

## Marine Biodiversity of India- A Perspective for RFM

K. K. Joshi

Principal Scientist, Marine Biodiversity Division  
Central Marine Fisheries Research Institute  
Cochin-18, Kerala.

---

### Introduction

The convention on Biological Diversity (CBD) recommends the conservation of ecosystem through policies for protected areas and sustainable management. Excerpts from the Article 8 of the Convention on Biological Diversity: In situ conservation, which promote the protection of ecosystem and the maintenance of viable populations of species in natural surroundings. In India we had several species of organisms belonging to different groups constitute the protected marine organism and majority of them are belonging to elasmobranchs, dolphins, whales, sea cow, turtles, molluscs, corals, sponges holothurians and gorgonids. India is blessed with rich biodiversity along the west and east coast resulting in the supply of essential ecosystem goods and services to the millions of population living in the coastal area. Vast regions of mangroves are found along the coast of West Bengal, Orissa, Andhra Pradesh, Tamilnadu, Maharashtra, Gujarat and Andaman Islands which extends up to about 682000 ha area. Coral reefs are found in the Gulf of Kutch, along the Maharashtra coast, Kerala coast, in the Gulf of Mannar, Palk Bay and the Wadge Bank along the Tamilnadu coast and around Andaman and Lakshadweep Islands (Devaraj *et al.*, 1998). The variety of coastal ecosystems include brackish water lakes, lagoons, estuaries, back waters, salt marshes, rocky bottom, sandy bottom and muddy areas provides a home and shelter for the mega biodiversity of India. These regions support very rich fauna and flora and constitute rich biological diversity of marine ecosystems. The long coastal line of 8129 Km<sup>2</sup> with an EEZ of 2.02 million Sq. km including the continental shelf of 0.5 million Sq. Km are not only rich in marine biodiversity but also faces several threats to biodiversity from various sources (Joshi, 2012). Most of these regions face serious threats due to increasing human population increase and resulted human interventions characterized by pollution, deforestation, over exploitation of marine resources, dredging, quarrying and other activities leading to environmental degradation.

The marine and coastal biodiversity conservation and protection mainly depends on the knowledge of the taxonomy of the flora and fauna constituting the biodiversity and the

species interaction in the ecosystem. Due to the inherent complexity of taxonomy and change of research priority in the marine fisheries sector during the recent years have resulted in the shortage of taxonomic experts in the case of a major marine organism like fin fish and ancillary organism like coelenterates, sponges, echinoderms and others. It is well known that taxonomic information offers an interesting connection between the economic and ecological studies on biodiversity measurement. If nothing else, taxonomic data are informative and the information has got great significance in marine biodiversity conservation. Several studies that revealed how the taxonomic information can be utilized for prioritizing conservation spending. The systematic information assumes the existence of complete taxonomic lineages for the species of interest as well as an understanding of the extent to which a successful intervention can reduce extinction probabilities of species in the branches at a given time (Faith *et al.*, 2004). Taxonomic research is extremely data demanding and comprehensive taxonomic information is not available for most of the species and the precision of such weighting exercise is limited by the cost of collecting data. Monitoring cost and decision urgency are issues when considering any level of biodiversity management. The higher order of classification like species richness, landscapes, distribution pattern are less costly to identify and monitor but offers less precision in terms of their approximation of lower level diversity (Faith and Basker, 2006). In general characters like ocean scapes, coastal classes, species assemblage, higher tax and species offer less cost for measurement but at the same time offer low precision. The genetic complementary data, phylogenetic tree assemblage offers high precision but needs higher monitoring cost. Considering these the present attempt is to review the status of different marine ecosystems and flora and fauna with reference issues and challenges concerned with marine biodiversity of India.

## **1. Status of Marine ecosystems**

The topographical features nature of the continental shelf and the distribution pattern of fish and shellfish diversity in the coastal region as well as in the Exclusive Economic Zone (EEZ) varies from region to region along the Indian coast. Earlier studies on the physical, chemical and biological oceanography of the seas around India have shown that inshore waters (0-50 m) are relatively more productive. As we know the large scale upwelling during south-west monsoon off the west coast of India and the strong convergences developing along the east coast of India and Andaman sea during the northeast monsoon, the change in the current pattern from season to season and the seasonal distribution of thermocline, Phyto and zooplankton biomass greatly influences the marine fisheries in different regions of the coast (Devaraj *et al.*, 1998).

