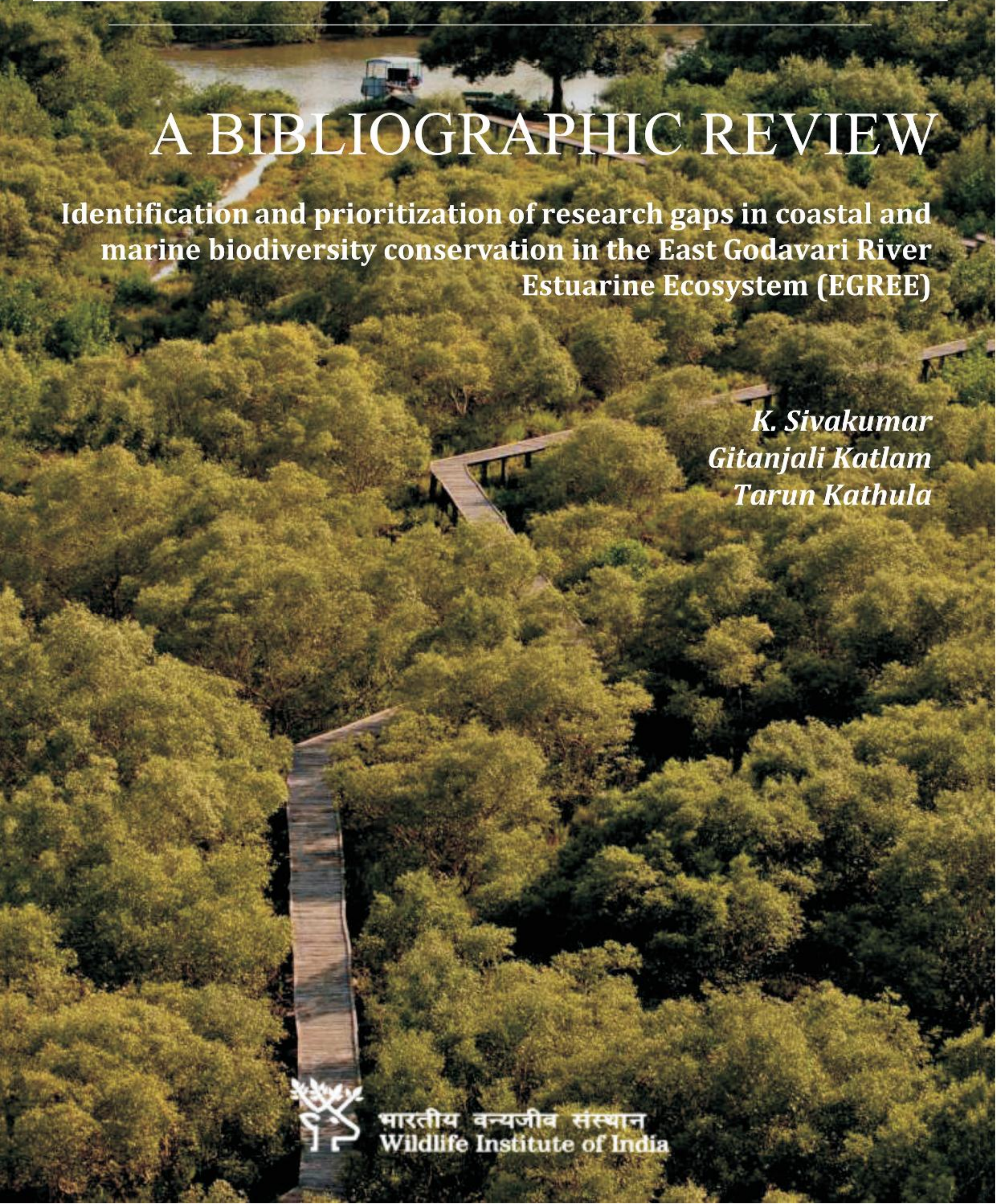

A BIBLIOGRAPHIC REVIEW

Identification and prioritization of research gaps in coastal and marine biodiversity conservation in the East Godavari River Estuarine Ecosystem (EGREE)

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Preface

India has a vast coastline of 7, 517 km, with an Economic Exclusive Zone of 2.02 million sq. km. This coastline also supports a high human population that is dependent on the rich coastal and marine resources. The ecological services of marine and coastal ecosystems of India play a vital role in India's economic growth and in ensuring human well-being. Despite the tremendous ecological and economic importance and the existence of a policy and regulatory framework, India's coastal and marine ecosystems are under 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. Further, climate change is likely to have an 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. A rise in the sea level is likely to have significant implications on the coastal populations and agricultural productivity.

East Godavari River Estuarine Ecosystem (EGREE) constitute, the second largest area of mangroves along the east coast of India. It has a rich biodiversity, and a part of the EGREE area has been gazetted as Coringa Wildlife Sanctuary (CWLS). It provides significant ecological and economic benefits and livelihood services to the local community. A noticeable rapid economic changes and emergence of large scale production activities have been seen in last few decades in EGREE. Moreover, people are dependent on mangroves for their livelihoods. These activities are resultant in the degradation of overall ecological integrity of the EGREE particularly the mangrove ecosystems, with associated impacts on the livelihoods of local people. Intensive conservation and management strategies are needed to ensure the protection of marine ecosystems. In this context, this study is being conducted to identify and prioritize the research gaps in coastal and marine conservation in East Godavari River Estuarine Ecosystem (EGREE) so that better conservation and management strategies could be prepared for EGREE. This study has prioritized 58 research programmes which are aimed to mainstream biodiversity conservation into the production sectors of EGREE through cross-sectoral planning, enhanced capacity of sector institutions for implementing biodiversity-friendly sector plans, improved community livelihoods and sustainable natural resource use. An effective implementation of these programs will keep to improve the conservation prospects of several globally significant species apart from contributing to the socio-economic well being of the region.

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Preface

The East Godavari River Estuarine Ecosystem (EGREE) is one of the important ecologically sensitive landscapes in India comprising Coringa Wildlife Sanctuary, a marine protected area notified for mangrove forest conservation. The project "Mainstreaming Coastal and Marine Biodiversity Conservation into Production Sectors in the East Godavari River Estuarine Ecosystem" has been initiated jointly by Government of India, Government of Andhra Pradesh, UNDP and GEF in view of the sustainability imperatives associated with the industrial activities such as oil and gas exploration, extractive industries, ports and industrial fisheries, which interact intensively with the living environment and biodiversity elements of the EGREE region.

As most of the intensive anthropogenic interventions in the area have occurred after the year 2000, one of the key barriers in achievement of the objective of sustainability is high prevalence of knowledge gaps related to not only the impacts of interaction of production sectors on the biodiversity and microenvironment of the region, but also on the environmental values including biodiversity in the EGREE region. Therefore a consultative process was undertaken involving the relevant institutions and individuals for identifying the key research gaps for mainstreaming coastal and marine biodiversity conservation into the production sectors wherein 58 research gaps have been identified to enhance the data with latest information for decision makers and planners for planning and management of EGREE region through developing a coastal and marine landscape level model. This publication is a compilation of the outcome of the consultation.

This research publication is intended to be a basic concept for developing partnership with various research institutions and to carry forward short term, mid-term and long-term research studies for the conservation and management of coastal and marine biodiversity in the EGREE region for reducing the knowledge gaps for achieving effective synergy between the conservation sector and production sectors to ensure enhancing implementation of biodiversity conservation strategies for sustainable industrial development in the EGREE region.

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Foreword

The East Godavari River Estuarine Ecosystem (EGREE) in Andhra Pradesh is the second largest mangrove forests in the east coast of India. In recognition of its national and global biodiversity significance, a part of the EGREE is notified as Coringa Wildlife Sanctuary. EGREE region has undergone rapid economic changes in the last two decades as a result of emergence of production activities like oil and gas exploration, industries and ports. The region is inhabited by rural communities who are also dependent on mangroves and other marine resources for livelihood.

It is imperative to develop partnerships among various sectors on the conservation of EGREE region and to encourage biodiversity friendly practices among production sectors through minimizing the identified knowledge gaps in the EGREE region. One critical decision taken in the 2nd State Project Steering Committee meeting is constitution of Research Advisory Committee (RAC) for bringing agencies, industries and communities together and work towards reducing existing knowledge gaps.

Creation of' "EGREE FOUNDATION' under the GoI-UNDP-GEF Project: 'Mainstreaming Coastal and Marine Biodiversity into Production Sectors in the East Godavari Riverine Estuarine Ecosystem, Andhra Pradesh' is also an attempt towards this direction, wherein the RAC will be part of it and act as an advisory committee to look after these studies.

I hope that this publication will contribute towards effective conservation of coastal and marine biodiversity, improving local livelihoods and sustainable development in the Godavari region by providing implementable methodologies for reducing impacts on EGREE from the Production Sectors.

A.V.Joseph, I.F.S.
Principal Chief Conservator of Forests (WL) and
State Project Director

Foreword

UNDP is pleased to introduce this publication titled "Identification and Prioritisation of Research Gaps in Coastal and Marine Biodiversity Conservation in the East Godavari RIVER Estuarine Ecosystem (EGREE)".

This publication identifies gaps in research based on a preliminary understanding of the current and potential threats to coastal and marine biodiversity conservation in the EGREE region. It enlists, categorises and summarises more than 700 publications related to the East Godavari ecosystem. This has been done with support of local non-governmental organisations, institutes and colleges.

Some of the key gaps identified include evaluation of ecosystem services provided by the mangrove ecosystem, impact of climate change on the region, impact of invasive species and status and trends of contaminants in coastal waters of the region.

The publication is part of the project "Mainstreaming Coastal and Marine Biodiversity Conservation into Production Sectors in the East Godavari Estuarine Ecosystem", implemented jointly by the Government of India, Government of Andhra Pradesh and UNDP with financial support from the Global Environment Facility. The project aims to put in place a governance model which reconciles biodiversity conservation with economic development in the richly bio-diverse ecosystem of EGREE. The region has witnessed a surge in industrial and extraction activities and creation of infrastructure in the last few decades. This has implications on the local biodiversity and livelihoods. There is a need for the governance framework to respond effectively to ensure environmental sustainability in the region.

We hope that this publication will contribute to increase in knowledge required for an effective landscape based approach to biodiversity conservation in India.

Srinivasan Iyer

Assistant Country Director and Head
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Acknowledgements

The Wildlife Institute of India (WII) has associated with the United Nation Development Programme (UNDP) since the 1980s in the field of wildlife conservation in India. WII is playing advisory roles in the conservation and management of coastal and marine ecosystems in the country. We wish to thank the Ministry of Environment and Forests, Government of India; Forest Department of Andhra Pradesh; Global Envionment Facility (GEF); and UNDP for this opportunity to develop research strategies for conservation of coastal and marine biodiversity in the East Godavari River Estuarine Ecosystem (EGREE), Andhra Pradesh, India.

We wish to place on record our gratitude for the trust and support provided to Wildlife Institute of India by Dr Jagdish Kiswan, Ex-ADGF (WL); Dr S.S. Garbyal, ADG (WL); Ms. Prakriti Srivavstava, DIG (WL); Sh. Vivek Saxena; Sh. Prabhat Tyagi, Ex-JD (WL); Sh. Shiv Pal Singh, JD(WL) and National Project Director from the MoEF, GoI; Sh. B.S.S. Reddy, PCCF (HoFF); Sh. A.V. Joseph, PCCF (WL) and State Project Director; Sh. Hitesh Malhotra, Ex-PCCF (HoFF); Sh. S.V. Kumar, Ex-PCCF (HoFF); Sh. A.K. Sinha, IFS; Sh. Pramod Krishnan, IFS; Ms. Lianchawii, Programme Analyst, UNDP; Dr. K. Thulsi Rao, State Project Coordinator; Dr. P. Sathiyaselvam; Sh. Y. Satya Sivanadh; Smt. P. Usha; and Sh. Kona Ravi Kumar from EGREE Project. We thank Sh. P. R. Sinha, Ex-Director, WII; Dr. V.B. Mathur, Dean, WII; Sh. B.C. Choudhury, Scientist, WII (Retired); and Dr. J.A. Johnson, Scientist, WII for their unflinching support and guidance throughout the preparation of this report.

In the process of the development of this report, the authors have interacted and gathered information and suggestions from many individuals and organizations, foremost among them Sh. S.N. Jadhav, Member Secretary, A.P. State Biodiversity Board; Dr. Manoranjan Bhanja, Addl. PCCF (Research); Sh. Kanwarjit Singh, Addl. PCCF (ET); Sh. Srinivasan Iyer, Head, Energy and Environment Unit, UNDP; Dr. Ruchi Pant, Programme Analyst, UNDP; Satyaranjan Behera, Research Fellow, WII, Dehradun; Sh. K.A. Narasimham, CMFRI, Cochin; Sh. T. Rajyalakshmi, expert on fisheries; and many others.

The development of the report necessitated interaction with a large number of professionals in various institutions, foremost among them Andhra University, Zoological Survey of India, MSSRF, CMFRI, Department Of Marine Living Resources, College of Science & Technology, WWF-Andhra Pradesh, CIFT, Institute of Wood Science and Technology, State Institute of Fishery Technology, IISER-Kolkata, Department of Ports, National Institute of Hydrology, District Industrial Centre, Department of Social Welfare of Andhra Pradesh, Irrigation Department of Andhra Pradesh, DRDA, P.R. College, Kakinada, M.S.N. College, Kakinada, ASHRAM, etc. We thank all of them.

- Authors

INTRODUCTION

Background

The East Godavari River Estuarine Ecosystem (EGREE), encompassing the Godavari mangroves, is the second largest area of mangroves along the east coast of India. The area is rich in coastal and marine floral and faunal diversity and generates significant ecological and economic benefits such as shoreline protection; livelihood sustenance; and carbon sink services. It is an Important Bird Area (IBA), with a recorded population of 236 bird species, of which 88 are migratory, including several that are threatened. In recognition of its national and global biodiversity significance, a part of the EGREE area is gazetted as Coringa Wildlife Sanctuary (CWLS). In addition to its biodiversity value, EGREE also has enormous economic significance, with the last few decades witnessing rapid economic changes and the emergence of large-scale production activities.

The main production sectors operating in the landscape/seascape are fisheries, aquaculture, saltpans, oil and gas exploration, tourism, ports and manufacturing industries (fertilizers, edible oil, rice products etc.). In addition, there is dependence on the mangroves and marine resources by local villagers. Their activities are influencing the overall ecological integrity of the EGREE, particularly the mangrove ecosystems, with associated impacts on the livelihoods of local people. In this connection, the GoI-UNDP-GEF intervention aims to mainstream biodiversity conservation into the production sectors of EGREE through (1) cross-sectoral planning in the EGREE that mainstreams biodiversity conservation considerations, (2) an enhanced capacity of sector institutions for implementing biodiversity-friendly sector plans and (3) improved community livelihoods and sustainable natural resource use. It is anticipated that by the end of the project, production activities in at least 80,000 ha will be streamlined with the above-mentioned objectives, thereby improving the conservation prospects of several globally threatened species apart from contributing to the socio-economic well-being of the EGREE region.

Significance of Indian Coastal and Marine Biodiversity

The sea around India is a part of the great Indian Ocean, and the Indian subcontinent forms a major physical feature dividing the Arabian Sea and the Bay of Bengal of the Indian Ocean. India represents 2.5% of the world's landmass and supports a population of over 1.2 billion people. India is also one of 17 megabiodiverse countries in the world, with 7.8% of the recorded species of the world, including 45,500 plants species and 91,000 animal species (Sivakumar, et. al, 2012). India has a vast coastline of 7,517 km, of which, 5,423 km belongs to peninsular India and 2,094 km to the Andaman, Nicobar and Lakshadweep Islands, with an EEZ of 2.02 million sq. km. This coastline also supports a huge human population that is dependent on the rich coastal and marine resources. It is estimated that nearly 250 million people live within 50 km of the coastline of India (Sivakumar, et, al, 2012). Therefore, the ecological services of the marine and coastal ecosystems of India play a vital role in India's economic growth.

More than 340 species of coral belonging to 76 genera have been recorded in India (Wafar et al. 2011). The highest diversity of 179 species has been recorded in the Andaman and Nicobar islands. India is ranked 14th among the 22 countries that hold the world's major mangrove areas. The Sundarbans make up the single largest contiguous block of mangrove forest in the world, with 40% of the area within India and the rest in Bangladesh. As is the case elsewhere, the mangroves of the region have great economic value and are being 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. Several species are exploited commercially on a large scale in the region. Marine invertebrate diversity is also high in India; this group has not been sufficiently studied in the EGREE. Many economically important invertebrates are extensively harvested. There is evidence that some mollusks and crustaceans have been overexploited, and species such as the coconut crab and horseshoe crab and certain mollusks are of conservation concern.

Commercial and subsistence fisheries are important in India (Pernetta 1993 b, c, d, e). The Bay of Bengal is particularly rich because of the nutrient input from the large rivers, and extensive information is available on the fisheries of this area through the Bay of Bengal Programme on marine fishery resources.

Five of the seven species of sea turtle found worldwide are reported to occur in Indian coastal waters (Kar and Basker 1982, Sivakumar 2002, Bhupathy and Saravanan 2003). These are the Olive Ridley (Lepidochelys olivacea), Green Turtle (Chelonia mydas), Hawksbill Turtle (Eretmochelys imbricata), Leatherback Turtle (Dermochelys coriacea) and Loggerhead Turtle (Caretta caretta). Except for the Loggerhead, all the species nest along the Indian coastline. A significant proportion of the world's Olive Ridley population migrates every winter to Indian coastal waters to nest on the beaches in Orissa, as well as along other parts of the Indian coast. All the five species of sea turtle that occur in Indian coastal waters are protected under Schedule I of the Indian Wildlife Protection Act (1972). In addition, they are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prohibits trading of turtles and their products by the signatory countries. At present, there is no commercial or international trade in marine turtles or turtle products in India. However, incidental capture in trawls is a well-known cause of mortality of sea turtles and has been reported all over the world, and India is no exception.

Globally threatened coastal wetland species such as the Spot-billed Pelican Pelecanus phillipensis and the Lesser Adjutant Leptoptilos javanicus are found in India. Important coastal areas for birds include the Gulf of Kutch and Chilka Lake. The seabirds of these regions are poorly known and do not appear to be abundant in India. The Sundarbans are an important staging and wintering area for gulls and terns. Many of the atoll islands in the Laccadives-Chagos archipelago have seabird colonies, such as Pitti and Baliapani in the Lakshadweep.

Apart from the larger cetaceans, namely the baleen whales and sperm whales, a large number of small cetaceans are also found in the Indian Ocean. 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 appearing to be closely correlated with the occurrence of mangroves. The most important area for this species in this region, and possibly in the whole Indian Ocean, is the Gulf of Mannar, Palk Bay and Gulf of Kutch in India. In the Andaman and Nicobar, the only remaining sites it definitely occurs are Ritchie's Archipelago and North Reef.

Statutory provisions such as the Coastal Regulation Zone Notification, 1991, National Biodiversity Act, 2002, and the Environment (Protection) Act, 1986, have been enacted in India for conservation of coastal and marine environments, along with the Indian Wild Life (Protection) Act, 1972, and facilitate the establishment of protected areas such as national parks and sanctuaries by state governments. So far, more than 18 marine protected areas (MPAs) have been established in peninsular India, and CWLS is one of them. 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.

Godavari River Estuarine Ecosystem: Issues and Threats

In spite of the above-mentioned legal, policy and institutional framework, the mangrove and coastal ecosystems of Andhra Pradesh in general, and the EGREE in particular, are under increasing threat. The Godavari Delta, like many other deltaic systems in India, has been highly altered by human activities. Causes for the degradation of estuarine ecosystem include conversion of mangroves to aquaculture, agriculture and salt pans; effluent discharge from industries; eutrophication; siltation of Kakinada Bay and its rivers; anthropogenically induced river flow change and erosion; seasonal hydrological changes and overexploitation of mangrove forests by villagers for cattle grazing, fuel wood and boat manufacture. It is estimated that 30-40% of the degradation of mangrove forests has taken place in the last decade due to agriculture, aquaculture and deforestation, and oil and pesticide pollution. The CWLS and other areas in the Godavari River Estuarine Region have been subjected to heavy cattle grazing, fuel wood collection, etc., resulting in large-scale depletion of mangrove forests.

The direct drivers of ecosystem degradation in the EGREE are (i) habitat alteration and destruction, (ii) overexploitation and consumption of coastal and marine resources and (iii) pollution from industries, aquaculture and urban agglomerations (Kakinada, Andhra Pradesh, and Yanam, Pondicherry).

As mentioned previously, the EGREE faces multiple threats from a number of sectors. A rapid analysis was undertaken to obtain a better understanding of the ranking of the various threats. The analysis suggests that the threats from the production sectors and fishing are the major ones that need to be given priority under the project. Conversions of land to other uses such as aquaculture, industrial activities, unsustainable fishing, and pollution from manufacturing units are the three highest-ranked threats.

The indirect drivers of ecosystem change relate to demographic pressures that are exacerbated by governance challenges and economic constraints faced by the local population. Key governance issues include the fact that management of the CWLS is not integrated with that of the wider landscape/seascape of the EGREE, enforcement of regulations and intersectoral coordination is weak, the information base for driving good management decisions is absent and the community support for promoting better stewardship of the EGREE is also not effectively organized. Economic factors include a lack of alternative sustainable livelihood options and adequate and fair credit arrangements.

Potential Threats to EGREE

Notable among the potential future threats to the EGREE are climate change, changes in the flow of the Godavari River and unplanned tourism development. At present, tourism is not placing significant pressures on the EGREE, but it has the potential to do so. The clearing of mangrove forests for tourism developments is a major factor behind mangrove loss around the world. Climate change, particularly a rise in the sea-level and changes in salinity, too will pose a threat to mangroves. Finally, the rapidly growing urban agglomerations in the EGREE region, particularly in Kakinada, Andhra Pradesh, also raise the issue of generation of large quantities of waste and sewage, which may ultimately find their way into the Godavari Estuary and exacerbate the degradation of the mangrove ecosystem.

With this background, the GoI-UNDP-GEF project envisages maintaining a knowledge management system (KMS) at the Wildlife Institute of India, Dehradun, for the EGREE. Assessing the existing data in the geographic scope of the EGREE and identifying gap areas and other potential information generation possibilities are proposed.

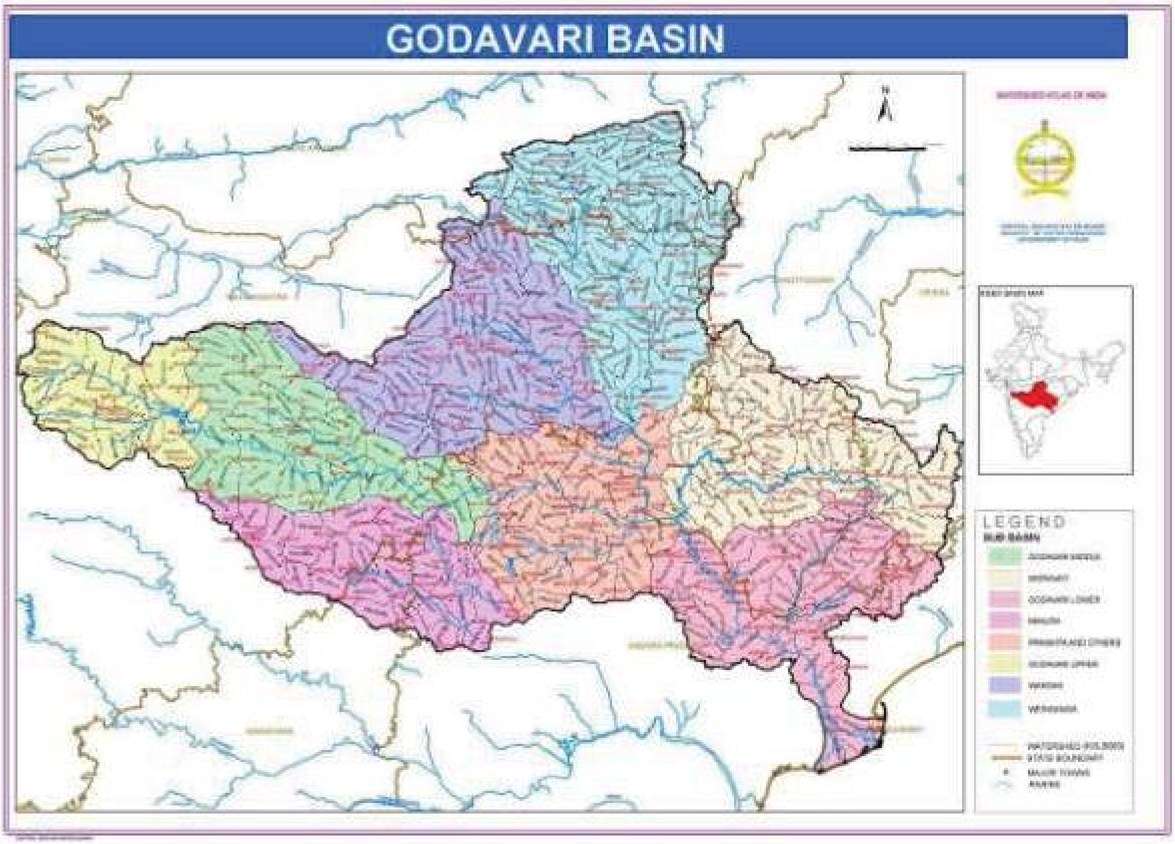
The Major Objectives of the Project

One of the main objectives of the project under Output 1.3 is to establish the KMS for the EGREE. Initially four major aspects of the KMS are being addressed□

1. Identifying research gaps in coastal and marine conservation in the EGREE
2. Evaluating the ecosystem services provided by the EGREE
3. Studying the impact of climate change on the EGREE
4. Conducting a national workshop on mainstreaming biodiversity conservation into production sectors for conservation of coastal and marine resources in the EGREE landscape.

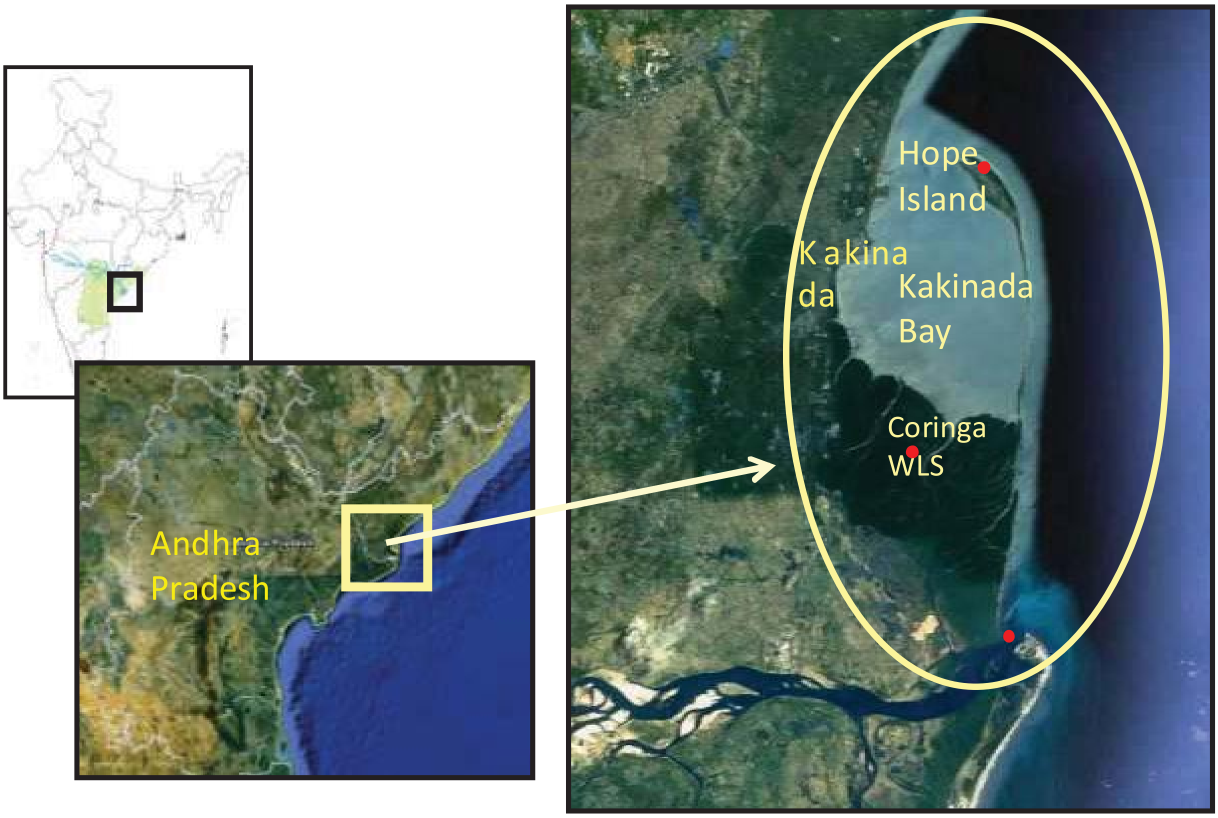
Scope of Study Area

The Godavari is the largest of the Indian peninsular rivers that originate in the Western Ghats, traversing a length of 1,446 km and having a catchment area of 3,14,685 sq. km, draining into the Bay of Bengal. This project is mainly focused on the Godavari River Estuarine Ecosystem and adjoining landscape/seascape. The Godavari mangrove wetlands are located between 16□30□17□N and 82□10□80□23E in the East Godavari District of Andhra Pradesh. Apart from the CWLS, the EGREE area includes six reserve forests, viz. Rathikalava, Masanitippa, Maltatippa, Balusutippa, Kothapalem and Kandikuppa.



About 30% of its human population is dependent on the rich, exploitable coastal and marine resources. The coastline of the Bay of Bengal and Arabian Sea continue to be rich fishing grounds in the South Asian region, wherein India is one of the nations producing the largest amounts of marine fish. The Godavari Delta/Estuary is most important fish breeding ground in India.

The Godavari River bifurcates into two major distributaries the Vasishta and Gautami, at Dawaliswaram and drains into the sea at Coringa, about 53 km upstream from Vrudha. The tidal channels are deep and usually U-shaped in cross section, with steep banks, and tidal creeks originating from these channels criss-cross the mangrove swamps. The mangroves are the Gautami's gift, and they grow on mudflats formed due to siltation accumulated over centuries. The estuary joins the sea at Coringa, geographically located between 16°27′-16°59′ N and 82°10′-80°22′E, covering an area of 235 sq. km. One can notice complex mangrove swamps and coastal lagoons forming the CWLS, in the northeastern part of the Godavari Delta.



Marine ecosystems such as estuaries, coral reefs, marshes, lagoons, sandy and rocky beaches, mangrove forests and seagrass beds are all known for their high biological productivity and provide a wide range of habitats for aquatic flora and fauna. They also act as important food resources and provide critical services to human beings. Therefore, the sustainability of these fragile ecosystems should be a primary concern. So far, we have largely looked at marine biodiversity as a source of commercial products instead of appreciating their ecological value, resulting in overexploitation of several species to the verge of extinction. Moreover, human activities such as destructive fishing, shipping, coastal development and discharge of untreated effluent from industries have caused considerable damage and pose a severe threat to the coastal and marine biodiversity resulting from the negative impacts of climate change.

Methods Adopted to Identify Research Gaps in Coastal and Marine Conservation in the EGREE

The conservation of biodiversity in the EGREE has gained importance in view of the need to sustain the livelihoods of people living in and around the EGREE. Further, research-based information is essential for better coastal and marine biodiversity conservation planning. Therefore, it has become inevitable to analyze the available research publications and identify the research gaps. Moreover, it is also important to prioritize these gaps so that certain research efforts, which are critical for the management plan, need to be taken up immediately. In this connection, this task was taken up with the following objectives:

1. Preparing a bibliography of the existing literature on the EGREE
2. Summarizing all past and ongoing research in the EGREE
3. Identifying and prioritizing research gaps.

All the available relevant published information from research in the EGREE region was collected through an in-depth search of various sources, viz. international databases, CD-ROMs, the WII Library and Documentation Centre and libraries of various research institutes in India. In the initial stages of the project, a thorough assessment was made, with inputs from research institutions, on the key research gaps, and this collated information was reviewed. Thus, based on a review of the literature, field visits and discussions with stakeholders, research gaps in the biodiversity and management of the EGREE were identified. The final document was prepared after obtaining inputs from a stakeholders' workshop conducted at the project site (Kakinada).

The following institutions, NGOs and colleges helped in gathering information and literature:

1. Andhra University, Visakhapatnam
2. Woods Institute of Science and Technology, Visakhapatnam
3. National Institute of Oceanography, Visakhapatnam
4. Central Institute of Fishery Technology, Visakhapatnam
5. State Institute of Fishery Technology, Kakinada
6. Central Marine Fisheries Research Institute, Kakinada
7. M.S. Swaminathan Research Foundation, Kakinada (NGO)
8. Integrated Coastal Management, Kakinada (NGO)
9. Women's College, Kakinada
10. P.R. College, Kakinada
11. M.S.N College, Kakinada
12. National Institute of Hydrology, Kakinada
13. WWF-Andhra Pradesh, Hyderabad

A total of 727 publications, including research papers, conference proceedings, popular articles and reports, related to the EGREE have been collected to date. Apart from these, a few newspaper clippings and articles from the Internet have also been collected.

Table1. Details of references collected on different subjects.

