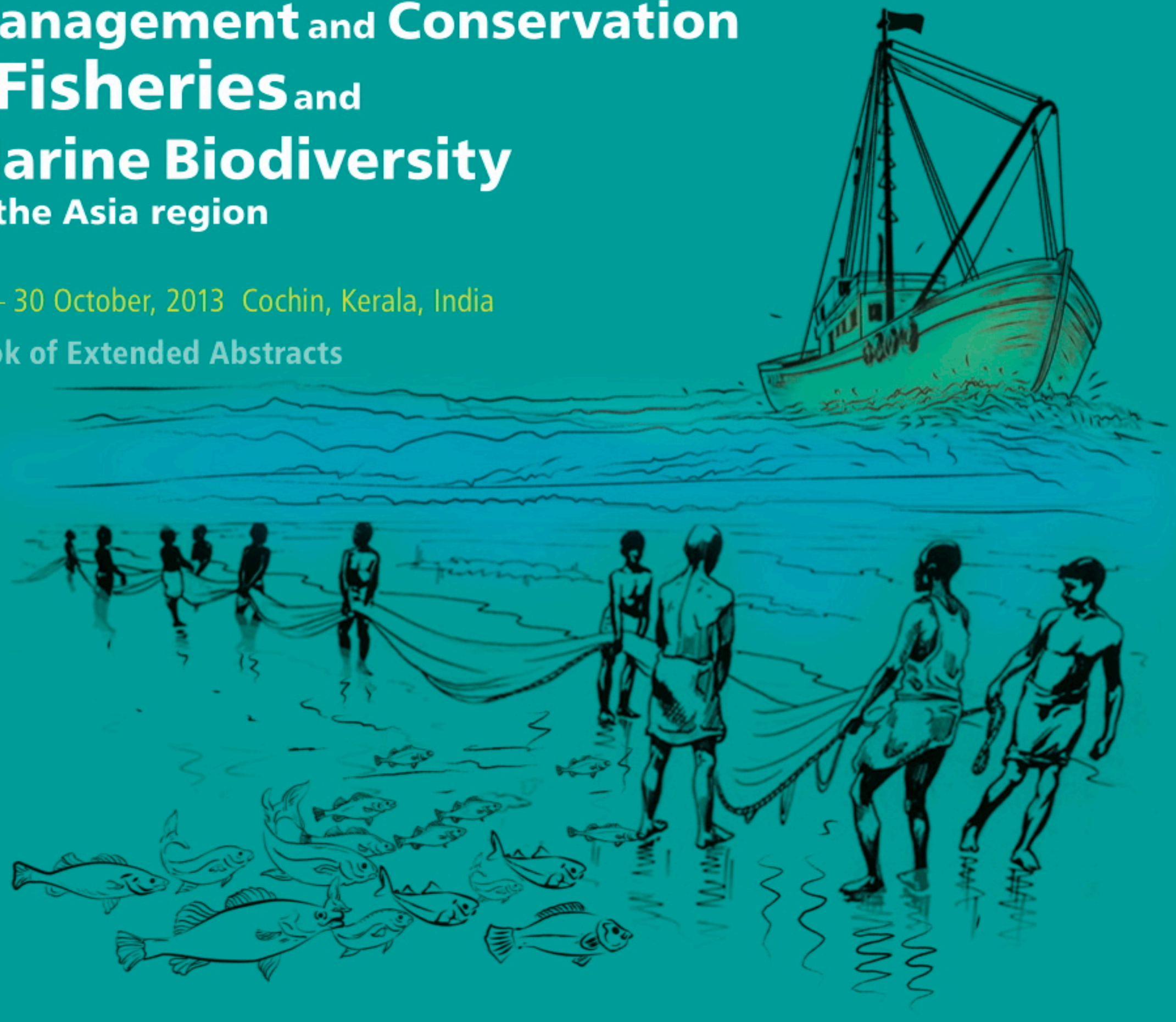
XI Conference of Parties
CONVENTION ON BIOLOGICAL DIVERSITY
HYDERABAD INDIA 2012

Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

Ecosystem approaches to the Management and Conservation of Fisheries and Marine Biodiversity in the Asia region

27 – 30 October, 2013 Cochin, Kerala, India

Book of Extended Abstracts



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Organized by:

Ministry of Environment and Forests, Government of India,

The MFF National Coordinating Body, India

Mangroves for the Future (MFF)

in partnership with

Food Agriculture Organization (FAO)

Bay of Bengal Large Marine Ecosystem Project (BoBLME)

United Nations Environment Programme (UNEP)

The Southeast Asian Fisheries Development Center (SEAFDEC)

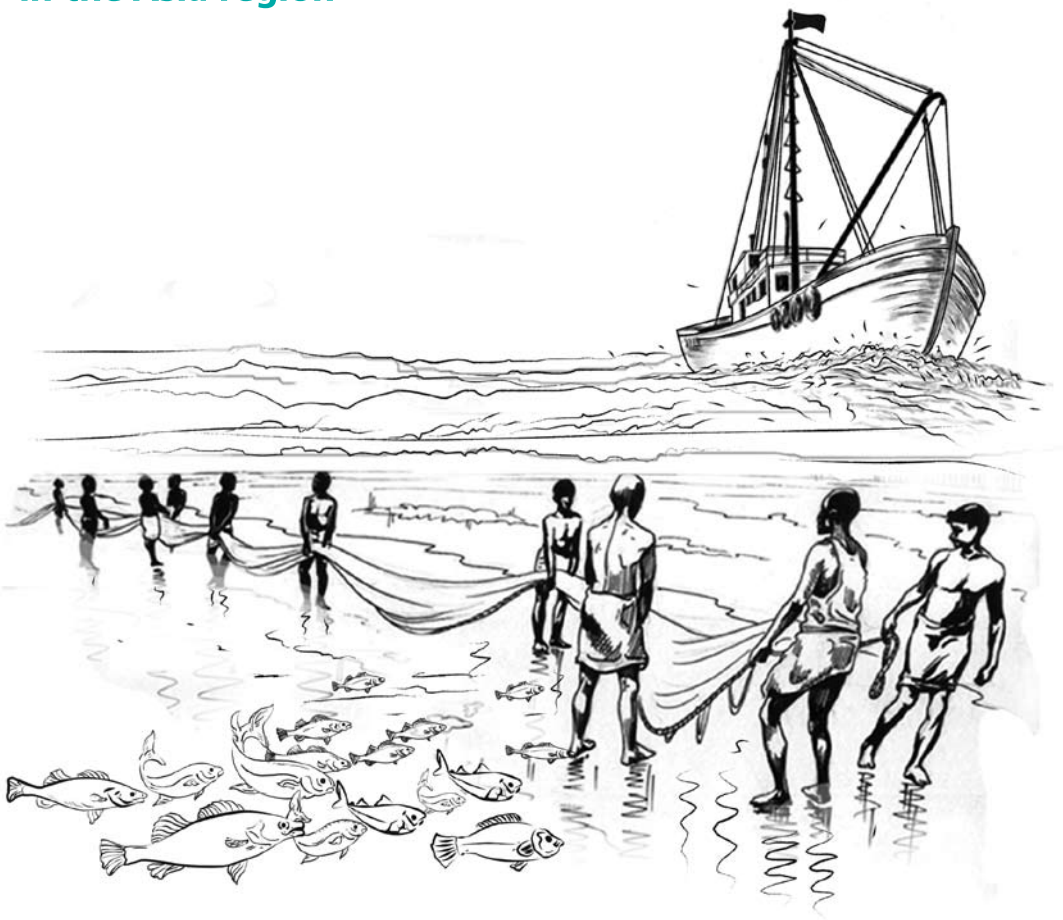
Central Marine Fisheries Research Institute (CMFRI)

IUCN India Country Office

This Book of Extended Abstracts is produced by Mangroves for the Future with the financial support of Danida, Norad and Sida

Cover Illustration by: Tamal Basu

Ecosystem approaches to the Management and Conservation of Fisheries and Marine Biodiversity in the Asia region



Foreword

Marine fisheries contribute substantially to nutritional, social and economic benefits to countries in the Asian region. The capture fisheries production in several countries in the region is increasing, but there is a growing concern on the sustainability of resources. Being the most populous region in the world, the dependency on coastal resources is high, impacting the resources as well as biodiversity. The situation today is that the region catches enormous quantities of fish, but with compromises on resource and biodiversity sustainability. Thus marine fisheries is important to the region as a whole, but complex human activities call for careful management more than any other region. Being a major contributor to global marine fish production, the developments in the region has a great bearing on fish protein supply to the world. A growing consensus is that the twin objectives of fisheries sustainability and biodiversity conservation can be achieved by adapting ecosystem approach only.

In spite of realization of the importance of ecosystem approach, a clear governance structure has not emerged in the countries of Asian region. While the reasons for this are many, the countries in the region are moving gradually through the process of accomplishing the objectives of ecosystem approach by adapting spatial management, fisheries refugia and bycatch reduction. Even this process is facing several challenges like information needs, compliance and political will, to name a few. In this context, the need for sharing the knowledge, expertise and lessons learned has been keenly felt.

Based on these considerations, the Mangroves for the Future (MFF) has taken the initiative to organize a regional symposium Ecosystem Approaches to the Management and Conservation of Fisheries and Marine Biodiversity in the Asia Region for sustainable use of aquatic ecosystems including countries from south and southeast Asia. The Symposium aims to extract and examine scientific information and knowledge that fill important gaps in understanding, to debate contrasting viewpoints stemming from the diversity of ideas and perceptions from stakeholders and interest groups and to seek practical and sustainable solutions to the complex problems currently being encountered. Another important goal of the symposium is to find ways to protect the interests of smallscale fishers and fishery dependent communities and the need for preferential rights for these stakeholders to be a part of management decision making, and stewardship of local resources in co-management arrangements.

The Symposium covers the following five thematic areas: (i) Coastal Ecosystems and Fisheries – Toward an Ecosystem Approach to Fisheries Management; (ii) Spatial Planning, Marine Protected Areas and Fisheries Management; (iii) Artisanal Fisheries, Livelihood and Biodiversity; (iv) Exploring the Issues of Bycatch and Bycatch Management; and (v) By-catch, Sharks, Marine Turtles and other Endangered and Threatened species. Participants were invited to share their research and experience, by submitting extended abstracts

related to the topics under the themes and presenting them for discussion at the Symposium. Thirty five abstracts covering the five themes were shortlisted for presentation by drawing experts from countries of the region, namely, Bangladesh, Cambodia, India, Indonesia, Maldives, Pakistan, Philippines, Seychelles, Sri Lanka, Thailand and Viet Nam besides experts from Abu Dhabi, Australia and China. Food Agriculture Organization (FAO), Bay of Bengal Large Marine Ecosystem Project (BoBLME), United Nations Environment Programme (UNEP), The Southeast Asian Fisheries Development Center (SEAFDEC) and Central Marine Fisheries Research Institute (CMFRI) have worked in partnership with MFF to organize the regional Symposium.

The design of the Symposium is paper presentations, followed by panel discussion under each theme. Considerable time has been allotted for panel discussion in each theme, facilitating exchange of thoughts and sharing the experiences. From the discussions, recommendations will be finalized, which will be shared with the regional partners and countries to plan the way forward.

The Symposium will be conducted in Hotel Gateway, Kochi, India during October 27-30, 2013. This Book of Extended Abstracts, released during the Symposium, consists of 35 abstracts in five themes. We thank all the partnering institutions, keynote speakers, presenters, observers and rapporteurs for their excellent contribution and support. The support extended for preparation of the Book of Extended Abstracts by the scientists of CMFRI Drs P.U. Zacharia, K.K. Joshi and Rekha J. Nair is gratefully acknowledged.

We are confident that the Book will be an important step to develop and implement sophisticated management plans for sustainability of coastal and marine fisheries and conservation of biodiversity in the region.

Kochi, India
October 27, 2013

Editors
E. Vivekanandan
Maeve Nightingale
N.M. Ishwar

Contents

Introduction

Ecosystem approaches to the management and conservation of the fisheries and marine biodiversity in the Asia Region

Background

Coastal fisheries and their associated ecosystems have encountered dramatic changes in recent decades in South and Southeast Asia, in particular changes arising from the introduction of motorized and highly productive fishing gear. This expanded use of capital-intensive technologies has created region-wide problems of over-exploitation of the resource base and includes significant by-catch (i.e. non-targeted fish and other animals that are intentionally caught in fishing and then discarded or retained). Habitat destruction and over exploitation of fisheries are considered two of the greatest and most pervasive threats to the balance of coastal ecosystems today. There is growing consensus that approaches for effective fisheries management, adopt an ecosystem based approach.

Mangroves for the Future (MFF) is a regional partnership based initiative promoting investment in coastal ecosystems for sustainable development. MFF promotes healthy coastal ecosystems for a more prosperous and secure future for coastal communities. Within this context the linkages between coastal ecosystems, fisheries and human well-being are of direct interest and importance to MFF. In light of the concerns for coastal fisheries MFF's Regional Steering Committee endorsed the recommendation of the National Coordinating Body (NCB) of India to hold a regional expert meeting to explore ecosystem based approaches to management and conservation of fisheries and marine biodiversity in the Asia region.

MFF and the NCB India, Ministry of Forests, Government of India, will host the symposium in partnership with Food Agriculture Organization (FAO), Bay of Bengal Large Marine Ecosystem Project (BoBLME), United Nations Environment Programme (UNEP), The Southeast Asian Fisheries Development Center (SEAFDEC) and Central Marine Fisheries Research Institute (CMFRI). Experts from more than 12 countries will be attending the Symposium.

The main theme of the Symposium is based on the 1995 FAO Code of Conduct for Responsible Fisheries (the Code), which calls for "the sustainable use of aquatic ecosystems and requires that fishing be conducted with due regard for the environment and promoting the maintenance, safeguarding and conservation of biodiversity of ecosystems by minimizing fisheries impacts on non-target species and the ecosystems in general".

This is the first regional collaboration that MFF has undertaken that deals directly with the issues of sustainable fisheries management, and paves the way for future regional and inter-organizational partnerships for practical action and policy influence. The MFF Secretariat will publish the Symposium Proceedings, which will include recommendations on good practices and an analysis of region-wide experiences. It will also include an "Action Statement" and scholarly contributions from participants.

Aims and Purpose

The Symposium aims to explore ecosystems approaches to management and conservation of fisheries and marine biodiversity in the South and Southeast Asia Region. It will draw out knowledge and share lessons and practical science based solutions for tackling these complex issues, to achieve sustainable fisheries. The Symposium discussions will explore multiple and integrated management measures, including spatial and temporal protection options. It will examine the adaptation of conventional fisheries management approaches, recognizing the wider interactions between fisheries and the ecosystem as a whole. The Symposium will not focus on cutting edge science already in the public domain but on drawing out and making available, practical experience and unpublished data important for filling information gaps and identifying practical solutions and actions. The Symposium will also present emerging recommendations from the recent APFIC workshop for the development of guidelines for tropical trawl fisheries. The Symposium proceedings will include major discussion points and recommendations and will identify practical actions for future collaborations between partners local to regional policy influence.

Date and Venue

The inaugural session will be held on 27 October at the Taj Malabar, Cochin, Kerala; the symposium will take place over three days, 28 – 30 October, at the Taj Gateway Hotel, Cochin, Kerala. There will be an optional field trip on 31 October – 1 November to Kollam, Kerala.

Participants

International participants (from MFF member and outreach countries; experts from FAO, BOBLME, UNEP and SEAFDEC; selected MFF partners) and national (India) participants will be invited. 30 international participants from over 12 countries and 30 national participants are expected to attend.

Scope

MFF bridges the gap between fisheries scientists and fisheries management practitioners in order to achieve greater understanding and willingness for collaboration between the environmental and fisheries sectors. This will also ensure that the perspectives of the small scale fishers are well represented in the debate.

The focus of the symposium is to explore ecosystem approaches for the management and conservation of fisheries and marine diversity. Discussions will probe practical and science based solutions for achieving sustainable fisheries, exploring multiple and integrated management measures, including spatial and temporal protection measures, as well as conventional fisheries management approaches, recognizing the wider interactions between fisheries and the ecosystem as a whole.

Themes for the symposium include:

1. Coastal Ecosystems and Fisheries – Towards and Ecosystem Approach to Fisheries management
2. Spatial Planning, Marine Protected Areas and Fisheries Management
3. Artisanal fisheries, Livelihood and Biodiversity
4. Exploring the Issues of Bycatch and Bycatch Management
5. By-catch, sharks, marine turtles and other endangered and threatened species

Organization

An Organizing Committee is formed to provide overall management of logistics related to the symposium. MFF India, through the IUCN India Office, is the lead of this committee.

A Scientific Committee is formed from a panel of experts to decide on the acceptance of papers, presentations, posters and proceedings of the symposium. The Scientific Committee is also tasked to arrange the programme of the symposium. The Senior Advisor, Dr. E. Vivekanandan from CMFRI, is the lead and focal point for this committee.

Field Trip

Chinese fishing nets in the backwaters of Kochi

A field visit to Kollam will be undertaken on 31st October and 1st November, 2013. This will include a visit to Ashtamudi Lake, the second largest estuarine system and deepest lake in Kerala. The lake is of extraordinary importance for its hydrological functions, biodiversity and number of livelihoods it supports. It was designated a Wetlands of International Importance by the Ramsar Convention in 2002. The site supports numerous mangrove species, over 40 associated plant species, more than 57 species of birds including six migratory species. Nearly 100 different species support the dynamic fishing industry on which thousands of fishermen directly depend. Population density, urban pressures, industrial and domestic pollution, sand-mining and conservation of natural habitat for development purposes, all pose a threat to Ashtamudi.

The field trip will also include a visit to two of the largest seaside fishing ports in India, Neendakara and Sakthikulangara. Both fishing ports are scenically located in Kollam, in close proximity to the Ashtamudi Lake.

Ecosystem approaches to the management and conservation of fisheries and marine biodiversity in the Asia Region

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'Ecosystem-based Management', or the 'Ecosystem Approach', involves the management of resources that promotes conservation and sustainable use in an equitable way. The use of ecosystem approaches is now globally recognised as the basis for capture fisheries management. It represents a move away from traditional fisheries management systems that focus on the sustainable harvest of target species, to integrated systems and decision-making processes that balance environmental well-being with human and social well-being, and promote strong governance.

In 1995, FAO published the 'Code of Conduct for Responsible Fisheries' which sets out the principles and international standards of behaviour for responsible fishing practices. This was followed in 2003 by FAO's "Technical Guidelines for Responsible Fisheries: The Ecosystem Approach to Fisheries", and a substantial range of other guidance materials from FAO and other institutions.

However, despite more than a decade having passed since its inception, there is still much work to be done to successfully apply the ecosystem approach to the management of international and national fisheries and, to realize the anticipated positive impacts relating to the conservation of resources and biodiversity.

The Ecosystem Approach to Fisheries allows for more inclusive and equitable fisheries and coastal marine resource planning and decision making, more transparent planning, and increased equity in the use of coastal resources. It recognizes cultural and traditional values, protects the fishing sector from the impacts of other sectors and vice versa; and it generates increased political and stakeholder support. It also provides a way to consider large-scale, long-term issues (e.g. climate change).

The Ecosystem Approach to Fisheries also promotes sustainable development i.e. development which meets the needs of the present without compromising the ability of future generations to meet their own needs, by balancing ecological and human well-being and supporting good governance (Fig. 1). It is a practical way to implement sustainable development principles for the management of fisheries and to fully implement the Code of Conduct for Responsible Fisheries. It is also a framework for risk based analysis that can assist managers make tradeoffs between the human, social, ecological and environmental elements of sustainability. Importantly, it can be used in data poor situations as it is precautionary and adaptive.

Fig. 1: The Ecosystem Approach to Fisheries (EAF) diagram

This presentation intends to emphasise further, with regard to the important "scaling issue" of any 'Fisheries Management Unit' that an ecosystem approach can also be taken to manage a rather broadly defined resource, e.g. the hilsa shad or Indian mackerel fisheries of the Bay of Bengal, in addition to taking a geographical, political or other spatial approach, or on the basis of a gear type.

Under the regional objective "fisheries and other marine living resources are restored and managed sustainably", the eight countries participating in the Bay of Bengal Large Marine Ecosystem (BOBLME) Project have produced fisheries advisories for Hilsa shad or Indian mackerel in the Bay of Bengal that incorporate the ecosystem approach. These advisories have been produced by a "Regional Fisheries Management Advisory Committee", which itself receives information from technical working groups on topics such as: the biological status of hilsa/Indian mackerel (regional stock); the impact the fishery is having on the environment, the impact the fishery is having on endangered, threatened and protected species; the impact the fishery is having on other species; the external factors that threaten the fishery; and the socio-economic and governance issues.

In response to the need for regional capacity development, expressed by representatives of fisheries agencies and institutions within the wider Asia-Pacific region through inter-governmental and regional fisheries bodies such as the Asia-Pacific Fisheries Commission

(APFIC), the Coral Triangle Initiative (CTI), and an ASEAN-SEAFDEC Ministerial Resolution, a training development partnership, consisting of BOBLME and collaboration partners APFIC, CTI, USAID and NOAA developed a one-week training course on EAF, entitled "Essential Ecosystem Approach to Fisheries Management" (E EAFM).

The E EAFM training course is structured into 18 modules, spread over 5 days. It covers basic topics such as why we need EAFM, and what exactly EAFM is. The course provides basic knowledge on the EAFM process and a framework for decision-making for responsible and sustainable capture fisheries management. Trainees learn about EAFM principles and concepts and use an EAFM plan template to develop a draft fisheries management plan. They also learn the principles of co-management and how to foster cross-sector coordination; and practise the crucial skills of effective communication, facilitation and conflict management.

The course is designed to be highly participatory with a range of exercises designed to consolidate learning. The course comprises 5 steps relating to planning, doing and checking and improving (Fig. 2).

Fig. 2. The 5 steps of EAFM

This Essential EAFM Course addresses mid-level managers and fishery and environment agency staff, as well as related economic development and planning staff, at the provincial / state and district / local levels, who are responsible for administrating or managing fisheries and the marine environment in which they operate. Training is supplemented with "training-of-trainers", and it is expected that with the roll-out of the training in early 2014 that large numbers of 'practitioners' will be trained and that the EAFM will be better understood and more widely adopted.

A typical fishing family in the Sundarbans, West Bengal

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Coastal and marine biodiversity conservation in India

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India's coastline holds many biological treasures. Handsome mangrove forests of Sundarbans, the world's largest congregations of nesting turtles in Odisha, beautiful seagrass beds in Palk Bay, enigmatic sea cows in the Gulf of Mannar, majestic yet gentle whale sharks in the Gulf of Kachchh and some of the world's most beautiful and striking coral reefs are examples of the some of the biological treasures of India's coastal and marine biodiversity. Besides being store houses of biological diversity, coastal regions are also home to a large human population. However, due to industralisation and urbanization, these ecosystems are under pressure. Global climate change is likely to put them under additional stress. Sustainable development of coastal and marine ecosystems may reduce the pressure on them and also help in preserving biological diversity.

Indian coastal ecosystems comprising mudflats, sandy and rocky beaches, estuaries, creeks, mangroves, coral reefs, marshes, lagoon and seagrass beds extend to approximately 42,808 km^2. They are known for their high biological productivity, which provide a wide range of habitat for many aquatic flora and fauna. The Indian coasts support about 30% of the total 1.2 billion human population. Several major cities, including some of the largest and most densely populated urban mega-agglomerations (eg.Mumbai, Kolkata, Chennai, Kochi and Visakhapattanam) are located on the coast. Activities such as fishing, ports, agriculture, oil and mineral exploitation contribute significantly to India's economy.

Major anthropogenic direct drivers of ecosystem degradation and destruction include habitat conversion to other forms of land use, overexploitation of species and associated destructive harvesting practices, spread of invasive alien species, and the impacts of pollution from agricultural, domestic and industrial effluents. In this paper, the major issues related to coastal and marine biodiversity conservation and measures taken to address them have been highlighted.

Corals: The extent of coral cover in Indian seas is 2375 km^2. Reefs provide economic security to the communities who live alongside them. Traditional fishers and people whose livelihood is dependent on the reef perceive reefs as a source of food and revenue. They also perceive the reef as a defense against erosion caused by ocean waves. Diverse human activities such as runoff and sedimentation from developmental activities, eutrophication from sewage and agriculture, physical impact of maritime activities, dredging, destructive fishing practices, pollution from industrial sources and oil refineries have emerged as threats to the coral reefs. Among natural threats, storms, waves and particularly cyclones are major stresses on corals. Another major challenge for sustainability of corals reefs is warming and acidification of seawater. As the reefs were common property, often conflicts in resource use were witnessed. Later, protection of all species of corals under Wildlife (Protection) Act 1972 and declaration of Marine Protected Areas and National Parks effectively reduced exploitation of corals. After the implementation of protection measures, the corals reefs are stated to be recovering from their status in the 1960s.

Mangroves: As per the State of Forest Report 2011, published by Forest Survey of India, the mangrove cover in the country stands at 4662.56 km^2. Compared with 2009 assessment, there has been a net increase of 23.34 km^2 in the mangrove cover of the country. This can be attributed to increased plantations in coastal States and regeneration of natural mangrove areas in the country. Mangrove ecosystems provide a life support system and income for people who use various Non Timber Forest Produces from them. In general the mangroves are resistant to environmental perturbations and stresses. However, mangrove species are sensitive to excessive siltation or sedimentation, stagnation, surface water impoundment and major oil spills. Salinities high enough to kill mangroves result from reductions in freshwater inflow and alterations in flushing patterns from dams, dredging and bulk heading. Seawalls, bunds and other coastal structures often restrict tidal flow, which is detrimental to the mangroves. In India, mangrove plantation programmes have been taken up, which are helpful in expanding the mangrove cover. The large expanse of inter-tidal mudflats (23,621 km^2) may provide scope of adjustment and adaptation in some areas, mostly in the semi-arid region.

Seagrass: Seagrass ecosystem provides a sheltered, nutrient rich habitat for diverse flora and fauna. The habitat complexity within seagrass beds enhances the diversity and abundance of animals. There are several reports of reduction in the spread of seagrass meadows along the Indian coasts. Several causes have been attributed for the deterioration of seagrass beds. Eutrophication, siltation, trawling, coastal engineering constructions and removal for commercial purposes are the major threats for seagrass beds. Seagrass occurs in shallow water bodies below the low tide line and since water bodies are not brought under regulations, the CRZ notification is ineffective to protect sea grass beds.

Seaweeds: Along the Indian coast, about 770 species of seaweeds are distributed, of this 184 species are green, 166 are brown and 420 are red algae. The estimated standing stock (wet weight) is about 541,340 t. Seaweeds are excellent breeding grounds for marine organisms, and are important as food for humans, feed for animals, fertilizer for plants, and for pharmaceutical purposes. Collection of wild seaweeds by the coastal population has reduced the seaweed cover over the years. Farming of seaweeds has become popular and is livelihood for coastal population in the Palk Bay and Gulf of Mannar (southeast coast of India).

Whaleshark: Until 2000, the whaleshark was exploited by unregulated and unsustainable fisheries to meet international trade demands for shark fins, liver oil, skin and meat. In July 2001, the whale shark was included in Schedule I of Indian Wildlife (Protection) Act, 1972, thus giving whaleshark protection and making it the first marine fish to be listed in the aforesaid Act. The whaleshark campaign has spread awareness on the species and the protected status in Gujarat (northwest coast of India). It helped convert the fishermen into protectors of the fish and brought about a change in the perception and attitude of local people.

Marine turtles: Of the seven species of turtles that occur in the world five breed along the Indian coasts. Among these, mass nesting of olive ridley occurs along Odisha coast (east coast of India) every year. Government of India is taking strict actions to protect the marine turtles under the Indian Wildlife (Protection) Act (1972), and in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna & Flora (CITIES). Fishing is prohibited during the mass nesting period of the olive ridley along the Odisha coast. Beach hatcheries are also in place in a few locations.

Marine mammals: All species of marine mammals along the Indian coasts are protected under the Indian (Wildlife) Protection Act (1972). However, they continue to be affected by incidental capture in fishing operations. The population of dugong has reduced to low levels over the years.

Sea cucumbers: As sea cucumbers were collected in large numbers and exported, the government prohibited the activity under Schedule I of the Wild Life (Protection) Act 1972. Central Marine Fisheries Research Institute has developed breeding techniques for sea cucumbers, enhancing the potential for sea ranching the seed for stock improvement as well as for establishing commercial hatcheries.

Marine Protected Areas (MPAs): India has 33 coastal and marine protected areas and 3 marine bioreserves, with a total area of 5,319 km^2. The protected areas cover less than 1.3% of the Indian coast.

Fishing: While India is moving from open access fishery towards regulated fishery, several issues remain to be addressed. Overfishing and habitat degradation are emerging concerns associated with fisheries. These factors jointly affect fish stock biomass as well as biodiversity of ecosystems. Fishing and pollution are perceived as two major threats to coastal and marine biodiversity in the country. Marine Fishing Regulation Acts (MFRA) and Comprehensive Fishing Policy are two major instruments aimed at regulating fishing operations to sustain the fisheries as well as biodiversity. Cap on the number of mechanized boats, seasonal closure of fishing, spatial fishing restrictions, mesh size regulation, use of bycatch reduction devices (BRD) and turtle excluder device (TED) are followed, but implementation of these measures remains as a challenge.

Coastal management policies: Under Environment Protection Act (1986), the Government of India has notified the Coastal Regulation Zone (CRZ) Notification, 2011. Accordingly there are four coastal management zones: (i) CRZ 1 consists of ecologically sensitive areas (mangroves, coral and coral reef associated biodiversity, sand dunes, mudflats, national parks, marine parks, sanctuaries, reserve forests, wildlife habitats, biosphere reserves, salt marshes, turtle nesting grounds, horseshoe crab habitats, seagrass beds and nesting grounds of birds), and the geomorphological features that play a primary role in maintaining the integrity of the coast. No new construction shall be permitted in CRZ I in the ecologically sensitive areas. (ii) CRZ II consists of areas which are developed up to or close to the shoreline and falling within government administrative limits. (iii) CRZ III consists of all other open areas including the coastal seas but excluding those areas classified as CRZ-I, CRZ-II and CRZ -IV. (iv) CRZ IV consists of islands of the Andaman and Nicobar and Lakshadweep.

Present day plans targeting marine resources continue to be oriented towards their optimal utilization. The concerns raised by fishermen organizations and environmental groups regarding development need to be examined and participatory decision making strengthened. Coastal areas are contested spaces and strong policies are required to safeguard the interests of the millions of stakeholders who occupy these areas and dependent on the resources. The need for ecosystem approach to management of fisheries and biodiversity is being increasingly realized and adopted.

Importance of considering reproductive characteristics for management of marine fisheries

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The status of fish stocks in relation to fishing may differ from one area to another. For example, FAO'S RAP Publication in 2010 reports that pelagic fishes and squids remain unexploited along the northeast coast of India but overexploited along the southeast coast. Hence adapting different strategies for spatial management of marine fishes has become important. Besides assessing stock status, this paper demonstrates the importance of integrating critical reproductive characteristics into the plan for management and conservation of marine fisheries and ecosystems, as well.

Overexploited fish population display symptoms including;
1. Decrease in female to male ratio,
2. Advancements in age and/or size at sexual maturity,
3. Changes in fecundity in gonochoristic (bisexual) fishes, and
4. Decrease in Reproductive Life Spans (RLS) by precocious sexual maturity and female to male sex change in protogynic hermaphroditic fishes. Consequent to these changes in reproductive characteristics, the spawning stock biomass (SSB) is decreased leading to depletion and collapse of a stock or species of fishes.

A few examples of the impacts of overfishing on fish reproduction have been collected from peer-reviewed publications and consolidated here. Advancing age at sexual maturity (ASM), say, from nine months during 1978-1981 to eight months during 2002-2005 in the threadfin bream *Nemipterus japonicus* off Chennai (southeast coast of India) reduces the time window for storage of adequate nutrients to meet the cost of vitellogenesis. Decreased size at sexual maturity (SSM) reduces the space availability within the body cavity to accommodate the ripening ovaries and hydrated oocytes. Oocyte hydration is a critical event in pelagic spawners, whose ovulated oocytes are hydrated prior to spawning. For instance, an ovulated oocyte

of the cod *Gadus morhua* is hydrated 8.2 times in volume and 7.2 times in weight before it is spawned. Oocyte hydration in pelagic spawners induces spawning stress, resulting in sex specific mortality. For example, the female ratio of the fast growing (30 kg in 3 years) tropical pelagic dolphinfish *Coryphaena hippurus* decreases from 0.75 in a young female (25 cm) population to 0.25 in a large (150 cm) female. Experimental rearing of *G. morhua* has provided evidence for the spawning stress-induced female mortality.

