IDENTIFICATION OF RESEARCH GAPS IN COASTAL AND MARINE BIODIVERSITY CONSERVATION IN INDIA

Background

India has a vast extent of coast line of about 8000 km spanning 13 maritime mainland states and Union Territories, which are home to a diversity of coastal and marine ecosystems, comprising nationally and globally significant biodiversity (Venkataraman and Wafar, 2005). It also supports almost 30% of its human population being dependent on the rich exploitable coastal and marine resources. The coastline of Bay of Bengal and Arabian Sea continues to be a rich fishing ground in the south Asian region and India is one of the worldôs largest marine product nations. Marine ecosystems such as estuaries, coral reefs, marshes, lagoon, sandy and rocky beaches, mangrove forests and seagrass beds are all known for their high biological productivity, which provide a wide range of habitat for many aquatic flora and fauna. It also provides important food resources and critically major services to human beings. Therefore, sustainability of these fragile ecosystems should be our primary concern. So far, we have largely looked the marine biodiversity as a source of commercial products instead of appreciating their ecological values and services which has resulted in over exploitation and several species are now in the verge of extinction. Moreover, human activities such as destructive fishing, shipping, coastal developments, discharge of untreated effluent from industries have caused considerable damage and pose a severe threat to the coastal and marine biodiversity. In addition to that, global warming due to climate change also pose major challenges to marine biodiversity.

In view of the dangers faced by various anthropogenic activities in recent past, the Ministry of Environment and Forests (MoEF), Government of India is committed to protect and conserve these endangered ecosystems. As a step towards achieving this goal, the Ministry of Environment and Forests, Government of India sponsored a two-day ôNational Consultation Workshopô to identify the gap areas in research so that steps can be initiated to conduct important research programmes on priority basis, which would strengthen the conservation

and management of coastal and marine biodiversity in the country. The Wildlife Institute of India has organised this two-day workshop at Chennai. Six important following thrust research areas have been discussed in the consultation workshop;

a. Landscape/Seascape/Ecosystem level research
b. Habitat level research on Coastal and Marine Biodiversity
c. Species level research on Coastal and Marine Biodiversity
d. Development of Technology for Coastal and Marine Biodiversity Research
e. Monitoring and Restoration Ecology
f. Socio-economic and Policy-level Research

More than 40 experts in various fields of coastal and marine biodiversity and forest managers from different parts of India have participated in the workshop (Annexure I). Participants belonged to various universities, research institutions, government organisations, national and international non-governmental organisations who are largely working for conservation and welfare of coastal biodiversity and communities respectively. After a brief introduction to the workshop, a key note address was delivered in each identified thrust areas by experts. After the key note addresses, six groups comprising 5-8 participants each have been formed for group work and discussion to achieve the workshop objectives. After the group works, identified research gaps in the respective thrust areas had been discussed with all the participants and then finalised.

Significance of Indian coastal and marine biodiversity

The sea around India is part of the great Indian Ocean and the Indian subcontinent forms a major physical division between the Arabian Sea and the Bay of Bengal of the Indian Ocean. Coral reefs are diverse and most vulnerable ecosystem in India. The reef biocomposition is quite significant and includes 180 species of benthic algae, 14 species of seaweeds, 12 species of seagrasses, 108 species of sponges, 4 species of lobsters, 103 species of echinoderms, 600 species of fin fishes and also a good number of species of crabs, bivalves, gastropods and cephalopods each in Lakshadweep and Andaman and Nicobar islands (Devaraj, 1997). In India, 208 species of hard corals belonging to 60 genera have been so far

described (Venkataraman *et al*. 2003) and many more species would be described soon by the Zoological Survey of India (pers. comm. from ZSI, Port Blair). Highest diversity of corals have been recorded in Andaman and Nicobar islands. India is one among 17 mega biodiversity countries in the world and also ranked 14th among the 22 countries which contain the world's major mangrove areas. The Sundarbans make up the single largest contiguous block of mangrove forest in the world, with 40 percent of the area within in India and rest is in Bangladesh. As is the case elsewhere, the mangroves of the region have great economic value and have been heavily exploited. Both in western and southern India, and throughout the Bay of Bengal, much of the originally extensive mangrove stands have been removed due to urbanization. Large seagrass beds are present in southern India in Palk Bay and the Gulf of Mannar. However, along much of the coast of western India dense seagrass beds are uncommon or not extensive, probably because of the degree of exposure and turbidity of these waters. There are some seagrass beds in the Laccadives and they are possibly extensive around the Andamans and Nicobars. It is estimated that perhaps five percent of the seagrass beds of the Indian Ocean had been destroyed by dredging or infilling.

About 844 species of marine algae are recorded from India (Venkataraman and Wafar, 2005). Of these, several species are exploited commercially on a large scale in the region. Marine invertebrate diversity is also high in India, and for some groups may show a similar trend to that for corals described above, however, there is not enough study in this group in India (Venkataraman and Wafar, 2005). Many invertebrates are harvested and are of economic importance; there is evidence that some molluscs and crustaceans have been overexploited, and species such as the coconut crab, horseshoe crabs, and certain molluscs are of conservation concern.