Subject	No.of Publication	Percentage
Algae	2	0.3
Bacteria	1	0.1
Climate study	7	1.0
Crafts and Gears	12	1.7
Ethnobotany	15	2.2
Fauna	197	28.6
Flora	66	9.6
Fungi	5	0.7
Geology	20	2.9
GIS and Remote Sensing	22	3.2
Hydrology	65	9.4
Others	48	7.0
Sedimentology	87	12.6
Socioeconomics	7	1.0
Physical Studies	171	24.9
Pollution	2	0.3
Total	727	100

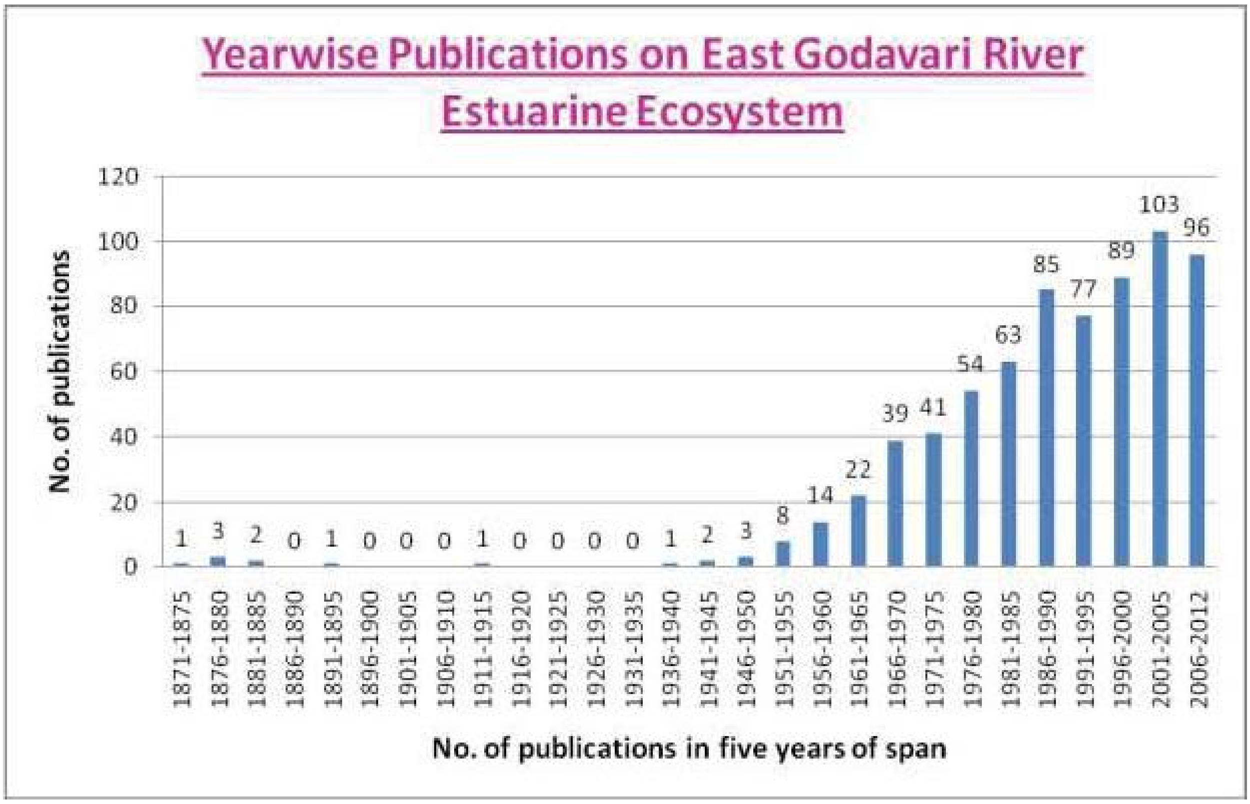


Figure 2 - Year-wise number of publications

According to the literature review, there are several areas, such as socioeconomics and climate change, in which very few investigations have been carried out. These require immediate attention. Most of the studies have focused on geochemical, geophysical and geological aspects. Since intensive anthropogenic interventions such as industrialization, overfishing and shipping in the area have developed recently, there is a need to undertake scientific assessments of these. Such assessments can be initiated on the basis of the present literature review.

THE MA�OR SCIENTIFIC AREAS OF RESEARCH INTO THE BIODIVERSITY OF EGREE

About 29� of the publications available are on the fauna of Godavari Estuary and its adjoining areas. Most of these studies have highlighted different aspects of the ecology, biology, taxonomy and distribution of different types of fauna (Krishna and Mishra 2001). Benthic faunal groups such as the microbenthos, meiobenthos and macrobenthos have been extensively studied. Faunal groups such as polychaetes, mollusks and zooplanktons were also studied in detail. Studies on finfish, shrimps, shellfish and prawns were well studied by the state government and central government institutions that are situated near Kakinada.

Benthic Fauna

Microbenthos

A total of 126 microbenthic species were observed in the CWLS (Critical Habitat Information System (CHIS) 1998-1999), including 27 species of microalgae, 28 species of flagellates and 71 species of ciliates. Ciliates were the predominated species throughout the EGREE region. The occurrence of microbenthic species varied from region to region in the Godavari Estuary. The microbenthic diversity was greater in mangrove patches compared with Kakinada Bay, which indicates that the microbenthos prefers organic matter/sediments in the mangrove ecosystem for its sustenance.

A study using the stable isotope analysis technique found that the carbon sources are vital in sustaining the benthic invertebrate communities in an estuarine mangrove ecosystem, especially during the post-monsoon season. Studies were also conducted into the selectivity of subtidal benthic invertebrate communities for local micro algal production in an estuarine mangrove ecosystem during the post-monsoon period (Bouillon 2004).

Meiobenthos

In total, 28 meiobenthic comprising nematodes, copepods, foraminifera, ostracoda, polychaetes, etc. have been observed in the Coringa mangroves and in Kakinada Bay (CHIS 1998-1999). In the Godavari Estuary, nematodes dominated the meiofaunal composition, and additionally the meiofauna density was observed to be higher in the bay regions than in Coringa.

The distribution, abundance and ecology of the macro fauna and meiofauna of Kakinada Bay and the backwaters have also been studied well (Sanders 1968, Kondalrao and Murty 1988). Studies on quantitative variations in different species of benthic ostracods of the Vasishta-Godavari river estuaries in relation to the water and sedimentological characteristics of the Gautami-Godavari and Krishna-Godavari have been documented (Annapurna 1988).

Macrobenthos

So far, 114 macrobenthic species, comprising 41 crustaceans, 26 polychaetes, 21 gastropods, 21 bivalves and 5 species from other taxa have been reported from the mangrove ecosystem of the Godavari estuarine area (Bhavanarayan 1975, Raut 1997, CHIS 1998-1999, Raut et al. 2004). The macrofaunal abundance (no/m^2) ranges from 67 to 116 and 94 to 186 in the backwaters and near-shore environment, respectively. Polychaetes and crustaceans constitute the bulk of the macrofauna in the backwaters, while polychaetes and molluscs dominate in the near-shore bottom deposits. The macrofaunal diversity is higher in the near-shore region of the Godavari estuarine ecosystem because of the availability of rich organic matter compared with Kakinada Bay. The homogeneity, diversity, abundance and distribution of intertidal polychaetes in the Vasishta-Godavari estuary have been documented (Ramasarma and Srinivasa Rao 1982, 1983, Srinivasa Rao 1981, 1982, Chandramohan 1988). Systematics and some other aspects of the ecology of the polychaete Heteromastus similis has also been studied here (Srinivasa Rao 1978, 1980, Chetty 1988, Rao 1999).

The chaetognatha have been poorly studied in the Godavari estuarine system, and there has been a single attempt to determine their distribution in Indian seas, especially off the Kakinada coast (Rao1959). Ecologically as well as commercially important invertebrates such as mollusks have also been poorly studied in the EGREE. Few records exist of the molluskan fauna and their ecology in the extensive mangrove forests of this region (Radhakrishna and Jankiram 1975, Narasimha et al. 19841973), but there no detailed study has been conducted on this taxonomic group in the recent past.

Data on the crab diversity of the Gautami-Godavari estuary are available (Krishna 2002), but detailed studies have not been carried out on the crabs of this region even though there is an important fishery for them in the region. In general, among the macrobenthos, the polychaetes of Godavari Estuarine Region are well documented, but the crabs and mollusks, which are economically important, are poorly studied.

Marine Wood Borers

Marine woodborers have always been a big problem for fishermen as they damage boats and submerged structures. Just three studies have been conducted on the marine woodborers in the EGREE. Ten species of teredinids, the pholad Martesia striata (Linnaeus) and a variety of Sphaeroma have been recorded from the Gautami-Godavari estuary. The studies conducted hitherto emphasize the need for sustained and planned investigation into the biology and distribution of these pests from the mangrove ecosystems (Ganapati and Rao 1959, Rao et al. 1986). It is important to carry out a comprehensive study on the woodborers of the region in the context of climate change and fluctuations in the water and sediment flow into the estuary. Such a study would also help boat makers minimize the adverse impacts of woodborers on fishing boats.

Zooplankton

A total of 81 species of zooplankton comprising 51 species of Crustacea, 6 species of Hydrozoa, 5 species of Sagittoidea, 3 species of Polyhymenophora and 16 species of other taxa have been reported from the Godavari Estuary. Copepods dominate the zooplankton composition, followed by bivalve veligers, gastropod veligers and decapod larvae (CHIS 1998- 1999).

The tidal cycle has been discussed in relation to the diversity, distribution and seasonal fluctuations of the zooplankton in Kakinada Bay with special reference to the mangrove habitat in some papers (Chandramohan & Stayanarayana 1972, Chandramohan 1963, 1977, 1997).

Studies on harpacticoid copepods have confirmed the presence of 32 species, with Pseudostenhelia secunda being a ubiquitous species in the intertidal mudflats of the estuary in the EGREE. A detailed account of the hydromedusae and a description of an unknown Pseudostenhelia secunda Wells from the Vasishta-Godavari estuary are also available (Kondalrao 1984, 1985, Satyanarayana 1996. Narasimham 1987, Satyanaryana 1996).

The distribution of zooplankton in relation to water movements in Kakinada Bay (Chandramohan 1999) and their taxonomy have also been studied. Several studies have analyzed the characteristics of the zooplankton, its production and its distribution in the mangrove habitat in the EGREE (Sreenivas 1998, Nutalapati 1998, Prasad 2001). A study was carried out on the sources of suspended organic matter and selective feeding by zooplankton in an estuarine mangrove ecosystem using stable isotopes (Bouillon et al. 2000). The investigators concluded that despite the large amounts of terrestrial and mangrove detritus present in the water column, the locally produced phytoplankton appears to be a more important source of organic matter for the zooplankton. A study has been conducted on estuarine hydrography in relation to production of plankton in Kakinada Bay (Bhavanarayana 1955).

The zooplanktons seem to be well-studied taxa, with their ecology, seasonal distribution, characteristics, taxonomy, seasonal fluctuations, diversity, etc. in the Godavari Estuarine Region having been investigated. However, the taxonomy of the zooplankton in this region still remains poorly studied and needs to be addressed by capacity building among students of this field. The greater abundance and distribution of zooplankton in the mangroves areas of the EGREE indicate that this environment plays a significant role as a nursery ground for commercially important shellfishes (CHIS 1998-1999).

FISHERIES

Prawn Fishery

Prawns are the most important fishery resources in the coastal areas of Kakinada. Among the shrimps, Metapenaeus dobsoni, M. monoceros, M. brevicornis, Penaeus stylifera, P. monodon and P. indicus were found to be the predominant species of this region (CHIS 1998-1999). The prawn fishery has been discussed in some Ph.D. theses and a number of other studies (Subrahmanyam and Rao 1964, Subrahmanyam and Ganapati 1966, 1971, Rajyalakshmi 1991, 1975, Sudhakar Rao 1972, 1975). The abundance of prawns, fluctuations in prawn landings and the migrations of prawns in the Godavari Estuary in relation to lunar, diurnal and tidal periodicity have been well documented (Subrahmanyam 1965, 1966, 1968). An abnormal form of Alpheus malabaricus (Fabricus) was reported from the Godavari Estuary in 1967 (Subrahmanyam 1967).

An observation on post-larval prawns from the Godavari estuarine system with a note on their role in capture and culture fisheries in the EGREE has been reported (Subrahmanyam and Ganapati 1971). The role of the Godavari mangroves in the production and survival of prawn larvae has also been discussed (Chandramohan 1997).

The biology of the prawn Penaeus monodon (Fabricus) from the Godavari estuarine system and ecology of Macrobracium rosenbergii, M. malcomsonii and Metapenaus monoceros in this region have been described in detail (Subrahmanyam � Ganapati 1975). The status of the prawn industry in the Godavari estuarine system was assessed in the 1970s (Subrahmanyan1976), but since then no detailed assessment has been made. A study has been carried out on the feeding biology of Metapenaeus monoceros (Fabricus) in the EGREE, its total length-weight and other dimensional relationships. Also, in two prawn culture experiments conducted in the salt pans of Neellarevu (Andhra Pradesh) the yield was

259 kg/ha after 168 days, with a net profit of Rs.1388 per hectare, with the salt production not being hampered (Rao and Nandakumar 1988, 1998).

Reproductive biology studies related to the ovarian stages, spawning season, sex ratio and attainment of maturity of the Brown Prawn Metapenaeus monoceros (Fabricus) along the Kakinada coast have also been carried out (Rao 1989, 1990). Estimation of the age and growth of Metapenaeus monoceros (Fabricus) was done separately for males and females, and it was observed that females grew faster and attained higher asymptotic lengths compared with males (Rao 1989, 1990). Mortality rates and stocks Metapenaeus monoceros assessed from 1974 to 1977 indicated that there was a gradual increase corresponding to the fishing effort (Rao 1994).

Brackish water and estuarine systems of importance to the prawn fishery in the region were also studied (Manisseri Mary and Sudhakar 2000). The distribution, biology and capture fishery of the Tiger Prawn in the estuaries and marine habitats were reviewed. Its stock was assessed and management measures drawn up to keep the wild population sustainable in the EGREE (Rao 2000). A study related to the shrimp farming practices and its socioeconomic consequences in the Godavari Estuarine Region was carried out (Kumaran 2003). In general, the prawn fishery is commercially the most important fishery in EGREE. To maintain a high economic growth of local communities, studies related to the status and socioeconomic consequences of the fishery need to be carried out.

Finfish Fishery

Fishery practices, especially among the finfish fisheries, in the Godavari Estuary have always been the focus of many researchers, especially from the CMFRI, ZSI, Andhra University and local academic institutions. Clupeids, scianeids, upenoids, Nemipterus, Trichiurus, Saurida, elasmobranchs and catfishes are some important finfishes recorded from this region (CHIS 1998-1999).

The first detailed observations on fisheries were made on the tidal fisheries of the Godavari due to their commercial potential at the time (Chacko 1947). Studies that have been carried out on the fisheries of Godavari estuary (Rao 1965) also include taxonomic studies based on which new species such as Incara multisquamatus, belonging to the family Elestridie, and Chiramenu fluviatitis, belonging to the Gobidea have been described from here (Rao 1961, 1970). Comparative studies on Setipinna godavariensis Rao (Pisces�Engraulidae) from the Godavari and Hooghly estuaries (Babu Rao 1968) and the species of the genus Setipinna swainson of the Godavari estuary have been carried out (Rao 1962).

Studies on the Scad Decapturus russelli (Sriramachandra Murthy 1991) have been discussed in a few papers along with some observations on the biology, population dynamics, maturity, spawning and sex ratio of the Ribbon Fish (Narasimham 1994). A study has also been carried out on the fishes of the upper reaches of the Vasishta-Godavari estuary (Mohapatra and Venkateswarlu 1995). In 1997, the AP Fisheries Department assessed that the total fish landings in Kakinada had increased from 7188 to 7647 tonnes during the years 1994-1997.

The occurrence of the Bicolor Parrotfish and the rare Elagatis bipinnulata off the Kakinada coast (Burayya and Suryanarayana 1998) and the Indian Ruff Psenopsis cyanea (ray-finned fish) in shallow waters hin this region have been reported (Abdussamad and Achayya 1999).

Recently, a study was conducted on the metazoan parasites of the freshwater fishes of the Godavari (Vankara 2008). A few molecular studies were carried out on the carangid and marine fishes of Kakinada (Persis 2008). A few studies have been conducted on the diversity of fishes (Padmavati 2008) and the ichthyofauna (Kandula 2009).

Recently, the fishery and population characteristics of the Indian Mackerel Rastrelliger kanagurta (Cuvier), sciaenid fishery resources (Sivakami and Ramalingam 2003) and the Ribbon Fish fishery have been studied, and the stock of Trichiurus lepturus (Linnaeus) has been assessed (Abdussamad et al. 2006).

In one of the studies non-clupeoid fishes such as Secutor insidiator, S. ruconius, Leiognathus dussumieri, L. fasciatus, L. ecjuulus, L. splendens and L. brevirostris, from the family Leiognathidae, have been listed from the EGREE (Rao 1976). The finfish fishery is a major commercialized sector in the EGREE. Although ample information is available about the fishery, diversity and reproductive biology of fishes, etc., more studies need be carried out in relation to their taxonomy and the composition must be monitored regularly.

Shellfish Fishery

Various studies have been carried out on different aspects of the shellfish fishery. Among the bivalve resources of the EGREE that are exploited, clams are by far the most abundant. The distribution of clams, their biology, ecology, physiology, exploitation, resource potential, utilization and marketing have been reviewed in some papers (Narasimha 1987, 1985, 1983, 1991). The monthly average water temperature; salinity; dissolved oxygen; phosphate, nitrate, nitrite and silicate levels; and the seasonal variations of these parameters were studied in the clam beds of the Kakinada Bay (Narasimha 1985). The monthly average organic carbon of the sediment was also recorded.

The habitat preferences of the Blood Clam Anadara granosa have been discussed in relation to some of the environmental factors. A biological study of the Blood Clam Andara rhombea in Kakinada bay reveals that the species is less abundant than A. granosa (Narasimha 1988). The maturity period, major spawning season, morphometric and length-weight relationships and abundances of these species have been described well in this work. An experimental culture of the Blood Clam Anadara granosa was carried out, and the growth rate and stocking density were found to be related to the maximum production (Narasimha, 1980, 1983, 1987, 1988). The fishery and the population dynamics of the Blood Clam Anadara granosa have been described in some publications (Narasimha, 1980, 1987).

The Windowpane Oyster (Placenta placenta) resources of the Kakinada Bay have been described (Murthy 1979). The resource characteristics of the exploited bivalves and gastropods of Kakinada Bay have been discussed by various researchers, and the stock has been assessed (Rao and Somayajulu 1996). Shell burning for lime production was observed in this region (CHIS 1998-1999). Spat settlement and growth of the Pearl Oyster Pinctada chemnitzii (Philippi) and the growth and survival of the Indian Pearl Oyster Pinctada fucata in Kakinada Bay have been studied (Abdussamad et al. 1998).

Based on this review, the lacunae in the present state of our knowledge regarding the development of clam fisheries and the constraints thereof have been identified. In view of their sedentary habits and easy accessibility for exploitation, the clams are particularly vulnerable to overexploitation. The thrust area is rational exploitation of clams, and research inputs are the need of the hour.

Cephalopod Fishery

The cephalopod fishery is another economically important fishery in the EGREE. The morphometric characters such as the length-weight relationship in the cuttlefish Sepiella inermis Obigny along the Kakinada coast have been described (Sastry 1989). The cephalopod fishery and the resource characteristics of Loligo duvauceli in the EGREE have been assessed and the stock has been assessed (Abdussamad and Somayajulu 2004).

Craft and Gear

In the EGREE, around 3000 mechanized crafts were found to be engaged in fishing, out of which about 1000 were trawlers and the others included beach landing crafts, gill-netters, liners and seiners. In addition, about 6950 traditional crafts were also engaged in fishing activities. Pelagic resources (sharks, seer fish, tunas, etc.) were exploited using hooks and lines, and boat seines were used for sardines, mackerels, stolephores, etc. Shore seines were also operated for near-shore fishery resources. Cast nets, gill-nets, drag nets and trawl nets are the major fishing gear used in this region. Smoking, salting and sun drying of fishes and shrimps are the major fish processing activities in the EGREE (CHIS 1998-1999).

The impacts of trawl nets and reduction of mesh size on the prawn fishery have been discussed in some reports (Rao et al. 1980). Some publications discuss issues such as exploitation of prawn resources by trawlers off Kakinada, and there is a note on assessment the stock of commercially important species. Annual prawn landings by trawlers operating from Kakinada showed a gradual increase from 132 tons in 1967 to 6191 tons in 1977 and an abrupt decline to 2026 tons in 1978. Although 38 species of penaeids and a number of non-penaeids were represented in the catches, only Metapenaeus dobsoni (28.3%), M.monoceros (11.9%), M. brevicornis (6.6%), M. affinis (5.9%), Penaeus indicus (4.8%) and P. monodon (4.4%) formed the mainstay of the fishery. The study indicates that almost all the penaeids species were being harvested at an optimum level and that any further increase in effort may lead to overfishing of the stocks (Rao 1988).

The marine fishery trends at the major mechanized centers and mechanized boat (bottom trawl) landings of Silverbelly at Mandapam, Rameswaram, Madras (Pudumanaikuppam) and Kakinada are available for the years 1982 and 1983 from January to June (Jacob and Srinath 1983).

There are a few publications on the resources of demersal fishes caught by bottom trawling in inshore waters off Kakinada by small-mechanized boats. Silverbellies formed 25% of the total catch (Narayanappa, et al. 1974). A publication on the commercial trawl fisheries off Kakinada during 1967-1970 is also available. With respect to species, the break-up value weight was 26, 2661 kg.with 6.44% . Catch rates varied with the boat, and Leiogrmthus sp. (10-25 mm) was dominant (Muthu et al 1975). In addition, one study highlighted unusual landings of goatfishes by trawl nets at Visakhapatnam (Appa Rao, 1989).

Comparative fishing experiments on catches of Silverbellies (as percentages) with two trawl designs used in the inshore waters off Kakinada have been documented (Sreekrishna 1970). Additionally observations on the otter trawl operations in the inshore and deep waters off Kakinada showed Silverbellies to be fourth in the order of abundance but conspicuously absent in the deeper zones (Naraynappa 1972). Experimental trawling from small and medium-sized mechanized vessels off Kakinada has been described (Satyanarayna and Narayanappa 1972). Introduction of 43-footer mechanized boats for commercial trawling along the coast of Andhra Pradesh has also been reported (Chitibabu 1988).

Studies on the growth and yield per recruit of Johnius carutta and Nemipterus japonicas (Bloch) and on the population dynamics of Silverbelly Leiognathus bindus (Valenciennes) in the trawling grounds off Kakinada have been carried out (Murty 1986, 1987). Multispecies stock assessment with particular reference to major demersal fish species (Murty 1987) and the characteristics of the exploited stock of Nibea maculata (Schneider) (Sciaenidae) as revealed by trawl landings at Kakinada have also been discussed in a few articles (Murty 1996).

There have also been a few reports on catches of prawn species such as Ecjuula edentula, Palaemon tenuipes, E. edentula, E. bindus, E. ruconius, E. insidiatrix, E. dussumieri, Equula sp., E. fasciatus and E. splendens. E. blochii associated with the penaeid prawns caught in drag nets, and E. ruconius, E. edentula, E. insidiator, E. bindasr, E. dussumieri and E. blochii associated with the prawns caught in stake nets (Subrahmanyam 1976).

Although there are many publications available on the different types of craft and gear used and experimental fisheries, dissemination of this information and education of fishermen regarding the correct operation of nets to minimize harm to pelagic fisheries and to reduce by-catches are required.

Insects

Preliminary studies on butterflies have documented 109 species under 4 families, with the Bush Hopper Ampittia dioscorides, Large Oakblue Arhopala amantes, Common Rose Atrophaneura aristolochiae, Common Albatross Appias albino and White Orange Tip Ixias Marianne being some of the predominant species found in the Godavari River Basin (Javed et al. 2011). Besides updating the current checklist of the butterflies of this region, the taxonomy, ecology, habitat and distribution need to be studied.

Aves

Around 236 species of birds were identified from the CWLS. About 120 species of resident and migratory birds (egrets, cormorants, etc.) depend on this area for breeding and nesting (Rao et al. 1996). However, species that are not likely to be present, such as the Yellow-throated Bulbul Pycnonotus xantholaemus, Wood Snipe Gallinago nemoricola and Sociable Lapwing Vanellus gregarius have been reported. Coringa is an extremely important area for waders and mangrove birds and has been designated as an IBA (Pittie 2001).

This area is reported to have been used by about 20,000 waders in a year and species such as the Oriental White-backed Vulture Gyps bengalensis and Long-billed Vulture G. indicus, both considered to be facing sharp declines in their populations, were found here (BirdLife International 2001). Among the near-threatened species, the Painted Stork Mycteria leucocephala, Oriental White Ibis Threskiornis melanocephala and Ferruginous Pochard Aythya nyroca have also been reported from this area. In addition, 17 species of ducks and 37 species of waders of the family Charadridae have been reported (Rao et al. 1996). Even though some species need to be confirmed, the site still holds a very high diversity of water birds (Hussain & Pittie), and detailed studies on the avian diversity are required.

The status of waterfowl at CWLS and birds observed in the region between the Mahanadi and Godavari rivers have been documented in some articles (Ball 1877, Rao et. al 1996). An article on bird-pollination in Sterculia colorata Roxb. (Sterculiaceae), a rare tree species found in the Eastern Ghats of Visakhapatnam and East Godavari districts, has also been published.

Since this area supports a variety of winter visitors and endangered species such as vultures, it should be regularly monitored to keep a check on the population status of these species. There is a need to study the ecology, habitat and distribution of these migratory birds and to maintain a bird checklist of this region.

Amphibians

So far, 14 species of amphibians under 4 families have been reported from the EGREE. Some of the species such as Common Indian Toad Duttaphrynus melanostictus, Skittering Frog Euphlyctis cyanophlyctis and Indian Painted Frog Kaloula taprobanica have been documented from the Godavari River Basin, Andhra Pradesh (Javed, S.M.M. et al 2011). The available information regarding this class is minimal. More efforts should be put in to gather more information regarding this class.

Reptiles

A 25 km stretch of beach between Tamilnadu and Andhra Pradesh, from Kakinada (16°57′N, 82°12′E) to Konapakapeta, was reported to be used by the Olive Ridley Turtle as a nesting site during its migration from the Orissa (Gahirmatha) coast (Whitaker and Kar 1984, Silas et al. 1984). In the Coringa region, the sand spit and Hope Island were cited to be important nesting grounds, with the nesting season recorded as being between October and February (Rao 1985, CHIS 1998-1999).

A study on the nesting biology and conservation of the Olive Ridley Turtle (Lepidochelys olivacea) was carried out at the Godavari river mouth and Krishna Delta of Andhra Pradesh. The work has been described in a Ph.D. thesis (Ananthraju 2010), and other studies have also been carried out (Subba Rao 1983, Tripathy et al. 2003). In these studies, observations on the profile of nesting beaches, grain size analysis and moisture content, nesting activity, reproductive success and assessment of threats for conservation of the Olive Ridley Turtle at the Godavari river mouth are highlighted. So far, no systematic survey work has been undertaken along the Andhra Pradesh coast, and it is speculated that there may be important arribada beaches particularly in the Godavari and Krishna deltas, which hold the major mangrove areas of the state.

Sightings of Olive Ridley Turtle Lepidochelys olivacea during April-May 1971 in shallow coastal waters near the Durgarajupatnam beaches (13□4′-14□0′N and 80□07′-80□10′E) and Yelatturdibba beaches, near False Divi Point (15□80′-15□85′N and 80□80′-80□90′E), have been reported by Lt. Col. P.V. Francis of the Indian Navy (MTN Chandra Sekhar Kar 1983).

Turtle excluder devices (TEDs) have been recommended for all mechanized trawlers operating in areas in the EGREE where there is mass nesting and incidental mortalities have been recorded, in order to bring down incidental catches and mortality of sea turtles. Conservation and management programs have been initiated along the northern Andhra Pradesh coast (NAC) for protection of the Olive Ridley Turtle. Awareness campaigns have been conducted at all fishing villages for implementation of TEDs (Rajasekhar 2009).

A rehabilitation program has been drawn up for the now extinct Saltwater Crocodile Crocodylus porosus at the CWLS. A total of 47 species of reptiles under 15 families have been reported from the Godavari River Basin, with the Indian Black Turtle Melanochelys trijuga, Indian Garden Lizard Calotes versicolor, Blanford's Rock Agama Psammophilus blanfordanus, Brook's House Gecko Hemidactylus brookii, Spotted Supple Skink Lygosoma punctata, Indian Rock Python Python molurus, Common Krait Bungarus caeruleus, etc. being the predominant species (□aved et al. 2011).

Although adequate information is available regarding some of the most endangered species such as the Olive Ridley, further research should be carried out to protect the recently established nesting sites in the Godavari Estuary for conservation of the species in this region. Moreover, a checklist of the reptiles of this region is needed. Studies on their ecology, distribution and taxonomy need to be carried out.

Mammals

A note on the mammals of the Godavari Estuary, with special reference to the populations of key fauna such as the Fishing Cat Felis viverrina and Golden □ackal Canis aureus, in the CWLS has been published (Srinivasulu 1999). The Godavari River is reported to be a stronghold of otters, with a large breeding population of the Indian Smooth-coated Otter Lutra perspicillata documented from this region (Nagulu et al. 1991, 1999). Sighting of otters in this region is very common, with the group size ranging from 2 to 12, indicative of a healthy breeding population (Hussain. 2003).

A brief review of the natural history, district-wise distribution and present- day status of non-human primates occurring in Andhra Pradesh has been published (Srinivasulu and Nagulu 2001). Loris tardigradus was found to be restricted to only 3 southern districts, and Macaca mulatta, M. radiata and Semnopithecus entellus have been recorded throughout the state, but in East Godavari District only the Rhesus Macaque Macaca mulatta has been reported so far. Except Loris tardigradus, whose populations are known to be under severe pressure due to rampant killing spurred by superstitious beliefs and the need for folk medicine, the populations of the other species are reportedly under moderate to low killing pressure and subjected to lower levels of man-monkey conflicts.

The information available regarding the mammals of this region is scattered, with only a few groups of macaques, otters, the Jackal and the Fishing cat being described. Detailed studies of the ecology, habitat, distribution and population status of the mammals of this region are the need of the hour.

Cetaceans and Elasmobranchs

The capture of a baleen whale and the landing of Bottlenose Dolphin Tursiops truncatus at Kakinada and Dummulapeta, in East Godavari District, Andhra Pradesh, have been recorded (Rao 1961, Venkataraman and Achayya 1998, Nageswara and Venkataramana, 1994, Thathayya and Achayya 1998).

A short- term survey of incidental catches of cetaceans at three landing centers along the Indian coast was conducted to quantify the number of marine mammals incidentally caught, and interviews were conducted to understand the perceptions of local fishers towards the issues related to by-catches (Yousuf, 1993). A total of 44 cetaceans were recorded in incidental catches during 80 days of observations at fishing harbours at Chennai, Kakinada and Mangalore. Six species of dolphins and one species of porpoise were also recorded during the survey. The Spinner Dolphin Stenella longirostris was the most frequently caught (38.6%), followed by the Finless Porpoise Neophocaena phocaenoides (31.8%). Gill-nets and purse seines operated from motorized boats accounted for the entire by-catch. It was estimated that 9000–10,000 cetaceans are killed by gill-nets every year along the Indian coast. The possibilities of reducing the number of cetaceans killed by gill-nets have been discussed.

There is serious concern regarding incidental catches of marine mammals. Although there are publications on the by-catches of dolphins and whales, there is no single report on direct sightings. Studies related to the ecology, habitat and distribution of these cetaceans also need to be conducted.

FLORA

Published data available on estuarine flora of Godavari (Venkateshwarulu 1944, Venkanna 1991) includes studies on mangroves, phytoplankton, algae and sea grasses.

Mangroves

The mangrove ecosystem, though it is essentially common and widespread, is the most specialized and productive coastal habitat in the world. Due to human interference in many ways, most of the mangrove forests are on the verge of destruction and disappearance. The main causes for the degradation of Indian mangroves are land reclamation, pollution and overexploitation of resources. A proper understanding of this specialized ecosystem and careful implementation of conservation measures alone will save the ecosystem from further destruction and extinction.

Most of the studies on mangroves are related to their ecological status (Rao 1959, Rao and Rao 1988), species distribution (Azariah et al. 1963, Rao and Rao 1997) and vegetation dynamics (Reddy 2008). Most of the publications discuss the mangrove-associated flora of the Pandi backwaters of the Gautami-Godavari estuary (Rao and Rangaiah 2010), Coringa mangroves forest (Dorathy 2003), Godavari and Krishna deltas (Banerjee et al. 1998) and Vasishta-Vainateyam estuaries (Rao and Murthy 2010).

Other studies on the mangrove ecosystem are on their extent, distribution, zonation, biological assemblage, hydrography, productivity, importance to humankind, man-made impacts and conservation aspects, with emphasis on the approaches for sustainable use of the ecosystem, with special reference to the mangroves of India (Selvaraj et al. 2000).

An extensive survey in the Godavari Estuary has resulted in the collection of a good number of mangroves and their associates. The total collections represent 45 species of 37 genera belonging to 26 families (45/37/26). Among them, 15/10/8 are true mangroves, 18/18/13 are mangrove associates and 10/8/6 are halophytes. The survey also resulted in the identification of Scyphiphora hydrophyllacea (Gaertn) (Rubiaceae), a rare mangrove species, and observations on Prosopis chilensis (Molina) Stuntz growing in association with Sonneratia, Acanthus, etc. (Venkanna 1991).

A report on the floristic and zonation patterns of the mangroves of Coringa, Kakinada Bay, describes the community structure of a mangrove forest. A total of 15 species of mangroves representing 8 families and 10 genera, besides 6 associate plant species and 6 marsh grasses. Avicennia marina, A. officinalis, Excoecaria agallocha, Aegiceras corniculatum, Sonneratia apetala, Ceriops decandra, Rhizophora apiculata and R. mucronata were reported to be the important mangrove species here. The tidal elevation and ambient salinity appeared to be important in determining the observed zonation (Satyanarayana et al. 2001).

A remote sensing based analysis was carried out to understand the changes in the extent of mangroves, accreted mangroves, erosion due to wave action and river water flow during floods, and changes due to forest restoration between 1986 and 2001. The geomorphological changes due to river water flow in and around the mangroves were also analyzed. The study revealed that the mangroves outside the forest boundary were converted to aquaculture ponds. It was also observed that the sand spit of Hope Island has changed with time (Sridhar 2003, Ramasubramanian 2006). The use of satellite data for quantification of mangrove loss and coastal management use over a period of 12 years (1992–2004) has been reported. The study revealed that, out of an area of 62,000 ha under mangroves, about 1250 ha was destroyed by anthropogenic interferences such as aquaculture and tree felling (Satapathy et al. 2007).