The advance sexual maturity (ASM) of the Northeast Arctic cod was advanced from 10 year in 1940 to 7 year in 2000 and SSM from 100 cm to 75 cm. ASM of *N. japonicus* in the Bay of Bengal was also advanced from 38 g during 1978-1981 to 28 g during 2002-2005, the decrease amounting to 0.4 g/year. While the ASM and/or SSM advance, the fecundity and egg size respond the following ways: (a) the fecundity decreases as in the European hake *Meruluccias meruluccias*, or (b) the egg size decreases, as in *G. morhua* or (c) both the egg number and size decrease, as in the roughy *Hoplotesthus atlanticus*. Consequent upon spawning stress-induced mortality in pelagic spawners, advancements of ASM/SSM and decreased fecundity, the SSB also decreases. For example, the SSB of the overexploited Baltic cod decreased from 50,000 females in 1970 to 18,000 in 2008, and in turn, the recruitment decreased from 200,000 in 1971 to 75,000 in 2009. Some of the negative effects of over-exploitation on reproductive parameters of gonochoristic fishes are summarized in Table 1.

In female to male sex changing protogynics, the male ratio ranges from 0.06 in *Mycteroperca bonaci* to 0.37 in *Epinephelus aakara*. Within a species like the black grouper *M. bonaci*, there are 15 females for every male in Florida, 30 in Cuba and 77 in Mexico. The differences in male ratios of protogynics and other unique reproductive characteristics will induce the fish to respond differently from other species to fishing impacts.

Irrespective of these differences, the protogynics economize male and sperm availability by behavioral acts like the spawning aggregation. However, the longer residency of such spawning aggregation in a particular site increases the vulnerability of reproductively active parents. Analyses of limited number of publications have shown that overexploitation (i) reduces not only male biomass but also female biomass, and also (ii) reduces the reproductive life span to 56% in female and 83% in male through precocious sexual maturity and sex change. Some of these negative effects of overexploitation on reproductive parameters of protogynic fishes are summarized in Table 1.

The location and species-specific differences in reproductive characteristics of marine fishes emplasizes the need for accumulation of data on reproductive characteristics. This data in turn needs to be considered whilst developing plans for fisheries and ecosystem management.

Table 1 Effects of overexploitation on reproductive potential of in gonochoristic and protogynic fishes

Group characteristics	**Reported/inferred changes**
	Gonochoristic fishes
Small, Short life span, Lecithotrophic, Non-superfetatious e.g. *Poecilia reticulata*	1. Advances age at sexual maturity 2. Increases RLS 3. Increases progeny output
Large, Long living, Determinate fecundity, e.g. *Hoplostethus atlanticus*	1. Advances size at sexual maturity 2. Reduces RLS , 3. Reduces fecundity 4. Reduces egg size
Large, Releatively short life span, Determinate fecundity, Hydrated pelagic eggs e.g. *Coryphaena hippurus*	1. Reduction in RLS due to spawning stress-induced mortality, 2. Reduced fecundity
Large indeterminate fecundity,Income breeder, Hydrated pelagic eggs, e.g. *Merluccius merlucccius*	1. Advances size at maturity? 2. Reduces daily egg production
Large, Releatively long life span, Low capital breeder, Determinate fecundity, Hydrated pelagic eggs e.g. *Gadus morhua*	1. Advances age at sexual maturity by 2-3 yr 2. Reduces age diversity 3. Decreases RLS due to spawning stress-induced mortality 4. Reduces SSB
	Protogynic fishes
Low income breeders, Hydrated pelagic eggs e.g.,*Pagrus pagrus, Mycteroperca microlepis*	1. Reduction mean size of landed fish indicating of large females with high fecundity are lost e.g 0.4kg/porgy and 4 yrs in porgy, 17 cm in grouper 2. Advance age and/or size at maturity, e.g. by 0.5 yr and 5.5 cm in grouper and 5 cm in porgy 3. Consequently, RLS of female is reduced by 44 % in grouper and 5 cm growth period in porgy. RLS of male is also reduced by 17% 4. Significant reduction in female stock biomass, e.g. reduction to 20% in porgy and corresponding reduction in fecundity 5. Significant reduction in male number

Collecting clams in the Mandovi estuary, Goa © NIO

Status of fisheries refugia and its contribution to fisheries governance and coastal fisheries ecosystem in Cambodia

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Coastal fisheries in Cambodia contribute to livelihoods of fishing communities providing food and nutrition, employment, trade, income and economic growth. However these resources are under pressure, increasingly threatened by human interferences, natural disaster and climate change. Coastal and marine ecosystems like seagrass beds, coral reefs, endangered species, and marine diversity, in general, are affected by coastal development, pollution, habitats destruction, unsustainable and destructive fishing operations, sand mining, ocean exploitation and global trade pressures. In eliminating such pressures/threats and reversing decline of coastal fisheries resources, fisheries sector has been reforming under intervention of the government aimed at healthy fisheries ecosystem and fish for people. The main approaches , in this are sustainable fishing operations, fisheries co-management by delegating the right to the small-scale fishing communities, enhancement and rehabilitation of ecosystem and fisheries resources, promoting other fisheries related activities and building capacities of different stakeholders in fisheries. Through this national conservation areas and community fisheries conservation areas have been established. Fish refugia has been recognised as an effective approach ensuring recovery of fisheries resources and reduce conflict among different fishing operators. The fisheries governance is now based on top-down and bottom-up approaches.

Policy

- Rectangular Strategy for "Growth, Employment, Equity, and Efficiency", and National Strategy Development Plan of the 5th Mandate of the RGC are an opportunity to integrate the sustainability of fisheries, water and land management, energy needs and agriculture sector with a green economic approach and sustainable livelihoods framework
- Reform in fisheries sector

Legal Status

- Law on fisheries

- Sub-decree on the establishment of community fisheries, and other related regulation
- Other legal instruments

Strategy and Plan

- The strategic Planning Framework for Fisheries: 2010-2019
- CAMCODE: Cambodia Code of Conduct for Responsible Fisheries
- Annual Fisheries Administration Plan

Mechanism

- National committee on management and conservation of fisheries recourse
- Co-management: Decentralized- fisheries management based community fisheries
- Technical working group on Fisheries
- District/commune development plan
- Join activities between fisheries administration and NGOs
- Regional/ International cooperation

Fishing communities have been given an opportunity to officially establish Community Fisheries (CFi) for management of fishing grounds and sustainable use of fisheries resources. So far 516 CFi's have been established, of which 39 are coastal CFi's. The coastal CFi's with their own fish refugia areas (Table 1), play an important role in the protection of coastal diversity as well as endangered marine species, such as marine turtles, dugong, dolphin and seahorse among others. While it is difficult and time-consuming to create fisheries conservation areas, it is easier and faster to make fisheries refugia with the support of fishing communities, which means that bottom-up approach may be effective and faster.

Table 1. Fisheries refugia established along the coastal province of Cambodia

Refugia for	Size (ha)	Number of refugia
Blood cockle	144	1
Mud crab	35	2
Fingerlings	263	1
Violet vinegar crab	630	3
Total	1,072	7

For coastal fisheries management and conservation, the concept of ecosystem approach to fisheries management has been introduced through a SEAFDEC project, and guided on the process of Establishment and Management of Fisheries Refugia under the Fisheries Administration in collaboration with UNEP/GEF South China Sea Project. In addition to sustainable use of fisheries resources a need for, good fisheries governance has been introduced, which is similar to the activities related to building the ecosystem approach to fisheries at the sub-national level. An example on the status of management and conservation in Preah Sihanouk province is given in Table 2.

Table 2. Status of management and conservation in Preah Sihanouk province

Type of ecosystem	Area (ha)	Status of management and conservation
Coral reef	1,198	Law on fisheries identified these ecosystems as protection and conservation areas
Seagrass	1,000	The Strategic Planning Framework for Fisheries includes targets for at least 7,000ha of seagrass and 840ha of coral reef to be under an appropriate form of protection and 1,000ha of mangrove to be rehabilitated by 2019
Mangrove	13,500	National Action Plan for Coral Reef and Seagrass Management in Cambodia aims to put at least 840ha of coral reefs and 9,000 ha of seagrass under an appropriate form of sustainable management by 2016.

Part of these ecosystems has been converted into fisheries conservation areas and fisheries refugia for management by marine/coastal Communities. The process of establishing this approach is given in Table 3.

Table 3. Process of establishing fisheries conservation areas

Result	Promoter	Purpose
16 fisheries community areas established	Fisheries Administration and Preah Sihanouk Provincial Governor	Better management of marine fisheries resources and habitat ecosystem
3 national marine fisheries management areas for protection of coral reef, seagrass and mangrove (410 km^2)	Fisheries Administration and Preah Sihanouk Provincial Governor, FFI, PEMSEA, Coral Cay Conservation, Marine Conservation Cambodia	Preparation of legal framework to support the establishment, creation and application of co-management system, conducting research and inventory of the resources, production of resource map, preparation of management zone, demarcation and law enforcement, capacity building capacity and public awareness.

The challenges of implementing fisheries refugia are as follows:

- Poor awareness of ecosystem approach to fisheries among fisheries administrators and partners. There is no information and guidance documents in relation to ecosystem approach in Khmer version
- Conflict between users who are protectors and not protectors of fisheries resources
- Problem in fisheries governance due to overlap of mandate between fisheries and other sectors.

Coastal fisheries management is under the frame of national and international initiatives in combination with community based decentralized- arrangement. Currently, there is a strong focus on the right of small-scale fishers involving them in management and conservation based on their own-decision making. From the policy reform, large areas of fishing grounds have been allotted to fishing community for engagement, management and conservation,

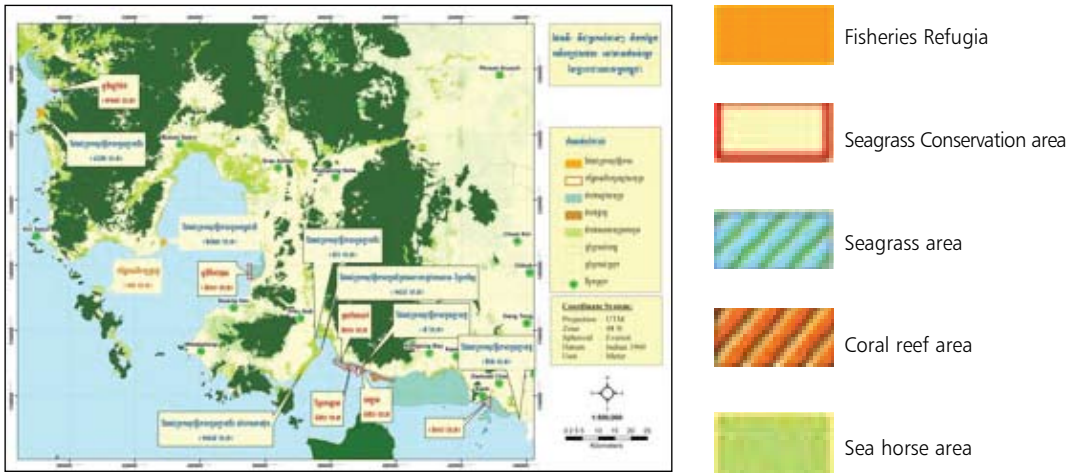

Fig. 1. Fisheries refugia and conservation areas in Cambodia coastal zone

and these have been identified as fish conservation area and fisheries refugium, and are under the management of the state and community fisheries, in collaboration with local authority, NGOs and other stakeholders. The concept of EAF (fish refugia) is at present implemented on a limited scale with the help of FiA's officials, community fisheries committee and stakeholders. The concept of fisheries refugia is included in training programmes related to fisheries co-management, but it is still not comprehensive. Nevertheless, it has provided a clear understanding among the stakeholders. There is a need to have a good programme in promotion of fisheries refugia. Based on short-term experiences, it is found that fisheries refugia is an effective approach to sustain fisheries resources and also not very difficult to manage. Establishment of fish refugia within the community fisheries' territory is much faster and low cost compared to the establishment of fisheries conservation area or refugia to be managed by the provincial fisheries administration.

In order to promote EAF among practitioners, it is necessary to focus on the following:

- Building understanding on fisheries refugia to practitioners in fisheries, develop EAF materials and other related capacity supporting to identification of fisheries refugia
- Good fisheries governance for fisheries and other agencies to avoid trade-off by other sectors.
- Setting up a mechanism to assess the effectiveness of EAF
- Providing support to small-scale fishing community through existing community fisheries
- Establishing more fisheries refugia based community fisheries organization
- Formulating supportive policy and strategy on fisheries refugia.

Towards an ecosystem approach to fisheries management in India - case study of the Ashtamudi Lake yellow-foot clam fishery

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Conserving marine resources and managing fisheries have been put in an ecosystem perspective in many parts of the world for some time now. The Ecosystem Approach to Fisheries (EAF) and its many variants as enunciated by the FAO differs from most fisheries or environmental policies, which tend to focus on single species or habitats, in that the interconnectedness of ecological, social, and economic parameters for developing local and regional management of an ecosystem is explicitly recognized. Despite the soundness of the concept of EAF, there are only a few successful examples of well managed fisheries using the approach. Even when EAF is ecologically and institutionally attainable, multiple problems can arise from competing interests among stakeholders, undeveloped or inappropriate governance structures, poor science, or lack of political will. The situation is perhaps more complex in the tropics due to the large number of co-occurring species, gears and fishers. In the developing world, this is compounded by the lack of a governance structure, and in places where they do exist, the lack of its implementation.

The guiding principles for EAF as given by FAO include the following six points and these have been adapted by many countries.

1. Application of the **precautionary approach**, implying that where there are threats of serious irreversible damage, the lack of full scientific knowledge shall not be used as a reason for postponing or failing to take measures to prevent environmental degradation.

2. The need of moving towards **adaptive management systems**, given the complexity and dynamics of ecosystems and society and the difficulty in predicting outcomes of different management measures.

3. The **principle of compatibility** stresses the importance of coherence of management measures across the resource/ecosystem range. Related to this is the need to collaborate at the regional level, when resources and ecosystems are transboundary (CCRF, Article 6.12).

4. The **principle of participation** is reflected in most recent international instruments, requiring that stakeholders be more closely associated with the management process, data collection, knowledge building, option analysis, decision making and implementation.

5. Using **incentives**, as compared to being prescriptive, is another guiding principle in the application of EAF. Conventional fisheries management is largely built on developing norms and punishing those who do not comply (negative incentives).

6. Coordination and **harmonization across sectors** (sectoral integration) are needed for a successful application of EAF.

In India, there are several legislations which directly impinge and/or touch upon marine fisheries management both at the level of the central and state governments. However, a clear governance structure has not been articulated. In 2004, India brought forth a comprehensive marine fisheries policy in which the concept of ecosystem based fisheries management was mooted. Eight years later, the guidance and framework of this approach has not been developed. Recently, the Central Marine Fisheries Research Institute (CMFRI) is considering the development of a National Marine Fisheries Management Code which would address EAF. Currently, India partly addresses point number one of the EAF guiding principles. Recent recommendations of an expert committee appointed by the Government of Kerala (southwestern part of India) gives guidance on fulfilling point 4 and 5 of the FAO EAF principles. The newly developed Ashtamudi Lake Clam Fisheries Management Plan (CFMP) does take in hand some of the EAF principles and is presented here as a case study.

Ashtamudi Lake is the second largest lake- estuary of Kerala. Small-scale clam fishery forms the livelihood of more than 500 families in and around the estuary. Clams are fished throughout the year except during unfavourable environmental conditions or during fishing ban periods. Initiation of frozen clam meat export, particularly short- neck clam, *Paphia malabarica* in 1981 led to increased fishing effort for clam exploitation, leading to catch declines. The alarming increase in the exploitation of clams in the following years forced the local administration to impose a ban on the fishing activities during the clam breeding season and also place restriction on the mesh size of clam dredges based on the recommendations of CMFRI in 1993. Although, they do not form a high unit value resource, short-neck clams are exported to niche markets such as Japan fetching high value. Almost 90% of this export is sourced from the Ashtamudi Lake, and in 2009, India exported 542 tonnes of clam meat in various forms valued at US$ 0.99 million.

Let us examine how the yellow-foot clam fishery in the Ashtamudi Lake in Kerala (southwest coast of India) complies with the EAF principles and operational framework (Table 1).

Table 1. Status of EAF operationalization for Ashtamudi Lake yellow-foot clam fisheries

EAF principle	Operational Framework	Implementation Status
Precautionary approach	Fishery management plan in place	Recommended
	Target and limit reference points (TRP & LRP)	Recommended
	Mesh size limits	Practiced
	Effort control – closed season	Practiced
	Size restriction - Minimum Legal Size	Recommended
	Closed area – clam sanctuary	Recommended
Adaptive management system	Annual biomass surveys leading to recommendations to the governance council	System in place
Principle of compatibility	Linkages to other resources	To be developed
Principle of participation	Twenty member Ashtamudi Clam Fisheries Governance Council (ACFGC) with multiple stakeholder representation	Practiced
Using incentives	Negative incentives exist, positives not developed	To be developed
Sectoral integration	ACFGC provides scope for representation from multiple stakeholders apart from core sector, for example, tourism, exporters etc	Practiced

The above table indicates that many of the EAF principles are applied in the Ashtamudi Lake yellow-foot clam fisheries, but much more needs to be done. The compliance to some of the precautionary principles has ensured that the fishery is carried out in a sustainable manner for the past several years (Fig. 1).

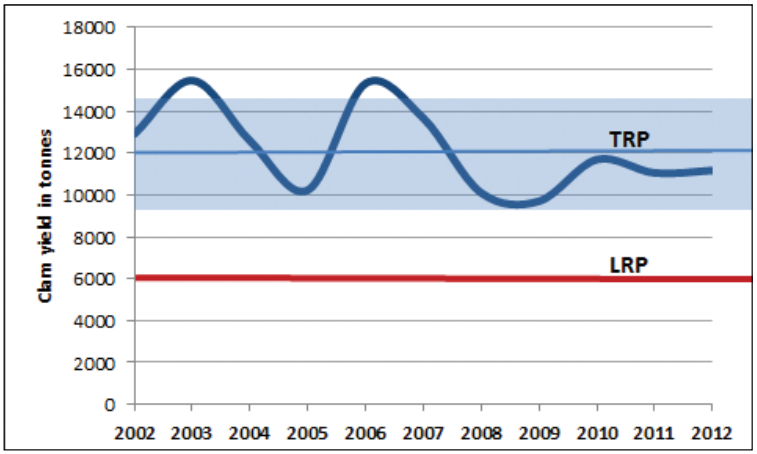

Fig.1. Catch trend of clams in Ashtamudi Lake with respect to Target Reference Point (TRP) (BMSY ± 20%) and Limit Reference Point LRP (0.5_{BMSY}). If the stock biomass falls below LRP, then target fishing must cease for a period sufficient to rebuild the stock as per the recommendations.

The formation of the governance councils proved to be tough, as the local self-governments could not comprehend the concept and its eventual benefits and also were not willing to take up the responsibility of governing the resource. Finally administrative support from the top-most district authority was necessary to form the ACFGC. A 3-tier council based on consultative participatory management system (Fig. 2) has been recommended to the state government.

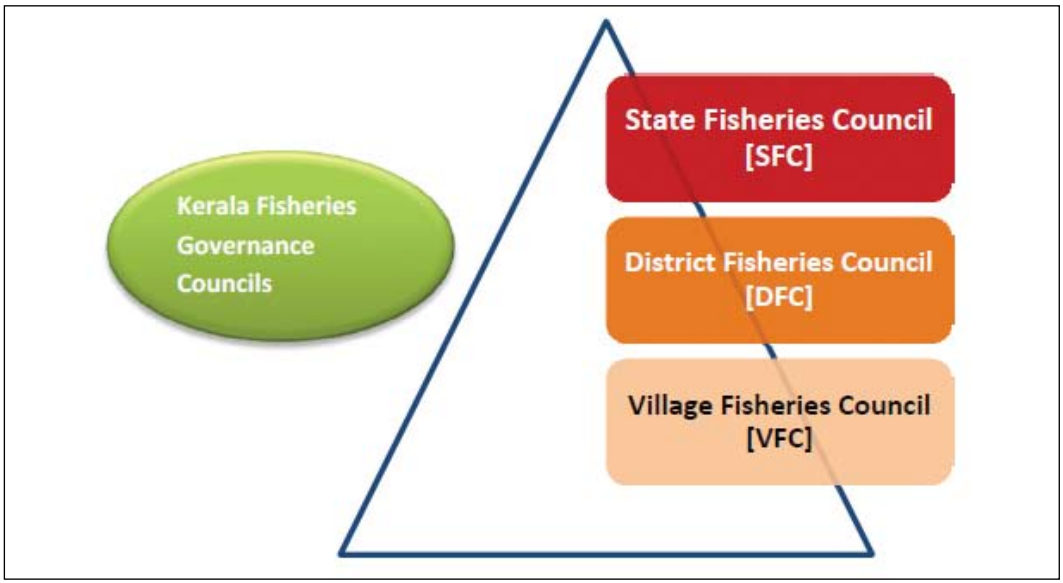

Fig. 2. Three-tier Fisheries Council proposed to be established for participatory management of clam fishery of Ashtamudi Lake

Environment impacts of undulated surf clam dredging operation in Prachaub Kirikharn Province, Thailand

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Environment impacts of experimental dredging operations for the undulated surf clam, *Paphia* spp. around Paknam-Pran and adjacent coastal area, Amphur Pranburi and Amphur Sam-roi-yod, Prachaup Khiri Khan Province, Thailand were investigated in collaboration with Department of Fisheries Thailand. From water samples, data were collected on sea surface temperature, salinity, dissolved oxygen (DO) and pH at surface layer (30 cm below sea surface). Data on nutrient parameters, *i.e.* ammonium-nitrogen (NH_4^+- N), nitrate and nitrite nitrogen (NO_2^-+NO_3^- -N), silicate-silicon ($Si(OH)_4$ – Si) and orthophosphate-phosphorus (PO_4^{3-}-P) were also collected at surface layer (30 cm below sea surface) and overlying water (50 cm above bottom sediment).

For the experiment, iron dredge, rectangular box shape, size 220 x 100 x 12 cm with dredge slit of 1.2 cm interval was used. The weight of dredge was approximately 80 kg. Eight dredging operations were conducted on six tracks.

Result shows that water quality changed by dredging operation in the following ways: Transparency reduced from 2.35 m to 0.8 m; Total Suspended Solid (TSS) during post-dredging was higher than pre-dredging from 25.50 mg/l to 10287.65 mg/l; range of dissolve oxygen concentration was higher during post-dredging than pre-dredging: Ammonium-Nitrogen (NH_4^+-N) changed in almost all stations, and ranged from 0.41 to 5.01 μM; concentration of Silicate-Silicon ($Si(OH)_4$ -Si) changed in almost all stations, and ranged from 0.90-4.15 μM; concentration of Orthophosphate-Phosphorus (PO_4^{3-}-P) changed in almost all stations, and ranged from 0.90-4.15 μM. Thus the concentration of nutrients, i.e. ammonium-nitrogen and silicate-silicon significantly increased by the dredging operations.

The most significant physical parameter impacted by dredging was increase in suspended solid. This enrichment of total suspended solids blocks oxygen exchange of marine organisms, and may cause death by hypoxia. The mortality of demersal fish due to deposition of sediment cover was also observed. However, the pelagic and fast swimming fish can escape from the turbid area. Fishers around dredging ground did not conduct demersal and pelagic fishing.

Nutrient enhancment by dredging operation directly influence the concentration of chlorophyll a. Among phytoplankton, diatom (Bacillariophyta) was dominant. The essential nutrients for diatom is $Si(OH)_4$ –Si and NH_4^+-N, which were found in extra concentrations at Ao Sam Roi Yod Bay and around Paknam Pran estuary, respectively. By combinations of these factors, there is a possibility of occurrence of red tide phenomenon during and after the surf clam dredge fishing season.

Exploratory drilling for hydrocarbon resources in the Cauvery basin of Sri Lanka: Potential impacts on artisanal fishery and fishing grounds

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The Government of Sri Lanka has identified five blocks varying from 4710 sq.km to 2146 sq.km in area in the Cauvery Basin (Fig. 1) for exploratory drilling and potential production of hydrocarbon. These blocks are located in shallow areas in the continental shelf, which are artisanal fishing grounds. The coastal area that may be affected from the dredging activities include four fisheries districts including the richest demersal fishing grounds of Sri Lanka.

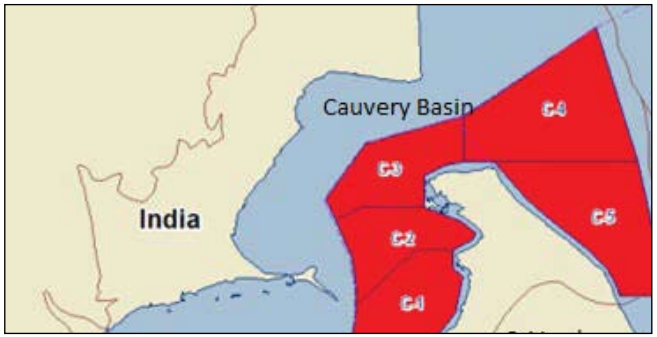

Fig 1. Areas earmarked for hydrocarbon exploration in the Cauvery Basin and their extents.

Areas selected for the hydrocarbon exploration in the Cauvery Basin

Block	Area (sq km)	Type
C-1	2,539.12	Shallow water
C-2	2,146.96	Shallow water
C-3	2,424.02	Shallow water
C-4	4,700.15	Shallow water
C-5	3,915.68	Shallow water

Exploratory activities for hydrocarbons include several activities that can affect the fishing environment, fishery resources, fish breeding grounds, fish migration and recruitment. There is a possibility of reduction in fish production affecting the livelihood and income of the fishing community living in the bordering fishing villages. There is a need to assess the present status of fisheries and potential impacts of the exploratory activities with the view of identifying possible interventions to minimize adverse impacts on fishery resources and fishing communities.

The present study is mainly based on available information, literature surveys and personal interviews. Published statistics of the Ministry of Fisheries and Ocean Resources (MOFAR),

and National Aquatic Resources Research and development Agency (NARA) were collected. Interviews with officers attached to MOFAR Head office and regional offices in Mannar and Jaffna districts were conducted. Fisheries inspectors, office bearers/ members of fisheries societies, community leaders were consulted. Selected landing sites were visited.

Four fisheries districts, namely Mannar, Jaffna, Kilinochchi and Mulltive in the northern province border the coastal area identified for the exploratory activities. The total length of the coastline is approximately 480 km and there are around 200 fishing villages. Fishing is the primary livelihood of the coastal communities in these districts. Preparation of dried fish, seaweed collection, collection of holothurians and ornamental fish trade are some of the other fishery related activities they are engaged in.

According to MOFAR (2009) the highest number of active fishermen (15,195) is recorded in Jaffna, followed by Mannar (7,900). There are 750 fishermen in Kilinochchi and Mullaithivu, majority are engaged in lagoon fishery. There is a significant reduction in the number of fishermen due to disturbances. But the fishing population is increasing rapidly at present. Fish production from the fishery districts bordering the areas earmarked for exploration is given in Table 1.

Table 1. Fish production (in mt) in fisheries districts bordering the areas earmarked for hydrocarbon exploration in year 2012 (Source: MOFAR).

Location	1983	1990	1995	2000	2005	2007	2008	2009	2012
Northern province	75,740	24,150	4,500	8,100	24,410	15,250	13,840	21,210	59,340
Sri Lanka	184,740	145,790	217,500	263,680	130,400	252,670	274,630	293,170	477,220
Contribution (%) to national fish production	40	16	2	3	18	6	5	7	14.2

When compared to the year 2009, contribution from the fisheries districts of Mannar (32.7%) and Jaffna (59.7%) were high in 2012 and accounted for the overall increase in the total fish production from the coastal sector. Relaxation of fishing limitations, and supply of fishing boats and gear to fishers are the main contributory factors for the increase (MOFAR, 2011). Ninety percent of the fishermen is engaged in artisanal fishery and the majority (72%) of them use non-mechanized traditional boats. Cast nets, drift nets, gill nets, set nets (for crabs), bottom nets, long line, hooks (for cuttlefish) and beach seine are the common fishing gear used.

Activities associated with petroleum exploration may include conduct of seismic and other geophysical surveys and exploratory drilling of wells. If exploratory drilling indicates petroleum

accumulations with commercial potential, production activities may follow. Production activities may involve drilling of development wells, installation and operation of equipments for, production and abandonment activities. However, the nature and scale of potential production activities could not be gauged at this stage.

Identified impacts of the oil exploration activities on fishery resources and fishing include, movement restrictions of fish, discharge of pollutants, disturbances to fish due to sound waves, movement of fishing vessels, entangling of fish nets to offshore ships' rudder cables, movement of offshore supply and crew change vessels, helicopter sounds and sound waves.

Creating a navigational zone with a radius of 500 to 1000m around seismic vessels and oil platforms, leaving platforms, their fragments on the sea bed, leaving suspended well heads for a period of time, leaving debris on the sea bed can cause problems to fish and fishing activities. Mortality of fish during sound wave generations, disturbances to spawning and fish egg and larval development can reduce fishery resources. Only positive impact may be that the abandoned structures may act as fish aggregation devices.

Chemical pollution due to discharge of drill mud, drill cutting, treated bilge water and treated sewage and accidental spills and blowouts can affect the health of fishes and other biota and may affect the proposed aquaculture activities.

Increased sedimentation and turbidity could affect fish production in several ways. Reduced light penetration could lead to reduced photosynthesis which could lower the primary productivity and density of plankton available for fish and crustaceans. Oil spills, ballast water and pollution could affect the coral reefs of the area that acts as an important ecosystem around which most of the current fisheries activities are concentrated. Impacts on secondary fishing activities such as oysters and other shells, echinoderms, and sea weed collection are likely to be affected by dredging and subsequent siltation. Increased sedimentation could lead to high levels of egg mortality due to adherence of particles to eggs. There may be impacts on present fish landing sites.

In addition to the direct impacts on fisheries resources, several socio-economic impacts have been identified. It is envisaged that fishing activities will be hampered during the exploration processes and remedial measures need to be identified. Certain activities can lead to restrictions in the fishing areas/ times and hamper the current routine of the fish harvest.

In conclusion, oil exploration activities may significantly affect fishery resources and fishing communities of the Cauvery basin and the bordering districts. The waste generated from the drilling operations should be dealt with in compliance to applicable MARPOL standards to reduce the environmental and fishery impacts. Preventive measures (*e.g.*,avoidance of

dredging during the breeding season of commercially important fish and crustaceans) have to be implemented. Any possible impacts on the current fish landing sites need to be assessed. Plans are to be developed for obtaining compensation to the local communities in the event of reduced fishery activities, oil spills etc. and responsible bodies have to be identified for this purpose.

There is no recent assessment on demersal fishery resource and breeding seasons of commercially important fish and crustacean species. Long term impacts of siltation and pollution on key fish species at different stages of their life cycle, assessment of livelihood status of communities and changes in fishery resources and biodiversity are some of the issues that may call for further investigations.

Assessment of sand extraction and use in a coastal fisheries community in Cambodia

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Coastal resources need to be maintained in order to support the livelihoods and well-being of local coastal resources-dependent communities, as well as to provide a balanced set of ecosystem goods and services. However, development projects along the coastal areas of Cambodia have been implemented at an alarming rate in recent decades, including infrastructure projects such as ports, modern settlements, resorts and tourist destinations. In addition to these development projects, coastal areas have been exposed to mining exploration and exploitation activities, and as a result, the coastal environment has been exposed to negative consequences.

In order to identify, measure and analyse the above issues, a causal framework namely DPSIR model with five key elements-Driving Forces, Pressures, State, Impacts and Responses developed by European Environmental Agency (EEA) have been used to collect primary data and information as shown in Fig. 1 below:

Based on the result of household survey and focus group discussion, the following observations have been made:

- Driving Forces: Environmental problems are a consequence of two key driving forces of sand extraction and use activities,and infrastructure developments taking place within Kampot port and the Special Economic Zone (SEZ) development projects.

- Pressures: The above two key drivers are the pressure on the resources and community livelihoods.

- States (environmental change): The results of the household survey showed that local resources face varying levels of degradation.