Prochordates in India is a very poorly studied groups. Balanoglossus *Ptychodera flava* is a wormlike animal with a localized distribution and the Krusadai Islands of Tamil Nadu is one among the few places in India where this species occur. Ascidians such as *Herdmania* and *Eceinascidia*, and Amphioxus *Branchiostoma lanceolatus* are also occur in India but these protochordates need more studies. Commercial and subsistence fisheries are important in India (Pernetta 1993). In India the bulk of the catch is subsistence or artisanal. *Hilsa* is the main species have been exploited in the Bay of Bengal. The Bay of Bengal is particularly rich

because of the nutrient input from the large rivers and there is extensive information available for the fisheries of this area through the Bay of Bengal Programme on marine fishery resources.

Five of the seven species of sea turtles found world wide are reported to occur in Indian coastal waters (Kar and Basker 1982, Bhupathy and Saravanan 2003). These are the olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*). Except for the Loggerhead, the remaining four species nest along the Indian coastline. A significant proportion of World's olive ridley population migrate every winter to the Indian coastal waters to nest on beaches in Orissa, as well as along other parts of Indian coast. All the five species of sea turtles that occur in Indian coastal waters are protected under Schedule I of the Wildlife Protection Act (1972), as well as listed in Appendix I of Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) which prohibits trade in turtle products by signatory countries. At present there exists no commercial or international trade of marine turtles or turtle products in India. However, incidental capture in trawls is a well-known cause of mortality for sea turtles and have been reported all over the world and India is not exception to this.

Globally threatened marine and coastal bird species such as the Spot-billed Pelican *Pelecanus phillipensis* and the Lesser Adjutant *Leptoptilos javanicus* are found in India. Important Birds Areas (IBA) along coasts includes the Gulf of Kutch, Gulf of Mannar, Coringa, Pulicat, Chilka Lake etc. The seabirds of the region are poorly known and do not appear to be abundant in off-shore India, The Sundarbans are an important staging and wintering area for gulls and terns. Many of the atoll islands in the Laccadives-Chagos chain may have seabird colonies, such as Pitti and Baliapani in the Laccadives and several of the Chagos Archipelago islands.

About 25 species of marine mammals known to occur in Indian water (Venkataraman and Wafar, 2005). Apart from larger cetaceans such as baleen, sperm whales etc., there is also a large number of small cetaceans occur in Indian Ocean, some of which are not well known, and many of which are harvested either intentionally or incidentally. The Indian Ocean

populations of the humpback dolphin *Sousa chinensis* and the spotted dolphin *Stenella attenuata* are considered to be at risk; the distribution of the latter appears to be closely correlated with mangroves. The distribution of the dugong extends over most of the region, but appreciable numbers are no longer found. The most important area for this species in the region, and possibly in the whole Indian Ocean, is the Gulf of Mannar, Palk Bay and Gulf of Kutch in India, and Andaman and Nicobar islands.

The Coastal Regulation Zone Notification, 1991, National Biodiversity Act, 2002 and the Environment (Protection) Act, 1986 have been enacted by India for the conservation of coastal and marine environment along with the Wildlife (Protection) Act 1972, which also provides for the establishment of wildlife Protected Areas by State Governments. So far, about 25 Marine Protected Areas have been established. The Gulf of Kutch Marine National Park, the Gulf of Mannar National Park and Wandoor Marine National Park are some of the important MPAs of India.

Threats to coastal and marine biodiversity

Coastal and marine ecosystems are among the most biologically and economically productive ecosystems in the world and the same is true for India where these ecosystems are both a source of livelihood as well as of a range of ecological services that are critical for the day to day well-being of millions of people particularly coastal communities. Despite their tremendous ecological and economic importance and the existence of a substantial policy and regulatory framework, Indiaôs coastal and marine ecosystems are under increasing threat. Numerous direct and indirect pressures arising from different types of economic development and associated activities are having adverse impacts on coastal and marine biodiversity across the country. 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, the spread of invasive alien species, and the impacts of agricultural, domestic and industrial sewage and waste. Additionally, climate change is likely to have a growing impact on coastal and marine ecosystems, including a likely increase in extreme weather events as well as sea level rise, warming of the sea surface temperatures and ocean acidification. Coastal habitats are also subject to powerful natural weather phenomena, such as tsunami, cyclones, hurricanes and storms. Indirect drivers of

ecosystem change include demographic, socio-political, cultural, economic and technological factors.