A study analyzing the ethnobotany- and fishery-related importance of the mangroves of the East Godavari deltas documented local utilization patterns and perceptions of ecosystem change. The study illustrated how information generated by ethnobiological research and local people's perceptions of change can be incorporated into management strategies to strengthen the management of an ecosystem where mangroves have been degraded due to overexploitation, extensive development of aquaculture, pollution from rural and urbanized areas and fishery-related activities (Dahdouh-Guebas et al. 2006). The diversity and socioeconomic values of mangrove ecosystems have been reported in some of the papers (Rao and Rao 1992, Rao 1998, Banerjee 2002, Raja Sekhar et al. 2002, Raja Sekhar 2009).

Tracing mangrove carbon in suspended matter and aquatic fauna, as well as the distribution and sources of organic and inorganic carbon, in the delta mangrove ecosystem during the pre-monsoon period was focus of a study. The mangrove creeks were clearly identified as an active site of mineralization and CO_2 efflux to the atmosphere (Bouillon and Dehairs 2000).

The transport of osmium and strontium isotopes through a tropical estuary has been described in one publication. The study determined the concentration and isotopic composition of osmium and strontium (heavy metals) in the estuarine waters of the Godavari Delta (Sharma et al. 2007).

Sea Grass

So far only one study has been conducted on the ecology and physiology of a sea grass, Halophila ovalis, at the Pandi backwaters of Andhra Pradesh (Rao et al. 2000), and 2 species of sea grasses have been reported from the mangrove forests of the Godavari and Krishna estuaries (Venkanna 1991).

Phytoplankton

The composition, abundance, vertical distribution and characteristics of phytoplankton from the mangrove regions of Kakinada, off the Krishna and Godavari river mouths have been reported (Rao and Sarojini 1992, Rohini and Raman 1997). The spatial and seasonal phytoplankton sigma ^{13}C variations in an estuarine mangrove ecosystem and the response of a natural phytoplankton community to increasing CO^2 concentrations during the pre-monsoon period have been reported (Bouillon and Dehairs 2000, Biswas et al. 2011).

FUNGAL STUDIES

The frequency of occurrence and biodiversity of intertidal fungi colonizing decaying litter of selected mangrove plants have been studied in the Godavari and Krishna deltas. A total of 73 and 67 species were identified from the Godavari and Krishna mangroves, respectively, with 55 species being common to both sites, 18 being unique to the Godavari mangroves and 12 being unique to the Krishna mangroves. Verruculina enaliawas was found to be very common at both sites, with a higher frequency of occurrence at Godavari. Decaying samples of Rhizophora and Avicennia were also studied. About 43 species were common to both hosts, while 22 species were recorded only from Avicennia and 20 only from Rhizophora. Verruculina enalia was the only fungus frequently recorded on both hosts (Sarma et al. 2001).

An examination of decaying mangrove materials from 9 host plant species collected from the Godavari and Krishna deltas resulted in the identification of 88 fungi. These include 65 ascomycetes (74%), 1 basidiomycete and 22 mitosporic fungi (25%, including 6 coelomycetes and 16 hyphomycetes). Verruculina enalia was recorded on all the host plants examined (Sarma and Vittal 2001). The seasonal variations of fungi in the rhizosphere soil of two agroforestry trees of the Godavari belt were also recorded (Srinivas et al. 2006).

BACTERIA STUDIES

Screening of rhizobacteria containing plant growth promoting (PGPR) traits from rhizosphere soils of Kakinada and their role in enhancing the growth of Pigeon Pea have been reported (Usha Rani et al. 2012).Three isolates were shown to be promising in Indole Acetic Acid production and phosphate solubilization. The use of these isolates as inoculant biofertilizers might be beneficial for Pigeon Pea cultivation as they enhanced the growth and improved growth parameters.

ALGAE STUDIES

A number of studies have been conducted on the spore discharge of the red algae Bostrychia tenella, Cologlossa leprieurie and Cantenella impudica from the Godavari Estuary (Rao and Rao 1991, Rao et al. 2008, Rao and Murthy 2011). The seasonal growth and variation, biomass, primary productivity, reproductive behavior and other life history traits of these species have also been discussed (Rao et al. 1995, Rao and Rangaiah 2008). The seasonality of the abundances of micro algae in the Pandi backwaters on one of the distributaries of the Godavari River Estuary have been reported (Narasimha Rao, et al.). Some publications have also highlighted the effects of physiological conditions such as salinity and temperature on the photosynthesis and respiration of some estuarine algae (Rao and Rangaiah 2008).

AQUACULTURE

With the backdrop of overexploitation of fishery resources, overfishing and anthropogenic activities, the impacts of aquaculture practices on the physical and socioeconomic environment have been discussed in one article (Rao 2009).

HYDROLOGY

A number of studies have focused on the water quality in and around the Godavari Estuarine Region. The concentrations of nutrients in the mangrove ecosystem are high compared with the bay and estuarine ecosystems, revealing the importance of this zone as a source of nutrients to the adjacent coastal ecosystems (S. C. Tripathy et al. 2005). Several authors have worked on the chemical and physical properties of water samples collected from different areas of the Gautami and Godavari estuaries (Rama Sarma DV 1970, PN Ganapati 1968). A study was conducted on the variability of the physico-chemical properties of the Vasishta–Godavari estuary (Sastry and Chandramohan 1990). Significant variations in physical parameters such as the temperature, pH, turbidity, biological oxygen demand, chemical oxygen demand and issolved oxygen in the Godavari River in the Nanded and Rajahmundry districts of Andhra Pradesh have been discussed in some papers (Srinivasarao et al. 2008, Raju 1970).

Others studies concentrate on the distribution of nutrients (Padmavathi and Satyanarayana 1999), hydrochemical and geological investigations carried out on groundwater, groundwater quality and the role of groundwater in water resource development (Suryanarayana et al. 2008, Rama Devi et al. 2008, Murthy et al. 2008, Machiraju et al. 2008, Eswara Rao 2006, Subrahmanyam 1980, 1982, 1983).

The water resources of the Godavari River basin (Ali 1982), river discharge (Reddy and Rao 1993) and water contamination (Devi 2008, Raju et al. 2008, Sarma et al. 1993) in areas such as the Gautami-Godavari estuaries, Kakinada and East Godavari District have been assessed in some articles.

Diffusion coefficients of the waters of the Gautami Godavari Estuary have been computed using a one-dimensional advection diffusion model in an unusual hydro-physical study (Jyothi D. et al.,2002), and in another, the causes of the growth of a sand spit north of the confluence of the Godavari (Mahadevan and Prasad Rao 1958) have been identified. A report has been published on the basis of a hydrobiological and faunistic survey conducted in the Godavari region (1964).

Apart from these, some studies have been carried out on the hydrography and planktons of a tropical tidal estuary on the east coast of India (Sai sastry 1985). The relation between estuarine hydrography and production of planktons has also been studied (Bhavanarayana 1955). A few oceanographic studies have been carried out in the neighborhood of a barrier beach near Kakinada Bay (Reddy 1972), and the influence of a barrier beach on sediment transportation and coastal circulation near Kakinada Bay has been studied (Ramanadham 1970).

The effect of freshwater discharge from the Godavari River on the occurrence of local upwelling off the east coast of India has been studied (Johns et al. 1993), and a numerical model has been described and used to investigate the the wind- and estuary-driven water off the east coast. A previous numerical modelling study has shown that the estuarial discharge from the Hooghlyand Mahanadi rivers may, consistent with an interpretation of observational data, inhibit the occurrence of coastal upwelling as far south as Visakhapatnam. Further south of this location, there is a substantial discharge of freshwater during the monsoon into the Bay of Bengal from the Godavari River that might possibly have a similar suppressive effect on the coastal upwelling dynamics. In a process-oriented evaluation, it has been shown that a representative rate of discharge from the Godavari River leads to a marked cross-shelf spread of a plume of relatively low-salinity water.

The associated dynamical structure is then correspondingly modified so as to weaken the local coastal upwelling tendencies in the surface layers of the ocean that would exist in the sole presence of south-westerly wind-stress forcing and the northern estuarial outflow.

SEDIMENTOLOGY

Sedimentological studies in and around the Godavari Estuarine Rregion include reports on sediment characteristics (Rao and Swamy 1991, Rao et al. 1992, Sengupta 1970), sediment subsidence (Rao et al. 2010), impacts of sediment retention by dams in the Krishna-Godavari Delta (Rao et al. 2010) and suspended sediment loads in the Gautami-Godavari Estuary (Reddy et al. 1994).

Other studies are related to the microenvironments of the late quaternary Godavari Delta (Suryanaryana 2007), observations on seasonal variations in sedimentation, grain size variations and organic matter content of the Vasishta-Godavari River sediments (Dora, and Borreswara Rao, 1970, 1975, 1967).

The texture, mineralogy and geochemistry of modern deltaic sediments (Naidu 1968) and geophysical, sedimentological and oceanographic studies of the Godavari Sand Spit have been discussed in some papers (Srinivasarao 1993). ??ray diffraction analysis of clays of coastal sediments from parts of the western part of East Godavari District (Radhakrishna 1980), certain aspects of the provenance and sedimentation of the modern sediments of the Godavari River and the Vasishta-Godavari distributary have also been described (Dora 1978).

TRACE METALS

Studies on heavy metal contamination of the Gautami-Godavari river estuarine region have been carried out, on lead (Srinivas et al. 2008), zinc (Phanendra et al. 2008, Chakradhar et al. 2008), copper and iron (Murthy et al. 2008, Chakradhar et al. 2008) in water samples collected from the Godavari River, Gautami River and groundwater of East Godavari District.

Trace metals (Fe, Mn, Cu, Co, Ni, Pb, Cd, S and Cr) in sediments and particulate matter from the Kakinada Bay, Gautami-Godavari Estuary and Krishna-Godavari and Coringa-Gaderu mangrove region have been analysed. High concentrations of trace metals have been found in particulate matter and sediments in the mangrove environment compared with the Kakinada Bay and Godavari region, reveals the significance of the mangrove environment as a source.Significant correlations between organic carbon (OC) and Cr, Co, Pb, Cu and Mn in sediments of all the regions indicate that organic matter is acting as a metal carrier, indicating that pollution is not a concern in this estuarine ecosystem in the present context (Ray et al. 2005, Naidu 1967, Naidu and Rao 1963 Dhanunjaya 1989, Rao 1989). The distribution patterns of heavy minerals and trace metals in the Godavari Delta have also been studied by a few authors (Malik 1976, Sreenivasarao 1995).

The Godavari River has been sampled for particulate inorganic carbon (PIC), particulate organic carbon (POC), particulate nitrogen (PN) and particulate amino acids (PAA, including 2 hexosamines (HA)). The biochemistry of all this particulate organic matter transported by the Godavari River has been studied. The amounts of particulate organic matter rank the Godavari River as one of the most important organic carbon-transporting rivers in the world (Gupta et al.1997).

POLLUTION

The physical characteristics of the Godavari River water at Nanded and Rajahmundry and the severe contamination caused by petroleum, hydrocarbon and trace metals at Visakhapatnam and Kakinada have been discussed in some studies. (Sarma et al. 1996, Srinivasarao et al. 2008). High concentrations of PHC were also observed in the inner channels of Visakhapatnam harbor, and there were high levels of trace metal contamination in surficial sediments in Visakhapatnam compared with Kakinada Bay (Sarma 1996).

FORAMINIFERAL STUDIES

There are very few publications on foraminiferal studies. Two studies have been published on the foraminiferan assemblages of the Godavari River (Narappa 1981 and 1982). The ecology of foraminiferans in the mangrove forest of Gautami and Nilarevu distributaries of the River Godavari has also been discussed (Bhaskar Rao1990). The occurrence of foraminifera in the shallow marine shelf and their use in reconstruction of the paleo-environment and sequence stratigraphy have also been explained (Raju 2005).

ETHNOBOTANY

Ethnobotany is the study of the plant lore and agricultural customs of a people. Several studies have been carred out on the ethnobotany of the upper East Godavari estuary region (Sudhakar 1980 and 1985, Kalpana 2008). In ethnomedicine and ethnopharmacology, the traditional knowledge of tribal medicine (Raju 1996, Suryanarayana 2003) and medicinal uses of plants and plant extracts are emphasized. Research has been carried out on food plants (Prasad 1999) and oil-yielding palms (Palla 2007). Publications are available on the medicinal plants of Kakinada, East Godavari, and the hydrophytic medicinal plants of Rajahmundry (Arunee 1990 and 1979).

STUDIES ON PHYSICAL PARAMETERS

There has been a plethora of research on physical aspects such as the geological, geophysical and geochemical characteristics of the Godavari Estuary. A number of stratigraphic studies have been conducted on the sediments of the Pranhita?Godavari valley (Kutty 1969, Raiverman 1984, Rudra 1982, Lakshminarayana 1994 and Dasgupta 1984) and those in the Krishna-Godavari coastal tract (Lakshminarayana et al. 1992), Gautami-Godavari estuary (Narasimham Rao 2001) and Gondwana formations in the Chintalapudi sub-basins Godavari valley (Lakshminarayana and Murty 1990). Apart from this, the geology of the valley has been studied (King 1881).

Other research on the physical effects includes numerical modeling of the flow and salinity (Rao 1995), studying the flushing and dispersion characteristics of the river discharge (Reddy and Rao 1993) of the Godavari Estuary, 3-D modeling of magnetic anomalies of the Godavari basin (Mohan Rao 2000), magnetic studies on iron ore deposits (Lakshmipali 1977), studies on the Godavari valley rocks (Brahman 1962), differential thermal analysis of pelagic clays from the deltaic regions of the Godavari (Sastry 1958) and geological (Vaidyanadhan 1953, Qureshi 1968, Kasheltiwar 1971, Chakrawarty and Chakrawarty 1994) and seismic studies (Gupta 1969, Deewan 1991, Kaila et al. 1990).

Geospatial studies carried out in the Godavari Estuary on the coastal morpho-dynamics of the Godavari Delta have been discussed in some publications (Rao et al. 2003, Rao et al. 2005, Rao 2006). Other studies are related to rises in the sea level and coastal vulnerability (Rao et al. 2008), coastal erosion and habitat loss (Malini and Rao 2004) and soil erosion at Gautami and Vasishta delta (Seetharamaiah et al. 2003). A report has been published on the geochemical characteristics of the Godavari Estuary (Somayajulu 1993). Several studies have been undertaken on the physico-chemical characteristics of the Vasishta-Godavari Estuary (Rama □bga Rao 1989, Rama Sarma et al.1989, Sai Sastry et al. 1990) and Godavari Estuary (Rama Sarma 1970, Ranga Rao et al. 1988).

Geological studies that have been carried out include those on the hydrocarbon prospects of the Krishna-Godavari river basin (Mishra 1987, Rao1967); geomorphology and evolution of the Godavari Delta (Rangamanna 1982); geo-mapping for coal resources (Khalid 1975, Bose 1979); investigating the mineral resources (Chandrasekhar 1982, Anon 1993) and geological evolution of the Godavari Delta (Mohinuddin 1993, Murty 1994, Sarma 2008).

Other studies include morphological analysis of landforms (Raman Murthy 1988, 1994, Babu 1973, Nageswara 1985), investigations into land suitability and management of floods in the Godavari Delta (Sambasiva 1981) and tectonic studies of sub-basins of the Godavari valley (Ramamohan 1994, Sreenivasa 1979, Murthi 1980).

SOCIOECONOMIC STUDIES

Socioeconomic aspects of the fishermen in the East Godavari Estuary have not been studied intensively for the last three or four decades. There are major socioeconomic problems such as deforestation, habitat destruction, poaching, unsustainable exploitation of forest resources, livestock grazing and fuel-wood collection in the EGREE.

Very few studies have been published on socioeconomic issues. A publication on shrimp farming practices and their socioeconomic consequences in East Godavari District is available (Kumaran 2003). In another recent publication, the impacts of aquaculture on the physical and socioeconomic environment of this region have been discussed (Rao 2009).

Despite their remoteness and the difficulties in accessing them, the mangroves of Coringa are heavily exploited by the local people. In a socioeconomic study, (Collin et al. 2002) it was found that 95□ of the fishermen of Ramananpalem village harvest wood in the mangroves and transport it by boat, usually while returning from fishing. Among the seven mangrove species collected for fuel-wood, Avicennia marina and A. officinalis are preferred. The survey confirmed the villagers' high dependence on the mangrove forest for their basic needs. Increased poaching and habitat destruction have imperiled the existence of otters in the CWLS. The forest department was also reported to have initiated steps for conservation of otters and for forestation of mangroves in the sanctuary. With the increasing industrialization of the entire Godavari Delta, and increasing aquaculture activities and fishing pressure, the survival of this isolated population of otters in Coringa is at stake (Hussain 1999).

REMOTE SENSING AND GIS

The major aspects of the Godavari Estuary have been studied using geographic information systems (GIS) and remote sensing. Remote sensing techniques have been used to study the ecobiology of Coringa atmospheric CO_2 flux from the waters surrounding the mangroves. These data, together with previously published data, suggest that overall oversaturation of CO_2 with respect to atmospheric equilibrium in the surface waters is a general feature of mangrove forests, though the entire ecosystem (sediment, water and vegetation) is probably a sink for atmospheric CO_2 (Borges 2003, Satyanarayana 2003, Ramasubramanyan et al. 2006).

Localizing alternate feasible outfall for the Kunavaram drain in Central Godavari (Rao1994), multidate and muti-source data determining shoreline changes in the Gautami-Godavari delta (De Solan et al. 2001) have been studied using remote sensing tehniques.

The geomorphology of the Krishna‑Godavari delta region has been interpreted from LANDSAT imagery, and a GIS-based atlas for land use planning, land cover change detection and mapping is available. The implications through remote sensing and assessment of three-decade vegetation dynamics in the mangroves of the Godavari Delta using multitemporal satellite data and GIS data (Babu 1978, NRSA 2006, NRSA 1994, Sarma 2001, Reddy and Roy 2008).

A publication on the application of remote sensing and GIS to sustainable management of shrimp culture in India has described the status of shrimp culture development in India. It has also discussed its ecological and socioeconomic impacts and recommended measures to achieve long-term sustainability using advanced tools such as remote sensing and GIS. These are essential in the context of sustainable development and management, particularly in developing countries, which are often more vulnerable to environmental degradation (Rajitha et al. 2006).

Geo-environmental studies in the Godavari Delta with an emphasis on mangroves and the Kakinada spit, carried out using remote sensing and GIS, have been discussed in a publication (Reddy et al. 2008). Another study was carried out on the Holocene evolution, morphodynamics and changing environments of the Godavari Delta using remote sensing and GIS (Sarma et al. 2008).

An overview of the possibilities in applying GIS and remote sensing (RS) to environmental monitoring has been presented by Vadlapudi et al. (2003). The results obtained from these techniques helps decision-making. Identification and quantification of changes in mangrove forests using remote sensing from aerial and space platforms have emerged as powerful tools for monitoring the aquatic environment. IRS data obtained over a period of time are applied for such monitoring.

The role of remote sensing in integrating coastal zone management has been discussed in an article (Nayak et al. 2004). The coastal zone represents varied and highly productive ecosystems such as mangroves, coral reefs, sea grasses and sand dunes. These ecosystems are under pressure on account of increased anthropogenic activity on the coast, as a result of globalization. It is necessary to protect these coastal ecosystems to ensure sustainable development. This requires information on habitats, landforms, coastal processes, water quality and natural hazards, to be obtained on a repetitive basis. Remote sensing techniques have been used extensively in mangrove areas classified up to community level through contextual editing. Various zones of coral reefs have been identified. Knowledge about bio-optical properties of water is vital for coral reef and sea grass bed monitoring. OCEANSAT I (IRS P4) Ocean Color Monitor (OCM) data provide useful information on the phytoplankton and suspended sediments. The information on phytoplankton and sea surface temperature (SST) has been used to predict potential fishery zones routinely. The information on sediments provides some insight into the movement of sediments along the coast. Satellite-derived information has been integrated with collateral information through GIS to select sites for aquaculture, zone coastal areas for regulatory purpose and assess possible impacts of rising sea levels. Realizing the value of remote sensing-derived information, the state and central agencies responsible for the conservation of these ecosystems are increasingly adopting remote sensing data for their routine use.

EVALUATION OF ECOSYSTEM SERVICES OF THE EGREE

Participatory management of natural resources in the developing countries has gained importance in recent years. The M.S. Swaminathan Research Foundation (MSSRF) implemented a community participation in mangrove conservation and management program in the Godavari and Krishna mangroves of Andhra Pradesh. The program involved multiple stakeholders, i.e., the state forest department, community-based organizations (village-level institutions) and non-governmental organization, MSSRF, in the management and conservation of mangroves. The experience of participatory mangrove management in the Godavari and Krishna mangrove wetlands of Andhra Pradesh has been described in a publication (Ramasubramanian et al. 2007)

Another publication mentions the formation of village-level institutions, which have been strengthened by enhancing leadership skills. Participatory Rural Appraisal (PRA) and other participatory tools have been used to identify the status of the resources, their utilization pattern and the issues related to mangrove conservation and management. The degraded mangroves identified through remote sensing imagery were restored using nursery raised mangrove saplings. The causes of degradation were studied and the degraded mangroves were restored by plantation of mangroves. Apart from restoration of degraded mangroves, the socioeconomic situation of the mangrove-dependent community was addressed through resource-based income-generating activities and alternatives for the exploitation of mangroves. An area of about 520 ha of degraded mangroves was restored using a scientific understanding of the mangrove ecosystem. An area of 9442 ha of mangroves was brought under the joint management of the eight village-level institutions (VLIs) formed by the project.

CLIMATE CHANGE

A major environmental change has occurred in the Godavari Estuary, which has resulted in drastic changes in the physical and chemical parameters of the Godavari waters. A report has been published in this regard on climate setting of the study sites in 2003. In addition, studies have been conducted on the atmospheric CO_2 flux from the waters surrounding mangroves (Borges et al. 2003).

The effects of harmful chlorinated cooling water discharges on the chemistry of estuarine waters and gases were studied (Smith 1997, Bouillon et. al. 2008, Krupadam et al. (2007). Recently insights have been obtained from stable isotope studies conducted on the annual cycle and inter- annual variability of ecosystem metabolism in a temperate climate embayment. The morphological changes in the Godavari Delta due to wave currents, other physical changes, organic matter exchange and cycling in mangrove ecosystems have also been studied.

Current Focus of Research Activities in the EGREE

Although research has been carried out on all aspects of biodiversity, socioeconomic issues and the ecosystem in the EGREE, the available information is inadequate to prepare ecosystem-level conservation plans. So far, the major scientific areas of research in coastal and marine biodiversity in the EGREE have included mangroves, fisheries, aquaculture, pollution and physio-bio-chemical properties of water. The finfish fishery research includes studies on perches, carangids, barracudas, mackerels, milkfishes, mullets, tunas, sardines, scombroids, silverbellies, pomfrets, letherinids, groupers, sharks and rays. The shellfish fishery is focused on mussels, clams, prawns, lobsters and crabs. The aquaculture research has concentrated on pomfrets, crabs, prawns, ornamental fishes etc. Extensive research has also been carried out on the biology, ecology and restoration of mangroves. Investigations into the culture of organisms of export value such as pomfrets and ornamental fishes have also been carried out by institutions including the state and central fisheries departments and academic institutions. Research on planktons, benthic fauna and certain threatened major fauna has also been carried out but in a sporadic manner and that too at selected sites. So far, most of the research carried out in the EGREE has considered the marine biodiversity as a commercial product and largely failed to appreciate its ecological role. Moreover, recent threats such as climate change, invasive species and faster economic development are posing major challenges for conservation of marine biodiversity, and this need to be addressed immediately through scientific research, which is lacking.

Major Requirements for Marine Biodiversity Conservation Research in the EGREE

Most importantly, identification and coordination is required among all the organizations/institutions working for conservation of coastal and marine biodiversity, development of the industrial sector and welfare of coastal communities in the EGREE. Research programs that could address the prevailing issues such as the human-biodiversity interface, restoration of threatened taxa and their habitat, climate change, economics of ecosystem services, spatial planning, status of various taxa and their habitats, harmonization of industrial sectors with biodiversity conservation and planning need to be carried out immediately. Moreover, documentation and creation of a database of research information on marine biodiversity is also required urgently.

Research Gaps Identified

a) Landscape/Seascape/Ecosystem-Level Research Areas

- Long-term monitoring studies on the dynamics of coastal geomorphology covering the entire coastline of the EGREE. A greater focus should be placed on ecologically sensitive coastal areas such as mangroves, turtle nesting beaches, sand dunes, mud flats and fishing villages. Studies should also focus on the impacts of climate change, infrastructure development, establishment of industries, etc. on the coastal geomorphology using advanced techniques such as remote sensing, satellite images and GIS. An attempt to study the coastal geomorphology has already been made in the past, but it should be institutionalized and continued.

- Climate change and impacts on coastal and marine landscape and biodiversity. Global climate change is known to affect the wildlife and marine biodiversity adversely. Therefore, it is important to monitor the coastal and marine environment and the biodiversity of the EGREE with respect to climatic variables.

- Assessment/estimation of coastal marine habitat lost or being lost, especially in mangroves, sand dunes, mud flats, etc. A considerable area of critical habitat has been lost due to developmental and industrial activities and natural calamities (e.g. sea erosion). An estimation of the area of habitat lost over the years and analysis of the reasons for the loss will enable the loss to be stopped, future loss to be stemmed and possibly restore the habitats.

- 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 landscape/seascape- level conservation. These studies should also analyze the impact of human activities on the linkages/connectivity between habitats/ecosystems. The linkage between the Godavari River and its estuary needs to be understood better so that a landscape-level plan covering both the Godavari Delta and the basin can be prepared.

- Study the structurally important elements of ecosystems. Studies on mangroves, shore birds, otters, benthic fauna, etc. should focus on the population processes, metapopulation processes, connectivity and other drivers of these structural elements. Studying the interactions between these elements and processes and human use will be necessary for understanding and safeguarding the linkages.

- Reduction in freshwater flow and sediment influx. Long-term monitoring of the impacts of reductions in the freshwater and sediments influx of the Godavari River on the Godavari estuarine system is required. Due to various developmental projects and changes in the land use pattern in the Godavari basin and along the coastal areas, the influx of sediments is increasing and the inflow of freshwater is decreasing. This needs to be studied immediately to prevent adverse impacts on sensitive coastal and marine habitats such as the estuaries, lagoons, mangroves and mud flats of the EGREE.

- Invasive species. Invasive species have been identified as the second most important threat to the marine biodiversity, next to habitat loss. A landscape/seascape-level study is required to study the impact of invasive species so that they can be managed at the seascape level/ecosystem level.

- Study functionally vital processes in various marine ecosystems. Studying the trophic linkages and process such as predation, herbivory, detrital pathways, productivity, community linkages, trophic redundancies and resilience is required to help us understand better the functioning of the ecosystem and its processes.

- Bio-shield — Enhancing species diversity. Studies need to be conducted to develop bio-shields along a selected coastal line to enhance the native coastal and marine biodiversity.

- Need for research and creation of a gene bank for coastal and marine flora. The National Biodiversity Action Plan emphasizes the importance of having a gene bank for all Indian flora and fauna. In this connection, it is important to have a gene bank exclusively for the coastal and marine flora and fauna of Andhra Pradesh, with special reference to Godavari Estuary. Studies need to be initiated in this regard. This gene bank is expected to contribute to the conservation of our natural treasures for a longer period as well as protect the species from illegal trades.

- Ecological services of coastal and marine habitats/ecosystem of the EGREE. 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 to study the impacts of human use on these ecological services.

- Understand the resilience of various coastal and marine ecosystem processes to disturbance — thresholds, discontinuities and recovery potentials.

- Ecosystem level assessment for high-saline mud flats. The diversity and values (traditional and commercial) of halophytes need to be assessed to safeguard them as well to develop their sustainable utilization.

- Experimental studies in estuaries and mangroves with special reference to environmental flow and bio-resource enhancement.

- Economic valuation including ecological services of various coastal and marine habitats.

- Review and management of the effectiveness of MPAs. It is important to review the existing management plan of the region, especially the CWLS, and carry out management effectiveness evaluation for the same.

- The impacts of pollution and their linkages with the industrial sector in the EGREE need to be studied to protect biodiversity in general and the livelihoods of people of the EGREE in particular.

b) Habitat-Level Research on Coastal and Marine Biodiversity

- Mangroves are considered as repositories of biodiversity. Therefore, an integrated study has to be undertaken to record the diversity associated with mangroves (to cite a few examples, the diversity of fungi, nematodes, amphipods, brachyuran crabs etc. is not known fully).

- Inter-tidal mud flats. Studies to assess their ecological significance, restoration and dynamics of mud flats, etc. in the EGREE are required. These studies should also focus on the importance of mud flats with reference to shore birds, horseshoe crabs, otters, etc.

- Inventory of sea grasses and lesser-known mangrove species. Sea grass beds and mangrove habitats provide feeding and breeding habitats for many organisms, which are attracted towards them. These fragile ecosystems need to be taken care of by long-term monitoring of the lesser-known species of mangroves and sea grasses. A research gap on restoration of these habitats also needs to be addressed. Sites associated with rich biodiversity include sea grass beds and seaweed-rich areas. While the biodiversity of the above plants is known sufficiently, the diversity of organisms associated with the above plants is poorly known. This gap has to be bridged.

- Coastal lagoon ecology and biodiversity. Lagoons, ignored for long, need to be studied in detail with respect to their biodiversity, ecological services and livelihood interactions with local communities or stakeholders.

- Habitats of threatened animals. Special habitats of certain threatened animals such as horseshoe crabs, otters, dolphins and whales need to be assessed and monitored.

b) Species-Level Research on Coastal and Marine Biodiversity

- Strengthening of taxonomic capacity. The current knowledge on the taxonomy of marine fauna and flora is inadequate. This is mainly due to the dwindling population of taxonomists many have retired and left without a legacy. The current curriculum of the education system (especially in the biology and marine sciences streams) is also to blame. The limited exposure of young researchers in the field of marine taxonomy and ecology is another reason. Thus, there is an urgent need to build capacity in the taxonomy and ecology of marine biota through a series of training programs. In addition to traditional taxonomic training, training in the use of molecular tools, including molecular markers and DNA barcoding, to strengthen/confirm the morphological identity is necessary. Universities and institutions in and around the EGREE should be encouraged to strengthen the taxonomic capacity of the region. A portion of the EGREE may be used as a living laboratory for the same.

- Preparation and implementation of species recovery plan. Recently the Ministry of Environment and Forests, Government of India, decided to conserve and manage highly threatened marine species using Species Recovery Plans in India. Similar efforts may be taken to locally recover certain threatened species such as the horseshoe crabs and otters in the EGREE. Therefore, scientific information is required and needs to be collected for preparation of species recovery plans of threatened marine species of the EGREE.

- Periodic assessment of threatened and endemic species, As a part of long- term monitoring of the populations and distribution ranges of all the threatened and endemic coastal and marine species of the EGREE, periodic assessments need to be carried out at intervals of five years to periodically review their status.

- Ecological studies of endemic and threatened species of invertebrates and prochordates. Most of the invertebrate fauna in the 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 as commercial perspectives. Detailed studies need to be undertaken for evaluating the status and distribution of the following groups sea-cucumbers; sea anemones; starfishes; sponges; Brachiopoda; Placozoa; Pogonophora; Gnathostomulida; Echiura; Phoronida; Ctenophora; Kinoryhncha; Priapula; Loricifera; Echinodermata; Cycliophora; and the endemic molluskan species. Studies on polymorphism among gastropods also need to be carried out. Studies also need to be carried out on poorly known meiofauna along the coast and intertidal mud flats. It is also important to study the ecology of horseshoe crabs, giant or coconut crabs, estuarine crabs, etc. The prochordates are a very poorly studied group in India.

- Impact of global warming and climate change. The effect of global climate change and global warming brings changes in trophic dynamics and in the abundance and distribution of fauna in various trophic levels. It is also one of the causative factors of the coral bleaching phenomenon. Studies on the long-term impacts of climate change on the marine fauna of the EGREE are required.

- Marine mammals. A status survey and monitoring of marine mammals in the coastal and mangrove habitats of the EGREE are urgently required.

- Coastal and oceanic birds. The available information on the shore birds and seabirds of the EGREE is inadequate. An ecological survey and long-term monitoring of coastal and seabirds is essential.

- Ecological studies on marine reptiles. Very few species of marine reptiles are found in the coastal and marine habitats of the EGREE, including sea snakes and the Olive Ridley, Hawksbill and Green turtles. However, there may be several terrestrial reptiles in the adjoining coastal habitats. These species are facing severe threats due to inappropriatefishing gear and various coastal developments. In order to conserve these species, it is essential to study their ecology and home range within the EGREE.

- Long-term monitoring and ecological studies on lesser-known fish species. Though we have historical documentation of the marine fishery resources of the EGREE, still there are lot of gaps existing in the lesser-known fish taxa. The important gap areas are composition, status and diversity of by-catch fisheries and 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 those involving mammals, reptiles and molluskans, is necessary.

d) Socioeconomic and Policy-Level Research

- Economic Evaluation. Working models for ecological benefits versus economic benefits in a dynamic marine ecosystem need to be established whenever and wherever required. A model prepared by MSSRF with respect to mangroves needs to be reviewed. The same model may be repeated with appropriate changes, if required.

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

- Determination of socioeconomic dependence 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 the impacts of their activities on the ecological resources in the EGREE.

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

- 'Before and after' conservation gaps. Information requirements (socioeconomic data gaps including basic facilities — housing, electricity, health, education, etc.)

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

- Baseline data collection on import of banned gear and craft use.

- Documenting and analyzing the impact of infrastructure projects (ports, power plants, etc.) on the communities and their livelihoods.

e) Policy-Level Research

- Unique UNDP-GEF program aims to mainstream biodiversity conservation into the production sectors of the EGREE in collaboration with the State Forest Department, Andhra Pradesh, and the Ministry of Environment and Forests, Government of India. The success of this program should influence the National Policy on Coastal and Marine Biodiversity Governance. Further, relevant sectoral (fisheries, tourism sector, etc.) policies and guidelines need to be streamlined, in tune with the biodiversity conservation policies.

f) Development of Technology for Coastal and Marine Biodiversity Research

- Strengthen 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. Selectivity and monoculture of mangroves is diminishing the overall biodiversity of this habitat. Therefore, it is important to develop silviculture technology to propagate other threatened mangrove species of the EGREE to promote restoration with more diverse mangrove flora.