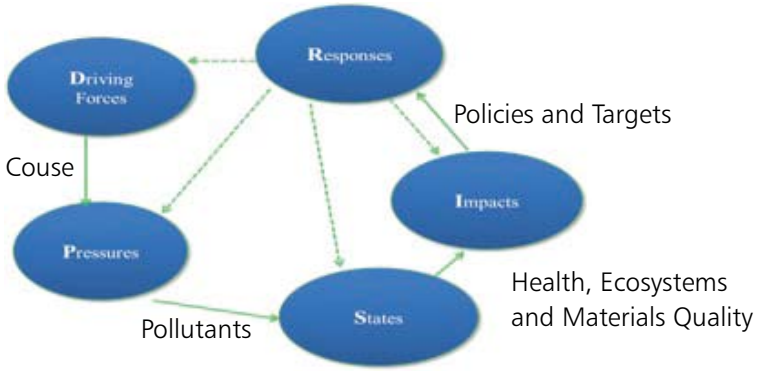

Fig. 1. The DPSIR Assessment Framework Source: Modified from Kristensen, 2004

- Besides the decreasing biodiversity levels, there have also been significant changes to other ecosystem elements such as increasing wind strength and environmental quality. In addition to these environmental problems, social problems have also started to occur and most common occupations of the communities have changed.

- Impacts: In terms of changes in the environment, the surveyed households rated pollution of water, air and noise are in medium impact level, and land is in high impact level. In addition to the impacts on biodiversity, significant impacts were also reported regarding the local communities' livelihoods as a result of alteration in mangrove forests. Conflicts now occur within the communities due to the SEZ projects and sand extraction activities.

- Responses: The local fishery communities have decided to face-up to their problems with some responding activities such as demonstration (advocacy by local NGOs), conflict mediation, mangrove replantation and job alternatives but these activities are on a low key.

Based on the above findings five key elements of DPSIR framework were evaluated as following:

- Driving Forces: Dredging of sand without the use of adequate safeguards is a risk to livelihood and ecosystems.

- Pressures: There are several pressures on coastal resources and local communities' livelihoods, such as the changing natural and social environment status. Biodiversity has been reduced by construction activities such as drainage and reclamation of mangrove wetlands in order to expand the harbor, as well as land fill activities and dust/noise pollution.

Significant social issues have also impacted the local communities, with a breakdown in the traditional social networks, increased livelihood risks, health and sanitation issues, outward migration, conflicts, and mental problems.

- States: There has been a change in the quality of sea water due to sand pumping and land/ sand filling activities.

- Impacts: Sea water pollution is a significant problem in the study area. Besides the natural environmental impacts, local communities are also facing a number of social problems. The fishing community in Rolous village had to be dissolved because around 800 ha of community land was grabbed for one of the development projects.

- Responses: Due to these conflicts, the local authorities are mediating but it is not effective. A number of local people have responded by finding alternative job opportunities, while few others have claimed for compensation for loss of jobs and earnings due to the development projects.

Current rapid coastal urbanization in Cambodia, particularly in the study area in Kampot Province, has led to sand extraction and use activities, including sand dredging. The development projects at the study site have adversely impacted the coastal ecosystem and coastal resources-dependent fishery communities.

The consequences of these project activities have led to unresolved issues within and around the study sites, such as a degraded natural habitat, presence of environmental pollutants, adversely impacted community livelihoods, outward migration, conflicts and mental stress. However, in order to resolve these problems, the communities have responded in a number of ways, but with limited success thus far.

Based on above research findings and evaluation, the issues may be addressed, in the following ways:

- A mediation mechanism and/or formal negotiation framework should be established in order to reach formal agreements between developers, local authorities and communities;

- A full Environmental Impact Assessment should be conducted;

- In order to strengthen community participation and good governance, the proposed Environmental Management Planning process should be adopted; and

- The use of an Integrated Coastal Management (ICM) approach should be considered.

Fishing at sunset in the Sundarbans

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Multidimensional planning on marine protected areas and fisheries management in Bangladesh

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In 2012, the Exclusive Economic Zone (EEZ) of Bangladesh was expanded from about 50,000 km^2 to more than 112,000 km^2 in the Bay of Bengal by ITLOS (International Tribunal on Law of Sea) verdict. Bangladesh has concerns on conservation and protection of marine resources from overexploitation, especially commercially important species in the nearshore. On the other hand, the country is unable to judiciously exploit open and deep water resources far from the shore. While the ITLOS verdict is welcome, it may help exploitation of hydrocarbon from sea bed, renewal of marine resource protection but sustainable exploitation in expanded sea areas will be difficult. It also increases the responsibility of declaring 10% of EEZ as Marine Protected Area (MPA) by 2020 (Aichi targets fixed at Nagoya COP of CBD) after judicious selection of sites and executable management planning. This task is not easy for a country where marine research and marine policy is in rudimentary stages, and without assistance from development partners and donor agencies, new initiatives is often ignored. An attempt was made during April 2012 - September 2012 to conduct feasibility studies for some designated locations as MPAs in Bangladesh coastal areas and EEZ. Bangladesh is mainly a delta based country basically formed by combined flow of Ganges, Meghna and Brahmaputra (GMB). The GMB delta with shallow and large continental shelves and continuous formations of small deltas at estuaries is considered as a living landmass that covers significant part of EEZ. It is unique among coastal and oceanic countries and designation of MPAs is a challenge. International Union of Conservation of Nature-Bangladesh (IUCNB) and BOBLME (Bay of Bengal Large Marine Ecosystem) project facilitated a study on MPA. IUCNB was assigned the task to collect and analyze primary and secondary data and draft a report. MPA related information base was established by networking; primary data gathering was completed by on the spot inspections, FGD (Focus Group Discussion) at grass roots with diverse stakeholders, Key Informant (KI) interviews, and regional workshops involved all patrons. National level seminars involved personnel engaged in marine teaching, research, planning, administration, department of

fisheries, local governments, extension services, NGOs, development partners and resource exploiters. A group of biologists led the study initiated by an inception seminar in Dhaka and collected data related to skills gained by PA (Protected Area); selection and management by both Forest Department (FD) and Department of Fisheries (DoF). After the inception seminar, six regional workshops were arranged in different coastal regions; Noakhali, Chandpur, Patuakhali, Khulna, Chittagong and Cox's Bazar. Each workshop was followed by a FGD in the same locality with fishermen, boat owners, depot operators, fishing input sellers and wholesalers. Also, surveys were conducted among KIs, public and elected local government officials. Then a draft report was prepared designating some areas, spots, habitats, ecosystems as probable MPA candidates with narrated rationales and steps needed to designate/declaration for inclusion as MPAs by concerned authority as well as MPA managements. The draft report was validated at a final seminar held in Dhaka in the presence of all concerned authorities and stakeholders, and a final list of prospective MPAs was provisionally finalized. The document is based on results of a table based analysis. Analysis was also made on current status of marine resources their exploitations and management of marine fisheries. Special attention was on the views of coastal communities on protection of natural habitats & resources, organizations, livelihoods, conservation initiatives based on current marine sanctuaries, ECA, PAs and future MPAs, land and sea based pollution sources and transboundary elements.

Based on the above, the initiative has identified a few coastal and marine spots, sites, habitats and ecosystems to be designated for some form of protection based on their importance to provide safeguard and preservations of marine lives, delicate habitat, fragile ecosystem, breeding, spawning, nursing, feeding and migration of endangered and critically endangered species and recruitment potentials. The designated MPAs were prioritized in descending orders as Area of Significance (AOS), most vital spot/sites for protection and management; Area of Interest (AOI), second most vital spot/sites for protection and management; Area of Curiosity (AOC), important but not immediate vulnerable spot/areas to be brought under protection and management; Area of Mind (AOM), important areas/spot to be considered for future MPAs and managements after adequate capacity developments. Since, only a few sites will be brought under pilot program initially, AOS will get prime importance as the designated MPAs. Each designated MPA from the AOSs has specific reasons for protection as candidate. Therefore management for individual MPAs will be need-based. The existing coast/mangrove based marine PAs under DF/DoF and designated AOS are shown in Table 1 and 2 respectively.

To establish a framework for a MPA and its management in Bangladesh, it is worthwhile to consider similar experiences from elsewhere The inadequate measures followed to conserve marine ecosystem and biodiversity, and overexploitation of resources call for speedy execution of MPAs in Bangladesh. There are still several unknown characteristics of the potential MPAs suchas undiscovered species, habitat, breeding, feeding, nursing and migratory routes, Bay's status, and ecosystem functioning.

Table 1. Existing PAs

Name of PA	Location	Area (km^2)/stretch	Agency	Comments
Nijhum Island	Noakhali	16.35 km^2	FD	National park
Sunderban (East)	Bagerhat	31.23 km^2	FD	Wildlife sanctuary
Sunderban (South)	Khulna	36.97 km^2	FD	Wildlife sanctuary
Sunderban (West)	Satkhira	71.50 km^2	FD	Wildlife sanctuary
Char Kukri-mukri	Bhola	0.04 km^2	FD	Fish sanctuary
Megha river	Chandpur&Lakshmipur	100 km stretch	DoF	Hilsa catch ban*
Meghna Estuary	Bhola	90 km stretch	DoF	Hilsa catch ban*
Tentulia river	Bhola & Patuakhali	100 km stretch	DoF	Hilsa catch ban*
Andharmanik river	Patuakhali	40 km stretch	DoF	Hilsa catch ban**
Lower Padma river	Shariatpur	40 km stretch	DoF	Hilsa catch ban*

* March to April, ** November to January

Table 2. Proposed AOS to be designated as MPAs as pilot project

MPA (AOS)	Location	Area (km^2)	Agency	Comments
NijhumIsland	South of Noakhali	100	DoF/DF	Breeding ground for commercial species
Inundated Island	South of ND	200	DoF	Breeding ground & migratory route of many species
Caring Char	South of Noakhali	50	DoF	Nursing ground for fish & shrimp
St. Martin Island	South of C. Bazar	150	DoF	Fragile coral Island & habitat
Shahparirdwip	Near Teknaf	30	DoF/DF	Fragile coast & fragile aquatic ecosystem
B. Channel	Same as above	20	DoF	Fragile aquatic ecosystem
Naf Estuary	Same as above	15	DoF	Migratory route
B.khali Estuary	Near C. Bazar	20	DoF	Fragile aquatic ecosystem
Sonadia Island	Near C. Bazar	30	DoF/DF	Mangroves & fragile aquatic ecosystem
Gotibanga	Near C. Bazar	30	DoF/DF	Mangroves & fragile aquatic ecosystem
Sundarban East	South of Bagerhat	200	DoF/DF	Mangroves, waterways, ECA & PA
S.ban South	South of Khulna	200	DoF/DF	Mangroves, waterways, ECA & PA
Sundarban West	South of Satkhira	200	DoF/DF	Mangroves, waterways, ECA & PA

While recommendations were made, collection of information on marine resource use capability, exploitation, pollution and socio-economic aspects of coastal dwellers and other related matters should be considered. Fisher groups opposed whenever a MPA initiative was discussed at national workshops, regional meetings and focus group discussions. This is partly due to lack of understanding on MPA and its goal. Full support of marine and estuarine fishers is needed for successful implementation of MPAs.

To conserve and protect marine habitats, ecosystems, resources, species and biodiversity in the EEZ of Bangladesh and peripheral areas for sustainable exploitation and future uses as well as to meet international obligation, it is important to establish MPAs. Besides, top reserve renewable resources for next generations, designation of MPAs with judicious selection procedure and their proper and adequate management is necessary.

Ecosystem-based management as a tool for conflict resolution and conservation of marine fisheries: experience from MFF's large project

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Had Chow Mai National park, Trang province was the target site of the "Ecosystem-based integrated coastal resource management through multi-stakeholder participation in southern Thailand" project, which is part of Mangroves for the Future (MFF) initiative in Thailand. This project is implemented by Sustainable Development Foundation (SDF) in collaboration with Save Andaman Network Foundation (SAN). This project aims to address the issue of depleting and threatened coastal resources by coastal communities, disaster and climate change. Introducing the concept of ecosystem based integrated coastal resource management through promoting meaningful multi-stakeholders participation, knowledge management, capacity building including bridging the gap between local and state policy makers and coastal communities in ecosystem management concerning natural resource regulation and disaster preparedness are the major agenda of the project.

Had Chao Mai National Park covers 231 km^2. Coastal communities have historically inhabited it. This area is rich in evergreen forest, mangrove forest, beach forest and limestone forest. Dugongs, the gentle sea mammals, are one of the outstanding species that inhabits the area. The aquatic zone consists of nearly 60% of the park. Special features are coral reefs, mostly found in sheltered spots around islands, sea grass beds found near the shores, which are important feeding grounds for fish, prawns and dugong. Seagrass density has reduced by 50% due to tsunami.

Had Chow Mai Marine National Park operates under National Park Law and is centrally managed by Government park office. The park is considered a protected zone, and no activities including fishing are allowed despite the fact that fishing is conducted by fishermen since their settlement in the area for more than 200 years. Within the area covered by the Park, there are many segregated and overlapping roles and responsibilities of many government

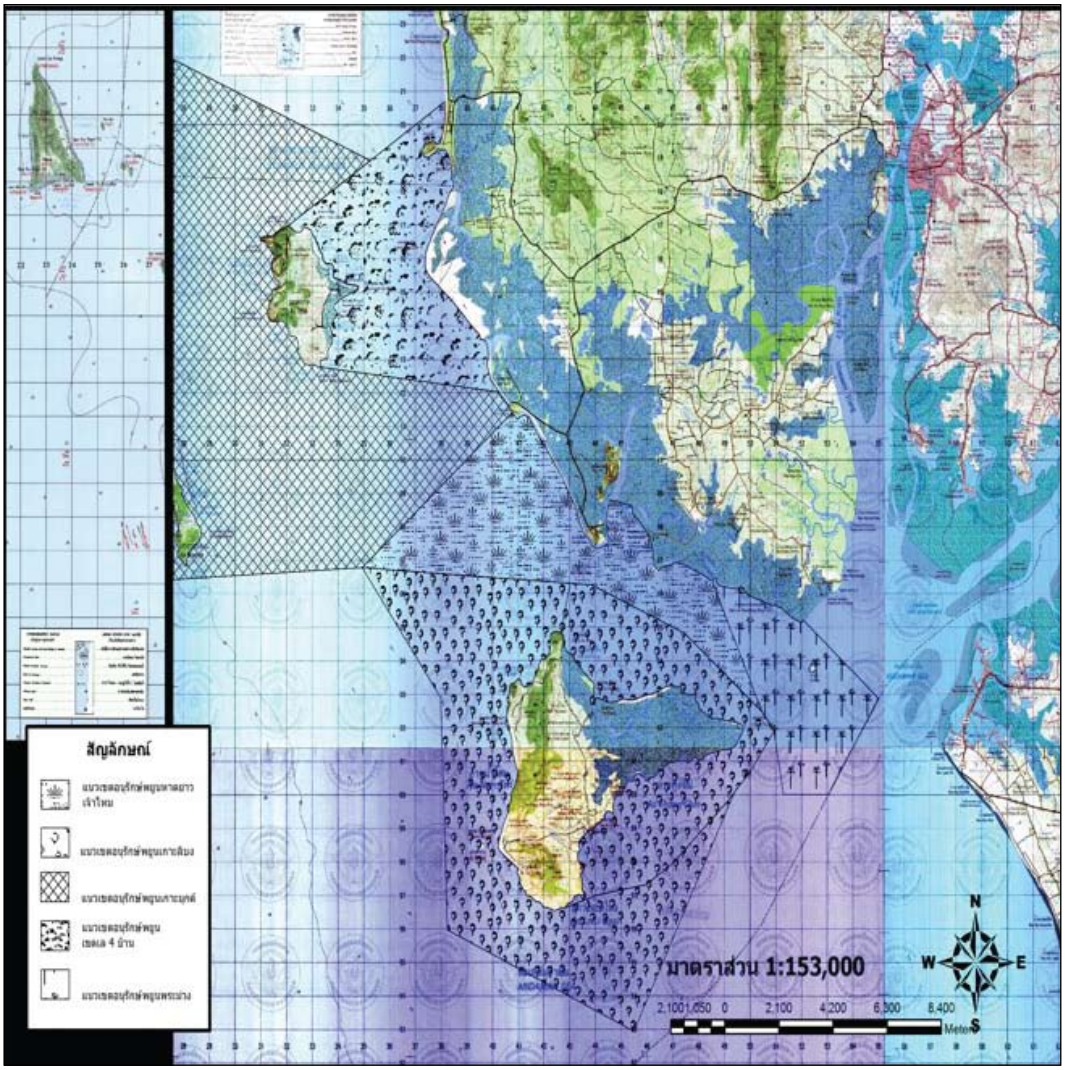

Fig.1. Had Chao Mai National Park

agencies such as the Department of Fisheries, Department of Marine and Coastal Resources, Port Authority, Department of Public Policies including local administrative organization like the Sub-District Administrative Organization which operate under different laws. All these inter-agency conflicts add to an existing conflict between the commercial fishers who illegally encroach into conservation zone which is a fishing area for small-scale fisheries. Recently, conflict is added from the tourism sector, negatively affecting marine resources and land grabbing for resorts.

Implementation of the project has brought together a diverse range of stakeholders to work in cooperation towards achieving common aims and objectives by adopting area-based approaches. Major stakeholders participated are from government agencies such as the Department of Marine and Coastal Resources (DMCR); Department of National Park, Wildlife and Plant Conservation; Global Change System for Analysis, Research and Training Research Center for Southeast Asia (SEA START RC); Koh Libong local administrative organization including provincial and district related agencies. Trang Fisher folks Federation and the NGO sector Save Andaman Network Foundation (SAN) also participated.

Project principles and approaches highlight meaningful participatory process among multi-stakeholders using data and knowledge shared and discussed to reach an agreement on appropriate rule and measures in solving existing conflicts. A series of fora had been initiated, resulting in trust-building and developing working-relationships. Despite the various related laws reaffirming centralized management of natural resources by related government agencies at the project working site, the collaborative mechanism has agreed on rules and regulations for coastal resource management. Protected conservation zones and rehabilitation areas were remarked and agreed upon. Conflict over the use of coastal resources especially fishing practices had been addressed. The participatory process has led to elimination of illegal and inappropriate fishing gears with significant data gathered from such practices. Improved coastal resources were obtained from increased collaboration in coastal resource protection, preservation and rehabilitation of sea grass, dugong and mangrove forest. This eventually led to an understanding by stakeholders of ecosystem functions in disaster reduction especially for mangrove protection and rehabilitation. A disaster warning network and disaster preparation establishment have been set up.

At present, there has been ongoing cooperation and collaboration among stakeholders. A memorandum of understanding has been signed and local legal codes were enacted at various levels, helping establishment of a regime for sustainable coastal resource management and risk reduction for the long term.

This case study reinforces the belief that joining forces can champion the initiatives, which can be used to advocate national endorsement and campaign for state policy incorporation. The process streamlined marine coastal resource regulations as well as response to community needs for livelihood and survival. Local partners concentrated their work on livelihood and community networking, while the national-level partners provided technical and management backstopping to substantiate the communities' measures in managing the ecosystem in a sustainable manner.

The following are the lessons learnt and the recommendations:

- Bridging gaps need strong commitment and trust from all parties involved. Common goals need to be discussed and agreed upon. Commitment should also come with the readiness to acquire skills necessary to lead meaningful participation process.

- Roles of different stakeholders must be identified and brought on broad terms. Furthermore, villagers must get involved, not just as leaders.

- Enabling environment for small scale fishing communities should be ensured.

- Participatory data collection can serve as basis for policy making and development of appropriate program intervention.

- Central level authorities need to ensure that sufficient management powers and resources have been devolved to local level so that effective co- management can take place. It is also a need to ensure high level support for co-management process including inputs and resources.

- Women participation needs to be ensured since they play dominant role in fishery.

- There is a need for co-management body to gain confidence and acceptance so that they can work together to reach an agreement relating to gear restrictions, fishing enclosures especially with regards to prohibition or restriction of actions by the community itself. It is also necessary to ensure balance in resource used and sustainability of natural resources.

Ecosystem approaches for managing Lake Chilika fisheries

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The diverse and dynamic assemblage of fish, invertebrate and crustacean species found in Lake Chilika provides the basis of fisheries which support livelihoods of over 0.2 million fishers and generates nearly 9% of Odisha State's foreign revenue from marine products. Sustainable management of fisheries forms an important component of integrated approaches adopted for ensuring 'wise use' of Chilika as a Ramsar Site (wetland of international importance under Ramsar convention). Ecological restoration, management of lake basin, inventory and assessment and promoting community managed fisheries are key measures that are being implemented to sustain fisheries and maintain overall ecological health of Lake Chilika (Fig. 1).

Hydrological connectivity of Chilika with the Bay of Bengal, tributaries of River Mahanadi and streams of western catchments sets a unique salinity gradient necessary for maintenance of rich diversity of fish (Fig. 2) and other aquatic flora and fauna. Nearly 86% of the fish species found in the wetland are migratory and dependant on the riverine and marine habitats for a part of their life cycle. Chilika underwent a phase of rapid degradation during 1950 – 2000 owing to increasing sediment loads from the catchments and reduced connectivity with the sea. The lake fisheries underwent a major decline, invasive macrophytes proliferated and the wetland shrank in area and volume. Introduction of shrimp culture further added pressure on lagoon ecology and ultimately led to significant disruption of traditional community governance of lake fisheries. This formed the background for inclusion of Chilika into the Montreux Record in 1993.

Government of Odisha in 1991, instituted Chilika Development Authority (CDA) under the aegis of Department of Forest and Environment to undertake ecosystem restoration. In September 2000, a major hydrological intervention was carried out by opening a new mouth to the Bay of Bengal which helped improve salinity levels, enhanced fish landings, decrease in invasive

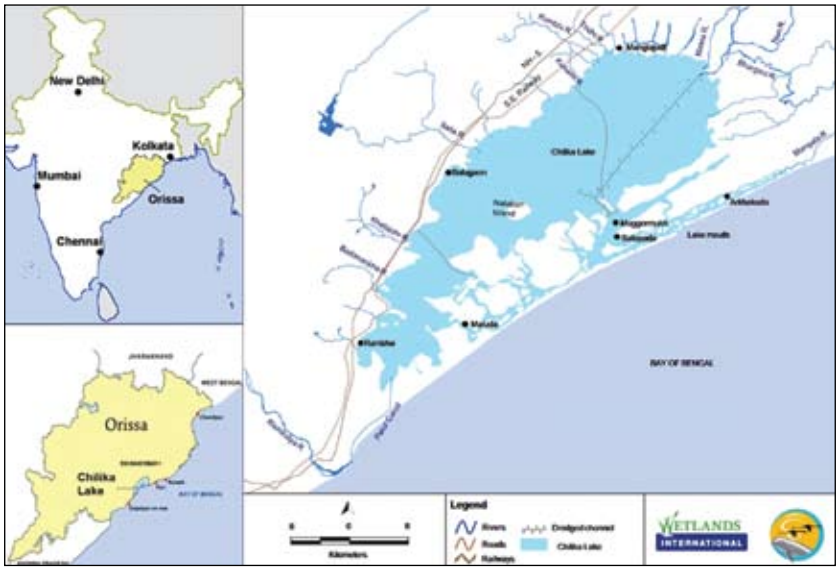

Fig. 1. Map of Chilika Lake

species and overall improvement of the lake water quality. The annual fish catch during 2001-11 was 11,961 tonnes as compared to a decline from 8,861 t to 1,735 tonnes during 1986-1999. The mouth is maintained through periodic dredging and extensive monitoring to ensure that the connection to the sea is maintained. A 22.6 km lead channel has been dredged in the northern sector to ensure that the sediments received from the Mahanadi River are flushed out from the wetland.

Sustenance of fisheries in Chilika is closely linked to ecological processes influenced by water, sediment and nutrient exchange with the lake basin and coastal zone. The CDA initiated a massive participatory watershed management in the western catchments to restore the vegetative cover, improve soil moisture and enhance resources for community livelihoods. Through dedicated capacity building, conflict resolution and trust building, the CDA enabled formulation of watershed management plans, and provided resources for their implementation. The overall forest cover in the basin which had declined from 1,255.43 km^2 to 1,099.46 km^2 during 1972 to 1990 was observed to increase to 1,267.27 km^2 in 2011.

The CDA has launched an intensive awareness campaign on values and functions of the wetland system, particularly amongst the villagers including school children in and around. Management of Lake Chilika is supported through a state of art ecological monitoring system using a network of 47 monitoring stations within lake basin and 30 stations within the lake. Fisheries biodiversity and productivity is primarily monitored through an intensive catch sampling, in place since the hydrological intervention of 2000. A fish tagging study on the

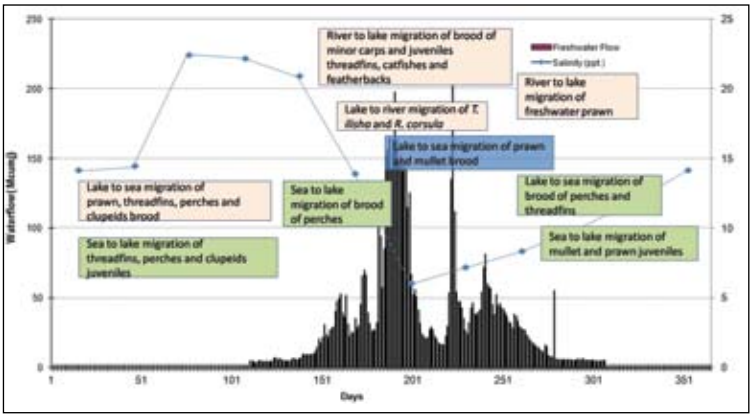

Fig. 2. Water regimes and fish migration in Chilika Lake

extent of seaward breeding migration of commercially important mullets (*Mugil cephalus* and *Liza microlepis*) has been initiated with active participation of local fishers.

While the hydrological intervention of 2000 was able to restore the necessary ecological conditions for rejuvenation of fisheries, the key to its sustenance lies in the design of institutional arrangements and mechanisms through which various stakeholders gain access and control over the resource base. Fishing in Chilika was historically managed by community institutions. For generations, Chilika fishers evolved a complex system of resource partitioning, wherein access to each fisher group was determined on the basis of species they catch. The norms include setting spatial limits (areas of fishing), temporal limits (seasonality), gear restrictions, and size of fish-at-capture. However, weak capacities and economic non-viability led to gradual decline of community fisheries institutions, with the fishers falling in debt trap in the hands of moneylenders. In 2010, CDA through technical collaboration with Japan International Cooperation Agency (JICA) formulated a Fisheries Resource Management Plan (FRMP) based on over 3 years of resource survey, assessment of biology and ecology of eight commercially important high value fish, prawn and mud crab species; modeling for various conservation and management options; wide-range stakeholder consultations and ratification by an expert committee. The plan entails convergence in fisheries governance to ensure sustainable fish production through wise use of fisheries resources as well secure livelihoods of fishers. The plan recommends a co-management strategy with active participation of fishers.

In July 2010, the State Government established a new Central Fishermen Cooperative Society called Chilika Fishermen Central Cooperative Society (CFCCS) Ltd as the apex agency for managing Chilika fisheries. Availability of credit at equitable terms plays an important role in economic viability of the PFCS. Under a pilot initiative, CDA through the Fisheries and Animal Resources Development Department is providing Rs. 7 lakh as revolving fund to PFCSs to

revive the institution and ensure fair access to credit to the member fishers. Several PFCSs have managed to become economically viable and functional with the financial and capacity building support.

Lack of appropriate storage facilities force the fishers to sell their catch to the middlemen who exploit their vulnerability by paying lower prices and manipulating weights. CDA through support of Marine Products Export Development Authority (MPEDA) has launched an initiative to provide ice boxes to the fishers so that the catch could be maintained for longer time and fishers could choose their preferred point of sale. A 70 liter box costs Rs. 2,200, of which 50% is subsidized by MPEDA, 30% by CDA and the rest is borne by the fisher. This scheme has been warmly received and thus far 1,000 boxes have been distributed to fishers reporting at least 30% increase in sale proceeds.

The fisheries values of Chilika co-exist with high biodiversity. The lake is a natural habitat of 224 species of waterbirds (including 97 inter-continental migrants) and regularly hosts over one million wintering migratory birds. It is also one of the two lagoons in the world that support Irrawaddy Dolphin (*Orcaella bervirostris*). Designation of Chilika as a Ramsar Site commits the Government of India and Government of Orissa to take actions to ensure wise use of wetland ecosystem. Wise use is the longest established example amongst intergovernmental processes of the implementation, which is known as ecosystem approaches for conservation and sustainable development of natural resources, including wetlands. The wise use approach identifies the critical linkages that exist between people and sustainable development of wetlands; and encourages community engagement and transparency in negotiating trade-offs and determining equitable outcomes for conservation. An integrated management planning framework for conservation and wise use of Chilika has been formulated with extensive community consultation and following international guidelines. The framework is a reference point for implementation of annual action plans.

Ecosystem approach to fisheries management: integrating fisheries and habitat management through the fisheries refugia concept

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It is widely known that Marine Protected Areas (MPAs) are important for the conservation of marine and coastal resources, including fisheries resources. Ecosystems usually considered as MPAs include coral reefs, seagrasses, mangroves and other coastal wetlands. Some of these MPAs contribute to the improvement of fish stocks, acting as refuge habitats for many commercially important species during critical phases of their life cycles. But generally, MPAs have been designed with the aim of marine conservation, protecting vulnerable habitats and endangered species, and not always particularly contemplating fisheries concerns. Despite the ecological importance of these areas, and the undoubted need to protect them for the conservation of marine and coastal biodiversity, natural and cultural heritage, the processes involved in designing MPAs have not always aimed directly at the improvement of fisheries stocks and their sustainability. The restriction or banning of fishing along MPAs, defined as "no-take" zones, has produced at times an adverse reaction among coastal fishing communities, whom, without proper consultation processes and late or inexistent engagement in decision-making, have seen their access limited to these areas. As a result, plans and regulations set to manage and restrict access to these areas have been difficult to enforce.

The Fisheries Refugia concept comes as a novel approach to the pressing demand of using an Ecosystem Approach to Fisheries Management, one that takes into better consideration fisheries resources and the linkages between fisheries species, their habitat (such as spawning or nursery areas), and their life cycle. With this aim, the Fisheries Refugia concept has been defined as "spatially and geographically defined marine or coastal area in which specific management measures are applied to sustain important species (fisheries resources) during critical stages of their life cycle, for their sustainable use".

To be fully effective, the Fisheries Refugia concept must be applied by using an Ecosystem Approach (EA) to Fisheries Management, involving EA's different dimensions:

- Ecological Dimension: by better understanding the ecology of fisheries species and their habitats, and particularly by taking into account their two more important life events, which are reproduction and the recruitment of juveniles. Fisheries species are most vulnerable during these events, and they may require migration between different habitats or during different seasons. Fisheries Refugia management tools can set measures such as juvenile refugia or spawning refugia, in order to avoid growth or recruitment overfishing respectively, allowing populations to spawn and maintain the new recruitment of juveniles, and by taking into account transboundary considerations.

- Human/Social/Economic Dimension: It has been increasingly recognized the importance of Small-Scale Fisheries to food security and employment, and the role that fisheries play as subsistence option for many of the coastal poor, particularly in the Asia Pacific region. The Fisheries Refugia approach promotes user and collective rights over fisheries resources. The implementation of the concept should follow the decentralization processes already taking place all over the region, setting up and supporting co-management mechanisms, and focusing more in the engagement of users groups in the management of the resources they depend upon. This should include wider stakeholder participation in decision-making, community patrolling and data gathering, and assessing the performance of rules of regulations through the use of appropriate participatory tools and indicators.

- Governance Dimension: In order to appropriately and actively take into account the Ecologic and Human Dimensions, it is necessary to have an enabling institutional environment. This must include the building of partnerships, the inclusion of measures for conflict management, as well as sound communication between environment and fisheries departments (locally, nationally, and regionally), and by taking into account transboundary habitats and movements of fisheries species. This dimension would benefit of the integration of Maritime Spatial Planning considerations into fisheries management frameworks.