Major Research Activities

So far, the major scientific areas of research in the coastal and marine biodiversity in India include Fisheries, Aquaculture, Seaweed and Mangrove research. The finfish fishery researches includes studies on perches, carangids, barracudas, mackerels, milkfish, mullets, tunas, sardines, scombroids, silverbellies, pomfrets, letherinids, groupers, sharks and rays. The shellfish fishery includes oysters, mussles, clams, prawns, lobsters and crabs. Aquaculture research has been concentrated on pearl oysters, edible oysters, crabs, prawns, milkfish, ornamental fishes etc. Extensive research has also been carried out on the biology, ecology, biochemistry and production of seaweeds. Research on culture of organisms of export value such as sea cucumbers, seahorses and ornamental fishes has also been carried out by institutions including the State and Central fisheries departments and academic institutions. Research on corals, mangroves, sea grass and certain threatened fauna have also been carried out but in sporadic manner that too in selected sites. So far, majority of the research carried out in India has considered marine biodiversity as a commercial product and largely failed to appreciate their ecological vale. Moreover, recent threats such as climate change, invasive species, faster economic development etc are posing major challenges for conservation of marine biodiversity which need to be addressed immediately through scientific research.

Major requirements for marine biodiversity conservation research in India

Most importantly, coordination among all organizations/institutions who works for conservation of coastal and marine biodiversity, and social welfare of coastal communities is required. Moreover, documentation and data base of research information on marine biodiversity is also urgently required. It is also important to develop a specialised higher-educational field based programme in marine ecosystem ecology with an emphasis on rigorous scientific research, hypothesis testing, taxonomy and conservation, based very much on models established by the M.Sc course in Wildlife Science at the Wildlife Institute of India or at National Centre for Biological Science. Human resource development to manage

the Marine Protected Areas of India is also required immediately. In this connection, it is prudent to establish a new research institution to do this work.

Research gaps

I. Landscape/Seascape/Ecosystem level research

- **Long term monitoring studies on dynamics of coastal geomorphology** covering entire coastline of the country. More focus should be given to ecologically sensitive coastal areas such as coral reefs, mangroves, turtle nesting beaches, sand dunes, mud flats, estuaries etc. Studies should also focus the impact of climate change, special economic zones, infrastructure developments, etc on the coastal geomorphology using all advanced techniques including use of remote sensing, satellite images, GIS etc.
- **Necessary to make an assessment / estimation of area of habitat lost or being lost on coral reefs, mangroves, sand dunes, mud-flats etc.:** Considerable area of critical habitats have been lost due to developmental activities and natural calamities (e.g. Sea erosion, land mass uplift in case of coral reefs of Andaman Nicobar Islands after the earth quake which caused Tsunami in December 2004). An estimation of the area of habitat-loss over the years and the analyses of reasons for it would enable stem the future loss and continuation of such loss.
- **Linkages/connectivity among habitats/ecosystems**: It is important to find out the linkages and connectivity between various coastal and marine habitats/ecosystems to understand their ecological functioning better. This kind of study is crucial to plan for landscape/seascape level conservation. These studies should also analyse the impact of human activities on linkages/connectivity between habitats/ecosystems.
- **Study the structurally important elements of ecosystems**: Coral, mangroves, seagrass etc, studies should focus on population process, metapopulation processes, connectivity, and other drivers of these structural elements. Study interactions of these elements and process with human use.
- **Reduction in freshwater flow and sediment influx**: Long term monitoring study on impact of reduction in freshwater and sediments influx on the coastal and marine environment. Due to various developmental projects and changes in the landuse

pattern along the coastal areas, influx of sediments is being increasing and inflow of freshwater is being reduced which needs to be studied immediately to prevent their adverse impacts on sensitive coastal and marine habitats such as estuaries, lagoons, mangroves, seagrass beds, coral reefs, mud flats etc.

- **Study functionally vital process in various marine ecosystems**: Trophic linkages and process like predation, herbivory, detrital pathways, productivity, community linkages, tophic redundancies, resilience etc.
- **Bio-shield - Enhancing species diversity**: Studies to develop bio-shields along selected coastal line to enhance native coastal and marine biodiversity.
- **Climate Change and impacts on coastal and marine landscape and biodiversity**: Global climate change is known to adversely affect the wildlife and marine biodiversity. Therefore, it is important to monitor the coastal and marine environment and its biodiversity of India with respect to climate changes.
- **Need for research and creation of a Gene Bank for coastal and marine flora**: National Biodiversity Action Plan emphasizes the important of having gene bank for all Indian flora and fauna. In this connection, it is important to have a gene bank exclusively for coastal and marine flora and fauna. Studies in this regard need to be initiated. This gene bank is expected to contribute to the conservation of our natural treasures for a longer period as well as to protect the species from illegal trades.
- **Invasive species**: Invasive species have been identified as second most important threat to the marine biodiversity next to habitat loss. Landscape/seascape level study is required to study the impact of invasive species for their management at seascape level/ecosystem level.
- **Biodiversity of estuaries**: Of the 200 odd estuaries present in India, only around 60 are listed in literature and the biodiversity of still fewer (estuaries) have been investigated. As these are facing increased anthropogenic disturbances they have to be covered on a priority basis. Information on biodiversity will also help in assessing the health of the estuaries.