- Less than 1% of microbes are cultivable, and so their biodiversity is less known because investigators depend upon culture-based techniques to identify them. In the backdrop of advancements in methodology, techniques such as pyrosequencing are 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 endangered coastal and marine habitats such as mangroves, sea grass beds, mud flats and sand dunes. However, these technologies need to be reviewed to suit the coastal environmental conditions of the EGREE, considering the regional hydrological and coastal settings.

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

- Development of technology to minimize by-catches. Indian fisheries have been witnessing a growing trend in by- catches, which may not be desirable for the well being of the entire marine ecosystem as well as for the fisheries. Therefore, it is important to help relevant institutions develop suitable fishing technologies to minimize the by-catch in the EGREE and in other coastal areas.

- Ecological modelling studies include (1) determining and predicting the effects of on sea turtles and marine mammals; (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. Models of this kind are useful in developing 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 ecosystems, including the deep-water benthos, to understand the cascading effect of climate change.

g) Monitoring and Restoration Ecology

Effective monitoring requires an understanding of long-term changes in the status of the resources and their environment in the EGREE. Long-term monitoring is a way of detecting and documenting these changes in environmental quality, ecology, and human activity and determining 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 us in understanding the general health of the EGREE. The 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 these functions, will improve our understanding of the relationships between ocean and terrestrial ecosystems. The findings of the monitoring program will be contributions to basic scientific research as well as to academic, education and applied management goals.

Environmental factors to be monitored include (1) the status and trends of contaminants in coastal waters; (2) environmental factors, such as the 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; (4) fluctuations in the abundances of otters, turtles and seabird species in the coastal and marine ecosystems; and (5) biological input of organics and fecal coliforms.

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 activities; (4) natural and anthropogenic (e.g., sand mining) erosion and sedimentation; (5) fishery/mammal-turtle interactions, such as incidental catches of whales, other mammals and turtles 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 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 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 that Need to Be Taken up Immediately

- Inventorization. This is required with a view to carrying out an inventory of the biotic and abiotic components of the coastal and marine environment of the EGREE continuously and to understanding the composition and status of by-catch fisheries. Information will be collected on meteorology, land use practices and the distribution and status of threatened species using remotely sensed satellite information supported by ground truthing the status of the intertidal zone and its biodiversity; invasive species and their impacts in the region; estuaries and mangroves and their biodiversity, including impacts of climate change; sand dunes and sandy beaches and their biodiversity, including impacts of climate change and land-based anthropogenic activities, fluvial origin and their impacts on biodiversity; land-use changes driven by anthropogenic and developmental activities and their impacts on important habitats; climate change and its possible impacts; identification and mapping of pollutant sources and their impacts on the ecological processes and biodiversity using indicator species; the importance of the flow of water and sediments from the Godavari River into the estuary; sea grass beds, including biomass and productivity; faunal assessment, including status of terrestrial island biodiversity (mangroves, estuaries and lagoons).

- Creation of baseline data on physio-chemical, geological and metrological parameters and primary productivity from the ecologically sensitive areas (especially MPAs, 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 for long-term monitoring of biodiversity in different parts of the EGREE.

- Temporal and spatial distribution pattern of migratory fauna in the coastal and marine environments.

- Monitoring the impacts of pollution due to ballast water release in the seascape.

- Documentation of fisheries practices and their impacts on habitats and species.

- Research on restoration of mangroves with special reference to endemics and threatened species using poly-culture techniques.

- Study on restoration of degraded horseshoe crab habitats along the east coast of India.

RESEARCH FRAMEWORK FOR THE EGREE

Overall, the research program in the EGREE intends to focus on broadening our scientific understanding of the coastal and marine ecosystems and developing research programs that will enhance our perceptions and provide the management with the scientific knowledge necessary to take informed decisions. In this connection, it is important to establish a Research Advisory Committee (RAC) under the umbrella of the proposed EGREE Foundation to coordinate all research and monitoring activities in the EGREE. It is equally important to establish an in-house Research and Monitoring Unit within the EGREE Foundation at Kakinada, East Godavari District, Andhra Pradesh. A Research Officer/Director, Research with adequate supporting research staff and facilities are to be provided for this in-house Research and Monitoring Unit (RMU).

The in-house RMU of the EGREE Foundation should focus on long-term monitoring of habitats, especially certain threatened taxa such as otters, monitor negative impacts of production sectors in the EGREE region, explore the latest technologies for minimizing emission/release of pollutants from industries, regularly monitor the carrying capacity of the EGREE, explore cost-effective adaptation techniques in view of the impacts of climate change on production sectors such as tourism, fisheries, oil and gas, salt pans, human activities, livelihoods, flora and fauna of the EGREE, conduct policy-level research to manage coastal and marine landscapes better, maintain a repository of coastal and marine data, etc. Landscape Level Coastal and Marine Governance System and help earn financial resources for the EGREE Foundation.
Long-term research programmes

a. Inventorization. This must be carried out with a view to continuously catalog the biotic and abiotic components of the integrated landscape of the Godavari estuarine ecosystem. Information will be collected on meteorology, land use practices and the distribution and status of threatened species using remotely sensed satellite information supported by ground truthing the status of the intertidal zone and its biodiversity; identification of invasive species and their impacts in the region; estuaries and mangroves and their biodiversity, including impacts of climate change; sand dunes and sandy beaches and their biodiversity, including impacts of climate change and land based anthropogenic activities fluvial origin and their impacts on biodiversity; land-use changes driven by anthropogenic and developmental activities and their impacts on important habitats; climate change and its possible impacts; identification and mapping of pollutant sources and their impacts on the ecological processes and biodiversity using indicator species; the importance of the flow of water and sediments from the Godavari River into the estuary.

b. Monitoring. Effective management requires an understanding of long-term changes in the status of the resources and their environment. Long-term monitoring is a way of detecting and documenting these changes in environmental quality, ecology and human activities and determining if changes in management strategies are needed. The primary purpose of the monitoring program will be to detect changes, determine their causes, whether natural or anthropogenic, and develop and evaluate management strategies. Overall, the monitoring program will assist us in understanding the general health of the EGREE. This programme should include pollution monitoring studies and studies monitoring the population dynamics of species in all habitats within the EGREE. The identified indicator species and critical habitats need to be monitored to detect possible changes. Changes in the relative distribution of these species could indicate natural or anthropogenic threats to EGREE resources. Monitoring the natural functions of the land-sea interface, as well as human interruptions of these functions, will improve our understanding of the relationships between ocean and terrestrial ecosystems. The results of the monitoring program will be useful for basic scientific research and for attaining the goals of academics, education and applied management.

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 activities; (4) natural and anthropogenic (e.g., sand mining) erosion and sedimentation; (5) interactions between fisheries and mammals/turtles, such as incidental catches of whales, other mammals and turtles in fishing nets; (6) pesticide usage; (7) sewage discharge; (8) dredge spoil disposal; (9) monitoring the socioeconomic profile of people in the EGREE in relation to changes in the biodiversity profile of the EGREE; and (10) recurrence of road repair debris being side-cast along the coast. Another important component of the monitoring programme is the assessment of the effectiveness of management strategies. Once a new management strategy (implemented by the UNDP Programme) has been put in place, in response to a change detected in the environment or in the use of the EGREE, monitoring must continue to determine whether the management strategy has 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 India GEF Coastal and Marine Programme in the EGREE.

It is important to identify long-term monitoring plots using standardized methods in the EGREE for monitoring the above-mentioned biodiversity. Identification and establishment of non-violate vegetation preservation plots for long-term monitoring is also required.

c. Economic valuation, including ecological services, of the mangroves and estuarine ecosystem in the region is urgently required the roles of mangroves, estuaries, seagrass beds and intertidal zones as breeding and nursery grounds of various fauna (temporally as well as spatially); the temporal and spatial distribution patterns of migratory fauna in the coastal and marine environment; identification of foraging and breeding grounds of migratory fauna, including determination of the migratory paths, through the use of advanced technology; and documentation of changes in the demographic profile in the region and the pressure they exert on the ecological setting.

d. Restoration ecology. Studies to restore degraded mangroves, the intertidal zone and sea turtle nesting habitats; restoration of mangroves with special reference to endemics; and stock enhancement of commercially important but native fishes, which will help local communities, who can later go for harvesting these resources in a sustainable manner.

e. Socioeconomic. Determination of the socioeconomic dependence 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 the impact of their activities on the ecological resources; gender issues involving resource use and management; development of empowerment mechanisms and models of the involvement of community-based institutions in resource management.

f. Policy research. Evaluating the efficacy of international, national and state policies and legal instruments in resource management in the EGREE; a mechanism of networking various governmental, non-governmental and communitybased institutions in participatory management.

g. Modelling. Three types of modelling activities (numerical simulations, ecosystem models and statistical models) will be used to interpret data, guide field programs, test hypotheses and predict potential outcomes from proposed uses and thereby influence management decisions. Modelling efforts will be based on the information gathered from the baseline, monitoring and experimental studies. As more information is gathered in these endeavors, the models will be continuously modified and refined. Modelling efforts can be used to analyze the causes and consequences of ecosystem changes and predict the effects of new and more intense human activity in the area. Unlike the monitoring program, some of these studies may be predictive, short term and directly targeted to an immediate management issue. Examples of modelling studies include (1) determining and predicting the effects of boating activity on sea turtles and marine mammals; (2) predicting the flow of an inadvertent discharge (such as a fuel spill) into the EGREE; (3) modelling the transport of sediments in the EGREE; 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. Once strategies are in place, monitoring information will determine their effectiveness and be used to refine the model.

Short-term research

The proposed EGREE Foundation should take up under its research and monitoring program specific problems posed by the local population and try to find out suitable solutions. These solutions will help attain higher standards of living and may provide avenues for gainful employment to local people. For example, a short-term study on economic impacts of land-use pattern changes along the sand dune habitat may be carried out.

In-house research and outsourced specialized research

The Research and Monitoring Committee (RMC) of the EGREE Foundation should be directly involved largely with monitoring programs and facilitate research by other institutions, other than monitoring. If necessary, other institutions can also be involved in the monitoring program. The Research Officer/Director, Research of the EGREE Foundation, who has (have) a strong research background in marine biology, and his/her team members need to be continuously sent to refreshment courses either in India or outside India for updating their knowledge, especially in monitoring the marine biodiversity of the EGREE and its ecological services to the local communities. The RMC of the EGREE Foundation should not expect to conduct all kinds of marine research programs on its own. The EGREE Foundation can outsource certain research programs that are very important for conservation of biodiversity and its dependent communities to various concerned research institutions mentioned in the Research Matrix Table or to any other professional institutions.

Coordination, documentation and maintenance of database of research information and posting on web page

One of the important activities of the RMU of the EGREE Foundation is coordination with all other research institutions, documentation of all the research findings and maintenance of a database and sharing this database with the outside world by posting on its own web page, www.egreefoundation.org.

Compiling research recommendation for implementation for management

The RMU also has to compile all the research recommendations, even in the local language if this found to be important, in a simple manner so that everyone can understand them. The RMU should assume the responsibility of monitoring the success of implementation of the various research recommendations made by the RMC to the EGREE. The RMU should also review the progress of the implementation program of the EGREE Foundation every year in its Advisory Committee meetings.

Capacity building for in-house research and monitoring

The RMU should regularly conduct training programs related to marine biodiversity and monitoring habitats, management of marine protected areas, etc. The field staff of the RMU should be trained regularly so that they will facilitate various research programs in this region. The RMU should seek the help of the best resource persons available in India and abroad for its training programs, especially while training production sector representatives in eco-friendly practices. The expenses incurred in conducting such training programs may be met by the EGREE Foundation, Ministry of Environment and Forests, Government of India, Forest Department of the Government of Andhra Pradesh, and other international and national donor agencies.

Community involvement in research and monitoring

It is important that the RMU take all efforts to appoint local people as the field staff of all the projects, which could send the message to the local communities that they are also part of all the activities of the EGREE Foundation in the EGREE. All the research activities of the RMU should be made known to the local communities. The findings of all the research activities, which are related to the local communities, need to be shared with them.

Annual Research Seminar

The EGREE Foundation will conduct an annual research seminar (ARS) for presentation and review of the research activities undertaken by all organizations and individuals. All the members of the Research Advisory Committee are expected to participate in this two-day seminar. New proposals made by any organizations including the RMU of the EGREE Foundation need to be reviewed and approved only during the ARS. All externally funded research proposals that have already been peer reviewed by the funding agencies are to be ratified with the condition that they must make a presentation on their research progress and must provide annual and final completion report copies to the EGREE Foundation.

Table 3. PRIORITIZED RESEARCH GAPS AND RESEARCH MATRI? FOR THE EGREE

A total of 58 research programs have been identified and prioritized in three categories based on group discussions and panel discussions during the stakeholders workshop. These research programs have also been identified based on intensive ?Review of Literature' available for the region.

Sl. No.	Research Program	Activities	Thrust Area	Priority	Term	Potential Funding Agencies	Potential Institutions
1	Development of integrated landscape-level management plan for Godavari Delta	1. Assessment of biodiversity profile and identification of threats 2. Spatial planning and setting ecological boundaries of the operational area 3. Zonation of the operational area into wilderness, buffer and tourism zones 4. Identifying degraded and fragile ecosystems 5. Identifying better ecological restoration plans	Ecosystem	I	Short term	EGREE-UNDP/APFD	APFD with WII/AU
2	Impact of climate change on the coastal and marine biodiversity and its habitat in the EGREE	1. Assessing and predicting the impact of climate change on biodiversity, community structure and ecosystem functioning in the EGREE 2. Assessing and predicting the impact of climate change on the distribution pattern and community structure of primary producers, mangroves, reptiles, birds and mammals with special reference to threatened species in the EGREE 3. Assessing and predicting the impact of	Ecosystem	I	Short term	EGREE- UNDP	WII

		climate change on the socioeconomic and demographic profile of coastal communities in the EGREE 4. Preparing a long-term ‘Conservation and Preparedness Plan’ to safeguard the marine biodiversity and coastal communities of the EGREE from the adverse impacts of climate change					
3	Economic valuation and ecological services	1. Identification of knowledge, innovations and practices of indigenous and local communities 2. Identification of impacts of developmental activities on ecosystem goods and services 3. Evaluation of negative and positive impacts using tools of market and non-market valuation 4. Economic analysis of conservation — development of scenarios using multiple criteria assessment and cost-benefit analysis 5. Ranking of scenarios and identification of options for conservation and sustainable development	Ecosystem	I	Short term	WI-SA/WII/IIE	
4	Biodiversity Atlas of EGREE	1. Biodiversity assessment and inventorization 2. Assessment of threat status of different groups of animals and plants 3. Preparation of distribution maps with demographical profile of threatened species in the EGREE 4. Preparation of atlas of threatened species and habitats of the EGREE	Ecosystem	I	Short/ long term	APFD/MoEF/DST	AU/IISER/WWF/ZSI/BSI/CMFRI
5	Impact of pollution from industrial sector in the EGREE	1. Listing the industries around the landscape and determining what effluents are released	Ecosystem	I	Long term		AU/WWF/CMFRI

		2. Analysis of samples of contaminated soil and water				
		3. Laboratory analysis of affected plants/animals to determine the concentration of toxicants				
6	Long-term monitoring studies on dynamics of coastal geomorphology in connection with ongoing developmental activities and climate change in and around the EGREE	1. Collection of available data on various aspects of coastal geomorphology and analysis in GIS domain to record the changes 2. Identification of drivers that might have changed the geomorphology and develop ecological modelling for expected future changes 3. Quantification and determination of importance of sediment and freshwater flow 4. Continuation of studies for comparison with data available for previous years	Ecosystem	I	Long term	NIOT/NIO/AU
7	Impact of changes in freshwater flow and sediment influx and its linkages with the estuarine and mangrove systems	1. Collection of available data on freshwater flow, sediment influx and tidal amplitudes 2. Collection of data on land use and infrastructure development in the upstream areas	Ecosystem	I	Long term	NIH/NIOT/IIT/AU
8	Identification and determination of the status and distribution of indicator species in different habitats of the Godavari estuarine ecosystem	1. Identification of bio-indicators to monitor the health of habitats 2. Assessment of status and distribution of the identified bio-indicators	Habitat I		Short term	WII/AU/IISER/WWF/APFD
9	Restoration of entire mangrove communities instead of selective mangrove species	1. Development of restoration technique for recovery of mangrove communities through polyculture instead of monoculture	Habitat I		Long term	MSSRF

		2. Initiating immediate restoration of degraded mangrove habitats using existing baseline data			
10	Intertidal mud flats — their ecological significance	1. Avifaunal diversity assessment in the intertidal mud flat habitats 2. Assessment of other intertidal fauna in the EGREE 3. Evaluation of the composition of the habitat of mud flats; bionomics and hydrological intervention for development/protection of mud flats	Habitat I	Short term	AU/ZSI/CMFRI
11	Long-term monitoring of mangroves	1. Identification and marking of long-term monitoring plots 2. Long-term evaluation/monitoring of mangrove habitats for sustainable resource management	Habitat I	Long term	MSSRF/AU
12	Ecology of lesser known habitats such as seagrass beds and lagoons in the EGREE	1. Preparation of exhaustive inventory of sea grasses/mangroves/lagoons/associates urgently 2. Analysis of linkages between lesser known habitats and other major habitats of the EGREE with respect to production as well as ecological services	Habitat I	Short term	CMFRI/ZSI/BSI/WII/APFD/AU/WWF
13	Coastal lagoon ecology and biodiversity	1. Ecological aspects and biodiversity of Pandi Lagoon of the EGREE vis-à-vis local livelihood issues	Habitat I	Short term	CMFRI/ZSI/BSI/WII/APFD/AU/WWF
14	Habitats of threatened animals	1. Identification and assessment of status of critical habitats of threatened species 2. Suggestions for habitat restoration	Habitat I	Short term	WII/WWF/AU

15	Status, distribution and community structure of primary producers, especially plankton	1. Species inventory 2. Diurnal and seasonal variations in productivity	Species	I	Short term	IISER/ZSI/AU
16	Ecology of jellyfish communities	1. Species identification and biodiversity 2. Biology and exploitation/production	Species	I	Short term	CIFT/CMFRI/CASMB
17	Ecological monitoring of benthic fauna in connection with climate change and various developmental activities	1. Documentation of nematodes and copepods 2. Documentation of polychaetes and mollusks 3. Temporal trends of benthic organisms 4. Application of modern tools (e.g., bar coding) to speed up biodiversity assessment	Species	I	Long term	IISER/CASMB/
18	Prawns and crabs (mud crabs)	1. Species identification, including preparation of atlas 2. Biodiversity assessment of prawns and crabs	Species	I	Short term	CASMB/CMFRI/ZSI
19	Mollusks and shellfish	1. Species identification and preparation of atlas 2. Economic assessment of mollusks and shellfish 3. Collection of data on the fisheries and population dynamics 4. Suggestions for rational exploitation 5. Use of mussels and oysters as sentinels to monitor aquatic pollution	Species	I	Short term	CASMB/CMFRI/ZSI
20	Finfish	1. Inventorization and preparation of atlas 2. Study of individual species' life cycles	Species	I	Long term	CFLR/CMFRI /ZSI/AU/SIFT/CIF

		3. Larval identification and density 4. Recording endangered species in the EGREE 5. Documentation of migratory species (e.g. economically important ones such as the Hilsa) 6. Alien and exotic species 7. Seasonal and annual variations in abundance of fish fauna 8. Developing hatchery technology for the economically important fishes including migratory ones 1. Designating and delineating MPAs along the coastline 2. Stock enhancement based on long-term studies including endangered species 3. Bar coding of finfish 4. Study of recruitment dynamics of juveniles of finfish and shellfish					T/APFD/SFD
21	Reptiles 5.	Assessment and monitoring of reptiles in the EGREE with special reference to sea turtles 6. Suggestions to improve the conservation of sea turtles in the EGREE 7. Long-term monitoring of nesting habitat and populations of sea turtles in the EGREE	Species	I	Short/ long term	APFD/AU/WII/C	MFRI
22	Birds 1.	Species inventory of birds associated with mangroves	Species	I	Short/ long	WII/AU/WWF	

		2. Monitoring terns and gulls 3. Atlas preparation 4. Population assessment			term		
23	Mammals 1.	Ecology and behaviour of otters in the EGREE 2. Long-term monitoring of otters in the EGREE 3. Otter recovery program in the EGREE 4. Assessment and long-term monitoring of other mammals in the EGREE	Species	I	Short/ long terms	WII	
24	Invasive species 1.	Ecology and impact of invasive species in the EGREE 2. Suggestions to manage invasive species in the region	Species		Short/ long term	WII	
25	Diseases/surveillance 3.	Identification of pathogens affecting biota of the EGREE 4. Temporal trends in pathogenicity	Species	I	Short/ long term	IVRI/APAH	
26	Status and trends of contaminants in coastal waters	1. Identification of different pollutants and their sources in the EGREE 2. Mapping the impact zone of existing pollutants 3. Suggesting measures to eliminate/minimize pollution in the EGREE	Monitoring and restoration ecology	I	Short/ long term		SPCB/CBPC/AU/C IFT
27	Monitoring pollution 1.	Establishing independent monitoring mechanism at various strategic points to detect contaminants continuously 2. Monitoring pesticide usage, sewage discharge,	Monitoring and restoration ecology		Short/ long term		SPCB/CBPC/AU/C IFT

		organic pollutants, fecal coliforms, agricultural runoff, industrial effluent discharge, dredge spoil disposal, etc.					
28	Monitoring various trophic levels of mangrove habitats	1. Quantification of litter fall through outsourced agencies 2. Estimation of carbon sequestration in mangroves in the EGREE	Monitoring and restoration ecology	I	Short/ long term	MSSRF	
29	Monitoring seawater intrusion through aquifers and backwaters, and natural disasters such as tsunamis and cyclones	1. Review of existing groundwater monitoring network 2. Additional monitoring network for aquifers, rivers and coastal areas 3. Evaluation of groundwater utility and well census 4. Modelling seawater intrusion	Monitoring and restoration ecology	I	Short/ long term	NIOT/NIO	
30	Strengthening silviculture technology for endemic and threatened mangrove species	1. A study on the phenology and reproduction of endemic and threatened mangrove species in the EGREE 2. Development of a technology to propagate these species in the EGREE	Habitat ecology	II	Short term		MSSRF/CASMB/AU
31	Impact of advances in fishing technology on biodiversity	1. Identification and development of efficient but eco-compatible fishing technology in the EGREE	Production sector	I	Short term		CIFT/SIFT/CMFRI/AU/WII
32	Assessment of socioeconomic conditions in the EGREE with special reference to traditional	1. Survey of demography 2. Assessment of dependence level	Socioeconomic	I	Short term		AU/WWF/ASHRAM/CZM

	communities practicing fishing, agriculture, etc.	3. Preparation of working model (micro plan)				
33	Sectoral study	1. Harmonizing different production sectors such as fisheries, aquaculture, agriculture and allied activities, and industries in spatial planning and monitoring	Socioeconomic	I	Short term	AU
34	Assessing the carrying capacity of industrial development without compromising other ecological services of the EGREE	1. Identifying the production sector in the geographic scope of the EGREE project 2. Production sectors and their impacts 3. Assessing the potential resource 4. Assessing the need 5. Identifying the industries and determining the sustainable limit 6. Standardization of the carrying capacity 7. Calculating MSY/fleet optimization/resource exploitation 8. Studying land-use patterns 9. Crop pattern 10. Water use 11. Assessing the carrying capacity of industries without compromising other ecological services of the EGREE 12. Following up action plan and monitoring the process/making changes if needed, based on the performance	Socioeconomic	I	Short/ long term	CMFRI/CIFT/AU

35	Identification of exclusive industrial zone with environment management plan and best practice guidelines	1. Identifying the area based on need/resource availability/strategic environmental assessment through study on ecological feasibility of individual EMPs 2. Make a road map/develop best practice guidelines 3. Identify the best exclusive industrial zone	Production sector	I	Short term		AU/NIO/CASMB/ WII
36	Economic services of industrial sector in the EGREE and impacts on local economics	1. Identify the economic services 2. Impact on livelihood 3. Impact on social status 4. Impact on livelihood of local individual/society/at national level	Production sector	I	Short term	AU/IIT	
37	Identifying and promoting eco-friendly industries in the EGREE	1. Identify eco-friendly industries 2. Eco-liability/responsibility 3. Mitigation plans 4. Promote eco-friendly industries in the EGREE			Short term	AU/IIT/IIM	
38	SEA and CIA studies	1. Assess the cumulative effects of the production sectors on the ecosystem 2. Mitigation methods 3. Implement policy framework 4. Reduce the impact of production sectors on biodiversity without affecting the extent of production	Production sector	I	Short term		IMT/IIM/AU/NIO /CASMB

39	Assessment of coastal marine habitat loss	1. Identification of the study areas within the landscape using GIS technologies 2. Analysis of the time series data of the satellite imagery of the identified sites 3. Grazing impacts under different management arrangements	Ecosystem	II	Short term	NIOT/AU	
40	Studying the awareness level among village-level institutions such as PRIs/SHGs/EDCs on biodiversity conservation vis-à-vis livelihood opportunities	1. Identifying the key village-level institutions through the random sampling method 2. Use of questionnaire survey method for biodiversity components used in livelihood activities	Ecosystem	II	Long term		WWF/ASHRAN/CZM
41	Linkages/connectivity among habitats/ecosystems	3. Data from short-term and long-term projects will be utilized for understanding the linkages between habitats and ecosystems	Ecosystem	II	Long term		CASMB/CMFRI/AU
42	Human influence on biodiversity and measures of conservation and sustainable use of its components	1. Forces driving human impact on biodiversity 2. Property rights in use of biological resources 3. Impact on access to information and intellectual resource rights 4. Consequences of increasing demand for resource	Ecosystem	II	Long term		
43	Documentation of biodiversity of rocky intertidal shoreline	1. Distribution and diversity of rocky intertidal shoreline fauna	Habitat	II	Short term		
44	Effect of commercial vessel traffic and recreational activities	1. Assess the impact of vessel traffic and recreational activities	Habitat II		Short term		

45	Development of better technology to monitor the benthic and pelagic biodiversity	1. User-friendly technology to monitor the benthic and pelagic biodiversity	Species III		Short term
46	Documentation of habitat-level biodiversity	1. Resource base 2. Paradigm change 3. Biodiversity manuals with multi-disciplinary approach	Socioeconomic	II	Short term
47	Collecting economic studies/documentation at national level	1. Analyze the GDP contribution for designing the national policy	Socioeconomic	II	Short term
48	GMP(Good Management Practices)	1. Collection of case studies (country/state/district/ITK level) 2. GMP (modified) 3. Group activity in homogenous groups	Socioeconomic	II	Short term
49	Empowerment mechanism (resource management)	4. Capacity building, skill upgradation, value addition in the aquaculture, agriculture, horticulture, etc.	Socioeconomic	II	Short term
50	Food security	1. Edible varieties to be identified with nutritional value/balanced diet 2. Identify suitable vegetable varieties for backyard cultivation 3. Schemes to support income-generative standards	Socioeconomic	II	Short/ long term
51	Production sectors	1. EIA studies 2. Impact studies and habitat degradation	Production sectors	II	Short/ long

					term	
		3. Depletion of natural resources				
		4. Hampering livelihoods				
52	Island villages	1. Assessment of resource base	Production sectors	II	Short term	
53	Fishing gear	1. Monitoring impacts and regulation of fishing and aquaculture	Production sectors		Short term	
54	Natural calamities	1. Resources (fauna/flora/groundwater/salinity)	Production sectors	II	Short term	
55	Impact of existing tourism at landscape and seascape levels in the Godavari Delta	1. Identifying existing tourism areas		III	Short/ long term	APTD/APFD/WWF/CEE
		2. Types of facilities created by the host agencies				
		3. Assessing tourist footfalls and the carrying capacity of the site	Ecosystem			
		4. Understanding the waste management systems offered in the tourism areas				
56	Bioshield—enhancing species diversity	1. Developing different bioshield models to reduce the impacts of different natural calamities	Ecosystem		Short term	AU/NIOT/MSSRF/NIO/CMFRI/APFD/MOEF
		2. Development of reclamation models for recalcitrant sites				
		3. Developing species recovery plans for the RET species		III		
		4. The impact of cultural values on the biodiversity of the EGREE area				

57	Long-term monitoring of environmental factors such as wind, rise in sea level and temperature	1. Long-term monitoring of environmental factors, such as the wind, rise in sea level and temperature	Monitoring ecology	III	Long term	IMD/APFD
58	Policy-level research	1. It is important to have a national policy on the coastal and marine environmen t and biodiversity and their sustainable use. 2. The efficacy of in ternational, national and state policies and legal instruments in resource management in the coastal and marine environment needs to be assessed. 3. Mechanism of networking various governmental non-governmental organizations and community-based institutions in the participatory management of coastal and marine resources. 4. Identify various components that need to be part of a national- or state- level policy for restoration and rehabilitation of comm unities affected by conservation initiatives.	Policy research		Short term	

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Abstract: This study gives an insight into the source of organic carbon and nitrogen in the Godavari river and its tributaries, the yield of organic carbon from the catchment, seasonal variability in their concentration and the ultimate flux of organic and inorganic carbon into the Bay of Bengal. Particulate organic carbon/particulate organic nitrogen (POC/PON or C/N) ratios revealed that the dominant source of organic matter in the high season is from the soil (C/N ~ 8-14), while in the rest of the seasons, the river-derived (in situ) phytoplankton is the major source (C/N ~ 1-8). Amount of organic materials carried from the lower catchment and flood plains to the oceans during the high season are 3 to 91 times higher than in the moderate and low seasons. Large-scale erosion and deforestation in the catchment has led to higher net yield of organic carbon in the Godavari catchment when compared to other major world rivers. The total flux of POC, and dissolved inorganic carbon (DIC) from the Godavari river to the Bay of Bengal is estimated as 756 x 109 and 2520 x 109 g/ yr respectively. About 22% of POC is lost in the main channel because of oxidation of labile organic matter, entrapment of organic material behind dams/sedimentation along flood plains and river channel; the

DIC fluxes as a function of alkalinity are conservative throughout the river channel. Finally, the C/N ratios (~12) of the ultimate fluxes of particulate organic carbon suggest the dominance of refractory/ stable soil organic matter that could eventually get buried in the coastal sediments on a geological time scale.

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Abstract: Group of plants taxonomically isolated and successfully adapted in colonizing saline intertidal zone at the interface between the land and sea along the deltas, shallow lagoons, bays and back waters in tropical and subtropical sheltered coast lines is known as Mangrove. This forest is restricted only along the saline intertidal habitat of sheltered coastline; Dark green foliage and negatively geotropic roots are the main characteristic of this forest. It shows maximum modification in the morphology, physiology and biochemical processes expressing some superficial characters like pneumatophores, stilt roots and vivipary for withstanding partly submerged saline conditions. Best mangroves formation is found where the tidal regime is normal (1-3 m) with regular mixing of sea water and fresh water from the rivers, where temperature does not optimally go below 20 ^{0}C, soil is mostly alluvial in nature with high salt, low oxygen, high Hydrogen Sulphide, high water content and rainfall remains 2000-3000 mm/year.

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Abstract: Iron-ore with magnetite as the chief ore mineral occurs in the Precambrians of Eastern Ghats. Vertical magnetometric surveys were carried out to delineate some of the ore bands, in the Ghats belt of Godavari Districts, Andhra Pradesh, around Addatigala, Devipatnam and Tekuru. Interpretation of the magnetic anomalies was based on the tabular models. Ore bands are at shallow depths of around 5m. The deduced inclinations of magnetization suggest that the magnetization is largely remanent. The intensities of magnetization are in the range of 5 to 10.5×10^{3} emu and agree well with the laboratory measurements on the ore samples. At Devipatnam and Tekuru the magnetic background seems to be high. At Tekuru the ore band appears to be very limited in depth extent. The limited depth extent coupled with high magnetic background explains the anomaly, which is not so prominent. It is

concluded that in such areas, it is only the high grade magnetite ore bands of considerable depth extent that can be successfully delineated by the magnetic method.

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Abstract: True mangrove plants and associated mangrove were present near to the waterfront whereas other halophytes were present near the transitional zone. High density of mangrove population was observed where silt was high in the sediments of mangrove environment.

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Abstract: A process-based facies model for asymmetric wave-influenced deltas predicts significant river-borne muds with potentially lower quality reservoir facies in prodelta and downdrift areas, and better quality sand in up drift areas. Many ancient barrier-lagoon systems and 'offshore bars' may be better reinterpreted as components of large-scale asymmetric wave-influenced deltaic systems. The proposed model is based on a re-evaluation of several modern examples. An asymmetry index A is defined as the ratio between the net long shore transport rate at the mouth (in m^3 $year^{-1}$) and river discharge (in 10^6 m^3 $month^{-1}$). Symmetry is favored in deltas with an index below ≈200 (e.g. Tiber, lobes of the Godavari delta, Rosetta lobe of the Nile, Ebro), whereas deltas with a higher index are asymmetric (e.g. Danube - Sf. Gheorghe lobe, Brazos, Damietta lobe of the Nile). Periodic deflection of the river mouth for significant distances in the down drift direction occurs in extreme cases of littoral drift dominance (e.g. Mahanadi), resulting in a series of randomly distributed, quasi-parallel series of sand spits and channel fills. Asymmetric deltas show variable proportions of river-, wave- and tide-dominated facies both among and within their lobes. Bayhead deltas, lagoons and barrier islands form naturally in prograding asymmetric deltas and are not necessarily associated with transgressive systems. This complexity underlines the necessity of interpreting ancient depositional systems in a larger palaeogeographic context.