The Fisheries Refugia initiative was initially established under the UNEP/GEF project entitled "Reversing the Environmental Degradation in the South China Sea and Gulf of Thailand", providing unique opportunity to establish a regional network of integrated fisheries and habitat management areas in Southeast Asia supported by national habitat action plans (NAPs) and fisheries policies. The new GEF/UNEP and SEAFDEC project, "Establishment and operation of a regional system of fisheries refugia in the South China Sea and the Gulf of Thailand", will build on the previous work, exploring the EAF dimensions in more detail. The project will focus on improving the integration of habitat and biodiversity conservation considerations in

fisheries management, by enhancing the scientific understanding of fish stocks and habitat links (Ecological Dimension), by the endorsement of policy and regulatory frameworks that take into account the sustainable use of fisheries habitats and biodiversity (Governance Dimension) and by focusing on empowering small-scale men and women fisherfolk, facilitating their contribution to the management of resources, including the enforcement of agreed management rules (Human Dimension). Ultimately, the project will achieve good practices recommendations on how to integrate fisheries management and biodiversity conservation aspects in the design and implementation of regional and national fisheries management systems.

Fishing in Pichavaram mangroves, Tamil Nadu

Marine spatial planning for biodiversity protection and fishery management: more should be done

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There is no doubt a fact that marine fishery resources in Asian seas have degraded in the last few decades; this has been reviewed in a number of UNEP publications. For example, fish catches from four traditional fishing grounds of China, *i.e.,* Bohai Sea Zhoushan, South China Sea coast and Beibu Gulf have significantly decreased since the 1990s; in Pearl River Estuary, current fish catch is only one tenth of that in 1990s. As another example, in Thailand fish catches from the Gulf of Thailand are well above the estimated MSYs. Catch rates (CPUE, kg/hr) in the 2000s were only 7% of the levels in the early 1960s, with nearly 40% of the catch from Thai waters consisting of low value fish.

Over-fishing and intensified land-based activities are two of the main reasons that have led to depletion of the marine fishery resources. There are three factors leading to over-fishing. The first one is increased capacities of fishing, which means more tonnage or horsepower of vessels. For instance, total fishing capacity of vessels in East China Sea in the 1990s was 7.6% more than in 1960s. The second factor more important than the first one is related to new or improved technologies of fishing. Besides largely increasing production, these new technologies usually result in large quantities of juvenile or trash fish and severely damage fishery resources. The third factor that can be the most important is that access to the resources is mostly uncontrolled. Impacts of land-based activities are also from three sources. The first one is coastal development, and particularly land reclamation that in many cases has directly caused fish habitat loss. The second one is due to industrialization and urbanization of coastal areas, which has led to the generation of large amounts of pollution and waste mostly discharged into the sea. The third source is related to inland human activities. Intensified inland activities also exert pressure on the sea through rivers that carry increasing pollutant loads, usually overwhelming those of direct discharges. Even Brunei, with a coastline less than 200 kilometers, had to warn people twice not to take poisoned fish due to red tide within 6 months in 2013.

Marine Spatial Planning (MSP) can play a key role in fishery resources conservation and/through biodiversity protection, particularly, against the above-mentioned threats. As seen in Fig. 1, by allocating certain areas as natural reserves and protected areas for fishery resources based on the ecosystem method, marine spatial planning can create a protective barrier between human activities and critical areas that ensure fishery sustainability. This barrier must be protective against all fishing efforts, though it may leave access to some other environment-friendly human activities, such as scientific research and education, maintenance, and, maybe, limited tourism and regulated use by local communities.

Obviously, the ecosystem principle should be the basis for selection of Marine Protected Areas with respect to fishery resources conservation. Protected areas for spawning grounds, fish nurseries and valued and endangered species protection directly benefit fishery resources conservation. These should be supported by other protected areas for critical habitats, such as mangrove forests, sea grass beds, coral reefs, and other general natural reserves including island natural reserves. The elements for fishery resources and biodiversity conservation in the whole marine spatial planning should constitute a coherent ecosystem.

Marine spatial planning should complement spatial planning of coastal zones (SPCZ). Firstly, spatial planning of coastal zones should allocate spaces for critical habitats such as mangrove forests, coastal wetlands and sea grass beds. Secondly and more importantly, spatial planning of coastal zones should help meet water standards set for marine protected areas both nearshore and offshore environments. This can be achieved by bringing land use for industrial and urban development in line with ecosystem requirements and by controlling pollutant load in the seas. In addition, pollution from inland activities through rivers must be well controlled, otherwise water quality requirements for many protected areas cannot be met. From this point of view, marine spatial planning is the final part of an integrated planning and management "from mountains to the sea approach". In China, this "unitized plan with waters and land" are legislatively supported by "marine spatial function zoning", "environment function zoning of coastal waters", "spatial planning of coastal zones", "pollution control planning of coastal waters", "water quality planning of river basins", etc.

Some experience and lessons can be gained from the following case studies:

Case 1: Daya Bay Natural Reserve of Fishery Resources

Daya Bay, located in the north of South China Sea and near Hong Kong, is an important natural reserve of fishery resources with spawning grounds, sub-tropic coral reefs, sea turtles and very high community biodiversity. Daya Bay was set up as a natural reserve in 1983. However, for various reasons, its coastal zone was selected as the site of a large oil refinery in 1994. Consequently, downstream chemical industries and urbanization increased drastically in

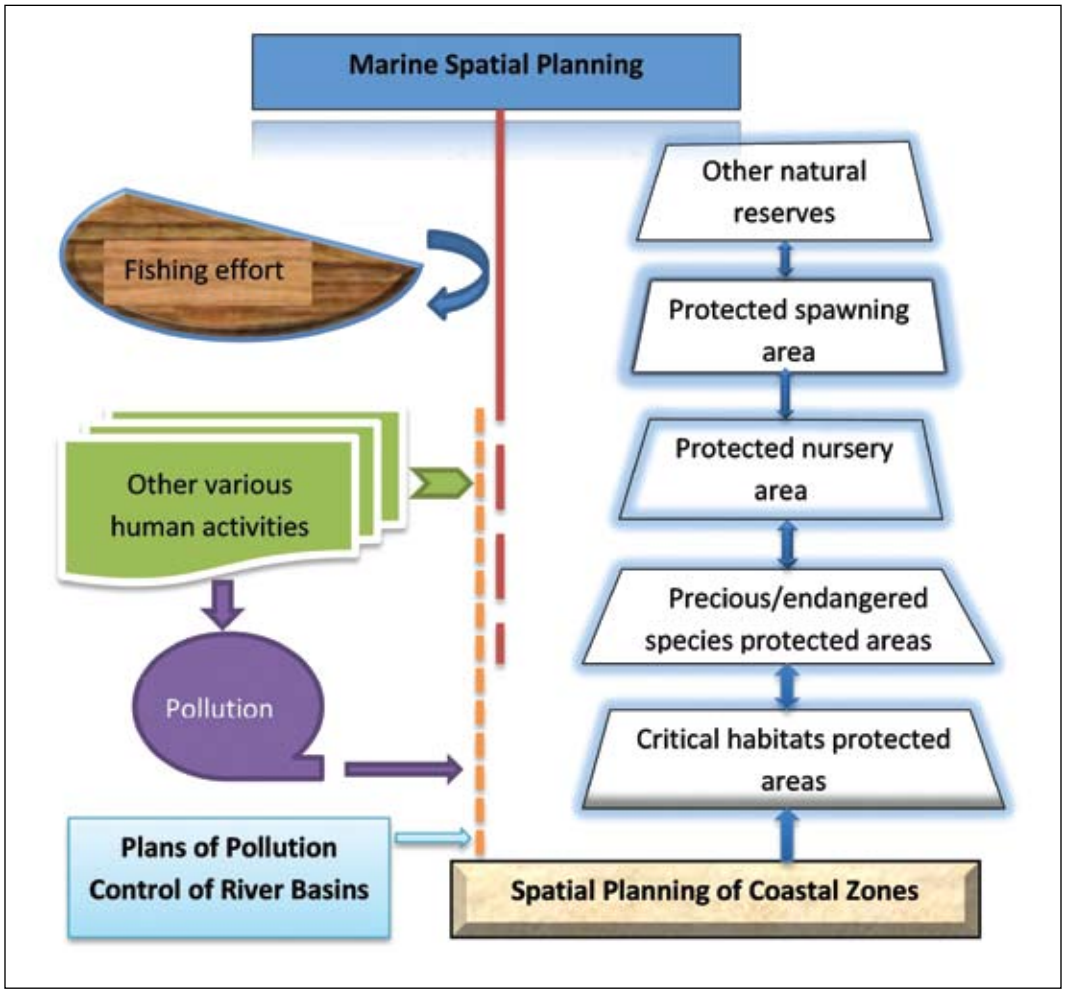

Fig.1. Marine Protected Areas ensured by coherent MSP and SPCZ

the area. Increasing demands for land has led to large-scale land reclamation along the coast. On the other hand, the government tried hard to reduce interference by the development to the natural reserve by firmly maintaining the legislative status of the natural reserve. In the meantime, measures have been taken to restore the ecosystem, like introducing fish fingerling to remedy the loss born from development activities. In recent years, four large artificial reefs have been constructed covering 35 km^2 and 2,80,000 corals were replanted with a survival rate of 95.2%. Fish catch in 1980s was between 11.1-18.1$\times$103 tonnes in this bay with an area of 600 km^2, this declined later and efforts to remedy this have been ongoing since 2004.

Case 2: Guangxi Hepu National Dugong Natural Reserve

Prior to the 1970s dugongs were fished, and it almost disappeared from the Guangxi coastal waters of Guangxi. In order to protect this endangered species, the Guangxi Hepu Dugong Natural Reserve was established in 1986. This natural reserve is one of the sea grass bed demonstration sites of the UNEP/GEF project "Reversing Environmental Degradation Trend in the South China Sea and Gulf of Thailand". Great efforts have been made to maintain this natural reserve. However, no dugong has been sighted up since 1997.

For successful marine spatial planning, improvements of the ecosystem method may be necessary. Firstly, requirements of landscape ecology must be taken into account in establishment of marine protected areas and natural reserves. This means that *"ecological corridors"* must be designated in some areas. Continuous and extensive sea grass habitat is not available for dugongs, which is the shortcoming of Hepu Natural Reserve; this could be the reason why dugongs never returned to the reserve. Secondly, marine protected areas are usually small, while quantitative requirements for space may change with seasons and climate due to migration in to and out of the reserve. Taking this temporal change into account in marine spatial planning needs further research. For the time being, setting closed fishing seasons may be the best option.

In conclusion, allocating protected areas through marine spatial planning can play a key role in fishery resources and biodiversity conservation. From a planning point of view, more can be done jointly with and beyond marine spatial planning, such as the complementary spatial planning of coastal zones and river basin environmental planning to ensure requirements of marine protected areas. In addition, requirements of landscape ecology should be better addressed through the ecosystem-based method for marine spatial planning. This will, in many cases, call for regional and international cooperation.

Refugia and marine protected areas - some of the tools used in managing fisheries

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This paper highlights approaches and practices in the establishment of fisheries *refugia* in selected sites in the countries surrounding South China Sea, and the establishment of fisheries sanctuaries in the Philippines. It will also touch on the consolidating role of marine spatial planning, particularly of fisheries use zoning, in enhancing fisheries management. These are primarily based on experience during the implementation of the UNEP-GEF South China Sea (SCS) Project and USAID's Fisheries Improved for Sustainable Harvest (FISH) Project in the Philippines.

The issues tackled by many fisheries management interventions are practically the same, namely, a fisheries that is overcapitalized, increasing fishing effort, a resource base that is degraded due to destructive fishing practices, and resource users who are highly dependent on fisheries and its resource base. In response, fisheries managers have resorted to viable interventions that are deemed acceptable to government, resource users, and stakeholders. These include establishment of fisheries *refugia* and marine protected areas. However, these initiatives can be further enhanced through consolidating interventions like marine spatial planning, specifically by fisheries use zoning.

The fisheries *refugia* concept as developed by the SCS project was based on the use of area-based or zoning approaches to fisheries management aimed at maintaining the habitats upon which fish stocks depend, as well as minimizing the effects of fishing on stocks of important species in areas and at times critical to their life cycle. The fisheries *refugia* concept focuses on fish life cycle and critical habitat linkages as the criteria for site selection.

The critical actions at regional, national and community levels for the planning and establishment of fisheries *refugia* include:

- Stakeholder consultation on the *refugia* concept at the national and community levels;
- Development of an intergovernmental guideline on the establishment of fisheries *refugia*;
- Technical workshops on mapping of known and potential *refugia*;
- Consolidation and review of existing fish egg and larvae data for *refugia* identification;
- Development of fisheries *refugia* information portal
- Conduct of regional training events on *refugia* science and management

A good example of the process of fisheries *refugia* establishment was in PhuQuoc Island, Vietnam. Seagrass bed and coral reef support a highly productive fishing ground and the area is also developing into a tourist destination. Stakeholders went through the process of introductory consultation, profile preparation, local consultation on *refugia* identification, and mapping of known spawning and nursery areas. The mapping and zoning were conducted together with the community and critical spawning and nursery areas were identified using fisher knowledge. Some outcomes of this initiative include current resource map now used in consultations to identify specific fisheries issues and appropriate management measures; high level of local community ownership of the process; the *refugia* establishment activity has built strong partnerships between habitat managers, fishermen, and local government officials.

Community participation in the establishment of a managed marine area is the norm in the Philippines. The establishment of fish sanctuaries by the FISH Project was always conducted together with the community from site selection process to establishment of management plans to enforcement. One key input of the project, however, was providing a scientific basis for the selection of fish sanctuaries so that they form a network of marine protected areas.

The project approached this by commissioning hydrodynamic and larval studies. The idea was primarily to produce hydrodynamic models to provide information on the prevailing current patterns during monsoons and inter-monsoon as well as during prevailing tides. Subsequently, numerical simulations produced dispersal models to find out possible movement or larval drift. Simultaneously, a larval study was conducted to determine distribution and density of larvae. Together, these sets of information were used by resource managers, resource users, and other stakeholders to determine ideal sites for marine protected areas, taking into consideration possible "sources" and "sinks" projected from the simulation and larval studies. With this set of information, candidate marine protected areas were evaluated and, through a consensus building process, some were rejected and other newly recognized viable sites, even those not in the initial list, were encouraged.

Ownership of the intervention is a very important element for the sustained implementation and, ultimately, the success of marine managed or protected area initiatives. Ownership may not be achieved through a prescribed set of interventions or patented steps but it helps a lot if necessary elements are in place to ensure higher chances of success. The key elements include:

- Participatory approach from planning to implementation
- Information, education and communication (IEC)
- Legal instrument (ordinance, management plan)
- Establishment of enforcement team
- Adhering to a form of MPA managed area rating system
- Establishment of local MPA monitoring team
- Measuring and communicating the gains

As mentioned earlier, participatory approach, all the way from conceptualization of the idea, to the planning, and ultimately to implementation, is the best assurance one can get to ensure success. And for this, effectively communicating the information plays a crucial role. Another key element is the legal instrument that legitimizes the intervention. With proper and visible markings of boundaries and rules detailing the use of subsets of the protected areas, resource users will be clearly guided by what was agreed upon during the consultations and planning processes. This and together with the establishment of an enforcement team, can increase the likelihood of properly implementing the initiative and achieving the desired impact.

Resource managers and resource users would like to see indications of success of protected or managed area initiative and this can only be achieved if proper indicators or rating system are set in place for stakeholders to refer to in the course of the implementation. This involves collection of baseline information such as coral cover, status of benthic community, fish biomass, as well as enabling instruments like ordinance, management plan, establishment of an enforcement body, from which stakeholders can measure the progress of the initiative. This set of information gathering activities will have to be done on a regular basis to monitor progress. Ultimately, the information gathered from this exercise can likewise serve as basis for communicating the biological and economic gains as result of the intervention.

FISH Project was able to show that a set of planned fisheries management interventions, with fish sanctuaries or marine protected areas playing pivotal roles, can result in increase in overall harvest. However, this increase does not necessarily benefit the resource users the project was designed to assist. Catch monitoring activities of the project showed that harvests have increased in subsequent years relative to the base period. However, the increases in harvest were mostly due to increase in catches by fishing gears using fine meshed nets like the Danish seine, fish corral, stationary lift net, and round haul seine. These are also the fishing gears that require higher initial capital investment. On the other hand, real small-scale fishing gears like the multiple handline, bottom-set longline, and bottom-set gillnet did not benefit from the improved fish stock. Putting in place a governance mechanism by which small-scale fishers can really benefit from interventions still remains a challenge. Hierarchy of priorities among various resource users is mentioned in many legislations around the region, but putting them in practice, especially in the marine fisheries sector, still remains a big challenge.

Marine spatial planning (MSP), as a tool, has been limited to the establishment and management of MPAs. However, there are also attempts in the region to use it on larger scales, for example initiatives by the Partnerships in Environmental Management for Seas of EAST Asia (PEMSEA). The FISH Project, on the other hand, also made use of the tool, or at least its fisheries use zoning component, to consolidate the various management interventions of the project.

It is understood from the very beginning that zoning as a tool does not replace any of the coastal and marine management tools already in place. In fact it tries to consolidate them by providing the spatial scale. It organizes where human activities can occur in a given coastal and marine space with the objective of encouraging compatibility of uses, reduce conflicts between human activities, and prevent conflicts between human uses and the environment. In the coastal and fisheries use context, zoning is meant to reduce conflicts among various capture fisheries activities, between capture fisheries and other sea uses (maritime, tourism and mariculture), and between human activities and marine environment, particularly key habitats such as mangrove forest, seagrass beds and coral reefs. Some guiding principles adhered to by the project included:

- Learning by doing such that it becomes participatory in every step.
- Use of stakeholder's and resource user's knowledge and the process to be adaptive.
- Building on existing initiatives

The project implementation areas have more or less similar fishing and water use activities but their development directions differ from one another and this became apparent later on in the setting of zoning objectives and prioritization of water use activities. The entire fisheries use zoning process is carried out in three to four phases depending upon the pace of the implementing partners. The first phase include orientation and objective setting; mapping of current fisheries and other water uses; determining and evaluating interaction among the various uses to identify possible multiple use conflicts and use and habitat incompatibilities; and mapping of current and future uses taking into consideration resolution of conflicts. The second phase consist of digitizing the draft zoning map, field validation with stakeholders and representatives of resource users, and revision of digitized maps incorporating information gathered during field validation. The revised zoning maps are then used for presentation and consultation with local government executives and legislators. The third and final phase consist of the finalization of the digitized fisheries use zoning maps, consultation with a broad base of stakeholders and resource users, and legitimizing zoning plans through legislation, resolutions or other kinds of policy instruments.

Managing marine protected areas in Indonesia

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Indonesia is an archipelagic nation that consists of 17,504 islands with a total land area of 1.87 million square kilometers and a total marine area of 5.8 million square kilometers. Its seas and coasts provide valuable resources and services to support the lives and livelihoods of local communitie. Approximatly 55 percent of Indonesia's fish production is from capture fisheries. However, overfishing, pollution from land-based and sea-based activities, unsustainable fishing practices, and destruction of nursery habitats have threathened the sustainability of marine and coastal ecosystems and resources.

There is a need for Indonesia to manage its marine and fisheries resources effectively and sustainably. Marine protected areas (MPAs) are considered as an effective tool to manage resources of marine and coastal areas and promote sustainable fisheries.

To date, Indonesia has established 157 million hectares of marine protected area that consists of national and district MPAs (Table 1). The government of Indonesia is committed to increasing the total area of MPAs to 20 million ha by 2020.The national target is not only for establishing new MPAs, but also managing the MPAs effectively.

This paper is based on a review of secondary literature, including books and reports published by several institutions involved in the management of marine protected areas in Indonesia, that includes Ministry of Marine Affairs and Fisheries, National Development Planning Agencies, Ministry of Forestry, and other institutions. This paper also provides an overview on roles and the status of existing marine protected areas in Indonesia and including their distribution amongst 31 of 33 provinces and within the existing 11 Fisheries Management Areas (WPP). The largest area of MPAs is located in WPP Indian Ocean and Southern Java (Wildlife Conservation Society and MPAG, 2013). Analysis of institutional and legal aspects, including the existing

national policies concerning marine protected areas have been reviewed. Potential strategies to achieve 20 million ha by 2020 have been suggested.

MPAs have played important roles in providing ecological and socio-economic benefits. They combine social and economic needs with the conservation of resources. MPAs conserve marine biodiversity, especially threatened species and associated ecosystems. They also contribute to sustainable fisheries by providing undisturbed habitats for fish spawning, increasing fish populations and productivity, and promoting healthy coral reef ecosystems that can lead to improved fish resources within the MPAs and in adjacent areas. Besides fisheries, MPAs contribute to local economy through marine ecotourism, and improved knowledge through research and education.

Table 1. Marine protected areas in Indonesia

No	Category	Total number	Area (ha)
A	Initiated by Ministry of Forestry	32	4,694,947.55
1	Marine National Park	7	4,043,541.30
2	Marine Tourism park	14	491,248.00
3	Wildlife Conservation	5	5,678.25
4	Marine Conservation	6	154,480.00
B	Initiated by Ministry of Marine Affairs and Fisheries and local governments	76	11,089,181.97
1	Marine National Park	1	3,521,130.01
2	Marine Conservation	3	445,630.00
3	Marine Tourism park	6	1,541,040.20
4	Local Marine Protected Area	66	5,581,381.76
	Total	108	15,784,129.52

Source : Ministry of Marine Affairs and Fisheries, 2013

Conservation of marine and coastal ecosystem involves several goverment agencies, predominantly the Ministry of Forestry and Ministry of Marine Affairs and Fisheries. Although each agency has defined duties, there is an overlap between in their responsibilities. A delineation of duties between the Ministry of Forestry and the Ministry of Marine Affairs and Fisheries is to be developed. As an initial effort, Ministry of Forestry handed over 8 marine conservation areas and marine tourism parks to Ministry of Marine Affairs and Fisheries in 2009. Besides management by central agencies, decentralization has mandated local governments to manage the protected areas in their territories. Since then, there has been improvement in local governments' initiatives to extent the expanse of protected areas. Until 2012, as many as 66 distric level-MPAs have been declared.

The policy and regulatory framework for marine and coastal resources in Indonesia is well developed. The current Long-Term National Development Plan (2004-2024) and the National Medium-Term Development Plans (2010-2014) have mainstreamed the principles of sustainable development in national development policies and programs. Regarding the marine, coastal and fisheries sectors, Indonesia's policies have been set up to meet the goals of improvement in fisheries production to support food security utilization of marine and coastal resources in a sustainable manner and conservation of marine and coastal ecosystems.

With respect to conservation and fisheries management, Indonesia's Law No. 31 year 2004 on Fisheries and its amendment (Law No. 45 year 2009), Law No. 27 year 2007 on Management of Coastal and Small Islands areas,and Indonesia's Government Regulation No. 60 year 2005 on Fisheries Resource Conservation address the concept of sustainable use. These regulations require MPAs to be managed and regulated by using a zoning system. Based on Government regulation No. 60 of 2005, there are four zones, namely core zone, sustainable fisheries zone, usage zone, and miscellaneous zone.The sustainable fisheries zone allows environmental-friendly fisheries and aquaculture activities, as well as marine tourism.

In order to manage MPA's effectively, recently Indonesia is promoting a tool to evaluate the MPAs management. There are five levels of management, namely, red (initiation level), yellow (establishment level), green (minimum management level), blue (optimal management level) and gold (sustainable management). Challenges in managing MPAs include the lack of infrastructure and human resources to manage and monitor MPAs, and inadequate management plans are the issues in managing the MPAs.

In order to designate 20 million ha of MPA, by 2020, the Government of Indonesia has to declare an additional 4 million ha in the next seven years. Potential strategies towards this have been identified. The first step is to integrate community-based MPAs (village level) into national MPAs by 2013, more than 300 community-based MPAs will be established. The second step is to develop new MPAs in several priority areas such as Aceh and Lesser Sunda Ecoregion (Wildlife Conservation Society and MPAG, 2013); these efforts require coordination between communities, local government and central government.

Indonesia is seriously engaged in developing and managing marine protected areas. MPAs are developed not only to achieve extended areas but also to implement effective and sustainable management in order to achieve environmental conservation and community prosperity through sustainable fisheries and marine ecotourism.

Long-term effective MPA management demands improved coordination between institutions directly involved in marine conservation management as well as capacity building within these institutions. The commitment of local governments and involvement of communities in

formulating and applying MPA zoning plans and designing new MPAs under their jurisdiction is crucial. Further to this awareness must be raised amongst coastal communities and other stakeholders in order that they have a better understanding in managing MPAs, developing effective plans, improving critical infrastructures and developing finance strategies.

Fisheries refugia: a regional initiative to improve the integration of fisheries and habitat management

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Fisheries of the South China Sea, including the Gulf of Thailand, are characterised by high levels of small-scale fishing. Increasing fishing pressure, coupled with continued decline in the expanse and quality of coastal habitats critical to the life cycles of most species, has raised serious concerns regarding the long-term sustainability of Southeast Asian fisheries. This paper presents the outcomes of a regional initiative to improve the integration of fisheries and habitat management recently published as part of a Special Issue of the journal 'Ocean and Coastal Management' on the UNEP/GEF South China Sea Project.

The complexity of the key threats to fish stocks and their habitats in the South China Sea necessitates adequate cross-sectoral consultation between fisheries and environment departments, particularly in relation to the identification and designation of priority places for the integration of fisheries and habitat management. The dilemma for the fisheries and environment sectors is that conservation of habitat does not necessarily result in increased fish stocks while lowering fishing effort does not necessarily result in the improvement of habitat.

The concept of fisheries *refugia* defined as *"Spatially and geographically defined, marine or coastal areas in which specific management measures are applied to sustain important species [fisheries resources] during critical stages of their life cycle, for their sustainable use"* was developed through this study a novel approach to the identification and designation of priority areas to integrate fisheries and habitat management in the context of high and increasing levels of small-scale fishing pressure in the South China Sea.

In developing the framework for a regional system of fisheries *refugia*, specific regional, national and local actions were planned with the objective of overcoming barriers to the integration of fisheries and habitat management. Key barriers were identified as:

- Limited practical experience in integrating fisheries and environmental considerations;
- Limited knowledge of fish life-cycle and critical habitat linkages; and
- Low level community acceptance of 'protected' area-based approaches.

The Regional Working Group on Fisheries (RWG-F) for the UNEP/GEF South China Sea Project agreed that any approach aimed at fostering integrated management should:

- Build the capacity of fisheries and environment departments and ministries to engage in meaningful dialogue regarding how broader multiple use planning can best contribute to improving the state of fisheries habitat management in areas of the South China Sea and the Gulf of Thailand;

- Improve understanding among stakeholders, including fisher folk, scientists, policy makers and fisheries managers, of habitat and fishery linkages as a basis for integrated fisheries and habitat management; and

- Enhance and sustain the participation of local fishing communities and private sector in management interventions for improved fisheries habitat management and biodiversity conservation through a focus on sustainable use rather than the prohibition of fishing.

Keeping in mind the approaches mentioned above, several activities were undertaken. This involved the following:

- Capacity building for identification, designation and management of fisheries *refugia*

- Defining and disseminating information on the fisheries *refugia* concept through: regional and national fisheries and environmental forums; national expert, stakeholder, and community consultations; regional and national publication of a series of popular articles about the concept; and online media;

- Development of criteria for identification of fisheries *refugia*: critical spawning and nursery areas. Most fish populations are vulnerable to the impacts of over-fishing in areas and at times where there are high abundances of (a) stock in spawning condition, (b) juveniles and pre-recruits, or (c) pre-recruits migrating to fishing grounds. Relevant scientific information was compiled and reviewed and used to agree on criteria for the characterisation of priority fisheries *refugia*. A total of 14 priority sites and additional 9 sites for inclusion in an initial system of fisheries *refugia* were agreed by the RWG-F;

- Enhancing the scientific and information base for management. A key constraint in the future development of the regional system of fisheries *refugia* is the shortage of information

regarding fish life cycles and critical habitat linkages in Southeast Asia. SEAFDEC has been working to fill this information gap by including larval and juvenile fish surveys as part of its regular fisheries research cruises; organizing the joint UNEP/GEF South China Sea Project-SEAFDEC "Regional Training Workshops on Larval Fish Identification and Fish Early Life History Science" for young scientists; establishment of a 'Network of Southeast Asian Larval Fish Scientists within the framework of SEAFDEC; and published textbooks entitled "Larval Fish Identification Guide for the South China Sea and Gulf of Thailand" in 2007 and the "Early Stages of Marine Fishes in Southeast Asian Region" in 2012.

- Strengthened enabling environment

- Regional guidelines on the use of fisheries *refugia* in capture fisheries management were developed and endorsed inter-governmentally for inclusion in the ASEAN SEAFDEC Regional Guidelines for Responsible Fisheries in Southeast Asia. The *refugia* concept was then included in the following national fisheries policies and plans as a priority tool for improved fisheries habitat management: Fisheries Law of Cambodia; South China Sea Fisheries Management Zone Plan in Indonesia; the Comprehensive National Fisheries Industry Development Plan in the Philippines; Thailand's Marine Fisheries Policy; and the National Plan for the Management of Aquatic Species and Habitats in Viet Nam. On the basis of this, a programme of targeted actions for operating a regional system of fisheries *refugia* was developed and included in the intergovernmental Strategic Action Programme for the South China Sea.

- Development of a regional project to implement the fisheries component of the South China Sea Strategic Action Programme.

In this connection, the 44th meeting (June 2013) of the Global Environment Facility (GEF) Council endorsed the development of a full-sized GEF International Waters project entitled "Establishment and Operation of a Regional System of Fisheries *Refugia* in the South China Sea and Gulf of Thailand" to test the *refugia* approach. This project will be executed regionally by SEAFDEC in partnership with six participating countries.

The initiative resulted in the following outcomes:

- Experiences in the uptake of the fisheries *refugia* concept: A relevant example is the experience of Vietnam in the use of fisheries *refugia* as a tool for integrated fisheries and habitat management in the Phu Quoc Archipelago. The extensive seagrass meadows adjacent to the Ham Ninh commune of Phu Quoc represent 8 percent of the total known area of seagrass in the South China Sea. As a strategy to improve communication between fisheries and environment managers in addressing this issue, the fisheries refugia concept was introduced to the Phu

Quoc Management Board responsible for coral reef and seagrass management as a means of improving the management of fish stocks and habitat links at Ham Ninh. The fisheries refugia concept was well received by the relevant stakeholders.

- Comparisons of MPAs and fisheries refugia: The RWG-F expressed concern that MPAs as currently planned and operated in the South China Sea would bring benefits to fisheries. There currently exists little evidence of overall increases in fishery benefits following the establishment of MPAs as increased catches frequently do not compensate for the decreased area of fishing grounds. In addition, MPA models have shown that, the effects of MPAs on fisheries yield are highly dependent on a number of factors, e.g., dispersal in the larval, juvenile and adult stages, configuration of the reserve, and the status of the fishery. The RWG-F agreed that traditional MPAs are unlikely to enhance fish stocks and catch in the South China Sea as they are directed towards achieving the wider objectives of biodiversity conservation that often precludes adequate consideration of fish life history and critical habitat linkages. The fisheries *refugia* concept has been developed to redress this imbalance.

Significance of the fisheries *refugia* approach: At the outset there was a widespread recognition amongest stakeholders of the need for coordinated action to address fisheries and habitat related issues. This had not been previously addressed due to the lack of regionally-relevant management approaches that fostered the establishment of common ground and improved dialogue between the fisheries and environmental sectors and between the community and government. The fisheries *refugia* concept has met this need in its focus on fish life cycle and critical habitat linkages and an emphasis on sustainable use rather than the prohibition of fishing.

The *refugia* concept appears to be a successful approach in addressing a significant barrier to the integration of fisheries and habitat management, namely the adverse reaction to the Marine Protected Area concept that is elicited from fishing communities and fisheries officers at the local and provincial levels. It is anticipated that the experiences gained from this novel approach to the use of spatial management tools in fisheries management will be suitable for scaling-up in the South China Sea and replication in other aquatic habitats. This experience is considered important because of the potential global fisheries and biodiversity conservation benefits associated with effective fisheries and habitat management at the local level. This is particularly relevant in Southeast Asia where the contribution of fisheries to food security and the maintenance and improvement of the livelihoods of coastal fishing communities is substantial.

Development of fisheries refugia on closed seasons and areas in the Gulf of Thailand

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Marine capture fisheries of Thailand had been placed in the top ten fisheries production countries. Indo-Pacific mackerel is one of the most important pelagic species among Thai people, particularly those caught from the Inner Gulf of Thailand. Increasing demand of protein sources together with rapid development and improvement of fishing techniques was the major cause to stock reduction of the Indo-Pacific mackerel and some other commercially important pelagic species in the Gulf of Thailand (GoT). Department of Fisheries, Thailand (Thai-DOF) had monitored the changes in status of aquatic species and also the fishing methods with the aim at determining appropriate measures from time to time for sustainable use of these pelagic species. Over the past 60 years, the "Gulf Closing" was one of the most important measures among various measures for fisheries management. Development of type of fisheries management measures implementing in the GoT can be summarized as follows:-

Period I (before 1953): There was no establishment of any measures before 1953 for conservation and management of marine resources due to the rich of natural biological diversity in the Gulf of Thailand. The Indo-Pacific mackerel was considered as the economically important species during those days.