- **Identification and conservation of important coastal and marine biodiversity areas of India**: Wildlife Institute of India is already in the process of finalising an ówAtlas for Important Coastal and Marine Biodiversity Areas of Indiaô, which needs to

be further reviewed with wider participations of various stakeholders, research institutions, NGOs etc. This study would guide us to decide on economic zones and other developmental projects along coastal areas.

- **Ecological services of coastal and marine habitats / ecosystems**: It is necessary to understand and monitor the ecological services of all coastal and marine habitats/ecosystems for better management and sustainable use of bio-resources and study on impact of human use on these ecological services.

- **Understand resilience** of various coastal and marine ecosystems processes to disturbances ï thresholds, discontinuities and recovery potentials.

- **National level assessment and specific site level studies for:** High saline mudflats, Halophytesï Diversity and values (traditional and commercial).
- **Experimental studies in estuaries and mangroves**: Environmental flow, Bio-resource enhancement.
- **Economic valuation** including ecological services of various coastal and marine habitats.
- **Review and Management Effectiveness of MPAs:** It is important to review the existing Marine Protected Areas Network in India and carry out Management Effectiveness Evaluation for all MPAs in the country.

II. Habitat level research on Coastal and Marine Biodiversity

- **Inter-tidal Mudflats** ï Studies to assess their ecological significance, restoration and dynamics.
- **Corals** - Studies to understand and analyse the connectivity within and between associated habitats. Detailed ecological study on corals associated micro-organisms and their responses to changing climate and various anthropogenic activities. No Zoothanthellae, no coral. Information on the taxonomy of zoothanthellae, their role in the coral habitat and biology is poorly known. This gap has to be filled.
- **Mangroves** are considered as repository of biodiversity. Therefore an integrated study to record the diversity associated with mangroves has to be undertaken (to cite

few- diversity of fungi, nematodes, amphipods, brachyuran crabs etc. is not known fully)

- **Sea grass and lesser known mangrove species inventory**: Sea grass beds and mangrove habitats _provide feeding and breading habitat for many organisms, which will attract species towards it. These fragile ecosystems need to be taken care of by long term monitoring of the lesser known species of mangroves and sea grasses. Research gaps on restoration of these habitats also need to be addressed. Sites associated with rich biodiversity include sea grass beds and sea weed rich areas besides others. While the biodiversity of the above plants are known sufficiently, diversity of organisms associated with the above plants is poorly known. This gap has to be bridged.
- **Documentation of biodiversity in intertidal rocky shoreline**: The important research gap area in intertidal rocky shoreline is the documentation of biodiversity of symbiotic and associated micro flora.
- **Coastal Lagoon Ecology and Biodiversity**: Lagoons are ignored for a longer period which should be studied in detail for their biodiversity, ecological services and livelihood interactions of local communities or stake holders.
- **Habitats of threatened animals**: Special habitats of certain threatened animals such as dugong, whale shark, sea horses, horseshoe crab need to be assessed and monitored.
- **Impact of coral bleaching on the biodiversity of corals and other associated organisms in coral reef ecosystems**: The frequency of bleaching events has increased in the recent past in reefs world over. While large-scale coral mortality is the immediate result, species-wise mortality and the actual coral cover last is often not clearly understood. Secondly, the process and chances of recovery of coral species need to be monitored. Thirdly and importantly, the impact of disappearance or the dramatic reduction in percent cover of a coral species ï which in turn would influence the associates ï need to be studied in a long-term basis.

III. Species level research on Coastal and Marine Biodiversity

- **Strengthening of taxonomic capacity**: Current knowledge on taxonomy of marine fauna and flora are inadequate. This is mainly due to dwindling population of taxonomists: many have retired and left no legacy. The current curriculum of education system (especially in Biology and Marine Sciences streams) is also to blame. It is also mainly due to limited exposure to young researchers in the field of marine taxonomy and ecology. Thus there is an urgent need to build capacity in Taxonomy and Ecology of marine biota through series of training programs. In addition to traditional taxonomic training, training on use of molecular tools including molecular markers and DNA barcoding to strengthen/ confirm the morphological identity is necessary.

- **Preparation and implementation of species recovery plan**: Recently the Ministry of Environment and Forests, Government of India has decided to recover the highly threatened marine species using the ósSpecies Recovery Plansô. More species need to be included in this programme and all the ósSpecies Recovery Plansô must be prepared with scientifically validated data. Therefore, required scientific information need to be collected for preparation of species recovery plans of threatened marine species.

- **Periodic assessment of threatened and endemic species**: As a part of long term monitoring of population and distribution range of all threatened and endemic coastal and marine species, periodic assessment at the interval of five years need to carried out to periodically review the scheduled species of Wildlife (Protection) Act, 1972 and also support the periodic revision of red list of IUCN, appendices of CITES etc.