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Abstract: The mean annual water flow and sediment transport of the Godavari river are estimated to be 92 km^3 and 170×10^6 ton (t), respectively. In terms of sediment transport and the rate of physical erosion (555 t $km^{-2} yr^{-1}$), the position of the Godavari would be ninth and fifth respectively among the world rivers. Geology of the basin is the main controlling factor of the sediment transport. The sedimentary rocks located in the lower part of the basin and constituting 7% of the total basins are responsible for 33% of the sediment load. More than 67% of sediment load is silt and clay. Annual, monthly and daily variations in sediment transport indicate that a few selected days in the hydrological year control the annual sediment budget. Our latest estimates are nearly twice that of our earlier values. The presently available global estimates on sediment transport need to be re-valued.

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Abstract: The nature of solute transport of the Godavari basin has been studied based on 59 river and four rain water samples collected four times during 1977-1980. The Godavari basin annually transports 16.8 $\times 10^6$ t load representing 6% of chemical load from the Indian subcontinent. The annual chemical erosion rate is 49t km^{-1} $year^{-1}$ after correcting for atmospheric recycling .The tributaries flowing through the Deccan traps (basalt) covering 48% t of the basin area are responsible for 85% of the dissolved transport. The remaining 15% is contributed by granites and other rock types. The sedimentary rocks located in the lower part of the basin covering 7% of the basin area actually retain 7×10^6 t of the annual dissolved load. Individual

elemental fluxes and their rates have also been calculated. Temporal variations in the dissolved transport are quite pronounced. The mean TDS of the Godavari River, 250 mg l^{-1} is much higher than the Indian and world average river water composition.

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Abstract: This paper reports for the first time upon the effects of increasing CO_2 concentrations on a natural phytoplankton assemblage in a tropical estuary (the Godavari River Estuary in India). Two short-term (5-day) bottle experiments were conducted (with and without nutrient addition) during the pre-monsoon season when the partial pressure of CO_2 in the surface water is quite low. The results reveal that the concentrations of total chlorophyll, the phytoplankton growth rate, the concentrations of particulate organic matter, the photosynthetic oxygen evolution rates, and the total bacterial count were higher under elevated CO_2 treatments, as compared to ambient conditions (control). $\delta^{13}C$ of particulate organic matter (POM) varied inversely with respect to CO_2, indicating a clear signature of higher CO_2 influx under the elevated CO_2 levels. Whereas, $\delta^{13}C$ POM in the controls indicated the existence of an active bicarbonate transport system under limited CO_2 supply. A considerable change in phytoplankton community structure was noticed, with marker pigment analysis by HPLC revealing that cyanobacteria were dominant over diatoms as CO_2 concentrations increased. A mass balance calculation indicated that insufficient nutrients (N, P and Si) might have inhibited diatom growth compared to cyanobacteria, regardless of increased CO_2 supply. The present study suggests that CO_2 concentration and nutrient supply could have significant effects on phytoplankton physiology and community composition for natural phytoplankton communities in this region. However, this work was conducted during a non-discharge period (nutrient-limited conditions) and the responses of phytoplankton to increasing CO_2 might not necessarily be the same during other seasons with high physicochemical variability. Further investigation is therefore needed.

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Abstract: With the help of high resolution satellite data (SPOT products), it has been possible to portray on maps the present distribution of main mangrove types and sub-types of the Bay of Bengal coastline. New figures have been given for the mangrove of each concerned country especially for Myanmar. The present ecological status of mangrove ecosystems in the three major deltas, the Godavari, the Ganges and the Irrawaddy are totally distinct. In the Godavari delta (India) mangroves are receding in area and biomass; in the Ganges, the Sundarbans (India and Bangladesh) are evolving very slowly in size but an important species sub distribution is in progress; in the Irrawaddy (Myanmar) mangroves are in continuous decline. The present distribution and status of each mangrove type is the result of direct anthropic factors. Conversion to agriculture, reforestation, fishponds constructions, forest exploitation are now easily detected from space. Conversely, indirect impacts, such as freshwater diversion or chemical pollution, cannot be monitored with sensors operating in the visible part of the electromagnetic spectrum.

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Abstract: The effects of human activities and sea-level changes on the spatial and temporal behavior of the coupled mechanism of salt-water and freshwater flow through the Godavari Delta of India were analysed. The density driven salt-water intrusion process was simulated with the use of a SUTRA (Saturated-Unsaturated Transport) model. Physical parameters, initial heads, and boundary conditions of the delta were defined on the basis of available field data, and an aerial, steady-state groundwater model was constructed to calibrate the observed head values corresponding to the initial development phase of the aquifer. Initial and boundary conditions determined from the areal calibration were used to evaluate steady-state, hydraulic heads. Consequently, the initial position of the hydraulic head distribution was calibrated under steady-state conditions. The changes of initial hydraulic distribution, under discharge and recharge conditions, were calculated, and the present-day position of the interface was predicted. The present-day distribution of hydraulic head was estimated via a 20-year simulation. The

results indicate that a considerable advance in seawater intrusion can be expected in the coastal aquifer if current rates of groundwater exploitation continue and an important part of the freshwater from the river is channeled from the reservoir for irrigation, industrial and domestic purposes.

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Abstract: The partial pressure of CO_2 (pCO_2)was measured at daily and weekly time scales in the waters surrounding mangrove forests in Papua New Guinea, the Bahamas and India. The pCO_2 values range from 380 to 4800 μatm. These data, together with previously published data, suggest that overall oversaturation of CO_2 with respect to atmospheric equilibrium in surface waters is a general feature of mangrove forests, though the entire ecosystems (sediment, water and vegetation) are probably sinks for atmospheric CO_2. The computed CO_2 fluxes converge to about plus ~50 m mol C m^{-2} day^{-1}. If this conservative value is extrapolated for worldwide mangrove ecosystems, the global emission of CO_2 to the atmosphere is about 50 $x10^6$ t C $year^{-1}$. Based on this tentative estimate, mangrove waters appear to be regionally a significant source of CO_2 to the atmosphere and should be more thoroughly investigated, especially at seasonal time scale.

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Abstract: Between January 1995 and August 1996, suspended matter and zooplankton were sampled at different locations in a mangrove ecosystem located in the Gautami Godavari estuary and adjacent Kakinada Bay (Andhra Pradesh, India). Suspended matter was sampled at 13 different stations, and was found to have a highly variable carbon stable isotope composition, with sigma 13C values ranging overall between -30.94 and -19.18‰ , and a highly variable elemental (C:N) composition. Our data suggest that the phytoplankton component has a seasonally and spatially variable sigma 13C signature, which is suppressed by the terrestrial signal, but may at times fall in the same range as the sigma 13C of the allochtonous matter. It is argued

that the phytoplankton sigma 13C decreases after the onset of the monsoon rains, most likely due to the 13C-depletion of the DIC pool caused by the microbial respiration of the allochtonous organic matter. At each of the 4 sites selected for concurrent zooplankton sampling, the zooplankton showed a much wider range of sigma 13C than did the suspended matter, with overall sigma 13C values between -30.14 and -16.45 . In addition, spatial differences in average sigma 13C were much more pronounced for zooplankton than for total suspended matter. These data indicate that zooplankton feed on a component of the suspended matter pool, which has more pronounced seasonal and spatial sigma 13C variations than the total suspended matter. Thus, despite the large amounts of terrestrial and mangrove detritus present in the water column, the locally produced phytoplankton appears to be a more important carbon source for the zooplankton.

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Abstract Mangrove ecosystems are highly productive tropical coastal ecosystems, which have a potentially high impact on the carbon budget of the tropical and global coastal zone. The carbon dynamics in mangrove ecosystems has been the subject of numerous studies during the past decades, but we are still far from having an integrated view of the overall ecosystem functioning in terms of organic matter processing. The application of recent analytical techniques has produced a wealth of new information but has also indicated the gaps in our knowledge on organic matter cycling in these ecosystems. This paper provides an overview of our current understanding of organic matter dynamics in mangrove ecosystems, and reviews data based on stable isotope analyses, on (i) the delineation of carbon sources in different organic matter pools, (ii) utilization patterns of organic carbon by microbial and faunal communities, and (iii) organic matter exchange between mangroves and adjacent ecosystems. Although the use of stable isotopes has a number of limitations and has not always been able to unambiguously assess source contributions, it has been invaluable in refuting some long-standing paradigms, and has shown that source characterization is crucial in order to better estimate organic matter budgets in these dynamic ecosystems. Future studies on process rates or flux measurements should therefore ideally be combined with a variety of chemical tracers to determine the source of the organic matter considered.

108. Bouillon, S., Dahdouh-Guebas, F., Rao, A.V.V.S., Koedam, N., Dehairs, F. (2003). Sources of organic carbon in mangrove sediments: variability and possible ecological implications. Hydrobiologia. 495: 33-39.

Abstract: Mangrove sediments from three different mangrove ecosystems (Coringa Wildlife Sanctuary in the Godavari Delta, Andhra Pradesh, India, and Galle and Pambala, south-west Sri Lanka) were analysed for their organic carbon content, elemental ratios (C:N) and carbon stable isotope composition. Organic carbon content (0.6 -31.7% dry weight), C/N ratios (7.0-27.3) and sigma 13C (between -29.4 and -20.6‰) showed a wide range of values. Lower stocks of organic carbon coincided with low C/N (atom) ratios and less negative sigma 13C values, indicating import of marine or estuarine particulate suspended matter. High organic carbon stocks coincided with high C/N ratios and sigma 13C values close, but not equal, to those of the mangrove vegetation. The variations observed in this study and published literature data could be adequately described by a simple two-end mixing model, whereby marine/estuarine suspended matter and mangrove litter were taken as end members. Thus, while in some mangrove ecosystems or vegetation zones, organic carbon stocks can be very high and are almost entirely of mangrove origin, there also appear to be cases in which deposited estuarine or marine suspended matter is the dominant source of organic carbon and nitrogen in mangrove sediments. This situation is remarkably similar to that observed in temperate salt marsh ecosystems where the importance of local vascular plant production to the sediment organic carbon pool is equally variable. The observed high variability in organic matter origin is thought to have a major impact on the overall carbon dynamics in intertidal mangrove ecosystems.

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110. Bouillon, S., Frankignoulle, M., Dehairs, F., Velimirov, B., Eiler, A., Abril, G., Etcheber, H., Borges, A.V. (2003). Inorganic and organic carbon biogeochemistry in the Gautami-Godavari estuary (Andhra Pradesh, India) during pre-monsoon: The local impact of extensive mangrove forests. Global Biogeochemical Cycles. 17 (4): 1114.

Abstract: The distribution and sources of organic and inorganic carbon were studied in the Gautami Godavari estuary (Andhra Pradesh, India) and in a mangrove ecosystem in its delta during pre-monsoon. In the oligohaline and mesohaline section (salinity 0-15) of the estuary, internal production of total alkalinity (TAlk) and dissolved inorganic carbon (DIC) was recorded, and the d13CDIC profile suggests that carbonate dissolution may be an important process determining the DIC dynamics in this section of the Godavari. The partial pressure of CO_2 (pCO_2) was fairly low along the entire salinity gradient, (293-500ppm), but much higher and more variable (1375-6437ppm) in the network of tidal mangrove creeks in the delta. Here, variations in the concentration and δ13C of the DIC pool were shown to result largely from the mineralization of organic matter. The present study clearly identifies the mangrove creeks as an active site of mineralization and CO_2 efflux to the atmosphere, but shows that these changes in the aquatic biogeochemistry are a localized feature, rapidly fading in the adjacent Kakinada Bay. Our data indicate that mineralization of dissolved organic carbon (DOC) of mangrove origin, and its subsequent efflux as CO_2 to the atmosphere may represent an important fate for mangrove carbon. Although further quantification of this process in a variety of systems is required, we suggest that some of the current ideas on the role of mangroves in the carbon budget of the coastal zone may need to be reconsidered.

111. Bouillon, S., Koedam, N., Baeyens, W., Satyanarayana, B., Dehairs, F. (2004). Selectivity of subtidal benthic invertebrate communities for local micro algal production in an estuarine mangrove ecosystem during the post-monsoon period. □ournal of Sea Research. 51□133-144.

Abstract□Stable isotope analysis was used as a tool to assess the main carbon sources sustaining the benthic invertebrate communities in an estuarine mangrove ecosystem along the southeast coast of India during the post-monsoon season. In particular, we wanted to test whether the large amounts of terrestrial carbon brought in during the monsoon influence the benthic food web in this area, by comparing with earlier data on the pre-monsoon period. The ^{13}C of the dissolved inorganic carbon (DIC) pool was spatially variable, with lower values in the mangrove creeks (10.6 to 8.9□) compared to those in the adjacent bay region (4.3 to 2.6□). Fixation of the ^{13}C-depleted DIC in the mangrove creeks should therefore result in a partial overlap in the $\delta^{13}C$ signature of mangrove-derived carbon and local phytoplankton. The lack of correlation between $\delta^{13}C$ values of benthic invertebrates (which showed a large spatial gradient of □8□) and those of sediments or suspended matter (both showing only small spatial gradient of greater than 2.5□) indicates that invertebrates were highly selective for locally produced algal food sources. These results are similar to those obtained during the pre-monsoon period in the same area, although in each region δ13C values were consistently more negative (by 1-3□) during the post-monsoon period, consistent with the seasonality in $\delta^{13}C_{DIC}$. By defining selectivity as the relative spatial gradient in consumer $\delta^{13}C$ compared to the $\delta^{13}C$ of bulk particulate organic carbon (POC) and $\delta^{13}C_{DIC}$ (as a proxy for the variations expected in local producers), and assuming that the selectivity is similar along the salinity gradient, we estimate that benthic invertebrates rely almost entirely on locally produced microalgal carbon sources. A critical evaluation of earlier studies shows that there is currently no unambiguous evidence for a trophic role of mangrove litter in sustaining subtidal benthic and pelagic invertebrate communities in adjacent aquatic systems.

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Abstract:In contrast to the large number of studies on the trophic significance of mangrove primary production to the aquatic food web, there have been few attempts to provide an overview of the relative importance of different primary carbon sources to invertebrates in the intertidal mangrove habitats. We determined carbon and nitrogen stable isotope ratios ($\delta^{13}C$, $\delta 15N$) in sediments, primary producers, and 22 invertebrate species from an intertidal mangrove forest located along the southeast coast of India in order to determine the contribution of mangrove leaf litter and other carbon sources to the in-vertebrate community. Organic matter in sediments under the mangrove vegetation was characterized by relatively high $\delta^{13}C$ values and low C:N ratios, indicating that mangrove-derived organic matter was not the principal source and that imported phytodetritus from the mangrove creeks and adjacent bay significantly contributed to the sediment organic matter pool. Invertebrates were found to display a wide range of $\delta^{13}C$ values, most being 3-1‰ enriched relative to the average mangrove leaf signal. The pulmonate gastropod Onchidium sp. showed unusually low $\delta^{15}N$ values (-5.6 plus or minus 0.9‰), but further work is needed to adequately explain these data. A compilation of stable isotope data from various sources indicates that significant assimilation of mangrove-derived carbon is only detectable in a limited number of species, and suggests that local and imported algal sources are a major source of carbon for benthic invertebrate communities in intertidal mangrove forests. These results provide new insights into carbon utilization patterns in vegetated tropical intertidal habitats and show a striking similarity with results from temperate salt marsh ecosystems where local plant production has often been found to contribute little to intertidal food webs.

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Abstract□ Metal ions play an important role in the life of humans. However, heavy doses will have impact on the health. The present study is aimed to measure the heavy metal contamination in the ground water in areas at 0.5, 1 and 2 km around the sugar industry in East Godavari region. Ground water samples from 12 areas are collected and analysed for heavy metals, such as □Cu□, □Zn□ and □Fe□ by Atomic Absorption Spectrometer (AAS).The results indicate that the concentration of Copper ranges from (0-0.005mg l^{-1}), Zinc ranges from (0-0.253mg l^{-1}),and are within the permissible limit. The concentration of iron (1.094mg l^{-1}) is marginally higher than the permissible limit of WHO drinking water standards (1mg l^{-1}) only at one area.

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126. Chandramohan, P., Raman, A.V., Srinivas, N. (1999). Distribution of zooplankton in relation to water movements in Kakinada bay, east coast of India. Indian Journal of Marine Science. 28: 192-197.

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Abstract: The Godavari estuarine system extending over approximately 316 km^2 has significant annual variation of salinity due to seasonal flooding, which is mainly monsoon, fed. This area has dense vegetation of mangroves, characterized by predominance of Avicennia sp. Excoecaria agallocha and Rhizophora sp. In the coastal waters adjacent to the mangroves three economically important species of prawns occur (Penaeus monodon, P. indicus and Metapenaeus monoceros). Their larvae migrate and dwell in the mangrove environment. By analysis for the natural stable carbon isotope ratios, it was possible to establish the primary carbon source from the mangroves to that of larvae and juveniles of P. indicus and P. monodon. This information can be used to exploit the mangrove habitat as prawn nurseries.

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Abstract: The Proterozoic succession of the Pranhita-Godavari Valley (PG Valley), defined as the Godavari super group, occurs in two NW-SE trending belts flanking the margins of the Valley. The super group comprises several unconformity-bound sequences of group status, and exhibits strong regional variations in the distribution of different groups deposited in widely variable conditions, ranging from fan-alluvial setting to deep-water slope, base-of-slope and basinal environments. The lithologic assemblages indicate that the basin experienced multiple rifting, and tectonic environment varied from an unstable rift setting to a stable shelf regime. The Godavari super group, with a complex history of stratigraphic evolution, is still plagued by multiple problems of classification and correlation that have long been the major impediments to basin analysis. In the present paper, the attributes of the genetically linked stratal packages, the unconformities separating them, and their correlation in the south-central part of the Valley have been critically evaluated to address the problems of regional stratigraphy. The Godavari super group is bounded by two inter-regional unconformities, separating it from the underlying crystalline cratonic basement and from the overlying Gondwana sedimentary rocks of late Paleozoic-Mesozoic age. The super group, in turn, is subdivided into four major sequences by three regional unconformities in the south-central part of the Valley. Comparison of stratigraphic profiles at different points indicates that the thickness of the unconformity-bound sequences, or of individual formation, and also the number of formations, increases from the central part of the Valley towards the southeast. The stratigraphic relationships collectively suggest that the basin deepened and opened in a southeasterly direction. The basin in its southeastern part appears to have been much wider than the present day outcrop width, and to have been continuous with other adjoining Proterozoic basins. The central part of the basin was a relatively stable and positive area compared to the southern part, where the basin floor repeatedly moved across the base level to the order of several hundred meters. The amplitude of movements indicates tectonically controlled subsidence and uplift.

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Abstract The Pranhita-Godavari (PG) Valley, a major lineament within the South Indian cratonic province, that preserves sediment dominated deposits spanning from Mesoproterozoic to Mesozoic, appears to be a key element in supercontinent reconstruction. The sedimentary basins of the Valley include a thick succession of Early Mesoproterozoic to Late Neoproterozoic rocks, the Godavari Supergroup, which is unconformably overlain by the Late Paleozoic-Mesozoic Gondwana sequence. The Godavari Supergroup is internally punctuated by several regional and interregional unconformities into a number of unconformity-bound sequences having group level and subgroup level status. The lithostratigraphic attributes of the succession indicate multiple events of fault controlled sedimentation marked by transgression and regression, as well as uneven rates of uplift and subsidence of the basin floor in an extensional tectonic regime. The amplitude of translation of the unconformity surfaces across the base level attests to collective role of tectonic movement and sea level changes in building the stratigraphic framework of the Valley. The stratigraphic framework and depositional systems, such as fan and fan-deltas, together with local outburst of felsic volcanism further indicate

repeated rifting of the craton. Geochronologic data indicate that the rift basin started to open in Early Mesoproterozoic, concomitantly with the breakup of the Mesoproterozoic supercontinent during which the India and East Gondwana fragments were separated. The spatial variation in the declivity of the unconformity surfaces, and the trend of thickness variation of the unconformity bound sequences point that the basin deepened and opened towards southeast to join an ocean that developed between the South Indian craton and East Antarctica. The contractional deformation structures preserved in several lithounits were produced under NE-SW directed regional compression during Late Neoproterozoic basin inversion.

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Abstract: Mangrove forests, though essentially common and wide-spread, are highly threatened. Local societies along with their knowledge about the mangrove also are endangered, while they are still underrepresented as scientific research topics. With the present study we document local utilization patterns, and perception of ecosystem change. We illustrate how information generated by ethnobiological research can be used to strengthen the management of the ecosystem. This study was conducted in the Godavari mangrove forest located in the East-Godavari District of the state Andhra Pradesh in India, where mangroves have been degrading due to over-exploitation, extensive development of aquaculture, and pollution from rural and urbanized areas (Kakinada). One hundred interviews were carried out among the fisher folk population present in two mangrove zones in the study area, a wildlife sanctuary with strong conservation status and an adjacent zone. Results from the interviews indicated that Avicennia marina (Forsk.) Vierh., a dominant species in the Godavari mangroves, is used most frequently as firewood and for construction. Multiple products of the mangrove included the bark of Ceriops decandra (Griff.) Ding Hou to dye the fishing nets and improve their durability, the bark of Aegiceras corniculatum (L.) Blanco to poison and catch fish, and the leaves of Avicennia spp. and Excoecaria agallocha L. as fodder for cattle. No medicinal uses of true mangrove species were reported, but there were a few traditional uses for mangrove associates. Utilization patterns varied in the two zones that we investigated, most likely due to differences in their ecology and legal status. The findings are discussed in relation with the demographic and socio-economic traits of the fisher folk communities of the Godavari mangroves and indicate a clear dependency of their livelihood on the mangrove forest. Reported changes in the Godavari mangrove cover also differed in the two zones, with significantly less perceptions of a decrease in the protected area, as compared to the adjacent non-protected, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is

properly cited area. A posteriori comparisons between sequential satellite imagery (retrospective till 1977) and respondents that were at least 15 years back then, revealed a mangrove decrease, which was however perceived to different extents depending on the area with which the fishermen were familiar. While local needs had not been incorporated in the existing policy, we created a framework on how data on ethnobotanical traditions, fishery-related activities and local people's perceptions of change can be incorporated into management strategies.

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AbstractStable carbon isotopic composition and C/N ratio were used to trace the input of carbon associated with mangrove litter into the estuary of the Godavari-Gautami delta system and Kakinada bay (Andhra Pradesh, India). Suspended organic matter in the mangrove channels was more depleted in ^{13}C (average ^{13}C 24.5) than in Kakinada bay which showed 13C values for suspended matter (average ^{13}C 22.7) closer to those expected for marine phytoplankton. Suspended organic matter from mangrove channels was enriched in nitrogen (average C/N atom ratio 12.7) and ^{13}C (average ^{13}C 24.5) relative to mangrove leaf litter, which had a C/N ratio of 75 and a 13C value of 28 . Lowest C/N ratios for suspended matter were observed during southwest monsoon when rainfall was highest. Although in general, mangrove litter fall was also lower during this period, no clear correlation was observed between litter fall and C/N ratio of suspended matter. In general, the composition of suspended matter pointed towards phytoplankton as a major component. Isotopic composition of zooplankton suggested selective feeding on ^{13}C enriched, marine phytoplankton in open Kakinada bay and on ^{13}C-depleted organic matter, such as estuarine phytoplankton and mangrove litter, in the mangrove channels. From the ^{13}C signature, it appeared that mangrove carbon was present to some extent in zooplankton and macrofauna from the mangrove mudflats and channels, but the signal rapidly decreased in Kakinada bay. Nitrogen isotopic composition of zooplankton and macrofauna indicated a progressive enrichment of ^{15}N away from the mangrove forest towards the northern part of Kakinada bay, in approach of Kakinada city. This is thought to reflect input of anthropogenic nitrogen enriched in 15N and subsequent uptake of this enriched nitrogen into the aquatic food chain. Stable carbon isotopic composition and C/N ratio were used to trace the input

of carbon associated with mangrove litter into the estuary of the Godavari-Gautami delta system and Kakinada bay (Andhra Pradesh, India). Suspended organic matter in the mangrove channels was more depleted in 13C (average 13C □ 24.5 □) than in Kakinada bay which showed 13C values for suspended matter (average 13C □ 22.7 □) closer to those expected for marine phytoplankton. Suspended organic matter from mangrove channels was enriched in nitrogen (average C/N atom ratio 12.7) and ^{13}C (average 13C □ 24.5 □) relative to mangrove leaf litter, which had a C/N ratio of 75 and a 13C value of 28 □ . Lowest C/N ratios for suspended matter were observed during southwest monsoon when rainfall was highest. Although in general, mangrove litter fall was also lower during this period, no clear correlation was observed between litter fall and C/N ratio of suspended matter. In general, the composition of suspended matter pointed towards phytoplankton as a major component. Isotopic composition of zooplankton suggested selective feeding on ^{13}C-enriched, marine phytoplankton in open Kakinada bay and on ^{13}C-depleted organic matter, such as estuarine phytoplankton and mangrove litter, in the mangrove channels. From the ^{13}C signature, it appeared that mangrove carbon was present to some extent in zooplankton and macrofauna from the mangrove mudflats and channels, but the signal rapidly decreased in Kakinada bay. Nitrogen isotopic composition of zooplankton and macrofauna indicated a progressive enrichment of ^{15}N away from the mangrove forest towards the northern part of Kakinada bay, in approach of Kakinada city. This is thought to reflect input of anthropogenic nitrogen enriched in ^{15}N and subsequent uptake of this enriched nitrogen into the aquatic food chain.

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reflections probably originating from Miocene sequence. Since the study area is located in shale tectonics regime where Miocene sequences are known to be over pressured, we interpret the zones of no coherent reflections as Miocene shale diapirs. The upward movement of shale diapirs has folded the overburden layer and resulted in the formation of numerous faults/fractures. These faults act as permeable pathways for fluid/gas movement facilitating the formation of gas hydrate and cold seeps close to shale diapiric mound.

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Abstract: Observations (1995-96) on mangrove leaf litter revealed a variety of microorganisms dominated by bacteria (5 types), 12 species of flagellates, 2 sarcodines, 17 ciliates, 2 suctorids and 2 sessile ciliates besides several diatoms, nematodes and nauplii. Overall, bacteria outnumbered (4.59 x 10^5 g^{-1}dry weight) all others constituting 80-90% of the population followed by flagellates (4.8%), ciliates (4.4%)and, sessile ciliates Protozoa associated with leaf litter degradation in Coringa mangrove forest , Kakinada bay east coast of India. (0.2%) Chromulina sp., Spumella socialis and Euglena acus (flagellates), Cyclidium sp., Prorodon sp., Euplotoides aediculatus and Zoothamnium sp. (ciliates) were relatively dominant (mean density 4,331 individuals l^{-1}) in the litter collected from Avicennia plot. Flagellates, Astasia sp., Heteronema sp. and Paranema sp. and, ciliates, Prorodon sp., Holosticha sp. and E. aediculatus were, however, more common in Excoecaria (mean density 3719 individuals l^{-1}). In situ experiments on leaf decay showed that the entire process lasted 12-18 days in summer and 26-32 days during monsoon. Bacteria were the first to settle, followed by nanoflagellates (2-20 µm), microciliates (20-100 µm), macrociliates (100-200 µm) and sessile ciliates. Nematodes indicated culmination. Bacterial (mean) biomass registered highest value (6.43 x 10mgC g^{-1}) within 24 hours but decreased (3.1 x 10 mgC g^{-1}) by day-3 to 5. Mean flagellate biomass peaked (32.6mgC g^{-1}) by day-2 and microciliates (92 mgC g^{-1}) by day-5 in summer and (47mgC g^{-1}) by day-24 during monsoon. Macrociliates registered highest biomass (168.4mgC g^{-1}) by day-6 in summer but lagged behind until day-26 to day-30 (154mgC g^{-1}) during monsoon. A distinct prey predator relationship, direct dependence of ciliate species on nanoflagellate and bacterial populations as well as, a well-marked microbial community succession were evident.

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Abstract: The Proterozoic Somanpalli Group, originally deposited in a NW-SE trending fault-controlled basin in the Pranhita-Godavari valley (PG valley), suffered contractional deformation as recorded in NW-SE trending large scale folds, imbricate thrusts, second order semibrittle shear zone, and smaller folds, faults, and cleavage. Three distinct structural stages dominated, respectively, by folding, thrusting and strikeslip faulting in that order, can be recognized from overprinting relationships, in outcrops. The local ENE-WSW fold axis azimuth and cleavage strike is related to variation in the original depositional strike controlled by E-W transfer faults rejuvenated as sinistral strike-slip zones during the main contractional deformation. A late extensional event, possibly occurring during the upper Proterozoic or Mesozoic (Gondwana), has been superimposed locally on the earlier fabric of the fold-thrust belt. The NW-SE trending folds and thrusts in the Somanpalli Group demonstrate the presence of a hitherto unrecognised compressional regime, records of which occur in a, 200 km stretch along the eastern margin of the PG valley. The Somanpalli Group may be correlated with the Mesoproterozoic Pakhal Group (1350 Ma). Since the former is overlain by grossly undeformed and unmetamorphosed rocks of the Neoproterozoic Sullavai Group, a Mesoproterozoic basin inversion in this region is suggested.

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Abstract: The role of mangroves in nature and their ecological significance have been realized of late and the Government, scientific Institutions and Universities are paying increasing attention to the Biology, conservation and management of mangrove areas.

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Abstract: Carbon biogeochemistry of a tropical ecosystem (The Cochin Estuary, India) undergoing increased human intervention was studied during February (premonsoon), April (early monsoon) and September (monsoon) 2005. The Cochin estuary sustains high levels of pCO_2 (up to 6000 µatm) and CO_2 effluxes (up to 274 mmolC m^{-2} d^{-1}) especially during monsoon. A first-order estimate of the carbonmass balance shows that net production of dissolved inorganic carbon is an order of magnitude higher than the net loss of dissolved and particulate organic carbon from the estuary. This imbalance is attributed to the organic inputs to the estuary through anthropogenic supplies. The bacteria mediated mineralization of organic matter is mainly responsible for the build-up of pCO_2 and increased CO_2 emission to the atmosphere indicating heterotrophy. The linear correlation between excess CO_2 and apparent oxygen utilization indicates respiration as the chief mechanism for CO_2 supersaturation. An increase in the net negative ecosystem production (-ve NEP) between premonsoon (-136 mmolC m^{-2} d^{-1} or -376 MgC d^{-1}) and monsoon (-541 mmolC m-2 d-1 or -1500 MgC d-1)is supported by a corresponding increase in O_2 influxes from 17 mmol O_2 m^{-2} d^{-1} (126 MgC d^{-1}) to -128 mmol O_2 m^{-2} d^{-1} (-946 MgC d^{-1}) and CO_2 emissions from 65 mmolC m^{-2} d^{-1} (180 MgC d^{-1})to 267 mmolC m-2 d^{-1} (740 MgC d^{-1}). There is a significant north-south gradient in metabolic rates and CO_2 fluxes attributable to the varying flow patterns and anthropogenic inputs into the estuary. The study reveals that the Cochin estuary, a previously autotrophic (CO_2 sink) system, has been transformed to a heterotrophic (CO_2 source) system following rapid urbanization and industrialization. Moreover, the export fluxes from the Cochin estuary appear to be quite important in sustaining net heterotrophy in the southeastern Arabian Sea.

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Abstract: The distribution and nature of sedimentary organic matter (OM) have been examined in sediment cores collected from the lower reaches, including estuary, of the Godavari River in order to understand sedimentation patterns, sources, and diagenesis of OM. The samples were analyzed for organic carbon (Corg), total nitrogen, amino acids and hexosamines. The observed irregular trends in Corg distribution with depth indicate the unstable nature of bed sediment in the lower reaches of the river. Yet, in the lower estuarine region, regular trends in Corg distribution with depth reflect the deposition of sediment. The atomic ratio of Corg and total nitrogen (C/N; 10.5-16.1) also supported this observation. The distribution of amino acids and diagenetic indicators (Beta- ala gama -aba mol. percent, AA/HA and Glc-NH2/ Gal-NH2) in individual cores revealed the post-depositional changes in the OM. In the core sediment from the lower reaches, there was no clear cut trend in amino acid content with depth. In the estuarine region, however, amino acid content was very low (50.5 and 186.5 g g^{-1}) in the upper layers compared to that in the lower layers (558.5) and 1099.3 g g^{-1}). Reactivity index (range 0.3-3.7) revealed that OM in the upper few centimeters, especially in the lower estuarine region, was more reactive to that in the deeper layers.

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Abstract The Godavari River, the third largest river of India, has been sampled for Particulate Inorganic and Organic Carbon (PIC, POC), Particulate Nitrogen (PN), and Particulate Amino Acids (PAA, including 2 hexosamines (HA)). During the dry season Particulate Organic Matter (POM) in the upper reaches is relatively fresh and autochthonous, in the lower reaches it is degraded and inorganic suspended matter content is higher here. In the wet season (wet monsoon) heavy rains cause a basin-wide flushing of humus from entire catchment area consequently POM in the river is mainly degraded and allochthonous. Annual transport of the Godavari River amounts to 2.81 x 10^6 ton POC, 0.29 x 10^6 ton PN and 0.10 x 10^6 ton Particulate Amino Acid Nitrogen. These amounts rank the Godavari River to one of the most important organic carbon transporting rivers in the world.

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Abstract Analysis of multi-date satellite sensor data and maps indicated loss of 1836 ha of land during 1976-2001 along the Godavari deltaic coast resulting in displacement of coastal communities and mangrove destruction. Decrease in sediment loads from an annual average of 145.26 million tons in 1971-79 to 56.76 million tons during 1990-98, apparently due to construction of dams, largely diminished vertical accretion at the delta, while continued coastal subsidence that might have been accentuated by possible neotectonic activity and consequent relative sea level rise led to shoreline retreat. The

extant conditions indicate that the problem may compound in future causing irreparable damage to this important deltaic ecosystem.

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Abstract: Landings of silverbellies at Mandapam, Rameswaram and Madras and trends in the landings of silverbellies by bottom trawl at Mandapam, Rameswaram, Madras and Kakinada are shown in polygons for the years1982-83 from January to September.

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Abstract: Abstract: Mechanized boat (bottom trawl) landings of silverbelly at Mandapam, Rameswaram, Madras (Pudumanaikuppam) and Kakinada are given in polygons for the years 1982 and 1983 from January to June.