Period II (1954-1967): As the result from improved/developed fishing gear and methods, it showed increased catch production of pelagic resources in GoT, particularly Indo-Pacific mackerel. Since then, Thai-DOF started to establish an appropriate measure to the Indo-Pacific mackerel stock by prohibiting the use of some fishing gear and methods (such as large-scale Chinese purse seine, Thai purse seine etc.) during their spawning period through the Notification of the Ministry of Agriculture and Cooperatives (MOA-N) dated 25th August 1953. In 1957, Thai-DOF first established a Technical Study Committee for Indo-Pacific mackerel Investigation in responding to the request/complaint from fishers on the increased number of fishing gears including bamboo

stake trap, Chinese/Thai purse seines that might have caused decline of the Indo-Pacific mackerel stock. MOA-N dated 18th March in 1959 was issued regarding determination of fish spawning and to prohibit the use of some fishing gears and practices. Consequently, the use of logbook was introduced to fishers for obtaining catch data of Indo-Pacific mackerel. At the same time, the use of purse seine and enmesh gillnet were prohibited in the restricted areas identified as the spawning ground of Indo-Pacific mackerel. MOA-N dated 8th March 1962 was issued to conserve Indo-Pacific mackerel during spawning season, and use of mesh size in some fishing gear was prohibited for catching small size Indo-Pacific mackerel. The first closed areas and life cycle of the Indo-Pacific mackerel in the Gulf of Thailand are shown in Fig. 1.

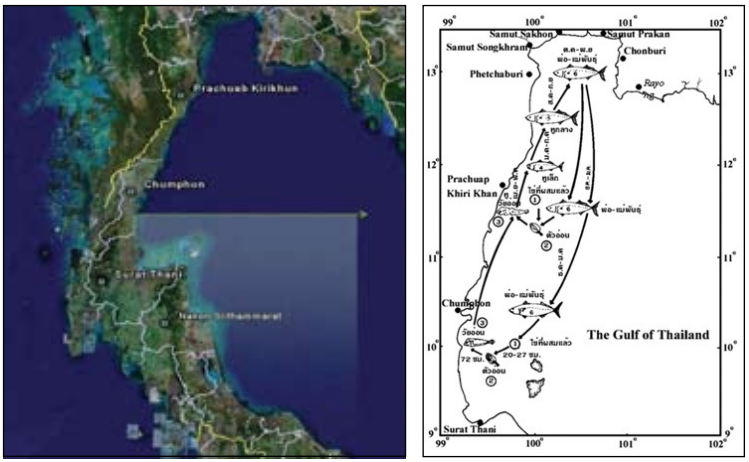

Figure 1. Closed areas and life cycle of the Indo-Pacific mackerel in the Gulf of Thailand

Period III (1968-1982): Over fishing capacity in the GoT became the serious problem, particularly from the development of the bottom trawlers introduced from Germany in 1960. Modified trawlers for catching Indo-Pacific mackerel were introduced, which resulted in higher of fish catch for many years. MOA-N dated 13th October 1972 was issued to prohibit trawler operations in Prachuap Khiri Khan, Chumphon, Surat Thani, and Nakhon Si Thammarat provinces. Oil crisis in 1973 was the major cause to the modification of the pelagic fishing gears. In addition, fish aggregating devices using a bunch of coconut leaves and luring lamp were initially used to increase the fishing efficiency. MOA-N dated 7th November 1975 was issued to prohibit the use of some fishing gears, and to regulate mesh size for catching young juvenile of Indo-Pacific mackerel. Under MOA-N dated 8th March 1962, the gear prohibition was also given to luring purse seine using coconut shelter with/without lamp. The Gulf Closing period was then extended from 15th April to 14th July annually. From 1977-1983, Thai-DOF attempted to revise the MOA-N/1975 to effectively manage marine capture fisheries by prohibiting all types of fishing boats.

Period IV (1983-1997): MOA-N dated 3rd March 1983 was issued by revising the MOA-N October 1972 and November 1986. To utilize the resources together with the attempt to reduce the pressure of trawling and purse seining - the trawl net equipped with motorized engine; purse seiners equipped with purse lines; and enmesh gillnet, the use of these gears in specific areas during the specific periods/areas are prohibited. Subsequently, MOA-N dated 28th November 1984 was issued to prohibit the use of other fishing gear and methods during spawning and nursery period in some specific areas, by extending the closing period from 2 months to 3 months and dividing into 2 periods: the first phase, spawning period from 15th February to 31st March; the second phase, nursery and juvenile period from 1st April to 15th May of each year. Since 1980, anchovy purse seine fishing fleets was rapidly expanded due to market driven demand. Thai-DOF issued Notification dated 12nd February 1994 based on the results that distribution of anchovy eggs and its larvae were extensively found in the area from 1～40 nautical miles from shore during January to March. The prohibition of daytime anchovy fishing operation during 15th February to 15th May was included under this Notification. By this way, it was found that Indo-Pacific mackerel production in the GoT was maintained at about 90,000 metric tons annually over the 6 years continuously.

Period V (from 1998 to date): Regarding the problem related to anchovy fishing activities, fishing gear/methods were modified to be unable to enforce under the existing MOA-Ns, as well as to increase fishing efficiency. Moreover, efficiency of push-netters was improved either by increasing length of the push-stick or constructing bigger boats. Push-netters and anchovy purse seiners were installed with light generator for operating cast net, falling net, and lift net for targeting anchovy. Consequently, MOA-N dated 24th September 1999 was issued to prohibit the use of some fishing gear activities during 15th February to 15th May in the important spawning areas and nursery period of Indo-Pacific mackerel. However, as they could not immediately respond to the Notification, rescheduling the use of measures was prolonged for a year. During that prolonged period, the Notification issued in 1984 was used on a temporary basis, and consented to seek for resolution through multi-stakeholders committee (representatives from each group of fishing gear, and relevant governmental officials) established in each province. The 2nd Edition of the Gulf Closing was issued in the year 2000 to prohibit the use of some type of fishing gear during spawning and nursery period in the area of Prachaup Khiri Khan, Chumphon, and Surat Thani. The major point was to temporarily stop implementing the Notification dated 24th September 1999, and make it effective from 15th February to 15th May 2000. Consequently, fishers of Lang-soun district protested the Notification. Through the consultation process with fishers on 22nd February 2001, permission was given, including: (i) during the first 45 days (15th February to 31st March 2001), permission only for beam trawl or bottom otter board beam trawl (small trawl) that use one single motorized boat and fish during the night; push net; anchovy purse seine operate during day time; lift net; anchovy cast net equipped with electronic generator; (ii) during the last 45 days (1st April to 15th May 2001), permission was given only for encircling gill net that

use together with motorized boat and use similar fishing method with Indo-Pacific mackerel purse seine. Fig. 2 shows the present closed areas and new challenge issue.

According to the prohibition on the use of mackerel encircling gillnet, it caused to increase in numbers of Indo-Pacific mackerel drift gill net significantly from 2002 to 2005. Fishers modified their prohibited fishing gears (trawl net, and mackerel encircling gill net) to be identified as legal gears (fish drift gillnet) as identified under this Notification dated 24th September 1999. In addition, various demersal fish (e.g. red snapper, big eyes, lizard fishes, and wolf herring)

Fig. 2. Closed areas and new challenge issue

were also caught by the drift gillnet. At the same time, some fisher groups improved the drift gillnet (also targeting at Indo-Pacific mackerel) by adding the net depth from 50～80 to 200～300 meshes. Fishing method was also changed from strait set up of net to operation of net in circles and, zigzag manner. This type of gillnet was called "Auon-short". In 2005, results of a study indicated that the catch rate of this gillnet consisted of 80 to 85% Indo-Pacific mackerel. It was also found that 75 to 98% of male and female were fully mature.

In conclusion, during the past 60 years (1953～2013), Thai-DOF issued totally 13 management measures involving the "Gulf Closing" with the aim at conserving spawning and nursery stages of aquatic resources in the GoT. The measures for conserving Indo-Pacific mackerel were used as a basis for formulation and development of the other conservation measures. Cancellation and revision of these measures were made from time to time according to the change of status of fisheries resources, and to effectively manage the resources for sustainable exploitation.

Development and management of fisheries refugia in Phu Quoc Marine Protected Area, Vietnam

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The Phu Quoc Archipelago in Vietnam is composed of 26 islands and was declared as Marine Protected Area (MPA) in 2007 under Decision No. 1297/QĐ-UBND by the Chairman of Kien Giang Provincial People's Committee. The MPA covers an area of 26,863 ha comprising two major habitats of seagrass beds (6,825 ha) located in the north-western part and coral reefs (9.720 ha) in the southern part and an area for socio-economic development (10.318 ha) located in the south-western part of the main island (Phu Quoc). The waters surrounding the MPA support a large area of seagrass beds (12,000 ha) and coral reefs (411 ha). Since its establishment, a series of management activities have been implemented towards conserving biodiversity and resources for the benefit of tourism, fisheries and the community. However, the results of monitoring seagrass beds and coral reefs monitoring studies conducted between 2006 and 2010 demonstrated that the conditions of these habitats had gradually declined and habitat associated resources did not significantly recover, especially the target species due to overfishing, trawling, destructive fishing, coral bleaching and sedimentation.

Consultations with local fishers indicated that some locations are important as spawning and nursery grounds for commercial species found on seagrass beds and coral reefs. However, these important grounds have not been considered under the MPA due to the insufficient information. Consequently, the linkages between habitats and the life cycle of habitat associated species have not received sufficient attention in MPA management plans. Zoning plans were mainly based on distribution and status of habitats, species richness, endangered species, resource use and human impacts on resources and environment. This approach led to the slow recovery of marine resources in general and target species in particular.

Establishment of fisheries refugia for sustainable use of fish stocks and their habitats has been recently considered as an important approach for fisheries management. Fisheries refugia was

developed in Phu Quoc at a pilot site of seagrass beds at Ham Ninh Commune in 2007 within the framework of the UNEP/GEF project "Reversing environmental degradation trends in the South China Sea and Gulf of Thailand". The activities under the project were continued in the project "Studies and establishment of some fisheries refugia in Vietnam" between 2012 and 2014 with support from the Ministry of Agriculture and Rural Development (MARD) of Vietnam.

Inventories and assessments of critical spawning and/or nursery grounds were developed through consultations and field surveys with involvement from local communities, managers and scientists to enable use of local knowledge. At each identified spawning/nursery ground, condition of habitats and abundance of associated target species were carried out by using transect methods. Selection of sites for establishment of a model for management of fisheries refugia was based on scientific data and consultations with local communities on habitat vulnerability, diversity and abundance of target species and management potential.

Data and information gathered from surveys in seagrass beds indicate 11 spawning and nursery grounds of several target species including octopus (*Octopus dollfusi*), cuttlefish (*Sepioteuthis lessoniana*), strombus snail (*Strombus canarium*), swimming crab (*Portunus pelagicus*), seahorses (*Hippocampus kuda* and *H. trimaculatus*), rabbitfishes (*Siganus canaliculatus, S. guttatus* and *S. javus*) and squids (*Loligo* spp.) on sandy bottom (Fig.1). Shrimp (*Penaeus latisulcatus*) and Indian whiting (*Sillago sihama*) are also important resources although their spawning/nursery grounds were very difficult to identify. Within coral reefs, there were 10 identified nursery grounds of barred-cheek coral trout (*Plectropomus maculatus*) found in the waters surrounding most of the islands group (An Thoi) in the southern part of Phu Quoc island (Fig. 2). The eggs of strombus snail were recorded mostly on the sand-gravel bottoms on or nearby seagrass beds while the eggs of cuttlefish were usually attached on seagrass or seaweeds. The spawned octopus and their eggs were mostly found inside the dead shells of gastropods or bivalves. Juveniles and mature swimming crab with full eggs, and juveniles of rabbitfishes and seahorses were found in grounds characterised by high cover and density of seagrass. Juveniles of groupers were commonly recorded on the outer reef slope with high cover of coral rubbles and sand-gravel compared to that on the reef flat with high cover of live corals.

Achievements of fisheries refugia management in Phu Quoc include the development of two pilot sites to protect the nursery grounds of groupers in coral reefs at Hon Roi fishing village and spawning/nursery grounds of strombus snail, octopus, swimming crab and seahorses in seagrass beds at Bai Thom fishing village. Through two consultations with local communities at each of fishing village, regulations and community-based management teams have been established for daily management at each site, especially during spawning/nursery seasons.

Lessons learnt from the undertakings are: 1) Using local fisher knowledge for scientific studies is an important step for inventory and assessments of fisheries refugia; 2) Involvement of local communities and local government officers (MPA and fisheries managers, Police and Border Army) plays an important role in all steps of the development of fisheries refugia, particularly in identifying specific fisheries related issues and appropriate management measures, which ensures success of sustainable management.

Fig. 1. Distribution of spawning/nursery grounds of target species in seagrass beds and sandy bottoms in Phu Quoc Archipelago

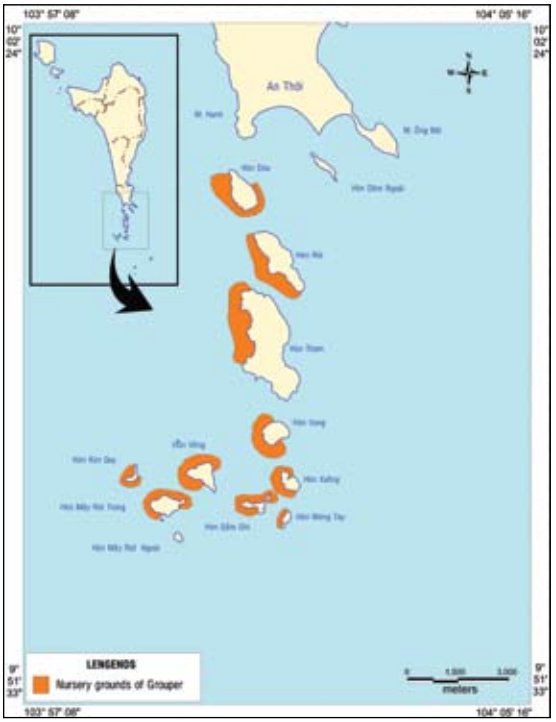

Fig. 2. Distribution of nursery grounds of barred-cheek coral trout in coral reefs in Phu Quoc Archipelago

More work will be conducted to develop fisheries profiles at each site as a basis for recognition of management measures (resources, fishing sector, post-harvest sector), to develop guidelines for sustainable use and training for monitoring the target species, development of mechanisms and measures for long-term refugia management at demonstration and other potential sites in Phu Quoc.

Lagoon fishing in Lakshadweep

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Application of spatial planning in establishing Marine protected area syatem for sustainable fisheries management in Vietnam

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Vietnam is a maritime country having potentials for marine fisheries development. Marine fisheries has been considered as high priority in socio-economic development of the country. In 2012, the fisheries sector has contributed to the national economy with over 61 billion USD of GDP value from the fishery export. However, fisheries development activities and other economic sectors, in its currently managed state, has caused loss of marine biodiversity, pollution, degradation of marine ecosystems, coastal habitat destruction, overfishing and oil spills. Therefore, the Vietnamese Government has fostered establishment and management of national system of marine protected areas (MPA) by using marine spatial planning (MSP) tool based on ecosystem approach.

Ecosystem-based MSP approaches have been used with following key steps:

(1) Defining marine biogeographical position of Vietnam seas
(2) Conducting marine biodiversity zoning
(3) Identifying marine-island clusters with high conservative potentials
(4) Screening priority sites for conservation in each cluster
(5) Selecting and listing the proposed MPA sites in national system to submit to the Government for consideration and approval.
(6) Developing management plan of MPA site in planned MPA system

The planning process of the national system of MPAs is given in Fig. 1.

Following the above mentioned MPA planning process, some thematic maps and maps of MPA sites have been created.

Fig. 1. A scheme of MPA screening and selecting MPAs

The Vietnam's sea has been divided into 6 marine biodiversity zones, and the planners have identified 9 high conservation potential clusters, including marine waters with islands which are important ecosystems and habitats for conservation. The conservation potential sites for MPAs have been considered as a relative range between total of biodiversity of the studied ecosystem and species per total of the threats to the tentative sites.

Based on the relative range of conservation potentials and MPA site profile, the first list of representative system of 16 MPAs with high conservative values has been selected (Table 1). The final report of MPAs planning results, including the list of the 16 MPAs had to be submitted to and approved by the Prime Minister in 2010 after the planning process about 12 years (due to institutional aspect of MPA governance). It is the first national system of MPAs in Vietnam and have been grouped in 3 of 6 IUCN/WCPA categories which integrated in Vietnam Law of Fisheries: Marine Park (I), Species and Habitat Protected Area (II), and Aquatic Naturally Resources Preserved Area (III).

The total planned area of whole MPAs system is 270,271 ha, of which 169,617 ha is marine area, including about 70,000 ha of coral reefs, 20,000 ha of seagrass beds, partly mangroves, breeding and nursery of coastal and marine species and about 100 rare/unique species, which have to be protected.

The three key programmes have been implemented in the period of 2006-2012 with total funds of some 1 billion USD, which include 40% from government funds, 30% from international supports, 20% from coastal provinces and 10% from local communities. The programs will be continued until 2015 with surveys on marine biodiversity for extended planning of the national system of MPAs.

Basically, the national system of 16 MPAs is representative of all ecological zones of the Vietnam sea (Fig. 2). However, most of them are distributed in marine biodiversity zone No. 1 (6 MPA sites), zone No. 2 (3 MPA sites), zone No. 3 (4 MPA sites), zone No. 4 (1 MPA sites), zone No. 5 (1 MPA sites) and zone No. 6 (1 MPA sites). We can see in the clusters with high conservation

potentials in Central and South Vietnam, there are less MPA sites than others. Therefore, the Ministry of Agriculture and Rural Development (MARD) is preparing an extended planning of the national system of MPAs for the next few years.

Table 1. List of marine protected areas in Vietnam planned until 2020

	Name of MPAs/Province	Category (IUCN, Fisheries Law)	Total area/ sea area (ha)	Biogeographical and marine biodiversity zone
1	Tran Island / QuangNinh	III	4200/3900	C-01
2	Co To Island / QuangNinh	II	7850/4000	C-01
3	Cat Ba/ HaiPhong	I	20,700/10,900	C-01
4	Bach Long Vi / HaiPhong	III	20,700/10,900	C-01
5	Hon Me / ThanhHoa	III	6700/6200	C-01
6	Con Co / Quang Tri	II	2,490/2140	C-01
7	Son Cha-Hai Van/ ThuaThien-Hue	II	17,039/7626	C-02
8	Cu Lao Cham / Quang Nam	I	8265/6,716	C-02
9	Ly Son / QuangNgai	III	7,925/7113	C-02
10	NhaTrang Gulf/ KhanhHoa	I	15,000/12,000	C-03
11	Nam Yet Island / KhanhHoa	II	35,000/20,000	C-06
12	Nui Chua /NinhThuan	I	29,865/7352	C-03
13	PhuQuy Island / BinhThuan	III	18,980/16,680	C-03
14	Hon Cau/ BinhThuan	II	12,500/12,390	C-03
15	Con Dao / Ba Ria-Vung Tau	I	29,400/23,000	C-04
16	PhuQuoc / KienGiang	II	33,657/18,700	C-05
	Total area		270,271/169,617	

Until now, only 5 among the 16 established MPAs have been effectively managed with function zoning scheme (Fig. 3)-key habitats, ecosystems, ecological processes and fishery resources inside MPAs preserved and initiatively restored. The remaining should come under management during 2014-2016. MARD plays a role in management of the MPAs with the following functions-development of a legal framework, technical supports, international cooperative promotion and supervise or check. The MARD has appointed line coastal provinces to be responsible in managing administratively the MPA sites belonging to their authority. The MARD is only managing directly the transboundary MPAs (inter-provincial) of special importance.

The establishment and management of the above MPAs have importantly contributed to sustainable fisheries development and to implementation of MDGs in Vietnam. These are first lessons learnt from ecosystem-based MSP application in MPA planning and managing in Vietnam. The key ecosystems in the MPAs if successfully managed will contribute to creating restoration and spillover effects in each MPA as well as in whole system of MPAs planned.

Fig. 2. Planned system for MPA in Vietnam towards 2020

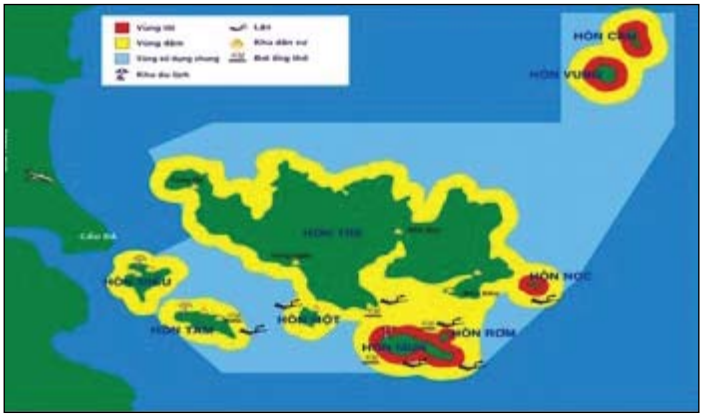

Fig.3. An example of function zoning scheme of Nhatrang bay MPA

The Nhatrang bay MPA in Vietnam is considered as the first site of good practices.In the MPA, after 4 years some detrimental traditional gears have been remarkably reduced, while fishery resources have been restored. The size and density of mussels and biomass of several other species have been increased.

For people in six fishing villages situated on the islands inside the Nhatrang MPA, alternate jobs have been provided (from fishing into eco-tourism services, including glass bottom boat for tourists and diving tourism etc). The livelihood of people who are living inside and near the MPA sites has improved in recent years.

The ecosystem and MSP approaches have been initially applied in all steps of the planning process of MPA national system in Vietnam. At present, these approaches are incorporated into the national policy and law to create a legal position and a strong tool for coastal and marine governance and management in Vietnam. In future, national guidelines on CMSP should be developed and approved as a technical assistance for the MPA planning in Vietnam. Most of the MPAs in Vietnam are in nearshore, which should be managed in an integrated manner for which CMSP is a strong supportive tool. The application of ecosystem and MSP approaches in MPA planning requires systematic data on biodiversity and database for the national system and for each MPA site.

The ecosystem-based MSP approaches are new for Vietnam and may be for the Asia region. So formulating a regional partnership of ecosystem-based MSP for supporting coastal and marine sustainable fisheries management is necessary for achieving long-term goals.

Spatial management of spinefoot shoemaker *(Siganus sutor)* spawning aggregation sites: what can be learned from tagging studies?

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The ecosystem approach to fisheries management requires that ecologically important areas such as fish spawning aggregation (FSA) sites are considered while developing fisheries management plans. Globally, strong emphasis is being placed on ensuring that exploited FSA sites are adequately protected to ensure that fish are able to successfully reproduce in appropriate numbers to sustain the stock and its dependent fishery. Spawning aggregations of the spine-foot shoemaker (*Siganus sutor*) forms around the time of the full moon at several sites along the west coast of the island of Praslin, Seychelles from September to April. The fishery management plan for the area has proposed certain control measures to prevent over-fishing of rabbitfish spawning aggregations. To improve current knowledge on the spatial scale at which these controls should be applied, we made use of acoustic and conventional tagging to study spawning aggregation related spatio-temporal movement of this species.

The study made use of acoustic and conventional tags and underwater visual census (UVC) to investigate spawning related movement of shoemaker spinefoot at several FSA sites off the south coast of Praslin Island, Seychelles. To study spawning site fidelity, residence time and timing of arrivals and departures of fish at the spawning aggregation sites, 39 fish were acoustically tagged between 20 and 22 October 2010 and 19 and 21 January 2011 at 3 spawning aggregation sites (Polite, Dividi, Désiré). Fish were caught in spawning aggregations at the study sites by local fishermen using traditional bamboo traps with a 1 to 2 h soak time. A Vemco V8-4H-S256 acoustic tag, sterilised in absolute ethanol, was then inserted in the body cavity through a small incision. Tagged fish were released in small groups at the point of capture within 3 h of the trap being hauled. The presence of the acoustically tagged fish at 3 spawning aggregation sites were monitored over 7 consecutive spawning months (October – April) by an array of acoustic receivers deployed at the sites. In order to obtain *Siganus sutor* density estimates, underwater visual census (UVC) was undertaken at Dividi and Désiré in 5

different months in 2010 and 2011. As *S. sutor* FSAs can start forming as early as 3 d before the full moon and last up to 3 d after the full moon, each monthly survey was conducted over 7 d, starting 3 d before the full moon and ending 3 d after it. During each survey, a single diver (J. P. Bijoux) counted the number of *S. sutor* 5 m in front of him in a 10 m wide belt transect running the approximate length of the site (125 m at Dividi and 100 m at Désiré).

To investigate the catchment area of the FSA sites we conventionally tagged fish (n = 1,592) at six FSA sites (Fig. 1) between April 2010 and March 2011. Once again fish were caught using bamboo traps with the help of fishermen. Fish were immediately tagged and released at the site of capture using uniquely numbered T-bar tags inserted at the 4th dorsal pterygiophore. A reward of 50 Seychelles Rupees (~US$ 4) was offered for each tagged fish that was recaptured and declared. Before the start of the project, we carried out an awareness campaign using face to face meetings and television adverts to inform fishermen and the general public about the tagging program and tag-return scheme.

The formation of spawning aggregation coincided with the full moon (Fig. 2). However, there were some differences in the exact time that aggregation formed between sites with aggregation at Polite forming before aggregation started at Dividi. Acoustically tagged fish showed high fidelity to spawning sites. Of the 35 tagged fish analysed, 22 (62.9%) were detected in more than one spawning period, while 13 were detected in only one. The fish that were detected in more than one spawning period exhibited a high but not absolute degree of site fidelity, with 19 of the 22 fish (86.4%) were detected at only one monitored FSA site (Fig. 1). Residence time of acoustically tagged fish at the monitored spawning aggregation sites varied between months and tended to decrease as average sea temperature increased (Fig. 3). It is believed

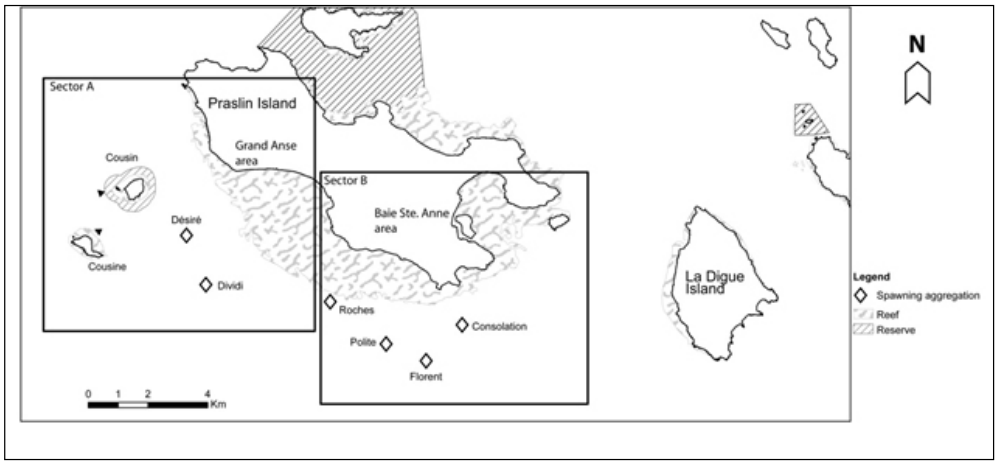

Fig. 1. Map of Praslin Island showing the location where the study was undertaken and *Siganus sutor* spawning aggregation sites where conventional tagging was undertaken.

that spawning aggregations form during every month of a reproductive period; however, it was found that they do not always form at the same site. Tagged fish arrived at spawning sites mostly at dawn and departed at dusk. When UVC data on fish density at spawning aggregation

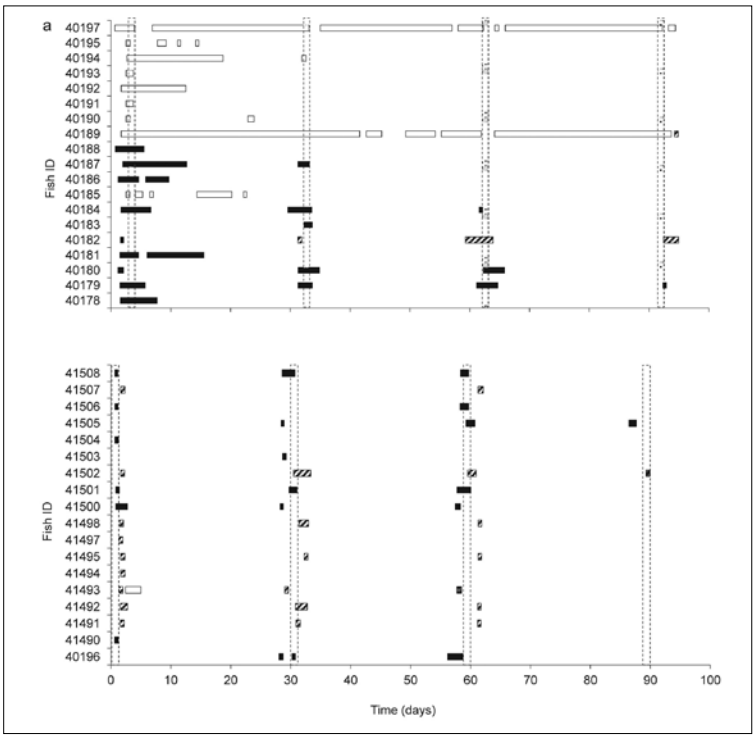

Fig. 2. Figure showing residence time of acoustically tagged fish at the 3 monitored spawning aggregation sites during the first (a) and second (b) monitoring period

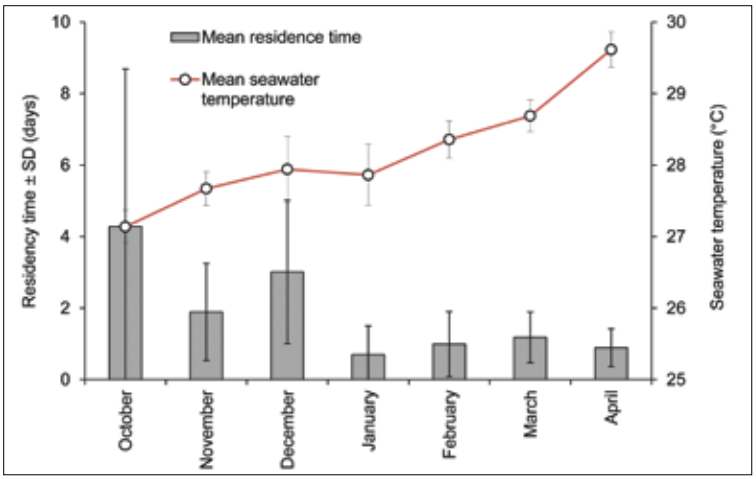

Fig.3. Changes in the average amount of time that acoustically tagged fish stays at spawning aggregation sites

sites were combined with residence time of acoustically tagged fish at the sites, turn-over of fish in the aggregation became evident. Average turn-over rate was about 3 times.

Recapture rate of conventionally tagged fish in the fishery was about 5%, much less than the 60% recapture rate we obtained in a pilot project in which fish were captured and tagged on the fringing reef of Praslin. The majority (64.6%) of fish were recaptured at FSA sites during spawning aggregation periods. Of those, 73.4% were recaptured at the same FSA site at which they were tagged and released. Twenty-nine tagged fish were recaptured off the FSA sites, mostly on the fringing reef of Praslin, in close proximity to the FSA sites. There was evidence of larger scale movements in two fish that were tagged at Polite and were recaptured more than 10 km away along the southeast shores of La Digue Island 49 days later. Another fish tagged at Désiré was subsequently recaptured 12 km away inside the Baie Ste Anne bay 52 days later.