- **Ecological studies of endemic and threatened species of invertebrates and prochordates groups**: Most of the invertebrate fauna in coastal and marine ecosystem are being commercially exploited for food, medicine and preparation of ornamental goods. As a result, the status of many endemic and threatened invertebrate biota is unknown from scientific as well commercial perspectives. The detailed studies need to be under taken for the status and distribution of the following groups: sea-cucumbers; seaanemones; starfish; sponges; Brachiopoda; Placozoa; Pogonophora; Gnathostomulida; Echiura; Phoronida; Ctenophora; Kinoryhncha; Priapula; Loricifera; Echinodermata; Cycliophora; and of the endemic molluscan

species. Studies on polymorphism among gastropods also to be studied. Studies are also necessary for poorly known meiofauna along the coast and intertidal mudflats. It is also important to study the ecology of horseshoe crabs, giant or coconut crabs, estuarine crabs etc. Prochordates in India is a very poorly studied group. Balanoglossus *Ptychodera flava* is a wormlike animal with a localized distribution at Krusadai Islands of Tamil Nadu are among the few places in India where this species occur. Ascidians such as *Herdmania* and *Eceinascidia*, and Amphioxus *Branchiostoma lanceolatus* are also some of the the protochodates which need more studies.

- **Impact of global warming and climate change**: the effect of global climate change and global warming brings changes in trophic dynamics, abundance and distribution of fauna in various trophic levels and it also one of the causative for coral bleaching phenomena. Studies on the long term impacts of climate change on marine fauna, including microbes, coral reefs and mitigation / prevention of coral bleaching.

- **Marine Mammals**: Status survey and monitoring of marine mammals especially, fishing cats and smooth coated otters in coastal and mangrove habitats and Dugong population in West coast & East coast (in particular Gulf of Mannar, Gulf of Kutch, and Andaman and Nicobar Islands).

- **Coastal and Oceanic Birds:** Base on birds of coastal and sea birds along the Indian coast line are inadequate. An ecological survey and long term monitoring of coastal and sea birds along West coast & East coast and identification and protection of nesting and feeding grounds of migratory birds in coastal areas are essential. The other research gaps are: study on flamingoôs habitats in Gujarat; ecological studies of terns in Lakshadweep bird sanctuary and identification of important habitats for shore birds.

- **Ecological studies on marine reptiles**: Very few species of marine reptiles are represented from the coastal and marine habitats of India, which include salt water crocodiles, sea snakes, Leatherback turtles, Hawksbill and Green turtles along the west, east coast and Islands. These species are facing severe threat due to improper

fishing gears and various coastal developments. In order to conserve these species, it is essential to study their ecology and home range.

- **Long term monitoring and Ecological studies on lesser known fish species**: though we have very good historical documentation of marine fisheries resources in the country, still there are lot of gaps existing in lesser known fish taxa. The important gap areas are: status and diversity of sea-horse population along the Indian coast; exploration of enzymic and non-enzymic anti-oxidants from by catch fishery; bait species managements; status survey of whale sharks and other threatened elasmobranchs (ecological study with state of art technologies). Life history and biology of threatened, endemic and commercially important fishes with special reference to their egg and larval stages.

- **Diseases**: Research on marine wildlife diseases especially mammals, corals, molluscans, etc,

- **Tridacnidae:** Habitat specialist and long lived species of these giant clams need to be studied intensively and required continuous monitoring. During 2010, they underwent massive bleaching thus threatening the entire population especially in Lakshadweep, which needs to be studied immediately.

IV. Socio-economic and Policy-level Research

- **Economic Evaluation:** Working models for ecological benefits versus economic benefits in a dynamic marine ecosystem needs to be established whenever and wherever it required.

- Impact of climate change and other economic developments in the demography of coastal communities.

- Determination of socio-economic dependency of user communities on coastal and marine resources versus other resources. Documentation, promotion and extension of eco-compatible alternate livelihood options. Identification of various stakeholders and assessment of impact of their activities on the ecological resources.

- Gender issues involving resource use and management. Development of empowerment mechanisms and models of community based institutions involvement in resource management.

- ñBefore and afterò Conservation gaps: Information requirements-(socio-economic data gaps including basic facilities- housing, electricity, health, education)

    - Data collection on fishing communities based on fishing village and Panchayat Raj Institutions (PRI)

    - Baseline data collection on usage of banned gear and craft

    - Document and analyze the impact of infrastructure projects (ports, power plants etc) on the communities and their livelihoods

- **Policy level research**:

    - It is important to have ónational Policy on Coastal and Marine Environment and Biodiversityô.

    - The efficacy of International, National and State policy and legal instruments in the resource management in coastal and marine environment need to be assessed.

    - Develop a national-level policy ï for collecting baseline information on communities depending on the resources (including the unorganized sector and allied sector).