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Abstract□ Andhra Pradesh is estimated to have 762.51 ha of brackishwater area under prawn culture. Prawn culture in brackishwater ponds as well as in paddy fields converted into prawn ponds is picking up fast in the coastal districts of Andhra Pradesh, especially in East Godavari, Krishna and Guntur districts. There are more than 200 ha of brackishwater areas suitable for prawn culture in west Godavari district alone. More and more are being brought under prawn farming in this district. Semi-intensive culture technology is employed by the fish farmers. The average yeild is estimated at 450 kg/ ha/ crop. This paper presents and discusses the status of prawn culture in Andhra Pradesh, identifies the constraints and suggests strategies for bringing the abundantly available brackishwater areas under scientific prawn culture to increase the yield from these ponds.

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199. □ha, P.K., Tiwari, □., Singh, U.K., Kumar, M., Subramanian, V. (2009). Chemical weathering and associated CO_2 consumption in the Godavari river basin, India. Chemical Geology. 264□364-374

Abstract: The study gives insight into the source of major ions concentration and their seasonal variability, chemical weathering rates and associated CO_2 consumption in the Godavari River Basin (GRB). The results show that the Godavari river basin water was mildly alkaline, with a wide range of TDS (40 to 550 mgL^{-1}). The most dominant anion was HCO_3-followed by Cl^- and the most dominant cation was Ca^{2+} followed by Na^+ for all three sampling seasons. The average molar ratio of Cl^-/Na^+ was 0.59 in pre-monsoon, 0.51 for post monsoon and 0.66 in monsoon, which is lower than the values, reported in earlier studies. The range of precipitation corrected molar ratio for (Ca^{2+}/Na^+) was 0.20 to 1.84 in pre-monsoon, 0.59 to 1.59 in post monsoon and 0.35 to 2.09 in monsoon season, (Mg^{2+}/Na^+) was 0.26 to 1.18, 0.24 to 0.62 and 0.17 to 1.42 in pre-monsoon, post-monsoon and monsoon respectively, while (HCO_3^-/Na^+) was 2.08 to 7.0 in premonsoon, 1.98 to 4.05 in post-monsoon and 1.67 to 5.79 in monsoon, which indicated the influence of basalt weathering on river water chemistry. Factor analysis indicated the vital role of silicate and carbonate weathering along with atmospheric and anthropogenic input that govern the water chemistry of the GRB. The chemical weathering rate of GRB varied from 17.61 to 68.16 $tkm^{-2}y^{-1}$with an average of 39.49 $tkm^{-2}y^{-1}$in pre-monsoon, from 27.94 to 65.67 with the average of 42.02 $tkm^{-2}y^{-1}$in post-monsoon season and from 17.53 to 62.95 t $km^{-2}y^{-1}$with an average value of 34.69 t $km^{-2}y^{-1}$in monsoon. The associated CO_2 consumption rate due to chemical weathering in the GRB was 0.25x1012 mol y^{-1} which is 1.04% of the annual global CO_2 consumption (24x1012 mol y^{-1})by chemical weathering of silicate and carbonate rocks. The average annual CO_2 drawdown by Deccan trap (area 5x105 km^2)based on CO_2 consumption rate due to silicate weathering determined in this study was 0.29x1012 mol y^{-1}, (2.48) percent of the annual global CO_2 consumption (11.7x1012 mol y^{-1}) by silicate weathering (Gaillardet, J., Dupre, B., Allegre, C.J.,1999. Global silicate weathering and CO_2 consumption rates deduced from the chemistry of large rivers. Chemical Geology 159, 3-30) The present study was the first attempt to calculate weathering rate of Deccan trap using major ion chemistry of the Godavari River water, the third largest river in India. The study further provides the inventory for CO_2 consumption on river basin scale, which is an important consideration from the point of view of global warming.

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Abstract: A numerical model is described and applied to investigate the combination of the wind- and estuarially -driven of water off the east coast of India. A previous numerical modelling study has shown that the estuarial discharge from the Hugli and Mahanadi Rivers may, consistently with an interpretation of observational data, inhibit the occurrence of coastal upwelling as far south as Visakhapatnam. Further south of this location, there is a substantial discharge of freshwater during the monsoon season into Bay of Bengal from the Godavari River that might possibly have a similar suppressive effect on the coastal upwelling dynamics. In a process- orientated evaluation, it is shown that a representative rate of discharge from the Godavari River leads to a marked cross-shelf spread of a plume of relatively low-salinity water and that the associated dynamical structure is then correspondingly modified so as to weaken the local coastal upwelling tendencies in the surface layers of the ocean that would exist in the sole presence of south- westerly wind-stress forcing and the northern estuarial outflow.

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Abstract: The major protected marine organisms belonging to elasmobranches, marine mammals, turtles, molluscs, corals, gorgonids and holothurians. A total of 10 species of elasmobranches, 5 species of turtles, were under the list of protected animals. Among the total 1700 species of marine fishes, 189 are pelagic and 150 are deep water, 830 are reef associated and about 43 belong to threatened groups and 270 belong to the dangerous category. There are 38 marine and coastal protected areas including nine National parks and 25 wild life sanctuaries and four biosphere reserves. Marine and coastal ecosystems in India is complex and comprises of rivers, estuaries,lakes, backwaters , salt marshes , rocky shores, sandy shores, coral beds, sea grass areas, seaweed beds, mangroves and tidal grooves. Three gulfs i.e. Gulf of Mannar in the east coast, Gulf of Kutch and Gulf of Kambath along the west coast. Two island systems Lakshadweep and Andaman and Nicobar Islands add to the biodiversity of India. The need for the protection of marine organisms was emphasized.

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Abstract: Deep seismic sounding investigations along two profiles, one along and the other across the Godavari Ciraben delineate the northeastern extension of the Bapatla Ridge which separates the Godavari Graben from the Godavari (coastal) Basin. The Godavari Graben is filled with a maximum of 2.8 km thick Lower Gondwana (Upper Permian to Lower Triassic) sediments. It is inferred on the basis of P-wave velocities that the Upper Precambrian Pakhal Formation does not continue south of Paloncha. The Upper Gondwana (Upper Jurassic to Lower Cretaceous) rocks with marine incursions appear to continue towards the southeast for about 15 km from the exposures, below the Rajahmundry sandstone (Mio-Pliocene). Two-dimensional velocity modelling of the upper crust indicates a major interface at 3.5 km depth in the upper crust where the velocity increases from 5.4-5.5 km s^{-1} to 6.2-6.4 km s^{-1}. This interface shows a domal upwarp across the Godavari Graben which may be an indication of NE-SW crustal extension in this region. The deeper part of the crust consists of a large number of almost horizontal small reflector segments. Two-dimensional crustal velocity modelling for some correlatable wide-angle reflections yielded a three-layered structure below 10 km depth, with the Moho at about 41 to 43 km.

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Abstract: Facies reconstruction and reservoir modeling of ancient deltas entail possibilities of over-, or under-estimation of reservoir distribution and quality,

since such studies are often based on drill-hole data from a few locations, which could be potentially unrepresentative of the subsurface conditions. Recent studies indicate significant asymmetries in sedimentation on both sides of the river mouths in the wave-influenced systems. The present study is an attempt to analyze the asymmetry in the depositional processes and its implications to the possible reservoir heterogeneity of the Godavari delta. The Godavari delta on the east coast of India exhibits wave-influenced morphologies by the presence of a number of spits and barrier islands at its two active distributary lobes of the Gautami and the Vasishta. The most prominent of them is the 21-km-long Kakinada spit, which in its initial stages in the late nineteenth century had even deflected the Gautami course. As a result, the Gautami has built an extensive bay head delta behind the spit. The 1965 satellite imagery showed several other smaller spits, especially at the southwestern side of the Gautami mouth and the northeastern side of the Vasishta, whereas barrier islands that are welded to the main coast by the back barrier mudflats occur on the other sides of the mouths. A comparison of a series of satellite imagery showed that the 15-km-long shoreline in the central part of the delta in between the Gautami and the Vasishta lobes retreated landward by about 500 m during the past four decades. The material eroded from this part, presumably, drifted in both the directions - northeastward toward the Gautami and southwestward toward the Vasishta. As the river effluent plumes act like groynes, the material drifted alongshore from the central part toward both the lobes is deposited at the respective updrift sides of the distributary mouths forming into spits, whereas the river-borne sediments are deposited at the downdrift sides, initially as bars that emerge as barrier islands, followed by the backbarrier-bay-filling with riverine muds. The presence of closely spaced beach ridges on the updrift side, and wide mudflats interspersed with narrow sand bodies on the downdrift side, that especially characterize the Vasishta lobe, indicate asymmetry of the sedimentation processes and facies architecture. The likely occurrence of better quality reservoir facies on the updrift side than on the downdrift side, besides the presumable shore-parallel than shore-normal prodelta clinoforms of the bay head delta in the Kakinada Bay reflect the possible reservoir heterogeneity in the Godavari sedimentary basin, considering that similar asymmetries possibly prevailed in the geological past.

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Abstract: Interpretation of landforms through high-resolution satellite imagery, supported by accelerated mass spectrometry C14 dating of fossil shells recovered from the subsurface sediments, has indicated that the strand plain of the Godavari delta has evolved through three major stages of progradation. After the slow development of parallel to sub-parallel beach ridge/swale complexes during Stage I in a wave-dominated environment, a series of cuspate delta lobes with convergent beach ridges at the distributary mouths (both past and present) developed under conditions of increased fluvial energy during stages II and III. A part of sandy beach ridge complexes belonging to stage II was formed around 2 ka. On the other hand, during stage III, beginning around 1 ka, the strand plain experienced rapid growth of beach ridge complexes due to increase in sediments supply.

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214. Kakani, N.R., Sadakata, N., Shinde, V., Rajawat, A.S., Ajai. (2010). Subsidence of Holocene sediments in the Godavari delta, India. Frontiers of Earth Science in China.

Abstract: The present study is an attempt to estimate the rates of subsidence in the Holocene sediments of the Godavari delta along the east coast of India. Two boreholes dug at Panangipalli village in the delta revealed Early Historic culture material such as potsherds including Coarse Red ware, Red-Slipped ware, Coarse Grey ware, and Black and Red ware, between 3.5 m and 9.0 m below the surface level. This suggests that the location was a human settlement of Andhra Satavahana period which flourished in the region between 3rd century BC and 3rd century AD. The fossil shells of Anadara sp. recovered from the borehole further downward at 11.5 m below the surface are considered to represent the intertidal swampy/lagoonal environment. The age of the shells was determined through AMS 14C dating as 6400 cal a BP. The presence of about 2.5m thick intertidal swampy/lagoonal material between 9.0 m and 11.5 m depth, suggests post-depositional subsidence at an average rate of less than 1.0 mm $^{-1}$. However, a higher rate of subsidence of about 2.0 mm to 4.0 mm $^{-1}$ is estimated for the upper 9.0 m thick floodplain sediment unit which embeds the Early Historic culture remains. The increased rates of subsidence during the last two millennia when compared to the earlier period in this part of the Godavari delta could be due to anthropogenic activity of deforestation and agriculture leading to accelerated soil erosion in the catchment and increased sedimentation in the delta.

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Abstract: River deltas are the major repositories of terrestrial sediment flux into the world's oceans. Reduction in riverine inputs into the deltas due to upstream damming might lead to a relative dominance of waves, tides and currents that are especially exacerbated by coastal subsidence and sea-level rise ultimately affecting the delta environment. Analysis of multi-date satellite imagery and maps covering the Krishna and Godavari deltas along the east coast of India revealed a net erosion of 76 km^2 area along the entire 336-km -long twin delta coast during the past 43 years (1965-2008) with a progressively increasing rate from 1.39 km^2 y^{-1} between 1965 and 1990, to 2.32 km^2 y^{-1} during 1990-2000 and more or less sustained at 2.25 km square per yr during 2000-2008. At present the Krishna has almost become a closed basin with decreased water discharges into the delta from 61.88 km^2 during 1951-1959 to 11.82 km^2 by 2000-2008; and the suspended sediment loads from 9 million tons during 1966- 1969 to as low as 0.4 million tons by 2000-2005. In the case of the Godavari delta, although the water discharge data do not show any major change, there was almost a three - fold reduction in its suspended sediment loads from 150.2 million tons during 1970-1979 to 57.2

million tons by 2000-2006. A comparison of data on annual sediment loads recorded along the Krishna and Godavari rivers showed consistently lower sediment quantities at the locations downstream of dams than at their upstream counterparts. Reports based on bathymetric surveys revealed considerable reduction in the storage capacities of reservoirs behind such dams. Apparently sediment retention at the dams is the main reason for the pronounced coastal erosion along the Krishna and Godavari deltas during the past four decades, which is coeval to the hectic dam construction activity in these river basins.

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Abstract: The eustatic sea-level rise due to global warming is predicted to be about 18 to 59 cm by the 2100 (IPCC 2007), which necessitates identification and protection of vulnerable sections of coasts. Assessment of vulnerability level of Andhra Pradesh (AP)coast as an example is demonstrated in this study using five physical variables, namely coastal geomorphology, coastal slope, shoreline change, mean spring tide range, and significant wave height. A coastal vulnerability index was prepared by integrating the differentially weighted rank values of the five variables, based on which the coastline is segmented into low, moderate, high, and very high risk categories. About 43 % of the 1,030-km-long AP coast is under very high-risk, followed by another 35 % under high-risk if the sea level rises by 0.6 m displacing more than 1.29 million people living within 2.0 m elevation in 282 villages in the region.

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months old) formed bulk of the catch. A growth rate of 16-18 mm month^{-1} in M. monoceros 27.5-32.5 mm month^{-1} in P. indicus and 32.5-37.5 mm month^{-1} in P. monodon was discernible. In most of the species female dominated in almost all the months and also in the larger length groups. The species composition in the Godavari estuary during December and February-May was similar to that obtained in the marine catches landed at Kakinada Fisheries Harbor. This may be due to the existence of somewhat marine conditions (physico-chemical) in the estuary in those months.

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sedimentary petrologic provinces: Vokalpudi nearshore province-characterised by muscovite, biotite, opaques, tremolite/actinolite and clinopyroxene; Vokalpudi, offshore province-characterised by garnet, sillimanite, orthopyroxene, opaques and hornblende; Sand-spit offshore province-characterised by an elongated north south zone consisting of a mixed mineral assemblage like hornblende, opaques, muscovite, biotite, epidote, zircon, and relict offshore province-characterised by a patch of tremolite/actinolite of zircon. The sediments of the minerals across the shore are difficult to generalize in terms of steady increase or decrease. The present mineralogical variations and products are influenced by basic parameters like river regime, long shoe current, etc.

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Abstract□Mangroves are very specialized forest ecosystems found at the land-sea interface of the tropical and subtropical regions of the world bordering the sheltered sea coasts and estuaries. These forest systems are dominated by the salt tolerant halophytic seed plants that range in size from tall trees to shrubs and being restricted to the intertidal belts, which are exposed ability to function in poorly oxygenated, water-logged saline habitats. Mangrove ecosystems are economically significant and commercially important for their forestry products (ranging from firewood, timber and construction materials to tannins)and fisheries. Mangroves stabilize the coastal shoreline, render protection to the landmass from tidal surges, cyclonic storms and high winds. Mangrove ecosystems are inhabited by innumerable taxa of invertebrates and vertebrate fauna, illustrating the high productivity of the ecosystem. Mangrove forests provide nutritional inputs to adjacent shallow channels and bay systems that constitute the primary habitat of a large number of aquatic species viz. finfish, prawns, crabs, molluscs of commercial importance. Further the culture and capture fisheries are ultimately dependent upon a common resource sustained by the estuarine mangrove ecosystem, which is recognized as world□s most potential nursery. It is now a realized fact that the mangrove ecosystems, if properly managed, can satisfy multiple resource

made on a sustainable basis. With proper management, biologists believe that the economic benefits from these mangrove forests can be optimized.

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Abstract: The shelf sediments off Visakhapatnam along the east coast of India were studied in detail for their clay mineralogy with the objectives of understanding the provenance, transport pathways and dispersal pattern of the sediments. In addition to the seabed samples, residual soils and fluvial sediments from the hinterland were also studied for comparative purposes. Illite, smectite and kaolinite, constitute, in that order of abundance, the chief clay mineral groups in the shelf sediments beyond the sand zone. In the sand zone in water depths of less than 30 m smectite is dominant. A high smectite zone and a high illite zone were identified on the inner shelf, the high smectite zone being confined to the sand zone and paralleling the coast. This zone is influenced mostly by the Godavari River smectite derived from the Deccan traps and transported northward by longshore currents. The high illite zone covers the entire area beyond the sand zone where the influence of longshore currents is negligible. It is supplied by the Rivers Sarada and Gostani and by ephemeral streams draining the Eastern Ghat. The conspicuous absence of Chlorite and paucity of kaolinite in the shelf sediments shows that the influence of the river -borne sediments from the north is negligible.

Comparison with onshore sediments shows that provenance influences clay mineral composition, whereas northeasterly littoral drift influences their distribution.

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Abstract: The survey of meiofauna in the Gautami-Godavari Estuary yielded 12 groups of meiobenthic organisms. Nematoda (90.5 %) was the most dominant group followed by harpacticoid copepoda (3.7 %). Maximum and minimum (2,292 and 267 no./10cm sq) densities were recorded in the lower and upper reaches of the estuary respectively. Significant positive correlation was observed between salinity and meiofauna density from mouth to head end of the estuary. 27 species of harpacticoid copepods belonging to 11 families and 22 genera were recorded. An attempt has been made to recognize ecologically equivalent meiobenthic harpacticoid copepod species in the estuarine systems.

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Abstract: The von Bertalanffy growth parameters are estimated as Loo = 158.4 mm, K = 0.58 per year a - d tp = -0.024 year. The yield per recruit analysis shows that the yield of L. bindus can be increased by increasing the cod end mesh size of trawl nets.

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306. Murthy, S.V. (1987). Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. Marine Biological Association of India. 27 (1-2)39-48.

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310. Murthy, V.S. (1989). Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada. In Contributions to tropical Fish Stock Assessment in India. Papers prepared by the participants at the FAO/DANIDA/ ICAR National follow-up training course in Fish Stock Assessment, Cochin, India, 2-28 November, 1987.

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Abstract The length-weight relationship of Leiognathus bindus can be described by the equation log W -4.77709 2.96182 log L. The length at first maturity is estimated as 80 mm. This species is a fractional spawner and appears to release the ova at least in two spawnings during the course of one year. It appears to spawn in almost all months, with a peak during December-

February. Based on length-frequency distribution, the species attains 65 and 90 mm at the completion of first and second year respectively. p. 965.

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Abstract□The biology and population dynamics of Secutor insidiator from the trawling grounds off Kakinada were studied. The estimated length at first maturity is 90 mm and the spawning season is protracted with a peak during □anuary-March period. The von Bertalanffy parameters of growth in length are estimated as Loe-123 mm, /f□1.2 per year and to□0.01 year. The estimated lengths on the completion of first and second years are 86 and 112 mm respectively. The length-weight relationship can be described by the equation□ log W(g)□ -5.73713 □3.43654 log L (mm). The instantaneous rate of total mortality during the period is estimated as 6.1 and the values of natural mortality rate, by different methods, are estimated as ranging from 1.8 to 2.6. Length and age at first capture are 80 mm and 0.87 year respectively. Under the present value of tc, yield increases with increased F without reaching a maximum; highest yield, however, can be obtained at tc ranging from 0.5 to 0.7 with the present Z and different value of M considered.

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Abstract□The blood clam Anadara granosa spawned in the shellfish hatchery laboratory, Tuticorin on two occassions. The fertilized eggs measured 50-60 □ in diameter, morula larvae developed in 3-4 hrs and the trochophore stage was reached in 5hrs. The straight hinge stage was attained in 20-26 hrs after fertilization and these larvae measured 83 □ length and 65.5 □ height. Advanced umbo stage was reached on day 12 (size 155.3 x140.5 □) and on day

16, majority of the larvae were in pediveliger stage with an average size of 182.7x162.9µm. Settlement began on day 16 and majority of the larvae were set on day 18. The growth of the spat in the hatchery is described by the exponential equation L=0.0002739 D2.2623 where L is length in mm and D, days. On day 59, the spat attained an average size of 2.42 x 1.70 mm. A total of 8090 spat were produced. During the nursery rearing in the field, the seed clam attained 20 mm average length in the following 5 months. In India, A. granosa seed were produced for the first time. The significance of this study for the mass production of the blood clam seed in the hatchery and its relevance to undertake blood clam culture are highlighted.

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Abstract: Species-wise break up value weight was 26, 2661 kg with the percentage of 6.44. Catch rates varied in each boat and Leiogrmthus spp. (10-25 mm) were dominant

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Abstract: With the progradation of Godavari delta in the east coast of India, increase in iron (Fe) concentrations in the groundwater was observed. High concentrations of Fe (greater than 10 mgl^{-1}) were observed in khondalite and charnockite formations. A lower portion of the Godavari river basin, viz. East Godavari district was chosen for the study of the distribution of iron with special reference to the existing geological formations and the geomorphology of the area. The concentration of iron was observed to vary from below detection limit to 69 mgl^{-1} in the groundwater while it was less than 1 mg Fel^{-1} in river and spring waters. The Fe of river water was reduced due to seawater mixing and the electrical conductivity (EC) was increased approximately to half of the seawater conductivity. Unlike the mixing of seawater at the surface, the same seawater mixing with groundwater yielded a water having similar order of EC with relatively high Fe. Fe was inversely related with nitrate in the groundwater. Fe was found to correlate considerably better with manganese in fluvial and coastal alluvium zones. The locations having higher Fe in delta are suspected to be related to palaeo channels. The association between Fe and Mn and their negative association with NO^3 may be due to the possible autotrophic denitrification that might have taken place in the subsurface.

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Abstract□ Based on the length and weight data of Metapenaeus monoceros (Fabricius) collected from trawl landings at Cochin Fuheriea Harbour during 1991-92, the relationship between total length and total weight and other

dimensional relationship have been worked out. These relationships are significantly different between males and females and hence, separate equation for each sex is given in this account.

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Abstract: Based on the biological data of Metapenaeus monoceros collected from shrimp trawler landings at Cochin Fisheries Harbour during 1991-93, an account on the reproductive biology of this species is given in this paper. The shrimp is a continuous breeder with two major spawning periods during December - April and August - September. The minimum size at maturity in females and males was 114 and 95 mm respectively. Females in general, outnumbered males and the average sex ratio of females and males during the period was 57.1:42.9. The mature ova measured between 0.145 and 0.261 mm. Ovary weight in comparison with total length and total weight was found to be the best fit against fecundity in M. monoceros.

327. Nandakumar, G., Damodaran, R. (1998). Food and feeding habits of the speckeled shrimp Metapenaeus mononceros Fabricus. Journal of Marine Biological Association of India. 40 (1 and 2):30-43.

Abstract: The food and feeding habits of Metapenaeus monoceros (Fabricius) from Cochin region are given in detail in this paper. Differences in food preference for this species had been noticed between marine and brackish water environment while M. monoceros from inshore grounds preferred polychaetes as their main food item, in Cochin backwaters, they mainly fed on crustaceans. Diurnal variation in the feeding intensity was noticed, where, M. monoceros fed more in nights than the day hours. Females in different stages of maturity were found to feed more vigorously than the immature ones. Juveniles and adults in the inshore waters did not show any significant difference in their food preferences. The present study shows that M.monoceros is carnivorous, mainly depending on animal food items, irrespective of size and sex in marine as well as estuarine conditions.

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332. Narasimha Murthy, A., Venkataramana, P.V., Lovaraju, G.Ch., Lavanya, R. (2008). Copper and Iron metal concentration in waters of river Gautami. National Seminar on Water and Health.

Abstract: Water is a prime necessity of life. Drinking water should be clean and pure to avoid many water borne diseases. The present study is aimed in the determination of heavy metal concentration in waters of Gautami River in East Godavari region. Water samples collected from ten stations are analysed for parameters pH, EC, also the concentration of metals "Cu" and "Fe" are measured by Atomic Absorption Spectrometer (AAS). The level of "Fe" at nine stations are within the permissible limits of WHO drinking water standards (1mgl^{-1}) except at Down stream Yanam (1.074mgl^{-1}). The levels of "Cu" ranges from (0.0.108mgl^{-1}) and the values are within the permissible limits. pH ranges from 7.32-8.35 and is within the permissible limit (6.5-9.2). E.C. values ranges from (0.174-34,200mumho cm^{-1}) and are extensively high at Yanam region. The higher values of E.C. indicate the salinity of water at Yanam and hence the waters at Yanam are not useful for drinking purpose.

333. Narasimha Rao, G.M., Murthy, P.P. (2010). Mangroves and Associated Flora of Vashista and Vainateyam estuaries, A.P. India. Notulae Scientia Biologicae. 2 (4):40-43

Abstract: Mangroves are highly productive ecosystems occurs intertidal regions only. Mangroves and associated flora occurring in two major estuaries of Godavari river (India) were studied using transect with 4x4 m^2 quadrats and the quadrat samples were analyzed. Seasonal data were collected on environmental, hydrographical and chemical observations from three different stations of the two estuaries. Low values in Secchi depth, salinity and pH were reported during the monsoon season, while higher values were reported in pre-monsoon and post monsoon seasons. In the present study three mangrove species and nine associated species were reported. Transect studies in these two estuaries showed that mangrove and halophytes occurred up to 40 meters from water front region. In some places mangrove vegetation was in the form of long strips only. In Vainateyam estuary, the species with the highest density was Suaeda monoica whereas the species with lowest density was Avicennia officinalis. In Vashista estuary, maximum density was reported for Suaeda maritima and minimum density for Avicennia officinalis. The maximum height in these two stations varied from 5 to 8 meters only. Percentage frequencies of DBH (Density at Breast Height) classes were estimated. In the present study only two diameter classes were reported. This is indicative of the small and bushy mangrove vegetation in the region studied. Human interference, urban settlements and aqua industry play a critical impact on the survival of these tropical ecosystems. If management and conservation programmes are not undertaken, these ecosystems may be depleted.

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335. Narasimham, K.A. (1986). The windowpane oyster resources of Kakinada Bay. R and D Series for Marine Fishery Resources Management. Central Marine Fisheries Research Institute, Cochin. pp. 133.

336. Narasimham, K.A. (1968). Studies on some aspects of biology and fishery of the Cockle, Anadara granosa Linnaeus, from Kakinada bay. Ibid., Marine Biological Association of India. pp. 28-29.

337. Narasimham, K.A. (1987). Biology of Crossostrea madrasensis of Kakinada. Bulletin of Central Marine Fishries Research Institute. 3840-47.

338. Narasimham, K.A. (1988). Biology of the blood clam Anadara granosa Linnaeus in Kakinada Bay. ournal of Marine Biological Association of India. 30 (1and 2)137- 150.

Abstract A. Granosa spawns throughout the year and the major spawning months vary between years. There can be 2-4 reproductive cycles in a year. Males attain first maturity at 20 mm and females at 24 mm length. The male, female ratio during different months, years and also in different length groups is 11. The monthly average condition index (CI) based on the percentage of wet flesh weight in total weight varies from 15.1 to 23.1 and the same expressed as percentage of dry flesh weight in wet flesh weight ranges from 17.2 to 24.2. The trends in the values obtained by these two methods are comparable. The CI does not vary in relation to length. The infestation of A. granosa by the pea crab Pinnotheres alcocki varies from nil to 46 during different months (average 10.8). In the crab infested clams there is no damage to the organs of the host. The CI is low in 41.1 of the crab infested samples when compared to the CI obtained in uninfested clams. The estimated parameters of the von Bertalanffy growth equation are Lus 73.4 nun, K 0.5816year^{-1} and t 0.4088 yr. A. granosa attains 41.1, 55.3 and 66.3mm on completion of 1, 2 and 3 years respectively. Various morphometric and length-weight relationships are studied.

339. Narasimham, K.A. (1973). On the molluscan fisheries of the Kakinada bay. Central Marine Fisheries Research Institute, Unit, Kakinada-2. Indian ournal of Fisheries. 20209-214.

340. Narasimham, K.A. (1980). Culture of blood clam at Kakinada. Marine Fishes Information ServiceTechnical and Extention Series. 207-9.

341. Narasimham, K.A. (1983). Experimental culture of the blood clam Anadara granosa Linnaeus in Kakinada bay. Proceedings of the Symposium on Coastal Aquaculture. Held at Cochin, Marine Biological Association of India.Cochin, India. 2551-556.

Abstract On an experimental basis the culture of blood clam Anadara granosa was taken up in the Kakinada bay. Three pens made of split bamboo screens, each measuring 100 m2, were stocked with clams of 25.1, 23.4 and 24.3 mm mean size at the rate of 3,000, 7,000 and 14,000 per pen respectively in May 1979. In order to determine the optimum stocking density 6 deal wood cases were filled with mud up to 10cm depth and were stocked with clams at the rate of 40 to 240m^{-2}. The results of these studies together with the environmental data are given in this paper.

342. Narasimham, K.A. (1985). Ecology of the clam bed in the Kakinada Bay. ournal of Marine Biological Association of India. 27 (1 and 2)97- 102.

343. Narasimham, K.A. (1987). Ecology of the clam bed in the Kakinada Bay. ournal of Marine Biology Association of India. 27 (1and 2)97-102.

AbstractIn the cam bed the monthly average water temperature varied from 24.8 to 33.5 ^{0}C, salinity 14.46 to 35.53 , dissolved oxygen 3.78 to 7.00 mll^{-1}, pH 6.55 to 7.00, Phosphate -P 1.98 to 7.08 g l^{-1}, Nitrate -N 1.70-6.62 g l^{-1},Nitrite -N 0.66 to 2.94 g l^{-1} and Silicate-Si 24.68 to 78. 00 g l^{-1}. The monthly average organic carbon of the sediment ranged from 0.55 to 1.26 . The seasonal variations of these parameters are studied. The habitat preference of the blood clam Anadara granosa are discussed in relation to some of the environmental factors.

344. Narasimham, K.A. (1988). Aspects of the bood clam, Anadara granosa Linnaeus culture in Kakinda Bay. Central Institute of Fisheries Research Institute, Cochin. 42313-317.

Abstract A.granosa of mean length 25.2-25.9 mm, when grown in boxes for about 4 and half months did not reveal any disparity in the growth rate at densities of 50-100/0.25 m^2 but at 125-150/0.25 m^2 the growth rate is significantly reduced. Growth in weight showed similar reduction. It is shown that in the Kakinada bay, a stocking density of 100 clams/0.25m^2 of about 7g average weight gives the maximum production of marketable size (25 g) A.granosa in about 4 and half months. In the absence of a pen enclosure, field culture of A.granosa gave a production rate of 21t^{-1}ha^{-1}6months^{-1} with 41.5 retrieval. Although the clams have restricted movements their mobility is large enough to reduce both the retrieval and production rates by about 50 if pen enclosure is dispensed.

345. Narasimham, K.A. (1988). Biology of the blood clam, Anadara rhombea Born in Kakinada Bay. Central Marine Fisheries Research Institute, Cochin. 42 138-144.

Abstract A.rhombaa occurs in small quantities in the Kakinada bay and is incidentally collected while fishing for the more abundant A. granosa. Males attain maturity at 22 and females at 24 mm length. It spawns during December-April (rarely in May) and major spawning is indicated in anuary-March. A single or two reproductive cycles occur during the spawning period. Increase in the ambient water temperature and salinity seem to induce spawning. The proportion of males and females during different months, years and also in different length groups generally conforms to 1:1 ratio. The average monthly condition index (CI) expressed as percentage of wet flesh weight in total weight, varies from 96 to 157. The CI does not vary in relation to length. It is high before or to the beginning of spawning and low when majority of the clams hive released bulk of the gametes. In the post-spawning period the CI is again high, probably due to the accumulation of body reserves. The estimated values of the Parameters of the yon Bertalanffy growth equation at Lco=90.2mm, K=04573 yr^{-1} and t=06315 yr^{-1}. A.rhombaa axxains 47.4, 63.1 and 73.1mm on completion of 1,2 and 3 years respectively. Various morphometric and length weight relationships are studied.

346. Narasimham, K.A. (1991). Present status of clam fisheries of India. Journal of Marine Biological Association of India. 33 (1-2):76-88.

Abstract: Among the exploited bivalve resources of India, clams are by far the most abundant. Several species belonging to a number of families constitute the clam resources and they are exploited along the Indian Coast. In recent times a steady export marker for the frozen clam meat is being developed. The distribution of clams, their biology, ecology, physiology, exploitation, resource potential, utilization and marketing are reviewed in this paper. Based on this review, the lacunae in the present state of our knowledge for the development of clam fisheries and the constraints thereof are identified. In view of their sedentary habits and easy accessibility for exploitation, the clams are particularly vulnerable for overexploitation. The thrust areas where research input is required for the rational exploitation of clam resources are highlighted in this paper.

347. Narasimham, K.A. (1994). Maturity spawing and sex ratio of the Ribbon fish Trichurus lepturus Linnaeus of Kakinada. Journal of Marine Biology Association of India. 36 (1and 2):199-204.

348. Narasimham, K.A.(1988) Fishery and the population dynamics of the blood clam Anadara granosa (Linnaeus)in the Kakinada bay. Central Marine Fisheries Research Institute. 1(42):130-135.

Abstract: The blood clam, Anadara granosa is fished throughout year in the Kakinada bay by fishermen residing in 15 villages. During 1978-81 at Yatlmoga Kakinada the blood clam, effort and catch per unit effort varied from 104 to 222 t, 3414 to 6295 man-days and 30.4 to 35.3 kg/man day respectively. The instantaneous rates of total (Z), natural (M) and fishing (F) mortality rates are estimated at 3.9, 1.3 and 26 respectively. In the presently exploited population, other parameters estimated are the age at recuitment (tr)

= 0.29 yr, age at first capture (to)= 1-0 yr and the maximum age (ta)= 5.62 yr. At present the yield in weight per recruit (Yw/R) is about 9-5g . It increases with increase in F and it is less for greater values of tc. It is suggested that at the current level of F, maximum Yw/R of 1042 g is possible if tc is reduced to 0.6 yr.

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Abstract: The trawl fishing industry in the Kakinada area had shown a phenomenal growth in the past decade. The important demersal fisheries resources during the period 1971-74 are given in this paper. The economics of commercial trawling by the three types of boats operated by the industry are worked out.