Acoustic tagging and monitoring allowed fine-scale spatio-temporal use of spawning aggregation sites. On the other hand, recaptures of conventionally tagged fish in the fishery provided approximated catchment area for each spawning aggregation site and home range locations for the fish that were recaptured away from FSA sites during non-spawning aggregation periods. A notable finding was the combination of short individual residency times relative to aggregation duration, leading to demonstration of turnover and estimation of rates. Detections of numerous acoustically tagged fish at the same FSA site over multiple spawning periods along with recaptures of conventionally tagged fish at the FSA sites indicate strong but not absolute spawning site fidelity. It was evident that exchanges occurred mostly between sites that are located close to each other, suggesting that sector based management of spawning aggregation sites would have more impact than site based management. The conventionally tagged fish that were recaptured close to La Digue and those that were observed by snorkelers on the reefs of that island suggest that the catchment area for the spawning sites in sector B could also encompass the fringing reefs around La Digue and that the trap fishery for these 2 islands should be jointly managed.

The application of tagging and UVC in this study has improved the understanding of spatial and temporal dynamics of commercially exploited *Siganus sutor* spawning aggregations that form close to the island of Praslin, Seychelles.The efficacy of management and conservation for *S. sutor* will depend, to a large extent, on designing measures that address the many complex spatial and temporal dynamics demonstrated in this study, including the use of offshore sites for spawning, partial infidelity to spawning sites, and turnover within aggregations.

Management of artisanal fisheries in the Bay of Bengal

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The objective of conventional fisheries management is to maximize output from the fisheries production system, while also addressing social issues such as employment generation. The decision-making processes depend more on scientific advisories and wisdom of the policy makers and they are often hierarchical, *i.e,*. top-down. On the other hand, Ecosystem Management, a term popularized after finding strong support at the 1992 UN Conference on Environment and Development (UNCED) and in the Convention on Biological Diversity (CBD), primarily aims at conservation of resources and/or achieving a desirable state. The Ecosystem Approach to Fisheries (EAF), advocated mainly by the Food and Agriculture Organization of the United Nations (FAO), takes a rather mixed approach and defines. EAF as "to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystem." Both the purpose and definition recognize that EAF as a means to introduce sustainable development concepts into fisheries by addressing both human and ecological well-being. In conventional management, fishing or more specifically the fishermen are exogenous to the system and hence their activities are regulated. However, in a sound EAF framework, the human beings, their objectives, their behavior and their institutions are the key to successful implementation of the fisheries management system. Therefore, EAF calls for a participatory approach, which is also in line with the guidelines for developing a responsible fisheries management system outlined in the Code of Conduct for Responsible Fisheries.

Fisheries management practices in the Bay of Bengal region, which have evolved from community-based practices and the rules and regulation introduced during the colonial rule, moved towards conventional fisheries management in the late fifties and early sixties. The countries around the Bay of Bengal invested heavily in developing knowledge and physical

infrastructure for the fisheries sector with the twin objectives of increasing production and creating employment. Earning foreign exchange through export of seafood later became the third major objective. These developments led to an inflationary process of mechanization and lateral entry into the sector. This is also in tune with the global development pattern in the fisheries sector. However, while these developments coupled with growing markets led to manifold increase in production, they also disintegrated the fisheries sector in terms of scales of operation and access to resources leading to emergence of industrial fisheries and small-scale and artisanal fisheries (SSAF).

While the exact number of people earning their livelihoods from fisheries is not known, an estimates provided by the FAO shows that globally about 38 million people are directly involved in fisheries (FAO, The State of the World Fisheries and Aquaculture, 2012). About 90 percent of them are SSAF fish workers. The problem in estimating the exact number of SSAF fish workers is also due to the difficulties in arriving at a universal operational definition for the sector. While FAO holds that SSAF clearly differs from industrial and recreational fisheries, the distinction between SSAF is hard to pin down. Appreciating these difficulties intrinsic to SSAF sector, the geographical scope of this paper is limited to the Bay of Bengal region. This region is not only home to the majority of fish workers, but fisheries here are usually dominated by the SSAF sector. Further, in line with the difference between SSAF sector, the scope of this paper is further narrowed down to fishing carried out without using power (or non-powered fishing vessels), which is also a traditional and indigenous fishing practice in the region.

Although the share of artisanal sector in total landings in the region is steadily on the decline, it still holds a sizable share in terms of fishing fleet and livelihoods (Table 1). The artisanal fishing is largely carried out by family units and caters to local needs. It also employs diverse fishing gear mimicking in a way the natural removal process. As long as fishing was done only for subsistence purposes, this was perhaps the closest possible approach to natural removal system. However, when it got linked with the market, subsistence fisheries were replaced with the commercial enterprises.

The management objectives of a responsible fisheries production system aim at meeting the needs of the growing population without compromising with the ecological security and well-being of the ecosystem. Within this management paradigm and the rapid pace at which the economies are developing in the Bay of Bengal region, it is essential to know why artisanal fisheries continuest to exist; whether they are a left-behind group or a strategic choice of the fishers. The answer to this question will perhaps be useful in building a framework for the management of artisanal fisheries in the Bay of Bengal region.

Managing artisanal fisheries through EAF will need an institutional overhauling, clarifying the role of fisheries sector in general and the artisanal fisheries in particular. At the global level, the

Table 1: Size of artisanal (non-powered) fishing vessels in Bay of Bengal region in 2010-11

Country	Fishing vessels		Share (%)
	Non-powered	Total	
Bangladesh	23,963	45,851	52
India	52,982	1,99,141	27
Indonesia	1,72,907	5,61,459	31
Malaysia	2,977	49,756	6
Maldives	22	838	3
Myanmar	17,054	32,919	52
Sri Lanka	19,485	45,847	43

Source: BOBP-IGO/SEAFDEC

FAO-led voluntary guidelines on SSAF could be conducive in creating the necessary debate and also in raising the profile of the sector. At the regional level, Bangladesh, Sri Lanka and India have reviewed the scope and position of SSAF. While within the fisheries sector, importance of the artisanal fisheries has been re-emphasized time and again and further carried forward in these global and regional initiatives, integrating fisheries in national land and resource use policy is likely to be the key to its sustainable development within the EAF context.

The waters of the Andaman Islands

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Conservation and sustainable use of marine and coastal biodiversity: What role can traditional knowledge of coastal communities play?

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Marine and coastal biodiversity may be defined as variety of living organisms integral to the marine and coastal ecosystems. Conservation and sustainable use of marine and coastal biodiversity would help maintain fish provision services to support nutritional needs and to protect, in the process, employment and income of fishers. Approaching from a fisheries, poverty eradication and food security perspective, conservation and sustainable use of marine and coastal biodiversity would mean conservation, management and sustainable use of commercially exploited fishery resources and associated and dependent species. They would also mean protecting marine and coastal habitats such as the coral reef ecosystems, estuaries, tropical wetlands including mangroves, sea grass beds, and other spawning and nursery areas.

The international obligations towards conservation, management and sustainable use of marine living resources are laid down in the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and its related instruments. Under UNCLOS, the coastal State is required to adopt conservation and management of living resources employing the best scientific knowledge available to the coastal State, taking into account, inter alia, the economic needs of coastal fishing communities. In the context of sustainable development, the Agenda 21 of the 1992 United Nations Conference on Environment and Development (UNCED) assigned a significant role for traditional knowledge to complement scientific knowledge.

Agenda 21 highlighted several lines of action towards recognizing traditional knowledge in the context of sustainable development: first, it sought acquiring and recording traditional knowledge concerning marine living resources and the environment and to incorporate such knowledge into management systems; second, it advocated traditional ecological knowledge to be made available to policymakers; third, it sought to highlight the links between traditional knowledge and current advanced science and to disseminate and apply the results for

environment protection and sustainable development; and fourth, it encouraged extending financial and technical assistance to local fishing communities to organize, maintain, exchange and improve traditional knowledge of marine living resources and fishing techniques and upgrade knowledge of marine and coastal ecosystems. The holders of traditional knowledge were also valorized under Rio Principles (Principle 22). The 1992 Convention on Biological Diversity (CBD) which was signed at the UNCED- recognized the role of traditional knowledge, innovations and practices in the conservation, sustainable use and sharing of benefits of biodiversity, including marine and coastal biodiversity.

The 1995 FAO Code of Conduct for Responsible Fisheries (CCRF) recognized the role of traditional knowledge of the resources and their habitat in complementing scientific evidence. The Code sought to investigate and document traditional knowledge and to assess its application to fishery conservation and development, particularly in the context of developing countries. The currently negotiated FAO International Guidelines for Securing Sustainable Small-scale Fisheries to complement the Code also reiterates the importance of traditional knowledge in sustainable use of fishery resources.

The 2002 Plan of Implementation of the World Summit on Sustainable Development (WSSD POI) sought recognition of the rights of local and indigenous communities who are holders of traditional knowledge, innovations and practices and to develop benefit-sharing mechanisms for the use of such knowledge, innovations and practices in consultation with these communities on mutually agreed terms. The WSSD POI also sought effective participation of communities in decision and policy-making concerning the use of their traditional knowledge. 'The Future We Want'-the outcome document of the Rio+20 United Nations Conference on Sustainable Development- renewed earlier commitments to sustainable development and further recognized the contribution of traditional knowledge of indigenous peoples and local communities to conservation and sustainable use of biodiversity.

Although there is no internationally accepted definition, 'traditional knowledge' has been described as knowledge systems, creations, innovations and cultural expressions that have generally been transmitted from generation to generation or knowledge pertaining to a particular people or territory that are constantly evolving in response to a changing environment. Categories of traditional knowledge of coastal communities, both men and women, include: technical knowledge, fisheries knowledge, ethological knowledge, taxonomic knowledge, ecological knowledge, biodiversity-related knowledge, therapeutic knowledge, geological knowledge, astronomical knowledge, wave and tidal knowledge, climatological knowledge, nutritional knowledge, culinary knowledge, etc. The traditional knowledge of coastal communities would further encompass certain types of customary practices and institutions; knowledge about natural calamities, disaster protection and mitigation measures; and knowledge about conflict resolution within and across sectors. Several of such elements

are relevant and could be successfully twinned with scientific knowledge for proper fisheries conservation and management.

Some guidance on how certain elements of traditional knowledge can be validated and incorporated in formal efforts to assemble selected knowledge for decision-making is provided by the United Nations, which are also relevant to conservation and sustainable use of fishery resources. Specific to fisheries, several authors have demonstrated how traditional knowledge can enrich conservation and management, especially by providing information on stock structure; spawning grounds and juvenile habitat; catch-rate; and on spatial and other changes in effort and fishing practices. Drawing upon traditional knowledge elements can be cost- and time-saving as well in determining the status of fish stocks.

In spite of being designated a clear niche in international legal instruments, efforts to gather and validate traditional knowledge and make it available for conservation and management of fishery resources, as well as for policy reforms, are very few. Even in countries recognizing traditional knowledge, innovations and practices, the emphasis is mainly on viewing them from the perspective of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) of WTO and less from the perspective of how traditional knowledge could complement scientific knowledge in the conservation and sustainable use of marine and coastal biodiversity. Governments and the scientific community should recognize the importance of traditional knowledge, innovations and practices and promote their application to fishery conservation and adaptive management-a process that can immensely contribute to establishing legitimacy of management regimes at the local level. Relevant conditions also need to be created for traditional knowledge, innovations and practices to be made accessible to formal management systems, including developing mechanisms at different levels to protect their normative and operational space. Benefits of improved conservation and management from incorporating traditional knowledge should belong primarily to fishers within a human rights-based framework, especially to help promote food security and to eradicate poverty in coastal communities.

Traditional shrimp fishing in the Muthupet region, Tamil Nadu © V. Selvam

The livelihood dependency on natural resources along coastal Bangladesh

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The coastal area of Bangladesh covers 47,201 km^2, which is about 32% of total area of Bangladesh. It covers several ecosystem types and is inhabited by 28% of the country's population. However, the density of the population is less compared to that of the country as a whole due to the calamity risk and access problem to coastal land.

The present study was conducted by focusing three major ecosystems to assess the availability of natural resources, biodiversity at-risk and dependency in terms of livelihoods of the poor inhabitants of the sampled area. The case study on natural resources covered South Western to South-Eastern coastal part of Bangladesh, two sites of Sunderbans mangrove forest ecological critical area (ECA) (Koira and Monglaupazilla), two sites at Meghna Estuary used for Hilsa fishing and conservation (Andermanik river mouth and Bhola Upazilla) and two sites in Cox's Bazar (Mognama Ghat and Inani ECA) (Fig. 1). Intensive random survey with Focused Group Discussion (FGD), Semi Structure Interview, seasonality, trend analysis and individual case studies was carried out following standard protocol of vulnerability reduction assessment of UNDP (2008) and PRA manual of NACA (2006).

Hundred percent people were found to have skill in fishing, and 86% in wood cutting. Besides skill in crab collection (20%), honey collection (10%) and small business (8%) were also observed (Fig. 2). Children were not involved in labour except in fishing and wood collection. Crab and honey collection were restricted to the Southwestern sites like Sunderbans mangrove ECA area.

It was found that the livelihood options depended on the resource availability. People living in the Southwestern ECA sites around the protected area of Sunderbans mangrove forest lost agricultural job due to expansion of shrimp culture in the area. This made them enter into Sunderbans protected forest area for poaching the resources. The non-timbered items like fish,

Fig. 1. Location of six study sites

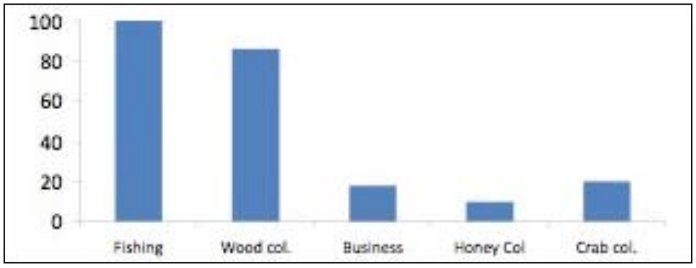

Fig 2. Distribution of work skill of the coastal people (% of total population)

crabs, clams, oyster, honey, small and large animals and fuel plants and seeds were the major items collected from the forest area illegally. Illegal collection of shrimp post larvae and brood as well as fishing of brood fish were found to be the major threats for the Sunderbans ecosystem. The protection efforts of Forest department are by licensing legal harvesting of forest resources or implementing ban periods for fishing, honey collection and timber extraction. However, poaching in ECA during the ban period resulted in loss of natural resources. The licensed individuals are involved in illegal extraction of other non-permitted items.

In the Meghna estuary, people are engaged in fishery of Hilsa and other species. However, the fishers are affected during 12 days ban period of Hilsa breeding, and juvenile Hilsa (or *Jatka*) fishing. Bangladesh government is identifying actual Hilsa fishers to compensate with money and food during the *Jatka* fishing ban period.

The situation of the population living in the South-Eastern coast is different. The majority was found to be fishermen and heavily dependent upon sea fishing. It was found that due

to lack of fish availability, they fish in distant grounds with risk to life or fish far from their village along the coast up to the outskirts of the Sunderbans. Sea pirates are the major threat for their livelihood and life in the sea (Fig. 3), besides bad weather. Natural disaster is viewed as god's act. Those who do not have the capacity to meet the cost of fishing in the sea are now poaching the natural resources from the protected forest in which they live. In land area, waterborne diseases are one of the major causes of loss of working days. They did care about the disease, but in most cases they do not get medical services in time. Other family members including children are engaged in extracting and sale of natural resources for food and fuel. Majority of the population was borrowing money from money lenders called *Mohajon*; and they had to sell their resources to the money lender.

In conclusion, the natural resources are heavily extracted by the populations. Overfishing, illegal fishing and poaching of natural resources are the major threats to the biodiversity of the study sites. Besides creating awareness, strict biodiversity conservation efforts should be put into place. Alternative livelihood options, drinking water and health services and supply of fuel should be the key items to offer for the improvement of the livelihoods of the poor coastal inhabitants and the future planning for conservation. Protective measures for disaster and other natural calamities will be the foremost task for the coastal inhabitants who live close to the sea.

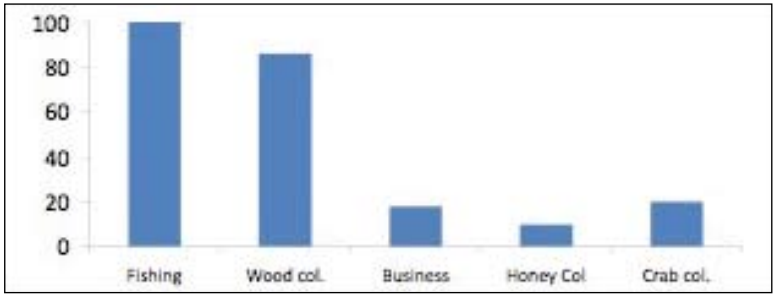

Fig. 3. Various shocks found among the coastal resource users (% opinion of total population)

This work is an output of three projects funded from the British Council-DelPHE and IUCN. I acknowledge the support of the NACOM, SHUSHILON, BFRI, Dept of Forestry, GoB, Dept of Fisheries, GoB and many others for their help during this study.

Traditional shore seine fishing occurs all along the Indian coastline © Deepak Apte

Managing tropical fisheries – using trawl fisheries to look at issues and solutions

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Industrial trawling in the Asia region began in the early part of the 20th Century and the modification of otter board gear to suit small, low powered vessels in the early 1970's allowed trawling to rapidly become a dominant form of fishing in the tropical Asian waters. These trawl fisheries underwent a rapid expansion over a period of decades and led to massive increases in the total catches of shrimp and finfish. Asian tropical trawl fisheries trawling is still largely confined to coastal fisheries, which results in significant overlap and/or interaction with other gear type fisheries.

There are now an estimated 83,000 trawlers currently operating in the tropical parts of the APFIC region. Trawl fishing is one of the chief methods responsible for placing the Asia-Pacific region as the world's largest producer of fish. Overall in the region where significant tropical trawl fisheries exist, they produce 25 to 52% of the total marine catch, making a total production of over 6.6 million tonnes. The increases in capture fishery production that are being achieved in the Asian region in recent decades can be attributed to large increases in fishing effort and the expansion of the geographical range of fishing activities as a result of mechanization, technology and globalization. They are also driven by the retention of most animals caught (including shorter-lived, small, fast-recruiting species), with very little discarding.

Tropical trawl fisheries in Asia catch approximately 800 species and about 300 species contribute to the fishery and this vast number of species are all utilized in some form. Discarding is relatively uncommon and at low levels, except in targeted shrimp trawl fisheries.

The rapid expansion of geographical range and effort of trawl fishing since the 1970's has meant that regulatory and management systems have either not been put in place or been unable to keep pace with development. The result is that many tropical trawl fisheries are

poorly-managed, giving rise to social and economic problems and increasing concerns on their effect on fish populations and coastal ecosystems.

Social & economic issues that arise from trawling can be summarized as follows:

- There are significant conflicts with other fleet segments
- Overcapacity: There are probably too many vessels for the size/value of the catch
- Unprofitable Trawl Sector: Many trawl fisheries operate at marginal profitability. This drives subsidies and a tendency for state support to the sector.
- Linkages to dependent industries: Onshore fish processing, surimi, fishmeal, aquaculture operations arisen because of availability of trawl products.

The ecological and environmental issues that arise from trawling are:

- Overfishing: The large scale trawling in Asia's tropics contributes to overfishing of stocks to unsustainable levels. Trawling is a relatively non-selective fishing method and may operate in fishing areas and at times where juvenile or spawning of commercial species occur.
- Bycatch: Bycatch is a common feature of any trawl fishery, but becomes a particular problem when at-risk species and juveniles are caught
- Catch of low-value fish: Catch and landing of low-value fish is a feature of many tropical trawl fisheries in Asia.
- Habitat impacts: Long-term intensive trawling can permanently change the benthic ecosystem, however, in some tropical benthic habitats recovery after trawling can be very quick.
- Effects on ecosystem function: impacts on benthic habitats and removal of large numbers of aquatic organisms affects the functioning of marine ecosystems
- Ghost fishing and other unidentified mortalities are considered a relatively minor issue.

Policy & governance dimensions are

- IUU (Illegal, unreported and unregulated) fishing: Most trawl fisheries are subject to some management measures, however, there is often poor compliance (over-capacity or weak fishery controls), which constraints management of the fishery and often leads to significant conflicts.
- Increased investment and subsidies: In many countries, governments try to promote the fishing industry to produce more fish for food security and job creation. A major principle should be that any subsidy provided should be used only as a temporary measure, and always be linked to mechanisms for improved fisheries management.

Well managed trawl fisheries are those which have addressed issues relating to impacts and

sustainability of trawl operations. They are typically operating profitably and within sustainable limits.

Trawl fisheries that have not been closely managed tend to be increasingly fished to a point that quality of the resources is declining. They have often lost top-end predators and have fewer long-lived, demersal species. These fisheries still have a reasonable chance of being restored to provide MEY/higher trophic index with the introduction of a management plan. They could be better-managed to improve or sustain the existing services and profitability.

Those trawl fisheries which are heavily overfished and have modified ecosystems have incurred significant changes to composition of the stocks. These fisheries often operate at marginal profitability, or are even subsidized. There is very little that can be achieved in these fisheries without major reforms of the fishery, its dependent industries and the supporting policies.

The contribution of trawl fisheries to fish production, occupation and income generation must be counterbalanced by concerns about the sustainability of catches and ecosystem impacts. To support a transition of trawl fisheries to more sustainable practices, trawl fisheries, more than any other in the region, require careful management underpinned by sound information and backed up by solid enforcement.

A particular challenge is that with no more new fishing areas for trawlers to exploit, there is a strong need to bring illegal fishing under control and develop and implement strategies that will limit the region's trawling effort to levels which will ensure long-term, sustainable demersal resources for all fleet segments.

The Asia-Pacific Fishery Commission at its 32nd Session recognized the importance of the trawl sector and its impacts on aquatic resources and benthic habitats and requested practical advice on trawl management. In response the Commission convened an Expert workshop on management of tropical trawl fisheries, to develop regional guidelines which are responsive to local management measures and the capabilities of the relevant management authorities. They will be simple, pragmatic and practical guidelines, applicable to fisheries that lack high levels of science, assessment and surveillance.

As catch rates and profits have declined, ecosystems have been altered, and conflict between trawl fishers and other users of the resources, especially small scale artisanal fishers are a common occurrence. These issues have resulted in Asian countries introducing various management reactions such as:

- complete ban on trawling (mostly at sub-national level)
- introduction of fishery zonation and trawl exclusion areas (many countries in the region)

- efforts to improve post harvest utilization of low value bycatch (e.g. surimi)
- subsidies to sustain production, despite declining catches and profitability.

Some of these have been effective and some have failed or even been counter-productive. This paper presents the measures that can be effective in addressing the range of issues that require management in a tropical trawl fishery.

The APFIC expert workshop on management of tropical trawl fisheries developed a series of general recommendations which could be applied to all trawl fisheries in the region. They provide a general rule of thumb for management based on the minimum standards which are found throughout the trawl fisheries of the region. The measures covered:

- Initiation of a process for managing trawl fisheries
- Reduce the impact of trawl through spatial, habitat and temporal measures
- Reduce the impact of trawl gear
- Strengthen Monitoring, Control & Surveillance
- Manage fishing effort and fishing vessel over-capacity.

The measures could be more stringent and these should be viewed as a first step to getting a tropical trawl fishery under more effective and responsible management. The paper concludes that although its focus is on trawl fishing bycatch and the need to manage, the need for management is not confined to the trawl sector; and throughout the Asian region there is strong need to manage most fisheries more effectively and this look at trawl fishing gives an idea where to start. Most of what is presented can be equally applied to other fisheries.

Strategies for trawl fisheries bycatch management in southeast Asia and coral triangle region

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The Coral Triangle (CT) subregion of Southeast Asia (SEA) is one of the world's most biologically diverse, economically productive and potentially vulnerable marine zones. Trawl fisheries in this subregion produces several marine products and contributes to national economy as well as to employment, both from fishing and processing industry sectors to countries in the region. More than 80,000 trawlers are estimated to operate in this region. The major detrimental impact of bottom trawling is the capture and removal of juveniles and non-target species from the ecosystem, which may be discarded at sea finally.

To mitigate the negative impacts of trawling, the FAO/UNEP/GEF project Reduction of environmental impact from tropical shrimp trawling through the introduction of bycatch reduction technologies and change of management (REBYC) was carried out during 2002–2008 with main objective to develope selective gear for bottom shrimp trawl. The project has collected information on the natural characteristics of tropical ecosystem with multi-species marine resources, various types and scales of trawlers poor fisheries resource management and the economic support by the utilization of bycatch. Significant conclusion project REBYC is that trawl gear modifications are important but they are not always the most appropriate tool or they may need to be combined with other management measures e.g. appropriate legal and incentive frameworks, new approaches for fisheries management, control fishing capacity and effort, etc.

A project "Strategies for trawl fisheries bycatch management (REBYC-II CTI)" has been started based on the lesson learnt from project REBYC, to contribute to the more sustainable use of fisheries resources and healthier marine ecosystems in the Coral Triangle and southeast Asian waters by reducing bycatch, discards and fishing impact by trawl fisheries. Specific technological practices have been identified and management plans developed in partnership with private sectors at both

national and regional levels. The plans are structured around four main interrelated components: 1) policy, legal and institutional frameworks, 2) resource management and fishing operations, 3) information management and communication, and 4) awareness and knowledge.

Five countries, namely, Indonesia, Papua New Guinea, Philippines, Thailand and Vietnam are participating in the project. The Southeast Asian Fisheries Development Center (SEAFDEC), a Regional Facilitation Unit (RFU), based in Samutprakarn, Thailand is responsible for supporting the participating countries for planning and implementation.

The project activities in the first year have revealed the following:

1) The participating countries have different background of trawl fisheries and it causes difference in trawl management regime of each country. Activities of each country are developed by the respective country considering their fisheries situation, e.g. fisheries resources, fishing capacity, behavior of trawl fishers, and level of legal and institution framework.

2) The countries have different interests, for example, Indonesia is interested in resource mapping, Thailand in gear-based and spatial-based management, Vietnam in developing legal framework, standardized data collection and gear-based management, Philippines in identification of nursery grounds at spatial and temporal levels, and Papua New Guinea in the assessment of bycatch of shrimp trawl fishery.

3) Establishment of stakeholders of trawl fisheries should be clearly identified and prioritized. Trawl fisheries stakeholders are different from stakeholders of coastal fishers. The demand from marine products processing industries may influence the trawl fisheries management. Stakeholder identification is one of the key activities that the participating countries will be conducting.

4) Data collection is one the major challenges. Thailand and the Philippines have data collection system in place, but have problems of lack of manpower and budget support. Vietnam has not developed a regular system of data collection. Island nations, namely Indonesia and Philippines, which have vast and scattered locations, data collection is a challenge. Papua New Guinea has less than 10 trawlers. Thus the situation in each country is different.

5) Gear modifications are important but they are not always the most appropriate tool or they may need to be combined with other management measures. Moreover, the socioeconomic drivers behind bycatch, livelihoods and poverty need to be understood and considered.

6) Monitoring, Control and Surveillance (MCS) are required. However, the requirements are different between the countries; for example, Papua New Guinea is interested to improve Vessel Monitoring System (VMS). Philippines and Indonesia have developed observer onboard programme by conducting training courses.

7) Scientific information from one country should be shared with other countries. For example, the number of trawlers, size of fishing fleet and attributes of trawler fleet of each country are unique to each country and are related to geographic uniqueness of each country.

8) Socio-economic study and research on the incentives for fishers to comply with measures to manage bycatch and reduce discards are very important to develop management plans for sustainable fisheries resource utilization. This information is not collected effectively at the national and regional levels. Support from FAO and relevant organization partners like SIDA and BOBLME, is necessary.

Traditional lagoon fishing in Lakshadweep

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Assessment of low value bycatch and its application for management of trawl fisheries

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In recent years, large quantities of low value bycatch (LVB) are landed by trawlers for use as fish meal and in fertilizer. Several fish meal plants have been established and high demand for the raw material is acting as an incentive for catching and landing large quantities of LVB. In Karnataka (a coastal state along west coast of India) alone, the annual turnover of fish meal and fertilizer plants is estimated to be around 270 million rupees (= 4.6 million US$).The landed LVB is turning out to be a sizeable income to the trawl operators. There are several concerns related to increasing bycatch of the trawlers. The bycatch is comprised of a high percentage of juveniles of commercially important species, resulting in recruitment overfishing. With the introduction of high speed semi-pelagic trawls, the adults of low-valued, small-sized adult fishes are also removed in large quantities, impacting the coastal marine resources. The current situation demands a robust management plan addressing the issues of the bycatch and in this regard information on quantities, value and composition of lVB landed and/or discarded, and seasonality of the catch are essential.

To collect data on low value bycatch and discards, Mangalore Fisheries Harbour (in the southern coast of Karnataka) was selected. Monthly data on fishing effort, landings and catch composition were collected for four years (2008-2011) from commercial trawlers. The price of catch and bycatch were also collected. The data on landings were segregated as those landed for human consumption and the rest for uses other than direct human consumption, designated as low value bycatch (LVB). Data was also collected from a few trawl operators, who provided information on date, depth, location and time of each haul, net type, mesh size, total catch and discard. Along with this information, an unsorted portion of catch that would have been discarded at sea was collected as sample, which was representative of each haul. The data collected were used for the spatial mapping of juvenile abundance of a few dominant species.

It is estimated that the low value bycatch has substantially increased from 3,100 t in the year 2008 to 30,000 t by 2011. Over the years the discard from the trawl fisheries reduced considerably from 88% to 15%, resulting in landing of the bycatch (Fig.1). Established market linkages for the LVB has helped its efficient utilization and reduction of discards. With increasing number of fish meal plants, the demand for raw material has increased; and catching and landing of LVB is a source of enhanced income to the trawlers. The annual raw material requirement for the fishmeal and fish oil factories in Karnataka in 2012 has been estimated as 60,000 t. With only half of the demand is supplied now, capture and landing of LVB is likely to increase in future.

In the ecosystem and sustainability perspective, incidence of large quantity of juveniles in the trawl bycatch demands intervention of specific bycatch management measures. Analysis of samples showed rich biodiversity of trawl bycatch, constituted by 204 species/groups, of which 95 species were finfishes, 20 belongs to molluscs and 27 were crustaceans. The threadfin bream *Nemipterus randalli* was the major species caught and the period of high incidence of juveniles of the species was during post monsoon months of September and October. Finfishes

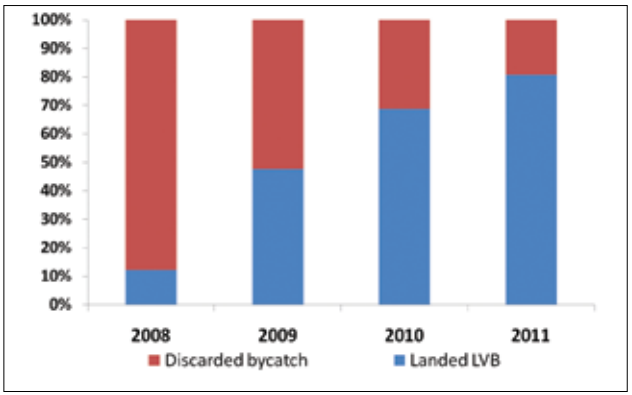

Fig.1. Contribution (%) of landed and discarded LVB by the trawlers of Mangalore Fisheries Harbour during 2008-2011

have more demand from fish meal plants as they form better raw material for fishmeal and fish oil production. During 2008-2009, about 34% of the bycatch by weight and 44% by number were formed by juveniles of commercially important species. These results stress the need for reduction of juveniles of commercial species in bycatch to sustain the stocks.

Information on seasonal availability of juveniles will be helpful in taking management decisions on the months of restriction of trawl operation to reduce the juveniles in trawl bycatch. Closure of nursery/spawning grounds or areas of special biological significance are effective options for reducing juveniles in the bycatch. With the GIS based resource mapping, seasonal and

spatial abundance of juveniles of four key species forming commercial fishery were identified (Fig. 2). This will facilitate establishing spatial restrictions to reduce juvenile capture. Similar maps of juvenile abundance of other key species will be helpful to arrive at conclusions on spatial and seasonal fishing restrictions

Reduced juvenile exploitation not only promotes sustainability of fish stocks, but also increases the profitability of the sector as larger fishes fetch better price. These measures are helpful for ecosystem-based management approaches and more fisheries can be managed through multispecies, multi-objective models with spatial component. To reduce the incidence of juveniles in bycatch, resource maps should be used as an excellent tool for the policy makers. It allows assessment of valuation of fishing grounds in terms of abundance of juveniles and adults. Illustrated maps with seasonal fishing grounds for juvenile exploitation would be a useful tool to educate the fishermen on the importance of protecting the areas of spawning and juvenile abundance if fish stocks.