    - Mechanism of networking various governmental, non-governmental and communities based institutions in the participatory management of coastal and marine resources.

    - Identify various components that need to be part of a national-level policy for restoration and rehabilitation of communities, affected by conservation initiatives, and recommend towards such a national-level policy.

- **Documentation of successful community**-led conservation initiatives, and develop indicators to identify the reasons for success. (region-specific case studies)

- Identify conflicts between policies at union and state-level for conservation, and development, impact on the communities, and on ecosystems

- Analyze, evaluate and recommend change in policies for conservation, looking at the impact on livelihood on communities (seven-month ban (trawl -ban)on fishing in Orissa)

- Develop precise definition for example on communities, fishers etc,

- Periodic review and analysis of the existing policies (based on research and supportive data)

- Identify and document the gaps in policy-making process, and recommend methods to support participatory policy-making process

- Undertake a study on the present institutional structure and function (for implementation of policies for marine and coastal biodiversity), and recommend measures for effective institutional re-structuring and functioning.

- Evaluation of existing institutions (like GOMBRT) for democratic decision-making process and management (including gender dimensions).

- Document and analyze the traditional governance systems and practices (institutions) of communities

- Study and Identify institutional models (government, non-government, and community-led organizations) that can be given responsibility for managing and conserving resources

- Study the socio-economic impact on communities (especially livelihood) due to the ban on collection of certain species (seaweed, sea cucumber).

- Need to study the livelihood skills of fishing communities (in specific locations), and recommend measures to enhance skills

- National-level documentation of existing livelihood options for coastal communities, specifically looking at the causes for success and failure.

V. Development of Technology for Coastal and Marine Biodiversity Research

- **Development of silviculture technology for endemic and threatened mangrove species**: So far, selected mangroves which are most adaptive have been chosen for mangrove plantation along the coastal areas. Due to selective and monoculture of mangroves diminishing the overall biodiversity of this habitat. Therefore, it is important to develop silliviculture technology to propagate endemic and threatened mangrove species of India towards restoring more diverse mangrove areas.
- As less than 1% of the microbes are cultivable, their biodiversity is less known as investigators depend upon culture based techniques to identified them. In the backdrop of advancements in methodology, technique like Pyrosequencing is being used to study the diversity at the world level. In India such studies have to be undertaken on the biodiversity of microbes.
- **Development of restoration technology for endangered habitats**: There are technologies available to restore the endangered coastal and marine habitats such as sea grass beds, coral reefs, mud flats, sand dune etc. However, these technologies are need to be reviewed to suit the Indian coastal environmental conditions, considering the regional hydrological and coastal settings of Indian marine ecosystem.

- **Impact of advances in fishing technology on biodiversity**: Fishing is one of the oldest professions and the fishing technology had a long history of evolution. Newer technologies are always aimed at getting more catch with least regard to biodiversity conservation or sustenance. Therefore, it is important to develop techniques with these concerns, in the mean time also assessing the impact of presently used tools on overall marine biodiversity.

- **Development of technology to minimize the by-catch:** Indian fisheries has been witnessing growing trend in by-catch which may not be desirable for well being of

entire marine ecosystem as well as fisheries. Therefore, it is important to develop suitable fishing technologies to minimise the by-catch.

- **Ecological modelling** studies include: (1) determining and predicting the effects on sea turtles and marine mammals from boating activity; (2) predicting the flow of an inadvertent discharge (such as a fuel spill) into the coastal environment; (3) modelling the transport of sediment in the coastal and marine environments; and (4) estimating the impact of the loss of kelp habitats on higher trophic levels. These types of models are useful for determining effective management strategies.

- **Development of better technology to monitor the benthic and pelagic biodiversity**. Cost effective technology is required to monitor the benthic and pelagic biodiversity of marine ecosystem including that of deep water benthos to understand the cascading effect of climate change.

- **Development of technology for facilitating the in-situ conservation of threatened species** by developing better captive breeding technologies for sea ranching of threatened species such as pipe fishes, holothurians, molluscs, corals, etc. Technology developed by CMFRI and CASMB on sea horses ranching needs to implemented in the field at appropriate sites that too in a larger scale.

- Development of cost effective technology to monitor the coastal and marine biodiversity of India for a longer period with use of latest sensor technologies.

- Development of advanced technology to assess the populations of marine living organisms such as mammals for their long term conservation.

- Technology to monitor the sea level changes and topography.

- Sensor technology for sea level rise and climate change.

VI. Monitoring & Restoration Ecology

Effective monitoring requires an understanding of long- term changes in the status of the resources and their environment. Long-term monitoring is a way to detect and document these changes in environmental quality, ecology, and human activity and determine if changes in management strategies are needed. The primary purpose of the monitoring program will be to detect change, determine its causes, whether natural or anthropogenic, and develop and evaluate management strategies. Overall, the monitoring program will assist in our understanding of the general health of Coastal and Marine Ecosystems. Monitoring program should include pollution monitoring studies and studies monitoring the population dynamics of species in all marine and coastal habitats. Changes in the relative distribution of these species could indicate natural or anthropogenic threats to marine biodiversity. Monitoring the natural functions of the land and sea interface, as well as human interruptions of those functions, this will contribute to increasing understanding of the relationships between ocean and terrestrial ecosystems. Results of the monitoring program will be applicable to basic scientific research as well as academic, education and applied management goals.