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Abstract:East Godavari region especially Kakinada and its surroundings have become places for rapid industrialization. As a result of this activity the industrial waste will have their impact on the quality of ground water sources. Presence of Chloride can contaminate fresh water streams and lakes. Fish and aquatic communities cannot survive in high levels of chloride. The present study is mainly focused on selective characterization of ground water to assess the chloride contamination. Twelve samples of ground water are collected and analysed for parameters such as pH, EC and Chloride. pH ranges from 8.01-8.66, EC values range from 960-3460 muhos/cm^{-1}. The chloride level is observed from 79.97mgl^{-1} to 699.78mgl^{-1}. The results reveal that pH is within the permissible limits. Electrical Conductivity is observed to

be high in five areas while chloride (699.78mgl^{-1}) in Madhavapatnam area is above the permissible limit of WHO drinking water standards.

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Abstract: In the inshore catches, silverbellies were in fourth place in the order of abundance but conspicuous absence was noticed from the deeper zone.

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Abstract: The coastal zone represents varied and highly productive ecosystems such as mangroves, coral reefs, sea grasses and sand dunes. These ecosystems are under pressure on account of increased anthropogenic activity on the coast, as a result of globalization. It is necessary to protect these coastal ecosystems to ensure sustainable development. This requires information on habitats, landforms, coastal processes, water quality, and natural hazards on a repetitive basis. In India, remote sensing data, especially Indian Remote Sensing (IRS) data, having moderate (23-36 m) to high spatial resolution (6 m), have been used to generate database on various components

of coastal environment of the entire country. However, the moderate resolution data provide macro-level information on 1:250,000 and 1:50,000 scale about the condition of habitats, type of landforms and areas under erosion and deposition. The major advantage of remote sensing data is monitoring of change periodically. The combination of moderate and high-resolution data provided detailed coastal land use maps on the 1:25,000-scale for implementing coastal regulation measures. The classification accuracy have been achieved is 85% or better at 90% confidence level. Mangrove areas were classified up to community level through contextual editing. Various zones of coral reef were identified; however, species level information is not possible to generate using such data. The knowledge about bio-optical properties of water is vital for coral reef and sea grass bed monitoring. The OCEANSAT I (IRS P4) Ocean Color Monitor (OCM) data provide useful information on the phytoplankton and suspended sediments. The information on phytoplankton and sea surface temperature (SST) has been used to predict potential fishery zones routinely. The information on sediments provides some insight in to the movement of sediments along the coast. Satellite-derived derived information were integrated with the other collateral information through GIS to select sites for aquaculture, zoning of coastal zone for regulatory purpose and assess possible impact of sea level rise. Realizing the value of the remote-sensing derived information, the state and central agencies responsible for the conservation of these ecosystems are increasingly adopting remote sensing data for their routine use.

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Abstract: Water is a universal solvent and renewable resource. Three unique properties of water make it to get polluted. As a result of human activities water becomes less suitable for drinking, domestic, agriculture, industrial, recreational, wildlife and other uses. The present is based on characterization of ground waters of city Kakinada. Ground water samples from twelve areas in Kakinada city. Ground water samples from twelve areas in Kakinada city are

collected and are analyzed for parameters like pH, EC and Sulphate. pH is observed to be 8.01-8.66. EC ranges from 960-3460 muhos cm^{-1}. The sulphate ion conectration is observed from a minimum of 41mgl^{-1} to 298 mgl^{-1}. The results indicate that the parameters pH and Sulphate are within the permissible limits of WHO drinking water standards. While the EC values at five areas indicate its salinity.

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Abstract Mitochondrial DNA, cytochrome oxidase-1 gene sequences were analyzed for species identification and phylogenetic relationship among the very high food value and commercially important Indian carangid fish species. Sequence analysis of COI gene very clearly indicated that all the 28 fish species fell into five distinct groups, which are genetically distant from each other and exhibited identical phylogenetic reservation. All the COI gene sequences from 28 fishes provide sufficient phylogenetic information and evolutionary relationship to distinguish the carangid species unambiguously. This study proves the utility of mtDNA COI gene sequence based approach in identifying fish species at a faster pace.

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Abstract: Pure and clean drinking water has significance in preventing many water borne diseases. The objective of the present study is to characterize certain parameters such as pH, E.C. and metal concentration in water of river Godavari. Ten samples of water are collected and analysed for parameters such as pH, EC and Zn metal. The results indicate that pH ranges from 7.3-8.3 and these values are within the permissible limits at WHO drinking water standards (6.2-8.5). E.C. values are within the permissible limits at six stations (174 -600 muhos cm^{-1}), while they are higher at four stations (12,410- 34,200 muhos cm^{-1}). The concentration of Zinc ranges from (0-0.079 mgl^{-1}) and are within the permissible limits (3 mgl^{-1})of WHO drinking water standards.

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Abstract: Wide variations are observed in textural characters along different geomorphic domains viz. the course of river and across the coast i.e. berm, fore, inter and rear dune along 60-km stretch between Varaha river and Mulapeta creek due to the varying geomorphic processes. River sediments from upstream towards confluence are coarse to medium, moderately to poorly sorted, and negatively skewed and meso kurtic to very lepto Kurtic whereas in mid-stream they are medium grained, well sorted, coarse to fine skewed and platy kurtic in nature. Berm zone sands are medium to fine, moderately well sorted, negatively skewed and leptokurtic. Dunal sands are characterized by medium to fine sand moderately well sorted, finely skewed (+ve) and meso kurtic. Scatter plot of standard deviation vs mean size demarcates between fluvial and dunal environments while skewness vs mean size plot clearly distinguishes between river and dune environment. The negatively skewed characteristics of river, berm and creek sediments pertain to high-energy environments involving multidirectional flow, while positively skewed dune areas correspond to relatively low energy environment. The linear discriminate function (Y) and the vectors (V1 and V2) reflect that the

river, berm and dune samples belong to the fluvial, beach and dune environments respectively.

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deterioration or water quality of the bay, which is known to receive effluents from the adjacent industries and city.

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Abstract: Wetlands of India, estimated to be 58.2 million hectares, are important repositories of aquatic biodiversity. The diverse eco-climatic regimes extant in the country resulted in a variety of wetland systems ranging from high altitude cold desert wetlands to hot and humid wetlands in coastal zones with its diverse flora and fauna. The review deals with the status and distribution of wetlands and causes and consequences of wetland losses. It also provides an overview of the use of Remote Sensing and Geographic Information System (GIS) tools in flood zonation mapping, in monitoring irrigation and cropping patterns, water quality analysis and modelling, change analyses and in mapping of surface water bodies and wetlands. The review provides a methodology and an action plan for evolving a nationwide network of conservation preserves of wetlands. The major elements of this methodology involve use of IRS LISS III sensors for delineating turbidity, aquatic vegetation and major geomorphological classes of wetlands. An extensive fieldwork to generate attribute information on biodiversity and socioeconomic themes is a significant component of the suggested methodology. GIS tools to integrate habitat information with the field information are envisaged to be the final component in evolving a conservation network of wetlands for the entire country.

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Abstract Mangrove vegetation in the parts of Guntur district, Andhra Pradesh, India is highly disturbed due to increasing population pressure, overexploitation, overgrazing and rapid conversion of mangroves rich areas into aquaculture ponds. In the present study an attempt has been made to quantify the diversity through relative abundance data obtained through phytosociological studies. In the present study mangrove rich areas viz. Kothapalem and Nizampatnam have been undertaken to study the taxonomic diversity and biodiversity assessment. Taxonomic survey has been carried out from wide range of habitats mudflats, flat lands, river banks, tidal creeks and along the canals. Through stratified random sampling, 20 quadrates of 10 x 10 m were laid down at two different sites, Kothapalem and Nizampatnam. The number of plants in the quadrats is listed along with the number of individuals of each species (count quadrate method). Dispersion of plant species in a community (frequency), numerical strength (density) and dominance were studied following standard methods.

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Abstract: There are extensive mangrove forests at the mouths of the rivers on the east coast of India, and the molluscs inhabiting the mangroves are quite characteristic. In spite of the extensive mangroves with their characteristic molluscan fauna, only a few attempts have been to study this group from such habitats. Hence an attempt is made to describe the molluscan fauna from the extensive mangrove forests supported in the Godavari and Krishna estuarine systems.

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Abstract: Distribution and flux of suspended sediments and turbidity in the Krishna estuary were examined. TSM showed an increasing trend from head to mouth. A vertical gradient from surface to bottom prevails at all stations in monsoon. Distribution to TSM in tidal cycle shows relatively high load during high tide indicating the dominance of saline water. Turbidity exhibited relatively high values in monsoon and low values in premonsoon and postmonsoon. Horizontal variation of turbidity closely resembles that of TSM with an increasing trend from head (St. 1) to mouth (St.3) of the estuary. Turbidity maximum, noticed with different intensities in all seasons. This was due to gravitational residual circulation and setting and resuspension processes of the fine sediment. The spatial distribution of turbidity resembles that of TSM in all seasons. Minor deviations observed in the distribution of turbidity from that of TSM were attributed to the differences in nature, particle and shape of TSM.

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Abstract: Olive ridley sea turtle, Lepidochelys olivacea is protected under schedule-I of the Indian Wildlife (Protection) Act, 1972. The IUCN Red Data Book (RDB) is assigned endangered status to Olive ridley turtles for conservation and management from all possible threats. The nesting population of Olive ridley turtles are migrating from Indian Ocean to the mass nesting (Arribada)beaches located in Orissa state through the coastal waters of Andhra Pradesh during winter months (November to February). A considerable size of migratory nesting Ridley population utilizes the beaches of

North Andhra Coast for their sporadic nesting activity. In recent times the breeding population is in declining trends due to direct threatening factors of incidental mortality at offshore waters to predation of eggs and hatchings on nesting beaches. Besides, loss of nesting sites and foraging habitats nearer to mangrove habitats are the indirect threats. Conservation and management programs have been initiated at Northern Andhra Pradesh Coast (NAC) for the protection of Olive ridley sea turtle from all possible threats. In situ (natural) protection to eggs and hatchings at nesting beaches and conducted awareness campaign at all fishing villages for implementation of Turtle Excluder Device (TEDs) to reduce incidental catches at offshore waters and protection to nesting habitats.

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Abstract: Studies were conducted to assess the traditional and subsistence utilization patterns of mangrove forest resources in Godavari region of Andhra Pradesh to ascertain their role in livelihood income generation and subsistence of local communities. Godavari mangrove forests are situated between 16°50' to 17°18'N latitude and 80°10' to 82° 25' E longitudes on east coast of India, spread to an extent of 265 sq.km areas. The mangrove flora of the Godavari region consists of 30 species (16 mangrove and 14 associates) belonging to 19 families. Faunal category is enumerated to be a total of 124 species consist of shell-fish, 30 species, crustaceans, 24 species and fishes, 70 species, which are abundantly found in mangrove habitats. The mangrove forest resources (flora and fauna) have been formed in to an important natural resource base to the local communities for traditional utilization and subsistence income generation. For traditional practices the local communities utilize the mangrove plant materials in housing construction, to make fishing implements and as ingredients for house hold medicinal preparations to cure body ailments and disorders. Besides mangrove flora, they depend on mangrove fauna (molluscs, crustaceans, fishes) to earn their livelihood and subsistence economy through selling of fishery products in local markets. In recent times the Godavari mangrove habitats and associate biological diversity. Sustainable management strategies have been recommended for conservation of the mangrove forest resources of the Godavari region, Andhra Pradesh, India.

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Abstract: The present study is aimed to assess the Nitrate concentration in ground waters of Kakinada City. Twelve samples of ground water are collected and analysed for parameters such as pH, EC, and nitrate. The pH values are observed to vary from 8.01-8.63. The electrical conductivity range from 960-3460 muhos cm^{-1}. In seven areas the Nitrate levels range from 66-250 mgl^{-1} and these are above the permissible limits (45 mgl^{-1}) of WHO drinking water standards while in the remaining five areas the Nitrate levels range from 0-40 mgl^{-1} which are below the permissible limits. The results reveal that water with higher levels of Nitrate in seven areas is hazardous to health.

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Abstract: The presence of gas hydrates along the Indian continental margins has been inferred mainly from the bottom simulating reflection/reflector (BSR) and the gas hydrate stability zone thickness map of India. Multidisciplinary investigations have been carried out in the Krishna-Godavari offshore area along the eastern continental margin of India which is known for its hydrocarbon potential. Processed multibeam data provided a high resolution seafloor mosaic with a fine scale geomorphology. Deep tow digital side scan sonar, multi frequency chirp sonar and 3.5 KHz sub-bottom profiler records depict various kinds of gas escape features over the regions where BSRs are prominent. Geochemical analyses of the 5 m-long cores show a general decrease trend in the pore water Sulphate concentration, while the gas chemistry reveals an increase trend of methane concentration with core depth. Total Organic Carbon varies from 0.6 to greater than 2.0% and $CaCO_3$ from 5.0 to greater than 29%. Observed geophysical, geochemical and microbial proxies suggest the likely presence of gas hydrates in the Krishna-Godavari offshore area. Recent drilling work carried out onboard JOIDES Resolution confirmed the presence of massive (greater than 80 m thick) accumulation of gas hydrates, and fully developed gas hydrate system in the Mahanadi offshore area and the Andaman Sea.

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Abstract: The expansion of agriculture and aquaculture farms in the coastal areas has led to conversion of mangroves in the recent past. The extent of mangroves has also changed due to the erosion of mangroves along the coast and accretion near river mouths, leading to the formation of new mangrove areas. This study has been undertaken in the mangroves of the Godavari estuary, Andhra Pradesh, India to understand the changes in the extent of mangroves, namely accreted mangroves, erosion due to wave action and river water flow during floods, and changes due to forest restoration between 1986 and 2001, through remote sensing. The geomorphological changes due to river water flow in and around the mangroves have also been analysed. The changes in the vegetation due to forest restoration and natural regeneration are appreciable, while the changes in the area due to erosion and accretion are more or less equal. An analysis of the remote sensing images of 1986 and 2001 reveal that the mangroves outside the forest boundary have been converted to aquaculture. The sand spit of Hope Island has changed with time and has grown nearly 2.6 km between 1937 and 2001.

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Abstract: Participatory management of natural resources in the developing countries gained greater importance in recent years. The M. S. Swaminathan Research Foundation (MSSRF) which is similar to Joint Forest Management of India implemented community participation in mangrove conservation and management program in Godavari and Krishna mangroves of Andhra Pradesh. The program involved multiple stakeholders, i.e., the state forest department, community-based organizations (village- level institutions), and the non-governmental organizations MSSRF, in the management and conservation of mangroves. Village level institutions were formed and strengthened by enhancing leadership skills. Participatory rural appraisal (PRA) and other participatory tools were used to identify the status of the resources, their utilization pattern and the issues related to mangrove conservation and management. The degraded mangroves identified through remote sensing imageries were restored using nursery raised mangrove saplings. The causes of degradation were studied and the degraded mangroves were restored by mangrove plantation. Apart from restoration of degraded mangroves, the socioeconomic situation of the mangrove-dependent community was addressed through resource-based income generating activities and alternatives for mangroves. An area of about 520 ha of degraded mangroves was restored using scientific understanding of the mangrove ecosystem. An area of 9, 442 ha of mangroves were brought under the joint management of the eight village-level institutions (VLIs) formed by the project. This paper describes the experience of participatory mangrove management in the Godavari and Krishna mangrove wetlands of Andhra Pradesh, India.

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Abstract: The results presented here are from a study conducted for the government of the state of Andhra Pradesh (GOAP) in India, as part of a World Bank project on cyclone mitigation. A set of detailed maps were prepared depicting the Physical Vulnerability (PV), specifically storm surge inundation zones are shown for frequent occurrence, 50-year return period, likely scenario for global warming and extreme global warming. Similarly vulnerable areas from strong wind field from tropical cyclones (TCS) are also presented for the same four parameters. Vulnerability zones are presented from a social point of view also based upon certain socioeconomic parameters that were included in determining the overall vulnerability of each Mandal in a coastal district (a Mandal represents a group of villages and towns) include: population, senior citizens, women, children under different age groups, type of housing, income level, cyclone shelters, hospitals and medical centers, schools and caste based population. The study is about scenarios that could happen if global warming and the predicted intensification of TCS actually occur as predicted by some numerical models.

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Abstract: The stomach contents of 470 specimens from inshore catches at Kakinada and 475 specimens from the backwater catches at Boddu Venkataya Palem collected from January 1974 to December 1975 are analysed to study tae food and feeding habits of Metapenaeus monoceros. The food of M. monoceros the inshore waters comprised of "other crustaceans" (30 %), polychaetes (19.1 %), prawns (17.5 %),detritus (10.6 %), fishes, (7.0 %), algae (4.6 %), molluscs (4.8 %) and sand (2.6 %) whereas it comprised of detritus (36.8%) "other crustaceans" (15.5%), algae (11.6%), copepods (9.3%), polychaetes (8.6%),prawns (8.4%), molluscs (3.1%), angiosperm matter (2.9%). diatoms (2.7%)and fishes (1.2%)in the specimens obtained from backwaters. No seasonal variation either in the food items consumed or in the feeding intensity is apparent. In the inshore waters, adults eat more of" other crustaceans" (38.9%), prawns (23%) and polychaetes (20.4%), whereas the juveniles preferred detritus (49.2%), algae (20.5%) and copepods (16%). In the inshore waters feeding intensity is formed to be better in adults and at night than in juveniles and during the day. The juvenile M.monoceros is an omnivore but it becomes a carnivore on attaining adulthood.

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Abstract: Annual prawn landings by trawlers operating from Kakinada increased gradually from 132 t in 1967 to 6,191 t in 1977 and declined abruptly to 2,026 t in 1978. Effort in trawling hours also indicated more or less a similar trend. The annual CPH indicated four phases in the abundance of prawns over the 12-year period. The annual percentage composition of prawns in the trawler catches varied from 16.7 in 1968 to 30.2 in 1972 with the average at 25%. Although 38 species of penaeids and a number of non penaeids were represented in the catches, only Metapenaeus dobsoni (28.3%), M.monoceros (11.9 %), M. brevicornis (6.6%), M. affinis (5.9 %), Penaeus indicus (4.8 %) and P. monodon (4.4 %) formed the mainstay of the fishery. However, during 1977 non-penaeids represented by Acetes erythraeus, Nematopalaemon tenuipes and Hippolysmata ensirostris formed about 55% of the prawn catches relegating the penaeids to a secondary status. Length-frequency distribution of penaeid species indicated that there was a decline in the proportion of larger size groups in the latter years. MSY and FMSY have been calculated for different species of penaeids to assess the present status of the stocks of these species. For the penaeids as a group the MSY has been estimated at 2,589 t. The study indicates that almost all the penaeid species are being harvested at the optimum level and any further increase in effort may lead to overfishing of the stocks.

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Abstract: Five ovarian maturation stages are recognized in Metapenaeus monoceros. Males and females attain size at first maturity at 96 and 116 mm total length (TL) respectively. Each female spawns at least four times in its life time with an interval of about 2 months between successive spawning. After attaining maturity, males are sexually active throughout their life. Spawning season is prolonged extending from January to October. The following linear relationships are obtained between fecundity and total length/ total weight/ovary weight. Fecundity (in thousands) = -507.1369 + 4.9593 x total length, Fecundity (in thousands) = -25.4832 + 9.7134 x total weight, Fecundity (in thousands) = -18.3825 + 96.6413 x ovary weight. Ovary weight is a better index of fecundity than either total length or total weight. Fecundity varies from 51,684 ova in female of 113 mm TL to 402,378 ova in a female of 181 mm TL. The ratios of males to females vary from 1:3.21 to 1:0.29 in different months. These wide variations in the sex ratio are found to be associated with the sex-wise segregation in the fishing grounds. Annual sex ratio in the population is significantly different at $P < 0.01$ level from the usual 1:1 ratio.

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Abstract: Prawn seed resource of the Godavari estuary and the adjacent backwaters was studied during the years 1969-71 based on the catches of push nets, drag nets and stake nets. Push net catches at Neelapalli were better in April-June while they were better in March-October at B. V. Palem. Drag net and stake net catches at B. V. Palem were better during April-May and November-December. Seed represented were of the species of Metapenaeus monoceros, Penaeus indicus, M. dobsoni, M. brevicomis, P. monodon, M. affinis and P. merguiensis in the order of abundance. Assessment of the species-wise seed resources for the entire estuarine system was based on catch and effort and gear census of the 21 villages spread over the area. 203 corers of prawn seed are annually harvested from this estuarine system which is enough to stock 21,800 ha of prawn farms of which 3,770 ha can be stocked with prime species like P. monodon, P. indicus and P. merguiensis.

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Abstract: Instantaneous total mortality coefficient (Z) in Metapenaeus monoceros has been estimated from the length-frequency distribution estimated to annual catch for the years 1974-1977 for both males and females. The estimates of Z based on Heincke's method, Beverton and Holt method and cohort analysis are closer to each other. The estimates of Z by these methods indicate a gradual increase in the values from 1974 to 1977 corresponding to the increase in fishing effort. The estimates of Z obtained by cumulative catch- curve and catch-curve methods are closer to each other and higher than those obtained by the other three methods. Reasons for these variations are discussed. The estimates of natural mortality coefficient (M) by Cushing's method and Pauly's method are closer to each other. Based on the values of Z obtained by Beverton and Holt method (4.364 for males and 3.664 for females) and the values of M obtained by Cushing's method (2.42 for males and 2.22 for females) fishing mortality coefficient (F) is estimated as 1.944 for males and 1.444 for females during the years 1974-77. Stock assessment by 'Surplus-Yield' model and yield -per -recuit model as well as baranov's catch equation and cohort analysis indicate that the stock is fished just at the optimum level of exploitation and any further increase in effort will reduce the catch per hour of trawling.

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AbstractThe largest penaeid Indian tiger prawn, Penaeus monodon is widely distributed in the Indian waters and forms an important fishery with high demand in the export market. By virtue of its fast growth, hardness and export demand it is cultured in about 1 lakh ha of prawn farms with an annual yield of 82850 t. As the demand is very high it is subjected to heavy fishing pressure at all stages of life history, seeds and brooders for farm and hatchery and all others for internal and export markets. The paper reviews the work done on its distribution, biology and capture fisheries from estuaries and marine habitats together with its stock assessment and management measures to keep the wild population sustainable.

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Abstract Age and growth of Metapenaeus monoceros have been estimated separately for males and females by length-frequency analysis in view of the differential growth observed in the species. Modes traceable for three months were considered for the application of Food-Walford plot to estimate growth parameters. L-io foi- males and females is estimated as 178.4 mm and 207.3 mm respectively. The K values are estimated as 1.68 for males and 1.62 for females. Values of to obtained by the method of GuUand are 0.048 years and 0.066 years for males and females respectively. Von Bertalanfly equa- 1 ions are derived as Males. It - 178.4 1-e -l-fi (t-0.048), Females. It 207.3 1-c -62 (t-o.066) The females are found to grow faster and attain higher asymptotic length with lower K value compared to males. The lengths attained by males and females respectively are 95 mm and 105 mm at the end of 6 months, 142 mm and 162 mm at the end of 12 months and 163 mm and 187 mm at the end of 18 months.

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Abstract: The paper presents the results of two prawn culture experiments conducted in the salt pans of (Andhra Pradesh). The first experiments was conducted in the salt pans of Neellarevu during June-December 1974. Two adjacent pans of 0.61ha (pond A) and 0.48 ha (pond B) were stocked with juveniles of Peneaus monodon and P. indicus of 65 mm mean lengths. In these ponds salinity varied from 21.97 ppt. to 47.39 ppt. and temperature from 29.2 °C to 35.0°C. At harvest in December, the prawn size of P. monodon was 165.4 mm and that of P.indicus was 140.7 mm. The production rate of prawns for the 6 months period was 164 kg ha^{-1} respectively in the two ponds. The net profit was at the rate of Rs. 980 ha^{-1} in pond A and Rs. 113 ha^{-1} in pond B. In the second experiment conducted at Lakshmipathipuram, 9470 juveniles of P.monodon, mean length at 54.2 mm, were stocked in a salt pan reservoir of 0.26 ha provided with a box type sluice gate in December 1976. The pond water temperature varied from 25.5°C to 31.0°C and salinity from 21. 27 ppt. to 45.39 ppt. Rice bran at a rate was found to be low in higher salinity (38.72-45.39 ppt.). At harvest, P. monodon had mean length of 123.4 mm with about 79.3 % survival. After 168 days the yield was 259 kg ha^{-1}. A net profit of Rs. 1388 was gained per hectare in 6 months without hampering the salt production.

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Abstract: Wood borers were collected from mangroves at ten stations located between the river mouths and a point 23.5 km upstream in the Gautami-Godavari estuary. Ten species of teredinids, the pholad Martesia striata (Linnaeus), and two species and a variety of Sphaeroma were recorded. Of these Sphaeroma annandalei Stebbing and the teredinids Dicyathifer manni Wright, Nototeredo edax Hedley, Lyrodus pedicellatus Quatrefages, Bankia campanellata Moll and Roch, and B. carinata Gray account for most of the destruction. Comparison with similar studies from other mangrove areas along the eastern and western coasts of India shows that the species composition and the agents causing maximum destruction differ between localities. It is suggested that the mangroves support resident populations of teredinids that are tolerant of fluctuating environmental conditions within the estuary and that these species could be instrumental in the re-establishment of natural populations after the annual floods. The need for sustained and planned investigations of the biology and distribution of these pests from the mangrove ecosystems is outlined.

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Abstract: Growth and different phases in the life histories of Bos-trychia tenella Vohl.J. Ag., Caloglossa leprieurii Mont. J. Ag., and Catenella impudica Mont. J. Ag. were estimated for 23 months from January 1986 to December 1987 in the Gautami Godavari estuary of India. Seasonal data on hydrographical conditions, biomass, and plant length were collected from three stations in this estuary. Biomass was minimum in August and September and maximum in January and February, as was frond length of tetrasporic and vegetative plants. Temperatures of 24°-27°C and salinities of 5-20 ppt. coincided with optimal growth for all three algae. In all three species, tetrasporophytes were present in all months of the year without any seasonal periodicity, and nearly 50% of the plants were tetrasporophytes. The gametophytes of B. tenella and C. Leprieurii and cystocarpic plants of C. impudica occurred from October to May, with greatest abundance in January. The abundance of spermatangial and cystocarpic plants in the populations of B. tenella and C. leprieurii ranged from 3 to 15% Spermatangial plants of Catenella impudica could not be identified, and the abundance of cystocarpic plants was very low.

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Abstract: Average whole sale prices of silverbelly per kg at Cochin, Sassoon Dock Market (Bombay), Karwar, Mandapam and Kakinada are given.

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Abstract: Purpose-The purpose of this paper is to emphasize mangrove reforestation as a counter measure for climate change mitigation and adaptation in the Godavari Delta in India.

Design/methodology/approach - Restoration of the mangrove forest in the Godavari Delta near Kakinada town in the south-eastern Indian state of Andhra Pradesh is carried out with participatory involvement of local communities depending for their livelihood on the mangrove forest. The extent of habitat restoration through reforestation in this area is explored. The possible contribution of restored mangroves in minimizing the impacts of sea-level rise due to climate change is highlighted. Reforestation information from 1999 to 2006 is collected from available published work and the Forest Department of the Government of Andhra Pradesh.

Findings -The positive result of reforestation since the past few years is seen as an increase in mangrove vegetation. The changing landscape due to restoration could stop erosion and salt water incursion up to some extent and help in maintaining the biodiversity of this place.

Practical implications -A long-term monitoring with ethnobiological study is required for managing such projects in future.

Originality/value -The Godavari Delta mangroves are rich in biodiversity and offer a wide range of ecological services. Adding to habitat degradation, predicted sea-level rise is likely to affect the local human communities. The role of mangroves as an economically viable barrier against sea-level rise has been recognized in other Asian countries. The results from this case study too could be disseminated to various stakeholders involved in sustainable development. The focus of the paper on India is particularly relevant, as the country is going to be integral in climate change debates.

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Abstract: Morphometric comparisons of samples of juveniles of Scomberomorus guttatus (Bl. and Schn.) from five localities are made. Analysis of covariance of the morphometric characters of all samples put together shows that highly significant differences are due to regression coefficients as well as adjusted means for all characters. Character by character comparisons of the means of morphometric characters of the different samples show that the Kakinada and Bombay samples share certain common feature compared to the Waltair samples. According to the D2 (distance function) analysis, samples from Waltair and Bimili (25 km apart) form one group. The Kakinada samples are the farthest removed from the Waltair-Bimili complex with Madras and Bombay occupying an intermediate position. The extreme variation of samples from Kakinada may be attributed to the typically high estuarine conditions in the locality.

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ppt.) are noticed. Tidal range increase by about 0.2 to 0.4 m from the bay mouth to Coringa River mouth. Tidal curves show longer ebb duration and the ebb currents are much stronger than the flood currents. The circulation pattern shows the pollutants released in canals are not flushed out completely, but tend to accumulate in the southern part of the bay where mangroves are located.

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Abstract: To examine the influence of river discharge on plankton metabolic balance in a monsoon driven tropical estuary, daily variations in physico-chemical and nutrients characteristics were studied over a period of 15 months (September 2007 to November 2008) at a fixed location (Yanam) in the Godavari estuary, India. River discharge was at its peak during July to September with a sharp decrease in the middle of December and complete cessation thereafter. Significant amount of dissolved inorganic nitrogen (DIN, of 22-26 mmoll^{-1}) and dissolved inorganic phosphate (DIP, of 3-4 mmoll^{-1})

along with suspended materials (0.2-0.5 gl^{-1}) were found at the study region during the peak discharge period. A net heterotrophy with low gross primary production (GPP) occurred during the peak discharge period. The Chlorophyll a (Chl a) varied between 4 and 18 mgm^{3} that reached maximum levels when river discharge and suspended loads decreased by greater than 75% compared to that during peak period. High productivity was sustained for about one and half months during October to November when net community production (NCP) turned from net heterotrophy to autotrophy in the photic zone. Rapid decrease in nutrients (DIN and DIP by w15 and 1.4 $mmoll^{-1}$, respectively) was observed during the peak Chl a period of two weeks. Chl a in the post monsoon (October-November) was negatively related to river discharge. Another peak in Chl a in January to February was associated with higher nutrient concentrations and high DIN:DIP ratios suggest possible external supply of nitrogen into the system. The mean photic zone productivity to respiration ratio (P:R) was 2.38-0.24 for the entire study period (September 2007-November 2008). Nevertheless, the ratio of GPP to the entire water column respiration was only 0.14-0.02 revealing that primary production was not enough to support water column heterotrophic activity. The excess carbon demand by the heterotrophs could be met from the allochtonous inputs of mainly terrestrial origin. Assuming that the entire phytoplankton produced organic material was utilized; the additional terrestrial organic carbon supported the total bacterial activity (97-99%) during peak discharge period and 40-75% during dry period. Therefore, large amount of terrestrial organic carbon is getting decomposed in the Godavari estuarine system.

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Abstract: Daily variations in nutrients were monitored for 15 months (September 2007-November 2008) in the Godavari estuary, Andhra Pradesh, India, at two fixed locations. River discharge has significant influence on nutrients loading to the estuary, which peaks during June August (peak discharge period; monsoon) where as exchanges at the sediment water interface, ground water and rain water contribute significantly during other period. Despite significant amount of nutrients brought by discharge to the study region, phytoplankton biomass, interms of chlorophyll-a (Chl a), did not increase significantly due to high suspended load and shallow photic depth. Nutrients showed downward gradient towards downstream of the estuary from upstream due to dilution by nutrient poor sea water and biological uptake. The N:P ratios were higher than Red field ratio in both upstream and downstream of the estuary during no discharge period suggesting PO_4 to be a limiting nutrient for phytoplankton production, at levels o0.10 mmoll^{-1}. On the other hand, Si:N ratios were always more than unity during entire study period at both the stations indicating that Si(OH)$_4$ is not a limiting nutrient. Our results suggest that suspended matter limits phytoplankton biomass during peak discharge period whereas PO$_4$ during no discharge period.

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Abstract: The concentrations of fluoride and dissolved silicon in Gautami-Godavari estuarine region have been measured as a function of chlorinity during seasons. Fluoride and dissolved silicon behave conservatively during post-monsoon season. However, during pre-monsoon season, removal of approximately 16% in case of fluoride and 41% in case of dissolved silicon was found during mixing of sea and river waters. The possible mechanisms for removal of both the elements have been explained. The net annual flux of dissolved silicon has been calculated to be 4.70 x 10^{-5} tons yr^{-1} from Godavari river into the Bay of Bengal.

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Abstract:High concentration of PHC were observed in the inner channels (viz., South lighter canal, Northern arm, North western and Western arm) of Visakhapatnam harbour. The estimation of trace metals (Cu, Zn, Pb, Cd, Co, Ni, and Ci) in surficial sediments indicated higher contamination in Visakhapatnam harbour than in Kakinada bay. Positive correlations between Cu, Zn, Pb, and Cd suggests common sources of these metals. lack of correlation between Co, Ni with the other metals indicates point sources. High concentrations of chromium reflects intense discharges due to electroplating and battery operations.

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Abstract:The examination of decaying mangrove materials belonging to 9 host plant species collected from Godavari and Krishna deltas (Andhra Pradesh), east coast of India from August, 1993 to November, 1995 resulted in the identification of 88 fungi. These include 65 Ascomycetes (74 %), one Basidiomycete and 22 Mitosporic fungi (25%) (including 6 Coelomycetes and 16 Hyphomycetes). Among the 9 plants examined, maximum number of species (64) were recorded from Rhizophora apiculata, followed by Avicennia officinalis (55), A. marina (45), Excoecaria agallocha (12), Aegiceras corniculatum, Ceriops decandra, Lumnitzera racemosa (8 each), Sonneratia apetala (5), Acanthus ilicifolius (2). Verruculina enalia was recorded on all the host plants examined. Hypoxylon sp., Lulworthia sp., Trichocladium achrasporum were recorded on 6 out of 9 host species. Lophiostoma mangrovei, Lulworthia grandispora, Halorosellinia oceanic and Hysterium sp. were recorded in 5 out of 9 host plants. Others were recorded on anyone or up to 4 host plants.