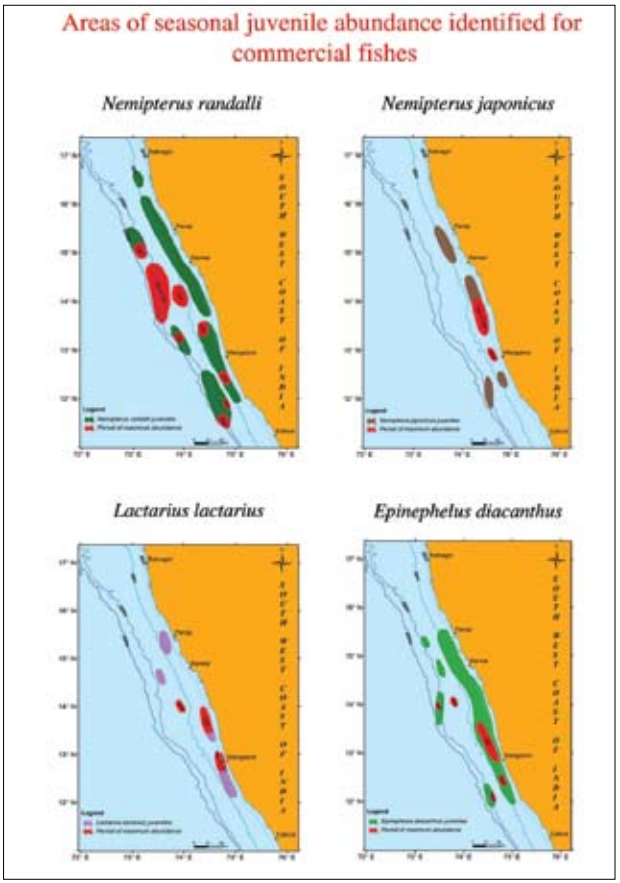

Fig.2. Spatio-temporal distribution of juveniles of important commercial finfishes in the trawling grounds off Mangalore.

Fishing in the Sundarbans, West Bengal

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Comparison of the efficiency of circle hook and J-hook from Vietnam offshore pelagic fishery in relation to shark and turtle bycatch

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In Vietnam, offshore longline fishery has been developed since 1990 mainly in Binh Dinh, Phu Yen and Khanh Hoa, the 3 provinces in the Central Vietnam. Offshore longline fishery is considered as one of the important contributing sources to the export of marine products from the country. Main target species of the longline fishery are tunas and a few other large pelagic fishes. However, the catch of nontarget bycatch and discard such as low value or discarded species, such as long snouted lancetfish and endangered species like sharks, rays and sea turtles were high.

As a member of CITES, Vietnam, together with many international organizations and NGOs (such as WWF, IUCN and SEAFDEC) has carried out many conservation programmes to protect threatened and endangered species such as marine mammals and sea turtles. Most of the activities under the programmes focus on habitat protection through fisheries law and marine conservation education and MPAs establishment. There has been no study as far on how to reduce interactions of sea turtles, shark and rays with the longline fishing gear and reduce the proportion of turtles caught and killed in the fisheries.

Therefore, this study undertaken by Research Institute for Marine Fisheries (RIMF) and World Wild Fund (WWF), Vietnam aimed to compare the fishing efficiency of J hook and C hook in relation to target and by-catch species including sharks, rays and turtles with following specific objectives:

- Compare overall catch between J hook and C hook
- Compare sharks, rays and turtle catch rates between J hook and C hook

Trial on efficiency of C hook and J hook was carried from commercial longline fishing boats

in Binh Dinh and Phu Yen provinces. A total of 347,290 baited J hooks and 327,310 baited C hooks were set at 275 fishing hauls of 7 fishing trips from November 2010 to May 2011 in the offshore areas of Vietnam. In the two hook types, the same baits (flyingfish and long-snouted lancetfish), were used alternatively, setting at a distance of 50 m between the two nearest hooks and operated at the depth of about 60 m.

Species were identified and catch compositions were recorded by both numbers and weights for J and C hooks at every haul. In the case of sea turtles, the fishermen who had been trained for turtle rescue, followed WWF guidance and released the turtles safely back after recording all necessary information. CPUE and NPUE are described as kilogram and number of fishes per 1000 hooks, respectively:

$$\text{CPUE} = \frac{C_i}{N_i} * 1000$$

where C_i is catch (kg or number) of hook i, N_i is the total number of that kind of hook. T-test for Dependent Samples was used to compare the differences between J hook and C hook catch efficiency by using Statistica 7.0.

Catch details are summarized for the two hook types in Table 1 and Figure 1.

Table 1. Catch composition of J hook and C hook from tuna longline fishery

Fish group	J-hook (N/1000)	C-hook (N/1000)	J-hook (kg/1000 hooks)	C-hook (kg/1000 hooks)	Catch J-Hook (%)	Catch C-Hook (%)
Marlin-Sword-Sailfish	1.47	2.23	29.72	90.51	3.91	11.22
Neritic tuna	3.26	6.91	8.03	19.76	0.46	1.07
Oceanic tuna	6.03	5.98	144.87	139.26	70.36	63.13
Pomfret	1.75	1.27	4.79	4.91	0.59	0.57
Rays	3.32	1.44	33.37	26.13	4.12	2.94
Sharks	1.31	1.90	29.93	82.93	3.57	9.00
Snake mackerel	8.33	6.23	10.50	7.44	3.46	2.28
Turtle	2.95	0.00	34.48	0.00	0.71	0.00
Wahoo	2.05	1.11	13.05	6.74	1.77	0.84
Others	9.82	7.39	24.82	21.60	11.03	8.95

A total of 38 species belonging to 18 families were caught from the trials for the two hook types. C hook and J hook caught 33 species and 29 species, respectively. In case of J hook, yellowfin tuna (*Thunnus albacares*) was found from 59.5% of total fishing hauls, followed by *Alepisaurus ferox* (50.4%), *Gempylus serpens* (49.6%), *Thunnus obesus* (32.1%),

Acanthocybium solandri (17.6%), *Lepidocybium flavobrunneum* (16.8%) and *Coryphaena hippurus* (16.0%). In C hook, *Thunnus albacares, Alepisaurus ferox, Gempylus serpens* and *Thunnus obesus* had frequencies of 59.4%; 38.3%; 32.8% and 28.9% from all fishing hauls, respectively. *Coryphaena hippurus, Xiphias gladius* and *Brama* spp. also had high frequencies from all fishing hauls.

The overall mean catch per 1000 hooks were 36 individuals and 30 individuals for J and C hooks, respectively (Fig. 1). There was no statistically significant difference in catch efficiency ($df = 273$; $p = 0.25$) between the two hook types. The target species, oceanic tuna (70.4% and 63.1%), and marlin-swordfish-sailfish (3.9% and 11.2%) groups were the most common and contributed high percentages in the total catches for both kinds of hooks.

Sharks and rays were high in the by-catch, i.e., 7.7% and 11.9% for J hooks and C hook, respectively (Table 1). The number of rays caught by J hook was significantly higher than by C hook ($df = 57$; $p < 0.05$); and the number of sharks caught by C hook was higher in comparison with J hook.

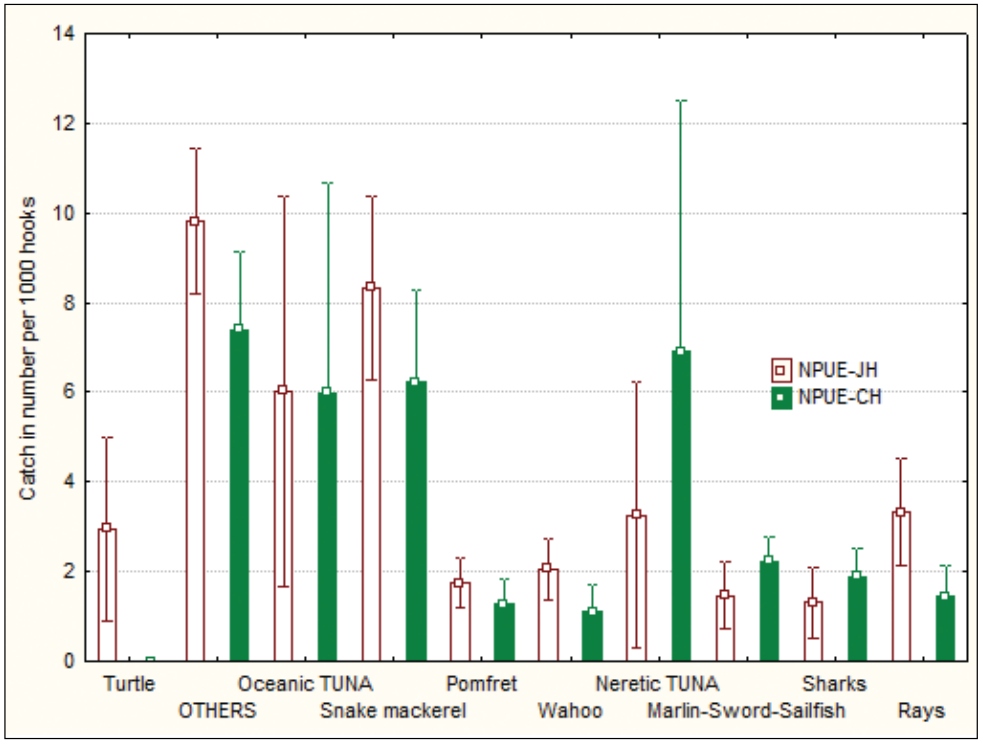

Fig. 1. Catch (in numbers) by J hooks and C hooks

In this study, 5 individuals of sea turtles were caught by J hook. Of this, 2 were the green turtle *Chelonia mydas* and 3 were the olive ridley *Lepidochelys olivacea*. Four of them were released live.

Although overall catch rates were similar in the two kinds of hooks, we found differences between catch rates of J hook and C hook of species like snake mackerel, rays and turtles. The catch rate C hook was higher compared to J hook. C hook avoids the the turtles. However, more studies are needed to confirm the results obtained in the present study.

Bycatch reduction devices

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Bycatch Reduction Devices (BRDs) are developed to reduce the capture of non–targeted species in fishing gears. Several types of BRDs have been developed and deployed in the fishing industries around the world. There are about 35,000 mechanized trawlers in India mostly targeting shrimps. Bycatch in trawls in the country constitutes a very high proportion of commercially important juveniles and sub-adults. The development and adoption of bycatch reduction technologies needs serious consideration. Keeping this in view, the Central Institute of Fisheries Technology (CIFT) developed several bycatch reduction devices for trawl fisheries.

The bycatch reduction devices developed by the CIFT for responsible shrimp trawling were field tested off Cochin, India during 2004-2007. These were conducted from a 17.5 m LOA (length overall) trawler (57.17 GRT; 277 hp @ 1000 rpm Kirloskar Mann engine) and a 15.24 m LOA trawler (30 GRT, 223 hp @ 1800 rpm Ruston MWM engine), the research vessels of Central Institute of Fisheries Technology, Cochin (India). The BRDs evaluated for bycatch exclusion and shrimp loss were hard BRDs *viz,* Bigeye BRD, Fisheye BRD, Oval grid BRD, Sieve net BRD and Juvenile Fish Excluder and Shrimp Sorting Device (JFE-SSD).The results presented here are a compilation of different publications related to BRD experiments carried out by the scientists of CIFT.

Bycatch exclusion from Bigeye BRD was approximately 11.4-37.3 % and shrimp loss was 2.1-4.1% (Table 1). Bycatch exclusion from Fisheye BRD was about 46.6-62.7 % and shrimp loss was 2.1-4.1%. Bycatch exclusion from Seive net BRD was 14.7% with shrimp loss of 4.5 %.. Bycatch exclusion from Oval grid BRD was 57.8-58.7% with shrimp loss of 6.1-8.0 %. JFE-SSD have realized bycatch reduction up to 42.9%, with shrimp loss of 5.2 %.

Three types of materials were developed for BRDs *viz*., Soft BRDs, Hard BRDs, and Combination

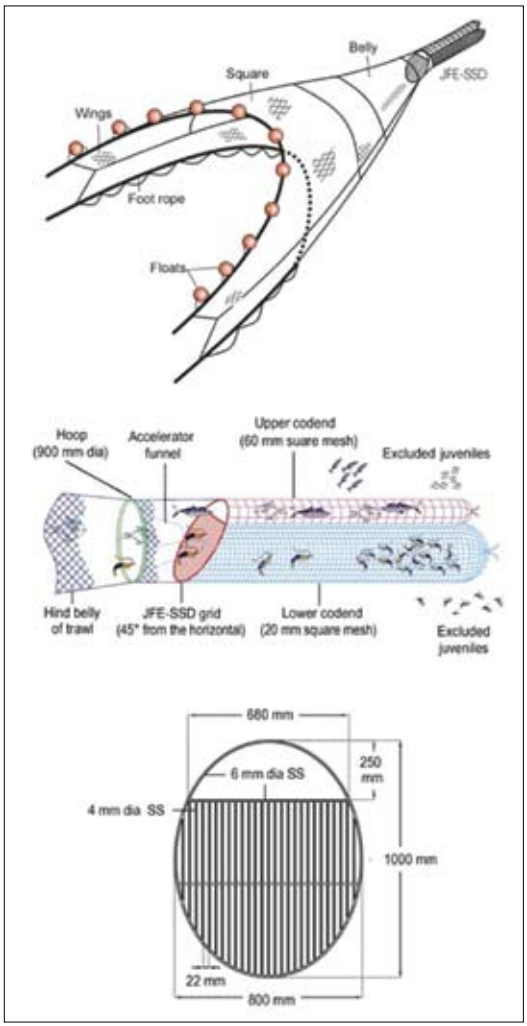

Fig. 1. Design and method of installation of JFE-SSD

BRDs. BRDs can reduce the amount of unwanted bycatch caught in shrimp trawls and reduce the impact of trawling on non-targeted marine resources, reduction in damage to shrimps due to absence of large animals in codend, reduction in sorting time, longer tow times, and lower fuel costs due to reduced net drag. The effect of BRD installation on total drag of the trawl system and hence on fuel consumption has been reported to be negligible.

The Bigeye BRD is constructed by making a horizontal slit in the upper part of codend or hind belly, where the opening is maintained by means of float and sinker arrangement or by

Table 1. Bycatch exclusion and shrimp loss in different BRDs, during shrimp trawling operations off southwest coast of India

BRD types	Bycatch exclusion (%)	Shrimp loss (%)
Bigeye BRD	11.4-37.3	2.3-4.1
Fisheye BRD	46.6-62.7	0.8-3.8
Oval grid BRD	57.8-58.7	6.1-8.0
Sieve net BRD	14.7	4.5
JFE-SSD	42.9	5.2

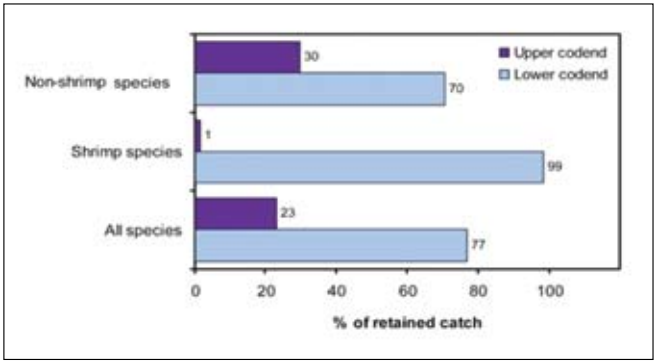

Fig. 2. In-situ sorting effect on species groups with JFE-SSD

binding with twine. The BRD provides a chance for the fishes that have entered the codend to swim back and escape by providing slits in the netting on the topside of the codend or hind belly, while shrimps are retained in the codend. Fisheye BRD facilitates the escapement of actively swimming finfishes which have entered the codend. It consists of an oval-shaped rigid structure with supporting frames made of stainless steel to form an opening. This facilitates the escape of the fish, which try to swim backward from the codend. Fisheye can be used either singly or in combination with other BRDs. Sieve net BRD is inserted into standard trawls which direct the bycatch to an escape hole cut into the body of the trawl leading to a second codend. The large mesh funnel inside the net guides the fish to a second codend with large diamond mesh netting, while shrimps pass through large meshes and accumulate in the main codend.

Oval grid BRD is a rigid grid sorting device developed for separation of shrimp from non-shrimp resources. The ideal configuration for a sorting grid system includes a funnel that accelerates the catch in conjunction with a sorting grate. Thus causes minimum disturbance to the water flow and separates small animals from large and resulting in little or no loss of target species in trawls. The use of rigid sorting grid is emerging as an effective tool for improving

size and species selection in many trawl fisheries. In spite of the multi-species nature of bottom trawling, the grids offer reasonably high bycatch exclusion rates with good shrimp separation and retention properties.

The Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD) a Smart Gear (WWF) award winning design (Fig.1) developed by the (CIFT) brings down the bycatch of juveniles and small sized non-targeted species in commercial shrimp trawl (Fig. 2). At the same time it enables fishermen to harvest and retain large commercially valuable finfishes and shrimp species

BRDs will have to be made mandatory in shrimp trawling for significant reduction in bycatch volume and growth overfishing, and consequent beneficial impact on the long-term sustainability and biodiversity of the marine living resources. BRDs which are most appropriate to regional fisheries will have to be adopted and enforced legally after scientific evaluation and commercial trails with stakeholder participation. BRDs such as Bigeye, Fisheye and Oval grid BRD have potential for adoption in Indian fisheries, for reducing bycatch and discards during shrimp trawling. The sieve net BRD and JFE-SSD, are designed to retain larger commercially valuable finfishes. The JFE-SSD combines the unique capabilities of excluding juveniles and small-sized non-targeted species caught in commercial shrimp trawl, retaining large commercially valuable finfishes and shrimps with an integrated *in situ* shrimp sorting mechanism, and has high potential for adoption among trawler fishermen in Indian and other tropical shrimp fisheries. The stakeholders will have to be made aware of the importance of using BRDs and they will have to be trained in the fabrication, installation and operation of BRDs. A National Plan of Action for bycatch reduction in fishing gears, particularly for the trawling sector, is needed for Indian fisheries.

Bycatch of tuna gillnet fisheries of Pakistan: a serious threat to non-target, endangered and threatened species

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The tuna gillnet fishery of Pakistan employs more than 500 fishing boats that operate in offshore waters. Gillnets being nonselective fishing gears, catch large quantities of bycatch species including billfishes, pelagic sharks, dolphinfishes and oceanic pomfrets as well as non-target species such as marine turtles and cetaceans. High levels of bycatch seriously affects the populations of some of these species. This paper provides quantitative information on bycatch of species and also suggests measures to adopt alternate fishing methods to minimize mortality of endangered and threatened species.

WWF-Pakistan has initiated monitoring of bycatch through collection of landings data at major fish landing centers in Karachi as well as by posting observers onboard tuna gillnetters. The paper presents quantitative data of bycatch species, including frequency and seasonality of enmeshment, areas of fishing and some biological information about bycatch species. Data were collected from landing centres intermittently since September 2011 and through an observer programme from October, 2012.

On an average, 30% of the catch consists of by-catch species dominated by sharks (*Carcharhinus falciformis, Alopias superciliosus* and *Isurus oxyrinchus*), billfishes (*Makaira indica, Makaira nigricans, Tetrapturus audax,* and *Istiophorus platypterus*) and dolphinfishes (*Coryphaena hippurus* and *C. equiselis*). Marked seasonality in areas of operation and catch composition of tuna species as well as by-catch was observed. Some of the bycatch species including thresher sharks (*Alopias* spp.) and oceanic whitetip shark (*Carcharhinus longimanus*), whose retention onboard is prohibited by Indian Ocean Tuna Commission, are still being retained by Pakistani boats and are landed at fishing harbours. Finning of sharks is not practiced and the whole carcass is retained for human consumption, Although only a small quantity of sharks are caught in tuna gillnet fishing, it is believed to have affected their population. Tuna

gillnet fisheries also seriously affect the population of threatened and endangered species of turtles, dolphins and whales in the area. Gillnet fishing poses a major threat to cetaceans because it results in the mortality of all entangled dolphins. The study reveals substantial mortality of spinner dolphin (*Stenella longirostris*), striped dolphin (*Stenella coeruleoalba*), Pantropical spotted dolphin (*Stenella attenuata*) and bottlenose dolphin (*Tursiops aduncus* and *T. truncates*) in the tuna gillnet operations along the Pakistan coast. Although annual mortality of cetacean has not been authentically determined, it is estimated that approximately 200 to 300 dolphins die in gillnet operations every month. Mortality of large cetaceans was rare but dwarf sperm whales (*Kogia sima*) and Arabian humpback whales (*Megaptera novaeangliae*) have been observed to be entrapped on a number of occasions. However, in most cases these entrapped whales were released successfully. A few cases of enmeshment of protected Whale sharks (*Rhincodon typus*) and mobulids (*Mobula* spp.) are also reported.

The data revealed that olive-ridley turtle (*Lepidochelys olivacea*) and to lesser extent green turtle (*Chelonia mydas*) are caught in gillnets. It is interesting that though no nesting of olive-ridley turtle has been reported from Pakistan in last 10 years, these species are caught in gillnet deployed in the offshore waters. Recent investigation by WWF reveals that most turtles survive enmeshment and are usually released by fishermen.

In order to control the mortality of non target species, it is suggested that gillnet fleet may be diverted to other modes of fishing such as longlining for which a plan is being prepared. In addition, compliance with IOTC and UNGA regulations will help in reducing the length of gillnet to 2.5 km in place of $>$ 10 km long pelagic gillnets used by fishermen for targeting tunas. Use of techniques which deter entrapment of vulnerable species should also be attempted.

Solving bycatch problems: successes in developed countries and challenges for protein-poor countries

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Humans have been harvesting fish for at least 90,000 years using technologies that have developed from simple harpoons through to huge factory trawlers. For most of this history, developments in fishing technology have focussed on methods that catch ever-greater quantities of fish of an ever-increasing diversity. This direction changed dramatically during the last few decades in the light of one of the world's most serious and controversial fishing issues- the waste associated with the incidental capture, mortality and discarding of unwanted **bycatch**. In response to bycatch issues, fishing technology altered its focus to one where fishing techniques are developed to be selective in what they catch, so that targeted species (and targeted sizes of species) are caught whilst unwanted bycatches are not. In more recent times, this field has expanded to address problems associated with fishing gears (especially dredges and trawls) impacting on the benthos and seabed ecosystems.

This focus on bycatch reduction and ecosystem-effects of fishing has resulted in many successful changes in fishing practices which are estimated to be conserving millions of fish and other organisms in many parts of the world. These successes have occurred in many types of fisheries and have improved many of the world's most non-selective and problematic fishing techniques.

These success stories in reducing bycatch cut across many different species (from turtles, sea-birds and sharks, to juvenile fish and crustaceans), using a diversity of fishing methods in a variety of fisheries and locations. One might expect that this diversity of approaches, gear types, species and fisheries would make it difficult to identify any overarching summary of how one might go about solving bycatch problems in a given fishery. However, the converse is true – there is actually a relatively simple framework that describes how bycatch problems get resolved that has proven to be quite consistent across many examples throughout the

developed and developing world (Fig. 1).

This framework involves industry and researchers each applying their respective expertise to the particular problem. It comprises five key steps (1) quantifying bycatches (mostly via industry-based observer programs) to identify the main bycatch species and their sizes, (2) developing alterations to existing fishing gears and practices that minimize the mortality of these species/sizes, (3) testing these alternatives in appropriately-designed field experiments, (4) gaining acceptance of the new technology throughout the particular fishery and, most importantly, (5) relaying the solution to the interested stakeholders who first raised the issue as a concern.

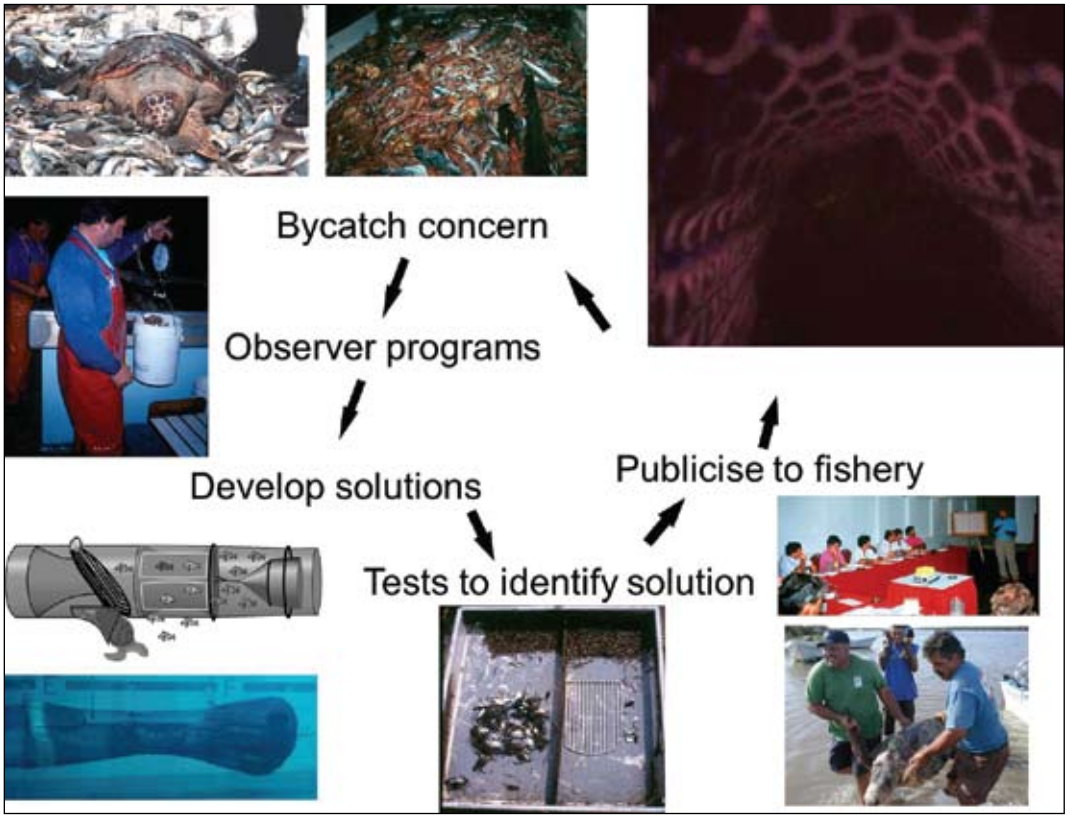

Fig. 1. The bycatch reduction framework

At all stages of this framework, but most importantly at its beginning and end, it is crucial that ALL interested parties fishers, environmental groups, government officials and scientists, engage positively to identify, resolve and then communicate the bycatch problem and its solution.

Using a variety of case-studies from around the world, this presentation will detail how this (inherently scientific) framework has proven to be effective in ameliorating many of the world's most problematic bycatches. It concludes that it is well worth considering such a process when new bycatch issues emerge, irrespective of the fishery, fishing gear or species involved.

This paper will also highlight the **vital** need for sustainable fishing practices in those countries where food security is a major, long-term problem. Using the term **"vital"** in this context is literal-the lack of sustainable fishing practices is actually **costing lives** in many parts of the world.

Recent data from FAO indicates that approximately one-third of world fisheries production occurs in low-income, food-deficient countries where seafood is a major source of protein. Unfortunately, however, many of the fishing methods used in such countries lack the improvements that have been implemented in developed countries which make fishing gears more selective. For example, the use of trawl nets in developing countries has, to a large extent, not incorporated the use of Bycatch Reduction Technologies that reduce the wastage associated with the capture and discard (or, in many cases, retention) of undersize fish. This leads to a sub-optimal use of the resource, with significant consequences for the population's food security.

Through case studies describing recent work in Nigeria, Cameroon, Madagascar and the Gaza Strip, this talk will describe some of the complexities associated with the implementation of sustainable fishing practices in these countries – as compared to the simpler situation in developed countries. It illustrates that the critical need for food security in poor countries goes hand-in-hand with the need for sustainable fisheries management – but the implementation of the latter is extremely complex and always country-specific.

This presentation marks a very successful period of achievement by the world's bycatch reduction specialists, gear technologists and fishers in ameliorating some of the most critical problems facing the world's fisheries. It also outlines how to continue this work and how to broaden the lessons learned to address other emerging fisheries issues. But it doesn't end there. This presentation also describes the enormous challenges faced by developing, protein-poor countries as they wrestle with bycatch issues whilst trying to feed the hungry.

Transferring fish to the markets in Tamil Nadu

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A low-cost solution for documenting distribution and abundance of endangered marine fauna and impacts from fisheries

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Conservation of marine mammals which have diverse social, cultural, economic and ecological values is complicated and challenging. The dugong is an interesting candidate species to identify pragmatic and effective solutions.

Dugongs are seagrass-dependant marine mammals found in tropical and subtropical coastal waters, broadly coincident with the tropical Indo–Pacific distribution of seagrasses. Their conservation is complicated as they are characterised by fragmented populations distributed over vast ocean areas, substantial differences in life history parameters associated with seagrass availability; high costs of real-time monitoring; and small-scale artisanal gillnet-fisheries, which cause the greatest mortality.

Dugongs are vulnerable to fisheries, traditional hunting, large-scale losses of seagrass, smaller-scale habitat loss and boat traffic. Entanglement in fishing gear is the predominant threat as dugongs are by-caught in many kinds of fishing gear, in both commercial and artisanal fisheries. However, the magnitude of the impact is largely unquantified in many countries.

Little reliable information documents these impacts, particularly because much of the dugong's range is in developing countries which lack the necessary resources to conduct surveys. Knowing where dugongs are and what pressures they are under is critical for conservation, but documenting impacts from fisheries and distributions / abundances of dugong populations in a cost-effective and timely manner presents a unique challenge.

The Convention on Migratory Species (CMS) Dugong MoU Secretariat, in partnership with the Marine Research Foundation and a team of global experts, developed a survey questionnaire which can be implemented at low cost and across large geographical areas. The survey is also

designed to collect data on marine turtles and cetaceans, and can be adapted to just about any marine or freshwater species. Indeed, the survey is providing baseline information for eight developing countries in a proposed Dugong and Seagrass Conservation Project funded by the Global Environment Facility. The questionnaire-based survey was developed by an expert panel using the outcomes of Project GLoBAL's Rapid Bycatch Assessment and builds on protocols developed at the Phuket Marine Biological Center, San Francisco State University and James Cook University. The multi-disciplinary panel ensured that the survey design would be widely applicable across regions and issues, scientifically sound, and culture-sensitive. The survey protocols were reviewed by a number of social science and bycatch assessment experts to determine language and scientific rigor. The questionnaire was then field tested in three countries and further refined prior to dissemination, and has undergone fine-tuning since it was first launched in 2010.

The questionnaire survey comprises 106 questions, of which the last six are internal questions to the interviewer which relate to interviewee confidence, knowledge and accuracy. These are used to provide quality control on the data sets. Questions address the personal background of the interviewee, the fishery (or other employment form), and numbers, trends, and locations of dugongs, sea turtles and cetaceans. It also includes a data table for sightings of all marine fauna, which are drawn on to maps during the interview. This spatial component is one of the key strengths of the process, as it captures locations of fishing pressure and seagrass distribution. Interviewees each get a clean map on which to mark fauna records and their fishing areas, eliminating bias. Maps and sighting tables are linked by a code number to the questionnaire itself.

A standardized Excel spreadsheet was developed into which data are uploaded, with locked fields controlled via filters to minimize data entry error. Locked formula cells process the data in real time and construct 27 different graphic and numerical outputs in a standardized form, so that data are similarly interpreted from location to location. Graphic outputs relate to respondent demographics, fishing vessel and gear types, dugong numbers and trends, and perceptions of changes and importance of dugongs by the respondents. Users are unable to edit the graphs, but are able to copy their data into a new file and analyse separately / more thoroughly should they wish.

A Project Manual was developed to explain the project rationale and introduce the CMS Dugong Questionnaire Survey. It discusses such topics as interview methods and techniques, data integrity, survey design effort and efficiency, stratified and random sampling, field data collection and control, and how to link graphics to table data and survey numbers. Other chapters address uploading graphics and spatial data and creating and exporting Google Earth layers to GIS, and basic GIS analyses once all data are uploaded.