Examples of environmental factors to be monitored include: (1) status and trends of contaminants in coastal waters; (2) environmental factors, such as wind, sea level, and temperature, collected by coastal stations, offshore data buoys, and satellites; (3) changes in the abundance over various life stages of invertebrates and fish and (4) fluctuations in the abundance of dugong, holothurians, whales, turtles and seabird species in the coastal and marine ecosystems; (5) biological input of organics and fecal coliforms from pinnipeds;

Certain activities and their effects, both individually and cumulatively, should be monitored. These include: (l) commercial vessel traffic; (2) recreational activities; (3) commercial fishing and nature observation activity; (4) natural and anthropogenic (e.g., sand mining) erosion and sedimentation; (5) fishery/mammal-turtle interactions, such as the coincidental catch of whales, turtles and other mammals in fishing nets; (6) pesticide usage; (7) sewage

discharge; (8) dredge spoil disposal; and (9) recurring road repair debris side-casting along the coast.

Another important component of the monitoring program is the assessment of the effectiveness of management strategies. Once new management strategies have been put in place, usually in response to a detected change in the environment or use of the MPAs, monitoring must continue to determine whether the management strategy is having the desired effect. In fact, in most cases, each new management strategy will require the design and implementation of specific monitoring activities to augment the long-term monitoring program envisioned by this plan. Some of the major research gaps which need to be taken up immediately are:

- **Inventorization**: It is with a view to continuously carry out inventory of biotic and abiotic components of the coastal and marine environment of India. Collection of information will be on meteorology, land use practice, distribution and status of endemic and threatened species using remote sensed satellite information supported by ground truthing. Coral reef status assessment based on ground truthing. Status of Intertidal zone and its biodiversity. Identification and impact of invasive species in the region. Estuaries and mangroves and its biodiversity including impact. Sand dune and sandy beaches and its biodiversity including various impacts. Land based fluvial origin and their impact. Anthropogenic and developmental activities driven land-use changes and its impact on important habitats. Climate change and its possible impact. Identification and mapping of pollutant sources and its impact on the ecological processes and biodiversity using indicator species. Seagrass beds including biomass and productivity, associated fauna assessment. Status of terrestrial island biodiversity, Mangroves, Estuaries and lagoons.
- Creation of baseline data on physio-chemical, geological and metrological parameters, primary productivity from the ecologically sensitive areas especially Marine Protected Areas, Sea turtle nesting areas, Estuaries, Mangroves, etc for long term monitoring to detect the changes due to various anthropological activities and climate change.

- Long term monitoring of flora and fauna of coastal and marine ecosystems of India with special reference to climate changes, developmental projects in coastal and marine environment, fishing, pollution etc.
- Identification of indicator species for evaluation of efficacy of management intervention on marine ecosystems.
- Identification and establishment of non-violate vegetation preservation plots and coral reef transects for long-term monitoring of biodiversity in different parts of the country especially from MPAs.
- Temporal and spatial distribution pattern of migratory fauna in the coastal and marine environment.
- Identification of foraging, breeding grounds of migratory fauna including determination of migratory path through use of advanced technology.
- Monitoring the pollution impact of ballast water release in the seascape.
- Documentation of kinds of fisheries practices and their impacts on habitat and species
- Long term monitoring of status and distribution of various threatened and endemic marine fauna in the Indian territorial water.
- Long term monitoring and study on ecology of birds, mammals and other fauna of southern Indian Ocean and Antarctica as India is one of the signatories of Antarctic Treaty.
- Study on restoration of coral reefs from different parts of the country including coastal areas of Gujarat, Maharashtra, Karnataka, Lakshadweep Islands, Tamil Nadu, Orissa and Andaman and Nicobar Islands.
- Research on restoration of mangroves with special reference to endemics and threatened species using poly-culture techniques.
- Research on restoration of seagrass beds to prevent several threatened species including dugong from the verge of extinction from India.
- Study on restoration of degraded horseshoe crabs habitats along east coast of India
- Study on restoration/stock enhancement of populations of various threatened marine species.
- Study on restoration of degraded habitats or lost habitats due to tourism related activities especially along the coastal areas of Goa, Maharashtra and Gujarat.