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Abstract:All the major deltas of India are on the east Coast, starting from the Ganges in the north to Cauvery in the south. In this article, Godavari delta is discussed in relation to the factors which cause morphological changes around the delta region. Wave conditions, the most important in coastal modification, prevailing in this region for different seasons are illustrated. The analysis of GEOSAT altimeter data for the period November 1986 to October 1987 shows that only during the southwest monsoon season waves reach heights of the order of 2m. Otherwise they are of the order of 1m. The fair weather promotes delta build- up. Tides and tidal currents are other important factors which affect the overall gradient of the deltas, especially their seaward section. Dye experiments conducted in Kakinada Bay show that tidal currents are generally of the order of 10-20 cm sec^{-1}. However, during the period of maximum discharge form the Godavari river (June-November) the ebb current exceeds the speed of 200 cm sec^{-1}.The morphological changes due to the effect of river discharge during various seasons are also briefly discussed. One of the factors controlling the circulation in the Kakinada Bay is the general coastal current, which runs along the East Coast of India. A few current measurements carried out in the Godavari basin are described. Wave

induced littoral currents are stronger during the southwest monsoon season and the net drift is northerly all along the Andhra coast. However it is surmised that most of the drift is towards shore restoring the beach to its normal state. The development of Godavari sand spit off Kakinada and its influence to delta modification are also detailed. It is concluded that a systematic approach using the past records, fresh field data and satellite imagery would alone bring out clearly the picture of deltaic process along the East Coast of India.

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Abstract: The mangrove formations of Godavari estuary are due to silting over many centuries. The estuary covers an area of 62,000 ha of which dense Coringa mangrove forest spread in 6,600 ha. Satellite sensor data was used to detect change in the mangrove cover for a period of 12 years (1992-2004). It was found that an area of about 1,250 ha of mangroves was destroyed by anthropogenic interference like aquaculture, and tree felling etc. It was found that mangroves spectral response/digital number (DN) value is much lower than non-mangrove vegetation such as plantation and paddy fields in SWIR band. By taking this as an advantage, spectral data was utilized for clear demarcation of mangroves from nearby paddy fields and other vegetation. Simpson's diversity index, which is a measure of biodiversity, was found to be 0.09, showing mangroves dominance. Ecological parameters like mud-flats or swamps, mangrove cover alterations, and biodiversity status are studied in detail for a period of 12 years. The increase in mangrove front towards coast was delineated using remote sensing data. The major advantages of remote sensing data is monitoring of change periodically. The combination of moderate and high resolution data provided detailed coastal land use maps for implementing coastal regulation measures. The classification accuracy has been achieved is 90 percent. Overall, simple and viable measures are suggested based on multi-spectral data to sustain this sensitive coastal ecology.

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Abstract: Different multivariate statistical analysis such as, cluster analysis, principal component analysis, and multidimensional scale plot were employed to evaluate the trophic status of water quality for four monitoring stations.

The present study was carried out to determine the physicochemical parameters of water and sediment characteristics of Pondicherry mangroves-southeast coast of India, during September 2008- December 2010. Seasonal variations of different parameters investigated were as follows: salinity (10.26-35.20 psu), dissolved oxygen (3.71-5.33 mgl^{-1}), pH (7.05-8.36), electrical conductivity (26.41-41.33 ms^{-1}), sulfide (1.98-40.43 mgl^{-1}), sediment texture sand (39.54- 87.31%), silt (9.89-32.97%), clay (3.06-31.20%), and organic matter (0.94-4.64%). pH, temperature, salinity, sand, silt, clay, and organic matter indicated a correlation at P smaller than 0.01. CA grouped the four seasons in to four groups (pre-monsoon, monsoon, post-monsoon, summer) and the sampling sites in to three groups. PCA identified the spatial and temporal characteristics of trophic stations and showed that the water quality was worse in stations 3 and 4 in the Pondicherry mangrove.

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Abstract: Suddageda basin is adopted as a representative basin of east flowing rivers of medium sized basins in the east coast of India by the Institute. The basin soil mainly grouped into clay loams to clay, sandy loams and forest and loamy skeletal. As a part of experimental studies in the basin total 28 infiltrations tests have been conducted using double ring infiltration meters. Using the experimental data the average infiltration rate of the soil groups are obtained from fitted Horton's equation. The correlation coefficient between observed data and fitted Horton's equation varied between 0.83 to 0.99. The average infiltration rates is clay loams to clay, sandy loams and forest and loamy skeletal are 2.50, 3.94 and 7.12 cm hr^{-1} respectively. The highest average initial infiltration rate (39.2 cm hr^{-1}) and average final infiltration rate (4.7 cm hr^{-1}) were observed in forest and loamy skeletal soil and lowest average initial infiltration rate (19.4 cm hr^{-1}) and average final infiltration rate (1.31 cm hr^{-1}) were in agricultural land. According to landuse classifications the highest average infiltration rate was obtained in Barren land (6.9 cm hr^{-1}) and lowest rate in agricultural land (2.50 cm hr^{-1}). A map showing the spatial distribution of average infiltration rates in the Suddagedda basin was prepared.

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AbstractStudies (1996-99) on the community structure of a mangrove forest in Coringa Wildlife Sanctuary in the Godavari estuarine system on the East Coast of India revealed altogether 15 species of mangroves represented by 8 families and 10 genera besides, 6 associate plant species and 6 of marshgrass. Description of forest structure (PCQM method) included measures of species composition, tree density, basal area and spatial

distribution patterns of component vegetation at 75 GPS fixed locations. Avicennia marina, A. officinalis, Excoecaria agallocha, Aegiceras corniculatum, Sonneratia apetala, Ceriops decandra, Rhizophora apiculata and R. mucronata were the important mangrove species. Tree density varied between 47 and 1731 stems/0.1 ha and basal area 0.1 and 10.9 m^2/0.01 ha. With the help of multivariate analysis (PRIMER) and based on species composition and tree density, it was possible to subdivide the sites into five groups that showed characteristic zonation patterns. For example, E. agallocha was typical of landward locations. A. marina (along with A. officinalis and A. alba) represented sites at the bed level and neap high tide level. There was a large group of sites inhabited by diverse species (14) indicative of spring high tide level conditions. Tidal elevation and ambient salinity appeared important in determining the observed zonation.

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Abstract The mangrove forest of the Godavari estuary, Andhra Pradesh, represents the second largest area of such vegetation formations along the east coast of India, next to the Sundarbans (West Bengal). Although declared as wildlife sanctuary since 1972, this rich but fragile ecosystem has undergone serious alterations largely induced by human activities. Continuous efficient retrieval of reliable information from the mangroves is therefore necessary for conservation purposes. Satellite remote sensing is a useful source of information as it provides timely and complete coverage of the study area, complementing field surveys of higher information content but which are more difficult to carry out, especially in mangroves. The purpose of the present study is 1) to map the mangrove formations and its surroundings based on a supervised classification of remote-sensing data and 2) to analyze the potential relationships between mangrove dendrometric parameters and spectral indices extracted from satellite data. The supervised classification was carried out with an IRS-IC LISS3 image of March 1999 and was trained from ground truth data and field knowledge. Among the resulting 14 classes, 3 correspond to different mangrove signatures. The ground truth includes 128 sampling locations for which mangrove vegetation parameters like basal area and tree density have been estimated using the Point Centered Quarter Method (PCQM) on transect lines of at least 100m. In a second stage, Vegetation Indices (VI) has been calculated at locations for which mangrove paramters were obtained from field surveys. Various statistical tools, among which scater-plots and analyses of variance (ANOVA), have been used in order to explore the relationships that may exist between VI and basal area whereas

this is not the case with density. Furthermore, when spectral indices and mangrove parameters are considered altogether, it appears that only two classes of mangrove can be discriminated.

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Abstract: An overview of the possibilities offered when applying Geographical Information Systems (GIS) and Remote Sensing (RS) to environmental monitoring is given, based on examples taken from an ongoing project entitled Assessment of mangrove degradation and resilience in the Indian subcontinent: the cases of Godavari estuary and southwest Sri Lanka. The capabilities of GIS (i) to integrate and manage huge amounts of multi-source data, (ii) to perform spatial analysis and, (iii) to produce synthetic results that can prove useful in decision making, are highlighted. RS, as a special type of spatial information used in GIS, (iv) allows land cover mapping and the inventory of natural resources, (v) provides quantitative estimations of biophysical properties of land surface features and, (vi) is useful in tracking how landscape changes over time. The examples show that synthetic

information and results, such as land cover maps at different dates, aerial estimates of mangrove extension or regression, and surfaces of aquaculture converted from mangroves, paddies or bare lands, can be obtained by analyzing data from different sources in the GIS. Decision-making can make use of such results, but should further benefit from the development of spatial modelling in GIS for the simulation of scenarios. Monitoring capabilities are also improving due to the increase in spatial and spectral resolution of the recently launched remote sensors.

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Abstract: In contrast to the general trend of north ward and southward movements of sediments in the east coast deltas during the SW and NE monsoons respectively, the Gautami and Vasishta beaches showed continuous erosion during the recent years. The rates of erosion are -122 m^3 m^{-1}, -116 m^3 m^{-1}, -110 m^3 m^{-1} at Gautami and -5 m^3 m^{-1},-28 m^3 m^{-1}, -23 m^3 m^{-1} at Vasishta beach. The grain size parameters showed higher Φ mean size and lower standards deviation at Gautami and reverse phenomena at Vasishta beach. The Gautami beach exhibits high wave sorting and high wave energy conditions. At present, the mouths are closed by large barriers spits and sedimentation is controlled predominantly by marine processes rather than fluvial input. The severe erosional conditions may result in changes in coastal circulational pattern or compaction of sediments due to overload.

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Abstract□ Macro-level environmental factors that determine the area, species diversity and biomass of the mangrove wetlands of India are analysed. On the basis of the spatial and temporal variations in these factors, major mangrove wetlands of India are classified. The Sunderbans and Mahanadi mangroves can be classified as tide-dominated, whereas Godavari, Krishna, Pichavaram and Muthupet mangrove wetlands can be grouped as river-dominated. The mangrove wetlands of Gujarat fall under the category of drowned-river valley type. Changes in some of the environmental factors, particularly changes in the periodicity and quantity of freshwater that flows into mangrove wetlands are examined, which indicates that reduction in freshwater flow would lead to reduction in the diversity of exclusive mangrove plant species. The current classification system can be utilized to develop strategies for long-term conservation of mangrove wetlands.

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Abstract□ Diurnal variation in hydrological variables and dissolved inorganic nutrients such as PO inf4 sup3- -P, N O inf2 sup- -N, NO inf3 sup- -N and NH inf4 sup3□ -N were studied in three interconnected biotopes including freshwater, marine and mangrove brackish water of the Kakinada coastal zone, Andhra Pradesh. Samples were collected at intervals of 3 hours, for a period of 24 hours. In the marine environment salinity varied from 26□ to 32□ whereas in the mangrove waters it fluctuated from 12□ to 20□ and in both biotopes salinity showed bimodal type of oscillation. Dissolved oxygen content was high in the mangrove waters during day time but decreased rapidly during the night hours. In the marine environment POinf4-sup3- -P concentration varied from 0.345 to 1.195 mu g at l^{-1} NO inf3 sup - -N from 1.03 to 6.62 mu g at l^{-1} and NO inf2 sup- -N from 0.086 to 0.506 mu g at l^{-1}. The highest and the lowest concentrations of POinf4 sup- -P, NO inf3 sup- -N, NO inf3 sup- -N recorded in the mangrove waters were 0.790 and 0.325 mug at l^{-1}, 7.10 and 1.60 mu g at l^{-1} and 0.278 and 0.060 mu g at l^{-1}, respectively. The concentration of POinf4 sup3- -P, NO inf3 sup- -N and NOinf2 sup- -N were high in the freshwater canal, the maximum and minimum values being 1.110 and 0.730 mu g at l^{-1}, 26.40 and .98 mu g at l^{-1} and 0.520 and 0.252 mu g at l^{-1} respectively. The concentration of ammonia was relatively high in the mangrove water. Gross and net primary production in the mangrove water was 4 times higher than in the marine biotope. There was no export of dissolved nutrients from the mangrove environment to the adjacent marine waters.

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Abstract: Mangrove ecosystem is one of the most specialized and productive coastal habitats in the world. Due to human interference in many ways, most of the in mangrove forests are on the verge of destruction and disappearance. The main causes for the degradation of Indian mangroves are land reclamation, pollution and overexploitation of the resources. A proper understanding of this specialized ecosystem and careful implementation of the conservation measures would alone save the ecosystem from further destruction and extinction. The present account deals with the ecological aspects of the mangrove habitats covering their extent, distribution, zonation, biological assemblage, hydrography and productivity, and giving importance to their role, man-made impacts and conservation aspects with emphasis on the approaches for the sustainable use of this ecosystem to the mankind with special reference to the mangroves of India.

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Abstract: Leaf anatomy of 13 species of Indian mangroves belonging to 11 genera and 9 families of the dicotyledons is presented. Leaves are dorsoventral in all the species except in Lumnitzera racemosa where they are isobilateral and amphistomatic. The cells of the lower epidermis are larger than those of the upper surface. Stomatal type and size are considered. Water storage tissue is present in all the species except Aegialitis rotundifolia. The significance of the findings are highlighted in light of the earlier available information and a key is constructed based on the leaf anatomical characters.

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Godavari estuary is discussed in relation to temperature, salinity, dissolved oxygen, substratum, composition and organic matter content in the sediment. Salinity in the estuary varied from near zero during July to 35‰ in May. The organic matter content of the sediment ranged from 0.11 to 4.2% . The polychaete abundance which was high during the summer period (March - June) reduced markedly during the annual freshwater flood period (July-september). The numbers gradually increased again during the recovery period (October-February) when the "seasonal migrants" started entering and setting in the estuary in progressive stages depending upon their capacities to tolerate fluctuating salinities and differences in the composition of substratum. The estuary exhibited high polychaete diversity.

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splendens and E. blochii associated with the penaeid prawns caught in drag net and E. ruconius, E. edentula, E. insidiator, E. bindas, E. dussumieri and E. blochii associated with the prawns caught in stake net are reported.

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laboratory conditions the average rate was about 13mm month^{-1}, while the estimated growth from size frequency distribution ranged between 5mm and 15 mm month^{-1}. The size of the prawn leaving the estuary was 45-50 mm. Laboratory experiments showed that the prawns were active at night and burrowed into the substratum during the day. The post-larvae entered the estuary in large numbers at night almost throughout the year. The overall sex ratio of the prawns was more or less unity. Plant matter, organic detritus, small crustaceans and foraminiferan shells formed the main diet of the prawn.

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Abstract: Diversity of eumangroves in Andhra Pradesh state and the natural/ anthropogenic pressures that cause degradation and depletion of mangrove habitats are dealt. Altogether 41 species of eumangroves and their associates have been reported from the state. Of these, 22 species are eumangrove belonging to 12 genera under 9 families and the other 19 their associates. Management of these extremely fragile ecosystems along with remedial measures to protect the eumangrove and their habitats are also suggested.

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Abstract Mangroves are worlds most productive ecosystems and support genetically diverse community of terrestrial and aquatic and flora and fauna. They provide innumerable direct and indirect benefits to human beings. Mangroves and their resources are often over exploited and need conservation and application of judicious management practices for their sustainable use. Bhitarkanika mangrove forests located in the confluence of rivers Brahmani and Baitarni in Orissa is the second largest mangrove formation in Indian sub-continent. These mangroves have high biological species diversity which is rated among one of the best in the world. Realizing the importance of these mangroves the State Government of Orissa declared it as a Sanctuary in 1975 under Wildlife (Protection) Act. 1972. Subsequently. The core area of the Sanctuary over an area of 145 Sq. Kms having all the mangrove forests have been declared as a National Park in 1998. In fact, this is the only National

Park of the State as on date. It has been declared as a Ramsar site since 2002. Gahirmatha coast (breeding grounds of over 6 lakh sea turtles annually), of Bhitarkanika has been declared as a Marine Sanctuary in 1998. At present the area is protected with declaration of two sanctuaries and a national park. There are many areas of conflict between the local residents and the protected area authorities. The Mangrove Forest Division has initiated eco-development programme in order to reduce the dependency on the mangrove forests. If properly implemented eco-development can be used as an effective tool in Protected Area management.

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Abstract: Large-river delta-front estuaries (LDE) are important interfaces between continents and the oceans for material fluxes that have a global impact on marine biogeochemistry. In this article, we propose that more emphasis should be placed on LDE in future global climate change research. We will use some of the most anthropogenically altered LDE systems in the world, the Mississippi/Atchafa- laya River and the Chinese rivers that enter the Yellow Sea (e.g., Huanghe and Changjiang) as case studies, to posit that these systems are both ‘drivers’ and ‘recorders’ of natural and anthropogenic environmental change. Specifically, the processes in the LDE can influence (‘drive’) the flux of participate and dissolved materials from the continents to the global ocean that can have profound impact on issues such as coastal eutrophication and the development of hypoxic zones. LDE also record in their rapidly accumulating subaerial and subaqueous deltaic sediment deposits environmental changes such as continental-scale trends in climate and land-use in watersheds, frequency and magnitude of cyclonic storms, and sea-level change. The processes that control the transport and transformation of carbon in the active LDE and in the deltaic sediment deposit are also essential to our understanding of carbon sequestration and exchange with the world ocean - an important objective in global change research. U.S. efforts in global change science including the vital role of deltaic systems are emphasized in the North American Carbon Plan.

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Abstract: The time-dependent salinity stratification in an environment of highly variable turbulence of Gauthami-Godavari estuary is described. From time series observations at three stations over two tidal cycles each in the winter (December 1989) and the dry (April 1990) seasons in the Gauthami-Godavari estuary, the development of stratification is correlated with periods of substantially reduced velocity shear. Stratification is observed to be greatest around the low water slacks and least around the high water slacks. The formation of stratification relaxes viscous constraints and a buoyancy circulation rapidly develops. The breakdown of stratification drastically modifies the circulation and largely removes the vertical shear associated with the density driven flow. Destratification occurs around the high water slacks in the lower reaches fairly close to the mouth of the estuary. The variations in the fields of mass will strongly affect the response of the velocity field.

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Abstract▯Some chemical and biological parameters were analysed at sixteen stations in the mangrove ecosystem, of the neighbouring Gautami-Godavari (GG) river estuary and Kakinada (KKD) bay to understand the present status of water quality and the impact of external terrigenous inputs during southwest (SW) monsoon in the study areas. High concentrations of nutrients in the mangrove ecosystem compared to the bay and estuarine ecosystems reveal the importance of this zone as a source of nutrients to the adjacent coastal ecosystems. Low Si▯N▯P (29 ▯4 ▯1) ratios in these ecosystems are due to the enrichment of these nutrients through external anthropogenic inputs even after the utilization by phytoplankton in the biological cycle. The mean Chl b equals to Chl a and Chl c equals to Chl a ratios and high phaeopigments (Pp) concentrations compared to Chl b and high ratios of Chl a equals to Pp suggests the possibility of the potential growth of phytoplankton populations in lower light intensity and low turbulent areas of these mangrove ecosystems.

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Abstract▯The present study focuses attention on the use of inverse modelling technique for estimation of rainfall recharge in a coastal aquifer. MODINV (Modular Inverse model) which is software for parameters optimization of 3D Ground Water Flow model, MODFLOW, is applied to Central Godavari Delta in Andhra Pradesh to estimate the distributed rainfall recharge during monsoon season. The model is formulated based on the available information on the physical and hydrological framework of the study area. A number of recharge zones are defined in the model to take care of the spatial variation of recharge.

The model is calibrated for the transient conditions during non-monsoon period of 1985 when the recharge takes place solely due to return flow of applied irrigation, the quantity of which is estimated before hand with the available data. The calibrated model is then used to optimize the recharge during different stress periods of monsoon season of 1985. The recharge from rainfall is computed by subtracting the estimated quantities of recharge due to return flow from the total model recharge. On a distributed basis, the rainfall -recharge coefficient in the lower, middle and upper reaches of the study delta is found to vary from 0.11 to 0.25. The recharge coefficient as calculated on lumped basis works out to 0.1717 for the study area.

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Abstract Mangrove resources are available in approximately 117 countries, covering an area of 190,000 to 240,000 km2. Countries like Indonesia, Nigeria and Australia have the largest mangrove areas. These ecosystems harbor 193

plant species, 397 fishes, 259 crabs, 256 molluscs, 450 insects and more than 250 other associated species. Mangrove ecosystem has the highest level of productivity among natural ecosystems, and performs several ecosystem services. The continued exploitation of mangroves worldwide has led to habitat loss, changes in species composition, loss of biodiversity and shifts in dominance and survival ability. Worldwide, about half of the mangroves have been destroyed. The Indian mangrove biodiversity is rather high. The increase in the biotic pressure on mangroves in India has been mainly due to land use changes and on account of multiple uses such as for fodder, fuel wood, fiber, timber, alcohol, paper, charcoal and medicine. Along the west coast alone, almost 40 percent of the mangrove area has been converted to agriculture and urban development. Our understanding of the natural processes in this vulnerable and fragile ecosystem is far from adequate. Environmental awareness, proper management plan and greater thrust on ecological research on mangrove ecosystems may help save and restore these unique ecosystems.

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Abstract: Plant growth promoting rhizobacteria (PGPR) colonize plant roots and enhance plant growth by a wide variety of mechanisms. The use of PGPR is steadily increasing in agriculture and offers an attractive way to replace chemical fertilizers and pesticides and supplements. Here, we have isolated enumerated and characterized the PGPR from the rhizosphere soil of Pigeon pea for the enhancement of growth of pigeon pea. Rhizosphere soils were collected from different areas of Samalkot, Pithapuram, Peddapuram and Kakinada. 65 Isolates have been identified and characterized for their morphological, cultural, and staining and biochemical characteristics of which 35 isolated have been selected for the screening of PGPR isolates. Sixteen isolates were successfully characterized for the PGPR traits like IAA production, Phosphous solubilization, enzyme productions like urease chitinase, amylase, cellulase, protease and β1, 3 glucanase and have been assayed. The antagonistic nature of these strains towards fungi and bacteria were estimated by Siderophore estimation, ACC deaminase characterization, dual plate culture method and HCN production technique and the best of these is selected. These are further investigated for showing the PGPR traits in pigeon pea seedling emergence, increase of shoot length, root length, dry, matter production of shoot etc. Furthermore, PGPR isolates remarkably increased seed germination of pigeon pea. Among the sixteen isolates seven were found to be high IAA producing. Six were found to be efficient phosphate solubilizers, five isolates found to be good antagonistic towards pathogen soil fungi and eight isolates were found to be better in enzyme productions and

thus may enhance the mineralization efficiency of soil. Three isolates were shown to be promising in IAA production, phosphate solubilization, antagonism towards fungi, and mineralizing capacity. Thus the present study suggests for the use of these isolates as inoculant biofertilizers might be beneficial for pigeon pea cultivation as they enhanced the growth and other growth parameters. IAA, PGPR, phosphorus solubilization, enzyme productions, seed germination.

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698. Vadlapudi, S. (2003). Identification and quantification of changes in mangrove forest using remote sensing a case study near Kakinada Bay, Andhra Pradesh, India. Forestry and Biodiversity. Map India Conference.

Abstract Remote Sensing from aerial and space platforms has emerged as a powerful tool for monitoring the aquatic environment. Rapid improvements in spatial and spectral resolution of satellite data obtained from Remote Sensing platforms, there is a need for continued research in the field of study. Besides this there are various image analysis and analytical tools like Geographic Information Systems (GIS) and Digital Image Processing (DIP) are available. There is a need to study the integration of Remote Sensing with GIS and DIP to evolve techniques for optimum planning of aquatic environment. The study consists of mapping of mangroves and its environs to identify the parameters that have affected the mangroves and the related ecosystem using Remote sensing data. The Indian Remote Sensing satellites temporal data corresponding to topographical sheets 65L/1, L/2,L/5, L/6 and H/14 has been used. The land use pattern is studied by analyzing maps prepared from Remote Sensing data by visual interpretation techniques. Limited ground truth is carried out. Sequential nature of IRS data provides opportunity to monitor changes in the landuse activities in the mangrove. The basic principle of change detection analyze using IRS data over a period of time is applied for such monitoring.

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702. Venkanna, P. □. (1991). Present status of the estuarine flora of the Godavari and the Krishna. Bombay Nat. Hist. Soc.. 88(1)□47-54. 0621.

Abstract□ While working for the district flora projects (1980-86), the author surveyed extensively the mangrove forests of the Godavari and the Krishna Estuaries and collected a good number of mangroves and their associates. The total collections represent 45 species of 37 genera belonging to 26 families (45/37/26). Among them 15/10/8 are true mangroves, 18/18/13 mangrove associates, 10/8/6 halophytes and 2/1/1 sea grasses. The survey resulted in the identification of Scyphiphora hydrophyllacea Gaertn. f. (Rubiaceae), a rare mangrove species for the Indian mainland. One very interesting observation is Prasopis chilensis (Molina) Stuntz growing in association with Sonneratia, Acanthus etc.

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705. Venkataraman, K. (2005). Coastal and marine biodiversity of India. Indian □ournal of Marine Sciences. 34 (1)□57-75.

Abstract□ This paper summarizes what is known of the coastal and marine biodiversity of the Indian seas and their various ecosystems, from past literature, museum records and other lesser-known sources of information. The synthesis suggests that the number of species known could be of the order 13,000 or higher. However, the inventory is very detailed only in the case of commercially important groups such as fishes or molluscs and is very

weak with respect to minor phyla or microbial organisms. In terms of spatial coverage, probably only two-thirds of the total marine habitats has been covered till today and the remote islands and other minor estuaries still virtually remain untouched. It is, therefore, likely that true inventory of coastal and marine biodiversity could be several times higher than what is known today. Lack of trained taxonomists, however, is a serious constraint to achieve this. Conserving what we have today is hampered by lack of management measure including outreach and our ability to predict what would live in Indian seas, by lack of data relating changes in biodiversity to those of environment.

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Abstract: Marine and coastal biological diversity (biodiversity) encompass an enormous variety of marine and coastal species, global oceans' cornucopia of living resources, myriad coastal and open sea habitats and a wealth of ecological processes that support all of these. Coastal ecosystems such as estuaries, wetlands and mangrove forests contain significant diversity and are highly valuable for communities living in coastal areas. Much of the world's biodiversity is found in highly diverse marine and coastal habitats. The Indian mainland coast is divided into two segments - the west coast and the east coast. Reefs are home to more species than any other ecosystem in the sea. In India, the reefs are distributed along the east and west coasts at restricted places. The mangrove habitats are dynamic, rich in species and are highly productive. Studies revealed that about 14 mangrove species are found along the India coast. Along the west coast of India, there are nine important coastal lagoons. The fauna of the marine ecosystem is not evenly distributed throughout the oceans. About 1925 pelagic copepods have been described from marine waters of India. A majority of these species occurs in coastal waters supporting valuable fisheries. Among the coastal wetlands estuaries, mangroves and coastal lagoons are biodiversity-rich whereas brackish habitats have only a few specialized species. The marine fauna of India is rich and varied. Out of a total 22,000 species, about 4,000 species occur in the Indian Ocean, of which 1,800 species are from the Indian seas. Majority of the nektonic species is found in the coastal waters. About 26 species of sea snakes belonging to one family, hydrophiidae and five species of sea turtles were reported from seas around India. About 120 species are estimated to occur in all the seas and of these 30 are reported from seas around India. Sea cow occurs in near shore waters. Marine resources and biodiversity have traditionally been undervalued. Unregulated use of resources, increased demand for resources and rapidly expanding coastal development imperil the marine resources. There are several protected marine areas such as Gulf of Mannar, Gulf of Kachch, Marine National Park of Andaman and Nicobar

islands (Mahatma Gandhi Marine National Park) and Rani hansi Marine National Park. Marine and coastal ecosystems with their rich species diversity provide a wide range of important resources and services as well as maintain sustainably fisheries and other marine living resources. The two island ecosystems Lakshadweep and Andaman and Nicobar add to the ecosystem diversity in India. Gulf of Mannar, Gulf of Kachch and the two island ecosystems have rich coral reefs harboring valuable marine biodiversity. In this paper I have proposed a fundamental 18 changes in the approach by which biodiversity is measured and studied in the ocean by emphasizing integrated regional-scale research strategies within an environmentally relevant and socially responsible framework.

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Abstract: Quantitative distribution of macro and meiofauna from Kakinada bay and backwaters was studied. Total macrofauna abundance (no. m^{-2}) ranged from 67 to 116 and 94 to 186 in the backwaters and near-shore environment respectively. Polychaetes and crustaceans constituted the bulk of macrofauna in the backwaters while polychaetes and molluscs in the near -shore bottom deposits. Meiofauna density (no.10 cm^{-2}) ranged from 346 to 603 and 674 to 1099 in the backwaters and near -shore region respectively. Nematodes, polychaetes, foramminiferans and turbellarians were the major groups constituting the bulk of meiofauna, both in the backwaters and near-shore region. Macrofaunal diversity was higher in the nearshore region. Impoverishment of fauna in the backwaters was related to lowering in salinity and poor oxygenation.

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721. Vijith, V., Sundar, D., Shetye, S.R. (2009). Time-dependence of Salinity in Monsoonal Estuaries. Estuarine Coastal Shelf Science. 85(4):601-608.

Abstract: The theories and classification schemes commonly used for understanding estuarine dynamics often refer to a steady state of the estuary in which the salinity field is time-independent. In this state salinity-ingress into the estuary due to different process (diffusion, gravity current formation, impact of tidal asymmetries, etc.) is balanced by salinity-egress induced by runoff. Here we point out that the salinity field of the estuaries that are located on the coasts of the Indian subcontinent and come under the influence of the Indian Summer Monsoon (ISM)is never in a steady state. We refer to such estuaries as 'monsoonal estuaries', an example of which is the Mandovi estuary located on the west coast of India. We describe the annual cycle of the salinity field in this estuary and conclude that the essential unsteadiness of the salinity field arises from two features of the run off into it. First, most of the runoff occurs as a series of episodes of highs and lulls spread over about 4 months of the wet summer monsoon. Second, the total runoff is large, well over an order of magnitude larger than the estuarine volume. We define two parameters to represent these two estuaries, and show that they can be used to distinguish the monsoonal estuaries from others.

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724. Visweswara Rao, V. (1969). Incara multisquamatus Gen. ET. SP. NOV. (Family: Elestridie) from Godavari estuary. Journal of Marine Biology Association of India. 11(1-2):329-332.

Abstract□ Eleotris fusca (Bloch and Schneider) is very common in Godavari estuary and occurs throughout the estuary, particularly in the mangrove in the mangrove creeks in lower reaches. During March 1963 many specimens of this species have been collected and kept aside for further study. A recent examination of these specimens has revealed that one among the lot does not belong to this species, although it closely resembles E. fusca externally. This specimen, on detailed examination was found to differ markedly from the known eleotrid genera of the Indo-west pacific (Day 1878, 1889, Fowler 1934, 1935, Guntur 1861, Koumans1953, Smith 1945, Smith 1958) and hence described here as a new genus. Its affinities with closely related genera of the family are discussed at the end.

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726. Yousuf, K.S.S.M., Anup, A.K., Anup, B., Afsal, V.V., Vivekanandan, E., Kumaran, R.P., Rajagopalan, M., Krishnakumar, P.K., □ayasankar, P. (2008). Observations on incidental catch of cetaceans in three landing centres along the Indian coast. □MBA2-Biodiversity Records. pp1-6.

Abstract□ A short term survey to quantify the number of marine mammals incidentally caught, and interviews to gain perceptions of local fishers towards issues of by-catch, were conducted. A total of 44 cetaceans were recorded as incidental catches at Chennai, Kakinada and Mangalore fishing harbours during 80 days of observation. Six species of dolphins and one species of porpoise were recorded. The spinner dolphin Stenella longirostris was the most frequently caught (38.6□), followed by the finless porpoise Neophocaena phocaenoides (31.8□). Gillnets and purse seines operated from motorised boats accounted for the entire by-catch. It is estimated that 9000-10,000 cetaceans are killed by gillnets every year along the Indian coast. The intricacies and possibilities of reducing cetacean kills by gillnets are discussed in the paper.

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Abstract□ Unlike the open ocean, the coastal zone is the most affected and vulnerable to human abuse with several nearshore areas including well-flushed regions and enclosed and semi-enclosed seas getting increasingly polluted. This paper examines the trends that have emerged concerning the health of marine areas with particular reference to the coastal zone of India. Mangrove and coral ecosystems have been degraded and continue to be under stress of the man induced changes. Tourism related ecological degeneration is prevalent in several coastal segments though measures taken by the Government may arrest these trends, if enforced vigorously. Many major ports planned along the Indian coast some of which in ecosensitive areas, would eventually result in localized degraded regions if the present state of environmental management of most ports continues. Indiscriminate release of liquid and solid wastes has degraded the ecology of localized inshore as well as openshore marine areas; the sewage; being the major contaminant. These waters are characterised by abnormally high and tide dependent levels of some nutrients, variable DO often falling to zero at low tides in some instances, widely fluctuating chlorophyll a, and zooplankton standing stock and abnormally high population of pathogens. The trends support increasing levels of NO_3-N and PO_4^{3-}-P along the central west coast of India and their utilization for primary productivity is suppressed perhaps by the high suspended particulate matter naturally occurring in these waters. The present impetus on coastal aquaculture a the culture stocks might be exposed, should a toxic bloom occur, requires implementation of a multilateral scientific research programme to systematically study the algal blooms. Scanty information on the levels of synthetic organics such as chlorinated hydrocarbon pesticides, polychlorinated biphenyls and polynuclear aromatic hydrocarbon as well as trace metals like lead, cadmium and mercury, suggests long-term monitoring with a large area coverage to reliably identifying the trends. Proposed establishment of refineries along the southern shore of the Gulf of Kachch and eventual increase in the movement and petroleum products highlights the urgent need of an adequately evolved environment management plan to minimize adverse impacts on the rich and diverse bioproductive regime of the Gulf. Likewise, an accelerated effort in offshore oil prospecting requires long-term systematic scientific monitoring of production as well as exploratory sites to identify ecological modifications to tune the marine environment strategy. Predicted sea level rise implies far sighted plan vulnerable area and devise a long-term approach to coastal zone management that periodically reviews ground realities and incorporates modifications in the plan accordingly.

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