The questionnaire was deployed in 18 countries spanning four key geographic areas (Pacific, Southeast Asia, South Asia and East Africa) with 4,553 respondents, and the results of the surveys provide the latest information on the distribution and abundance of dugong populations, while identifying and mapping areas of important dugong habitat such as seagrass beds, and assessing the relative risks to distinct populations from fisheries.

While it is impractical and illogical to provide an indication of the results from every data point, or indeed an overall synthesis given the geographical extent and the limitations on coverage within each individual country, we provide below a selection of facts derived from the programme. Data can be scaled at local, national (e.g. states in Malaysia) or regional (e.g. all African countries) levels depending on analytical needs.

"In India, over 70% of participants had fished for more than 10 years. The majority of respondents were 25 years old or above, and over 90% of interviewees claimed fishing to be their only activity."

"In east Malaysia respondents most commonly encountered dugongs while fishing. >50% of dugongs were released alive. <15% of interviewees knew about dugong hunters in their village or in other villages."

"In the Philippines, >90% of respondents were aware of what a dugong was. Most dugongs were encountered while fishing and most were released alive."

The questionnaire programme resulted in a rapid, low cost, low technology and easy to implement process for addressing information needs across the dugong's range. The average expense per country on deploying teams to conduct the interviews, analyse and enter data was around USD5000. Much of this was used for transport to and from remote survey sites, as staff costs were kept to a minimum by using volunteers and graduate students as interviewers. However some countries did not use the maps, and others adapted the questions and did not follow the prescribed format. Others used their own analysis methods and summarized dugong locations prior to submitting the reports, each of these resulting in incompatibility with other programme results. Thus an important lesson learned was that volunteers and graduate students who are not experienced require further training to provide compatible results. Overall however, the questionnaire provided contemporary data on small-scale fisheries and the locations, trends and numbers of dugongs which can already be used by managers and decision makers.

Given the nature of the questions and the variability in responses, potential bias and respondent misinformation, the programme is not envisioned to provide absolute numbers and precise locations of fishing areas and dugong hunting grounds. Rather, the questionnaire provides a rapid, low cost solution to dugong and fishery data acquisition which is scientifically robust, with a spatial analysis component which results in an identification of 'hotspot' areas where dugongs and fisheries overlap. These data along with the graphic outputs of the Excel sheet and the GIS analysis can be used to highlight priority areas for further detailed study and assessments.

The value of the work has already been demonstrated in the buy-in from the eight countries engaged in the GEF Dugong and Seagrass Conservation Project and the CMS Dugong MoU Secretariat plans to use the results of the questionnaire in other countries including India, Myanmar and Thailand to develop pilot projects to provide incentives to fishing communities to manage fishing interactions with dugongs.

Marine mammals and fisheries interactions in Indian seas

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Incidental capture of marine mammals in fishing gear is a major cause of concern. The International Union for Conservation of Nature (IUCN) identified bycatch as one of the serious threats to the marine mammals. The International Whaling Commission (IWC) estimated that at least 308,000 dolphins and porpoises are killed in bycatch every year in the world oceans. The Indian seas support 26 species of cetaceans and one species of sirenian. Until 2003, knowledge on marine mammals of India was restricted to incidental catch of different species in fishing gear. Between 2003 and 2012, the Central Marine Fisheries Research Institute (CMFRI) undertook a research project on marine mammals and conducted extensive visual sighting cruises onboard FORV *Sagar Sampada* in the Indian EEZ and contiguous seas to explore diversity, distribution and ecological characters of this mega fauna. The project also undertook a survey on the marine mammals that are incidentally captured by fishing gear.

However, the extent of mortality caused due to fishing has not been properly documented so far. The available records are limited to a few beachcast specimens published occasionally in grey literature. The records that are available in the Indian seas for the last 200 years are consolidated in Table 1. The table does not show the number of marine mammals that had been caught so far, as the actual numbers must have been higher by an order of several magnitudes. Most of these records have stated that the capture is mainly by gillnets. In 2001, Government of India listed all marine mammals under Wildlife (Protection) Act. Under the act, capture and trade on marine mammals is punishable. This act has considerably reduced intentional capture of the mammals, but incidental capture still remains an issue. In 2007, the CMFRI estimated that 9,000 to 10,000 cetaceans are incidentally caught every year, mostly by gillnets along the Indian coast. .

While Table 1 is in no way a total estimate of the number of kills by the fishery, it indicates the species that are relatively more vulnerable to fishing. The spinner dolphin, common dolphin, bottlenose dolphin, humpback dolphin, pilot whale and dugong have been recorded in relatively large numbers in the beachcast specimens over the years, indicating the vulnerability of these species to fishing. The maps generated by the CMFRI on the distribution of marine mammals in the Indian seas shows that the first four species, along with finless porpoise have been distributed in large numbers in the coastal and nearshore waters, whereas several other species are relatively oceanic. Hence, it is not a surprise that those species that are distributed nearshore are encountered in greater frequency and numbers in fishing operations. Stomach content analysis of the beachcast samples has confirmed the coastal feeding habit of these species. For example, the stomach content of bottlenose dolphin incidentally caught in Gulf of Mannar (southeast coast of India) consisted of fishes like *Saurida tumbil, Sphyraena* spp., *Ilisha* spp., *Trichiurus* spp., *Polynemus* spp., and *Stolephorus* spp, which are commonly found in the coastal fisheries. The stomach contents of humpback dolphin collected from southwest coast of India also consisted of dominant fishery groups such as *Nemipterus* sp, *Saurida* sp and *Lactarius lactarius*.Thus the intense interaction of a few species of dolphins with coastal fisheries is evident.

Table 1. Bycatch of marine mammals in Indian seas

Species	Number in catch
Blue Whale *Balaenoptera musculus*	63
Bryde's Whale *Balaenoptera edeni*	14
Minke whale *Balaenoptera acutorostrata*	3
Humpback whale *Megaptera novaeangliae*	9
Fin Whale *Balaenoptera physalus*	30
Sperm whale *Physeter macrocephalus*	32
Pygmy sperm whale *Kogia breviceps*	3
Dwarf sperm whale *Kogia sima*	3
Killer whale *Orcinus orca*	5
False killer whale *Pseudorca crassidens*	21
Pygmy killer whale *Feresa attenuata*	2
Melon-headed whale *Peponocephala electra*	5
Short-finned pilot whale *Globicephala macrorhynchus*	152
Cuvier's beaked whale *Ziphius cavirostris*	2
Spinner dolphin *Stenella longirostris*	332
Spotted dolphin *Stenella attenuata*	5
Striped dolphin *Stenella coeruleoalba*	2

Rough toothed dolphin *Steno bredanensis*	2
Indo-Pacific bottlenose dolphin *Tursiops aduncus*	201
Long-beaked common dolphin *Delphinus capensis*	300
Humpbacked dolphin *Sousa chinensis*	156
Risso's dolphin *Grampus griseus*	11
Finless porpoise *Neophocaena phocaenoides*	68
Irrawady dolphin *Orcaella brevirostris*	24
Dugong *Dugong dugon*	477

For advocating measures to reduce incidental kills by fishing gear, the marine fisheries setting in India needs to be recognized. Marine fisheries have very important roles for food supply, food security, income generation and employment. About one million people work directly in this sector, producing about 4 million tonnes annually. The value of fish catch at production level is about US $ 4.4 billion and India earns nearly US $ 3 billion by exporting fish and fishery products. As it is not mandatory for the fishermen to declare details of fishing operations and catches, monitoring the marine mammal – fisheries interaction is not easy. In the absence of information on fishing grounds, bycatch and discard of marine mammals, it is difficult to quantify the number and recognize the species of marine mammals caught by fishing gear. To develop time series database on incidental capture, stranding and beach cast marine mammals, the potential role of fisheries organizations such as Central Marine Fisheries Research Institute and fisheries departments of state governments, who regularly record fish landings along the Indian coast, should be explored. With support from Ministry of Environment and Forests, Government of India and Wildlife Conservation authorities, a mechanism needs to be developed for collection of data on incidental capture, stranding and beachcast marine mammals.

Possible modifications of fishing gear and strategies in gillnet fisheries such as lowering the net height, changing the mesh size, changing the hanging ratio of the net and increasing the gap between the bridle may reduce bycatch of cetaceans in gillnet. However, management of cetacean bycatch problem is not simply a matter of designing effective by-catch reduction devices. It is important to recognize that marine mammal conservation can take place only with the support and participation of fishermen. If fishermen want, they can avoid by-catch of marine mammals. A skilled fisherman knows the area of marine mammal's occurrence and he can avoid those areas from fishing. There is a need to create awareness among fishermen and public on the importance of mammals in the marine ecosystems, their status and threats, and the need for conservation. Training to fishermen, wildlife managers and non-governmental organizations should be organized on handling the live strandings and dead carcasses of marine mammals. Fishermen should be encouraged to report live or dead marine mammals caught in fishing gear.

Conservation of marine mammals could be achieved by integrating the agenda into fisheries regulatory mechanisms. The fisheries regulatory instruments such as Code of Conduct for Responsible Fisheries and Ecosystem-based Fisheries Management, which have conservation of endangered animals enshrined in the articles, need to be put in place. Establishment of Marine Mammal Sanctuaries should be initiated where populations of dolphins and dugong are abundant. The articles on conservation of endangered animals need to be suitably amended into the Marine Fisheries Regulation Act of state governments. A National Action Plan on Marine Mammals is needed for India.

Shark ban in its infancy: successes, challenges and lessons learned

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Expansion of shark fisheries took place in the late 1970s in Maldives. With new developments in the fisheries, there were growing concerns over the exploitation rates on the status of the shark stocks. In 2009, research indicated decline in the status of shark fisheries, but in the absence of information on stock status, the Ministry of Fisheries and Agriculture (MoFA) advocated precautionary approach and took a series of actions which ultimately lead to a total ban on shark fishing.

This paper aims to give a brief history of the shark fishery and a review of the existing issues that are affecting MoFA's ability to successfully implement the shark ban. Information was gathered from existing literature on shark fisheries and anecdotal interviews with former shark fishermen and also from consultations with the tourism sector.

In the early 1980's three distinct shark fisheries were established; the deep water gulper shark fishery, oceanic shark fishery and the reef shark fishery. Little importance was given on the collection of statistical information on shark fisheries. Catch was estimated from export data on fins and squalene-rich oil. The gulper shark fishery boomed and reached its peak between 1982 and 1984. After 1984, the catches declined significantly, due to over-exploitation of the stock. From the anecdotal information from fishermen, it was deduced that catch had reduced to 50% within a few years of starting the fishery.

As shark fin exports were from both oceanic and reef shark fishery, catch was estimated for both fisheries combined (Fig. 1). From 1975, the shark catch showed a steep increase, and by 1980, the catch reached 1900 tonnes. Publications show that the contribution by each fishery to total catch was approximately 50% in 1992. By the early 1980s, reef shark stocks of the northern atolls of Maldives were reported to be over-fished. A drop in reef shark gillnet fleet

was reported in 1998 while the oceanic longline fleet increased in the same year. With the moratorium on reef shark fishing in the central atolls, it was assumed that the contribution by the reef shark fishery was less than half (about one third or one quarter) to the total catch. Oceanic shark fishery too started showing reduced catch. The northern longline shark fishery in Kulhudhuffushi, which primarily targeted oceanic sharks, reported declining catches after 2000. Shark fishermen reported low levels of large silky sharks in their catch. In an opinion survey, tuna and shark fishermen reported low levels of silky sharks in their catch in 2009.

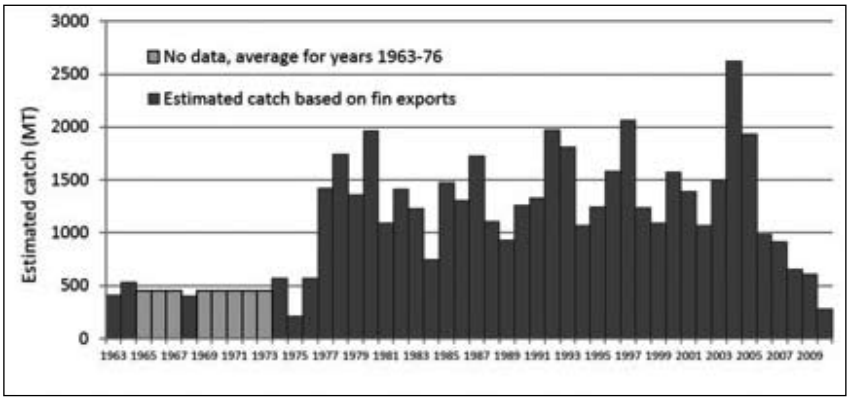


Fig. 1: Estimated annual catches of reef and oceanic sharks (Source: Sinan *et al.,* 2011)

On the basis that the continuation of the shark fishery could have adverse effects on the pole and line tuna fishery and tourism industry which are the two main contributing sectors to the economy, on March 2010, a total ban on shark fishing was declared. Decisions were made to determine ways to facilitate alternate income generating options for shark fishermen and to provide them with compensations. Hence, MoFA initiated MRF 5 million gear-buy-back scheme. In addition to this, MoFA opened a trust fund on sharks to garner funding to facilitate alternative income generating ways for the shark fishermen. In 2010, the Ministry of Economic Development implemented a MRF 5 million scheme, where shark products were bought from primary traders.

Issues affecting the implementation of the ban

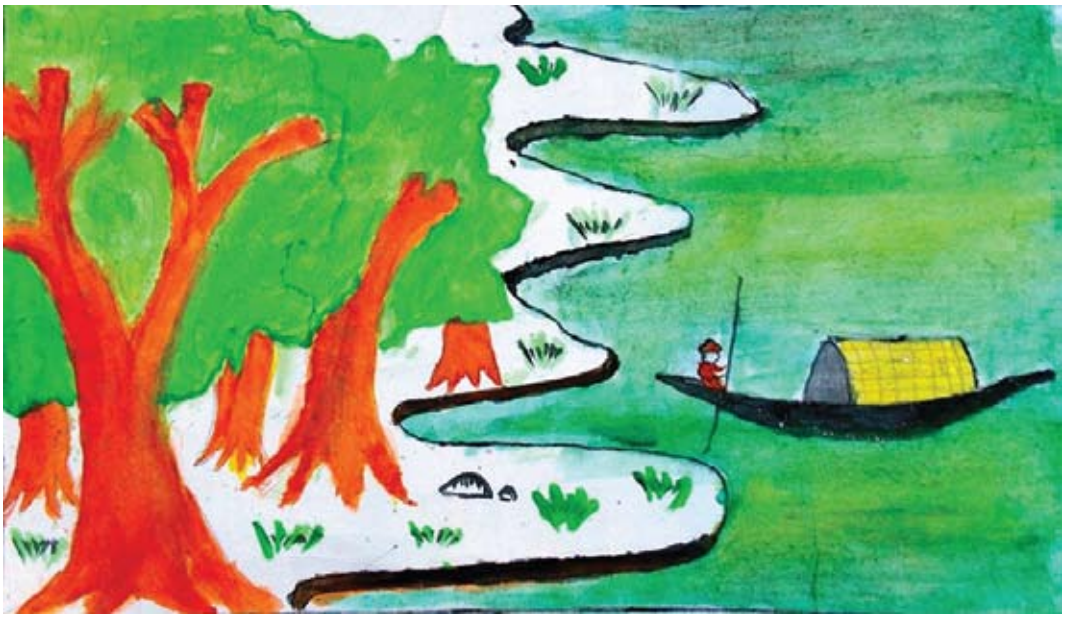
The Fisheries Law of Maldives (Law no. 5/87), provides for the conservation of living marine resources for a special purpose, and under this law a total ban on shark fishing was declared. However, the Fisheries Law is not provisioned to ban the trade of marine species or protected marine species. In 2011, the Ministry of Housing and Environment announced a ban on capture, keeping, trade and harming of sharks under the Environment Protection and Preservation Act (Act No. 4/1993). This manifested major conflicts between the laws and mandates of the Environment, Economic Development and Fisheries Ministry.

Illegal shark fishing was MoFA's concern, but reported events were few. Complaints from the tourism industry on illegal shark fishing activities have been brought to the attention of MoFA, but most were not officially reported. As the country does not have a fisheries observer programme, the fate of sharks caught dead as by-catch cannot be validated.

In 2008, the tourism industry lobbied for a complete ban on shark fishing which called for an immediate management decision, where reef shark fishing was banned abruptly. When the ban came into effect, neither were stakeholder consultations held, nor were alternative livelihood options identified. With the lack of monitoring of the ban and lack of awareness on conservation of sharks, many fishermen continued shark fishing even after the declaration of reef shark ban in 2009. After the total shark ban, except for the gear buyback scheme, some attempts were done to secure the livelihoods of fishermen. Many exploited other types of fisheries such as reef fishing. With the limited employment opportunities in the islands, and having skills only in fishing, it was not easy for the fishermen to give up shark fishing. Oceanic shark fishery, which had no conflict with the tourism sector, also was banned, forcing oceanic shark fishermen to give up their livelihood.

Numerous complaints have been received from reef fishermen on depredations caused by sharks. Contrary to fishermen's sayings, divers say that sharks have not showed a significant increase in abundance. A proper study needs to be conducted whether sharks are showing a substantial increase and if not why there are more nuisances from sharks now than before.

The main issue with the current shark ban is that MoFA is unable to do much in imposing a ban on trade, import and export of shark products. In New Zealand's fisheries management system, the laws that provide for bans, have key statutory tools that ensure conservation of protected species. Hence, in New Zealand when a marine species is protected, taking, trading or possessing of all or parts of the species are also banned. Further, Maldives, being a member of Convention on International Trade in Endangered Species of wild fauna and flora (CITES) and with the total shark ban, has an obligation now to ban export of shark products. In addition to this, the conflicts between the Acts and mandates of different Ministries are major factors hampering successful implementation of the ban. Another major issue is the lack of stakeholder consultations prior to the ban. When such complete bans are imposed, it is imperative that stakeholders are consulted, a formal analysis on alternate livelihood options is done and a phase out period for the fishery is provided. For indefinite bans to be successful, commitments are needed from all stakeholders including the government. Without regular monitoring of the ban, the shark ban cannot be a success.



Children depict fishing in the mangroves in Orissa

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Shark fishery and conservation in Indian waters: need for a National Plan of Action

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Shark fishing in India has, over the years progressed from "incidental" to "targeted." Sharks, which were predominantly landed as by-catch in different gears, is shifting from an artisanal coastal fishery towards oceanic targeted fishery, employing drift gillnets, hooks and line, and longlines operated from mechanized craft in recent years. Decades ago, artisanal fishermen in India conducted shark fishing in a sustainable way. Shark finning was practiced in the past, *i.e.*, the carcasses were discarded after removing the fins. In recent years, the meat of sharks are in high demand in fresh, salted and dried form, particularly in the southern states of India and hence fishing for fins alone has stopped. In recent years, increase in demand for sharks in international markets, especially for fins, has encouraged directed fishing and expansion of fishing areas for shark fishery. In spite of attempts to increase production, the landing of sharks is on the decline indicating that their abundance is dwindling in the Indian seas.

India is ranked second, next to Indonesia in shark landings, contributing about 9% to world catch in 2010. Time series landings data indicate that small-sized sharks have increased in the landings as opposed to larger sharks. Most of the sharks have biological characteristics typified by slow growth, delayed maturation, long reproductive cycle, low fecundity and long life span. Due to these disadvantageous biological characteristics, the sharks are vulnerable to overexploitation, and unplanned and indiscriminate exploitation could lead to population decline. Moreover, sharks occupy a position high in the marine food chain and their indiscriminate removal may alter the structure and function of the ecosystem.

For sustainable management of sharks, the primary requirement is estimation of the status of shark stocks. Recent stock assessments and a number of studies in the Northwest Atlantic Ocean have found declines in many shark species (sandbar shark, dusky shark, hammerhead sharks, blacknose shark, porbeagle shark, shortfin mako shark, spiny dogfish etc.).

The landings of sharks in India over the last 32 years shows an increasing trend up to 2000 (48,000 t) and a declining trend thereafter. The landings were only 22,530 t in 2012 (Fig.1), i.e., less than half of the landings in the year 2000. The Indian seas are home to more than 70 species of sharks, most of which however, are of either limited occurrence, or of low commercial value. Carcharinid sharks contribute about 50% to the shark landings in India, major species landed being *Carcharhinus sorrah*, *C. limbatus* and *C. dussumieri.* In the last few years, *C. falciformes* has emerged as an important species in the landings along the west coast.

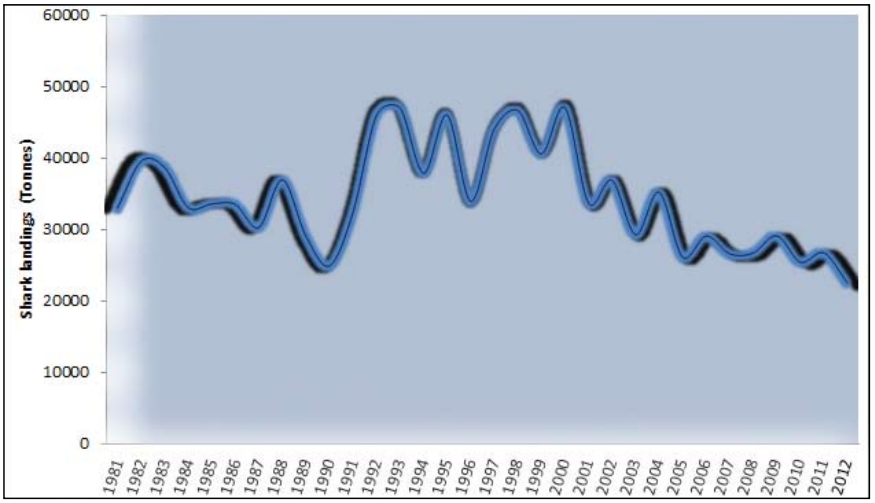

Fig. 1. Shark landings in India

The scalloped hammerhead shark, *Spyrna lewini* also features significantly in the landings. Recently, small - sized shark species belonging to the genera *Iago, Mustelus, Squalus* and *Centrophorus* have also emerged in the fishery.

The exploitation of sharks in India is carried out by trawlers, gillnetters, hooks & lines and long lines operated from mechanised and non-mechanised vessels. The fishing village of Thoothoor in Tamil Nadu (southeast coast of India) is well known for its specialised shark fishery. The fishermen of this village venture all along the Indian coast in medium-sized vessels, which are converted for oceanic fishing. This fleet uses bottom longlines in continental and oceanic waters, up to 1000 m depth, for shark fishing. It is estimated that a total of 15,000 – 20,000 fishers are engaged in targeted shark fishing in India. However, the number of registerd boats has decreased from 600 to 500 in recent years, out of which only 100 are engaged in targeted shark fishing. Other boats are targeting for tunas in Andaman & Nicobar and Lakshadweep waters.

Shark fins are one of the commodities in great demand in international markets. The shark fins find their way to East Asia to meet the demands of an expanding international shark fin market. Hong

Kong is the major centre for shark fin trade and the Indian export of shark fins is directed there. As per MPEDA statistics, India exported 195 tonnes, worth US $ 14.99 million in 2011 against 960 tonnes worth $2.74 million in 1998. Due to the intervention from conservation groups and research organisations against finning and discarding of half-dead animals, the ban on landing of sharks without fin, as enforced in some countries including USA, has been implemented in India too for the conservation of sharks through an order dated 21st August 2013.

Developing strategies for conservation and management of shark populations are becoming increasingly important globally, especially because many species are exceptionally vulnerable to overfishing. IUCN has included Whale Shark *Rhincodon typus*, Pondicherry shark *Carcharhinus hemiodon*, Ganges shark *Glyphis gangeticus* and Speartooth shark *Glyphis glyphis* in the critically endangered list whose populations have reduced drastically owing to indiscriminate fishing. These species have been listed in the Wildlife Protection Act (1971) of India. Capture and trade on these species are punishable under the Act.

Success story of the ban on whale sharks needs special mention here. The Whale shark, which migrated towards Saurashtra coast (northwest coast of India) formed a regular fishery for several years for its meat, fins, liver, skin and cartilage. Over 1000 whale sharks were hunted off Saurashtra in 1998. Most of the whale shark landings in Gujarat were by directed fishing, whereas the capture was incidental in other states. Following a ban on whale shark fishery by the Government of India, the fishery has totally stopped along the Saurashtra coast in the last ten years.

Considering the importance of India as a major shark fishing nation and vulnerability of sharks to fishing, it is important that the country evolves a management plan for shark fisheries. Preparation of National Plan of Action for Sharks (NPOA – Sharks) will pave the way for implementation of an effective management plan. Following FAO's technical guidelines for the conservation and management of sharks (FAO, 2000), the four elements of the IPOA-Sharks may be considered:

- species conservation;
- biodiversity maintenance;
- habitat protection; and
- management for sustainable use.

The guiding principles of NPOA-Sharks may be as follows:

1. All maritime states and Government of India have to participate in shark management with support from research institutions
2. Management and conservation strategies should aim to keep fishing mortality for each stock within sustainable levels by applying precautionary approach.

3. Management and conservation objectives and strategies should recognize that shark catches are a traditional and important source of food, employment and income. Such catches should be managed on a sustainable basis to provide a continued source of food, employment and income to local communities.

Being a major shark fishing nation, it is important that India should evolve Shark Plan and participate in their conservation and management for their long-term sustainable harvest. The participation of fishermen is essential for the successful implementation of the policies.

Sharks and rays in Indian commercial fisheries: need for revision of taxonomy

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India is one of the leading chondrichthyan fishing nations, with an estimated landing of 52,602 tonnes (sharks 44.6%, rays 51.5% and skates 3.9%) in 2012 , contributing 1.3% to the total marine fish landings in the country. While there is a targeted fishery for sharks and rays, these groups constitute an important bycatch of commercial fisheries for bony fishes and shellfishes as well. The fishery is dominated by species belonging to families Carcharhinidae, Dasyatidae, Alopiidae, Sphyrnidae and Mobulidae. Earlier publications during different periods have recorded that 84 to 114 species occurring Indian seas. A study by Akhilesh (2013) catalogued 220 chondrichthyans listed from India, including 60 species of uncertain taxonomic status indicating the need for species diversity surveys. Thus there is confusion and inconsistencies in species identification, which is an impediment for arriving at conclusions on species listing and protection. The present paper is an attempt to highlight this issue with examples and stress the need to resolve the issues through conventional and molecular identification techniques.

Chondrichthyans were collected at various fish landing sites along the Indian coast from April 2008 to October 2013. Species identification was based on standard keys. Tissue samples were collected and preserved in 95% ethanol and DNA was extracted. Partial sequence of COI gene was PCR amplified and the neighbour-joining (NJ) tree was constructed using MEGA 3.1.

The following eleven elasmobranch species found in the bycatch landings are first records from the Indian waters: *Isurus paucus, Deania profundorum, Centrophorus zeehani, Centrophorus*

atromarginatus, Hexanchus griseus, Zameus squamulosus, Chiloscyllium burmensis, Rhynchobatus australiae, Rhinobatos thouin, Aetomylaeus vespertilio, Himantura granulata. The species identity was confirmed using DNA barcode comparison.

In this study, 105 species of chondrichthyans from 56 genera, 34 families, 10 orders from two subclasses, the Holocephali (Rhinochimaeridae and Chimaeridae, two species) and the Elasmobranchii (sharks and rays, 103 species) were barcoded for a 655bp region of COI from 484 specimens. Species were represented by one to seven numbers, and a total of 484 sequences were generated. The average Kimura 2 parameter (K2P) distances separating individuals within species was 0.32%, and the average distance separating species within genera was 6.73%. The sequence variability of *Dipturus* sp. A shows the possibility of cryptic speciation that warrants further taxonomic examination.

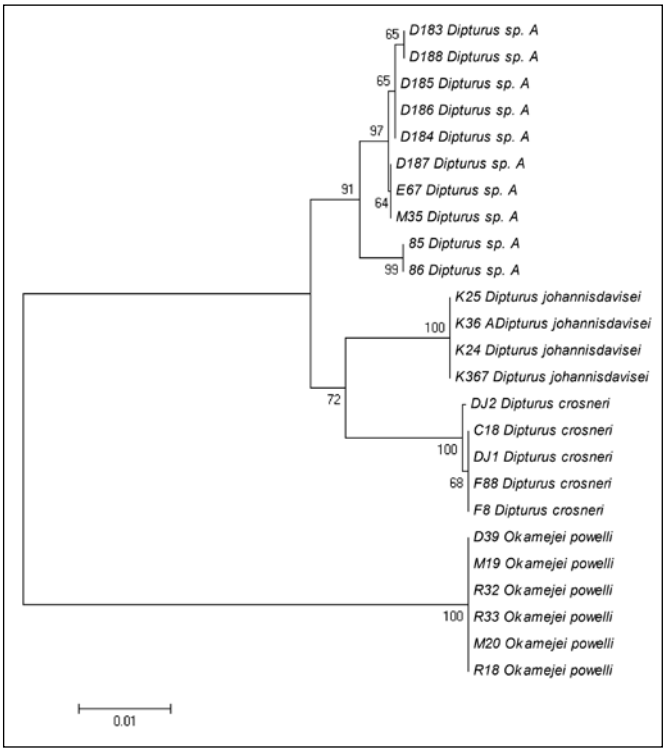

Fig. 1. K2P distance neighbour joining tree of COI sequence from Rajidae

The partial sequence of 16S rRNA was also used along with COI genes in certain families such as Rajidae, Scyliorhinidae and Centrophoridae that are showing considerable morphological similarity and overlapping characters. In Rajidae, four species belonging to two genera (*Dipturus* and *Okamejei*) were examined, with an average interspecies distance of 5.25%.

The mean interspecies distance within the family was 4.5%.One species is not yet formally described, shown here as *Dipturus* sp. A (Fig. 1). In Dasyatidae, using COI genes eleven species of *Himantura* were barcoded. Of the eleven species, three species were undescribed, *Himantura* sp. A, *Himantura* sp. B and *Himantura* sp. C. The average genetic distance within species in the family Dasyatidae was 0.84% and within species in the genus *Himantura* was 7.45%. The average interspecies distance in the family was 10.32%. The partial sequence of 16SrRNA and COI were generated for several undescribed species such as *Apristurus* sp. A, *Iago* sp. A and *Torpedo* sp. A. The present study demonstrates that sequencing a ~650 bp region of mtDNA COI permits discrimination of 100% of 105 species of chondrichthyans.

Critical analysis of past literature, new published data on elasmobranchs and our study show that at least 150 valid species of elasmobranchs occur in Indian waters. However, confusion persists on confirmation of species identity. The ambiguity in species identity needs a systematic revision with support from molecular analysis. Molecular results have confirmed seven new species to Indian waters which require formal species descriptions, showing the need for undertaking surveys along the coast to confirm the species diversity of chondrichthyans. Taxonomic revision of families such as Triakidae, Centrophoridae, Torpedinidae, Dasyatidae, Rajidae, Rhynchobatidae and Rhinidae should be initiated with wide regional sampling, comparisons and collaborations using conventional and molecular techniques. As many of these are distributed in the region, it is suggested IUCN regional status assessment workshops may be conducted to validate the Arabian and Bay of Bengal species, which are under Data Deficient and Not Evaluated categories.

Notes

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Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

About Mangroves for the Future

Mangroves for the Future (MFF) is a unique partner-led initiative to promote investment in coastal ecosystem conservation for sustainable development. It provides a collaborative platform among the many different agencies, sectors and countries who are addressing challenges to coastal ecosystem and livelihood issues, to work towards a common goal.

MFF builds on a history of coastal management interventions before and after the 2004 Indian Ocean tsunami, especially the call to continue the momentum and partnerships generated by the immediate post-tsunami response. It initially focused on the countries worst-affected by the tsunami; India, Indonesia, Maldives, Seychelles, Sri Lanka, and Thailand. MFF has expanded to include Bangladesh, Cambodia,Pakistan and Viet Nam. MFF will continue to reach out other countries of the region that face similar issues, with an overall aim to promote an integrated ocean wide approach to coastal zone management.

The initiative uses mangroves as a flagship ecosystem, but MFF is inclusive of all coastal ecosystems, including coral reefs, estuaries, lagoons, sandy beaches, sea grasses and wetlands. Its long-term management strategy is based on identified needs and priorities for long-term sustainable coastal ecosystem management. These priorities emerged from extensive consultations with over 200 individuals and 160 institutions involved in coastal management.

MFF seeks to achieve demonstrable results in influencing regional cooperation, national programme support, private sector engagement and community action. This will be achieved using a strategy of generating knowledge, empowering institutions and individuals to promote good governance in coastal ecosystem management.

Learn more at: www.mangrovesforthefuture.org

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