Annexure: Participants List

NATIONAL LEVEL CONSULTATION WORKSHOP FOR IDENTIFICATION OF RESEARCH GAPS IN COASTAL AND MARINE BIODIVERSITY CONSERVATION IN INDIA

Date: 24th & 25th June 2010 Venue: Hotel Raj Palace Sundar, Chennai

LIST OF PARTICIPENTS

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Annexure : Workshop Agenda and Schedule

Ministry of Environment & Forests,
Government of India

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

NATIONAL CONSULTATION WORKSHOP FOR IDENTIFICATION OF RESEARCH GAPS IN COASTAL AND MARINE BIODIVERSITY CONSERVATION IN INDIA

Date: 24th & 25th June 2010 Venue: Hotel Raj Palace Sundar, Chennai

PROGRAMME

DAY ONE: Thursday, 24th June 2010

9.00 ï 9.30	Registration
9.30 ï 9.35	Welcome Address: Dr. K. Sivakumar, Wildlife Institute of India, Dehradun
9.35 ï 9.45	Opening remarks: Shri. B.C. Choudhury, Wildlife Institute of India
9.45 - 10.10	Inaugural Address: Dr (Mrs) Aruna Basu Sarkar. Chief Conservator of Forests & the Director, Gulf of Mannar Biosphere Reserve Trust, Tamil Nadu.
10.10 ï 10.15	Vote of thanks: Dr. J.A. Johnson, Wildlife Institute of India, Dehradun.
10.15 ï 10.30	**High Tea**

Session I

A. Landscape/ Seascape/ Ecosystem level research

Chairperson:	Dr. S. Ajmal Khan, CAS in Marine Biology, Parangipettai.
Co-Chairperson:	Dr. Bhadury, IISER, Kolkata.
10.30 ï 11.00	Prof. B.C. Choudhury, Wildlife Institute of India, Dehradun
11.00 ï 11.15	Discussion

B. Habitat level research

Chairperson:	Prof. B.C. Choudhury, Wildlife Institute of India, Dehradun.
Co-Chairperson:	Dr. T. T. Ajith Kumar, CAS in Marine Biology, Parangipettai.
11.15ï 11.35	Dr. Rohan Arthur, Nature Conservation Foundation, Mysore.
11.35 ï 11.55	Dr. V. Selvam, M.S. Swaminathan Research Foundation, Taramani Chennai.
11.55 - 12.15	Discussion

C. Species level research

Chairperson:	Dr. P. S. Raja Sekhar, Andhra University
Co-Chairperson:	Dr. Mohanraj, Kamaraj College, Tuticorin.
12.15-12.35	Dr. S. Ajmal Khan, CAS in Marine Biology, Parangipettai.
12.35 ï 13.10	Dr. Deepak Apte, Bombay Natural History & Society, Mumbai.
13.10-13.25	Discussion
13.25-14.30	**Lunch**

Session II
D. Development of Technology

Session Chairperson: Director, Gulf of Mannar Marine Biosphere Reserve.
Co-Chairperson: Dr. Gopalakrishnan, CASMB, Annamalai University.

14.30 ï 14.50	Dr. S. Rajaguru, National Institute of Ocean Technology, Chennai.
15.10-15.20	Discussion
15.20-15.45	Tea break

E. Monitoring and Restoration Research

Session Chairperson: Dr. V.Selvam, MSSRF, Chennai.
Co-Chairperson: Dr. Bharat Jetva, Wetland International.

15.45 ï 16.05	Dr. Diraviyam Raj, Suganthi Devadason Marine Research Institute (SDMRI), Tuticorin.
16.05 ï 16.25	Dr. Syed Ali, Deputy Conservator of Forests, Union Territory of Lakshadweep, India.
16.25 ï 16.40	Discussion

F. Socio-economic and Policy-level research

Session Chairperson: Dr. Aruna Basu Sarkar, Gulf of Mannar Biosphere Reserve Trust (GOMBRT) Ramanathapuram.
Co-Chairperson: Dr. Vinod Malayilethu, WWF, India.

16.40 ï 17.00	Dr. Ritesh Kumar, Conservation Programme Manager, Wetlands International - South Asia.
17.00 ï 17.20	Dr. Remya Rajagobal, International Collection in Support of Fish Workers, Chennai.
17.20 ï 17.30	Discussion & Group formation

DAY TWO: Friday, 25th June 2010

Session III

9.30 ï 11.30	Research Gap analysis & Group work
11.00 ï 11.30	Tea break

Session IV

Research Gap Analysis (conti....)

Co-ordinator(s): Shri. B.C. Choudhury & Dr. J.A. Johnson

11.30 ï 11.50	Presentation by group ï 1
11.50 ï 12.10	Presentation by group ï 2
12.10 ï 12.30	Presentation by group ï 3
12.30 ï 12.50	Presentation by group ï 4
12.50 ï 1.10	Presentation by group ï 5
1.10 ï 1.30	Presentation by group ï 6
1.30 - 2.30	Lunch
2.30 ï 3.00	Workshop recommendation
3.00 ï 3.05	Vote of thanks ï Dr. K. Sivakumar
3.05 ï 3.30	Tea Break