Diversity in the species complex, typical of tropical waters and co-existence of different fish and shellfish species in the same ground are important features of Indian Marine Biodiversity. Past studies on the biological and fishery characteristics of the important groups shown that most of the species supporting the fishery are short lived with an average life span up to 3-5 years, but the fishery being mainly supported by under an year olds and one year old. They are highly fecund and spawn over longer periods mostly with fractional spawning and show wide annual variation in recruitment. Several issues in the captive fisheries sector adversely affect the marine biodiversity of the country especially in the fish as ecosystem good for human beings. The issues such as limitations of growth

and production in the inshore fishing grounds, less profitability and economic returns due to increased cost of fishing operations, management problems in the context of common property multigear, multispecies nature of fisheries (Devaraj, 1996). The above issues brought about by the uncontrolled fishing effort put into the fishery without any regard to stock-production-recruitment relationship. Besides these the ecological problems created by increasing pollution of coastal waters by release of untreated effluents and pollutants by agro industrial complexes operating in the coastal zone. It has been observed that the sediment in certain waters contains high levels of Copper, Zinc and Lead. The mercury content in some of the marine organisms in certain places has been found to be higher than the normal which may alter the genetic makeup of a species. The fly ash deposits from thermal plants in certain places changing with the increase and its the bottom topography of the affected area and chances of species depletion and replacement. To address these issues a thorough knowledge about different marine ecosystems like mangrove ecosystems, coral reef ecosystem, estuarine ecosystem, coastal marine ecosystem, lagoon, systems, coastal ecosystems and marine protected areas of India is a prerequisite.

**1.1 Mangrove ecosystems:** A large number of Islands along the Indian coast in the Gulf of Mannar, Gulf of Kutch, Lakshadweep and Andaman group and the vast mangrove ecosystems along the coast of Goa, Karnataka, Kerala, Tamilnadu, Andhra Pradesh and West Bengal constitute rich marine biodiversity supporting a variety of species of corals, sponges, ornamental fishes, crustaceans, mollusks and plants. The diversity of the species provides several ecological services like shoreline protection, sea erosion, larval dispersal, breeding and larval rearing and safe habitat for migratory species for the ecosystem. Indiscriminate fishing, quarrying, dredging, deforestation, industrialization and other anthropogenic activities are the main threats causing considerable damage to these environments and consequently to the associated flora and fauna (Gopinathan and Selvaraj, 1996, Kathiresan and Rajendran, 2005).

Mangroves are good breeding and nursery grounds for a variety of prawns and fishes. It provides nutrition for various organisms through recycling of plant and animal remnants. Mangroves give protection to the coastline from natural disasters like Cyclone, flood and Tsunami (Gopinathan and Selvaraj, 1996). Mangrove ecosystem provides opportunities for boating, hunting, bird watching, wildlife observation, education trips for specimen collection and photography. Apart from these capture and culture fishery activities in many coastal regions are dependent on mangrove dominated estuaries. Some of the endangered and vulnerable species associated with Indian mangroves are Dugong (*Dugong dugon*), the Bengal tiger (*Panthera Tigris tigris*), Smooth-coated otter (*Lutrogale perspicillata*), Fishing cat (*Prionailurus viverrinus*), Sambar deer (*Rusa unicolor*), Hawksbill turtle (*Eretmochelys imbricata*), King cobra (*Ophiophagus Hannah*), Sharp tooth Lemon Shark (*Negaprion acutidens*) and Mangrove Whip ray (*Himantura granulate*).

**1.2 Coral reef Ecosystems:** India is blessed with vast stretches of coral reefs in the Gulf of Mannar and Palk Bay, Gulf of Kutch, South-west coast and along the Andaman and Lakshadweep islands. Coral reefs are the most biologically productive and diverse of all natural ecosystems. Reefs are equivalent to tropical rain forest for their rich biological diversity. Corals have many uses like recreation, tourism and shore limp protection. Coral reefs are huge amounts of calcium carbonate which forms the raw material for many lime

waste industries, cement and calcium carbide. They are also used as building blocks in many parts of India. The fin fish fauna of coral reefs are extremely rich and diverse. Besides they are raw materials for industries such as cement, lime and calcium carbide. About 225 species of corals are known from the Indian seas (Pillai, 1996). Indiscriminate exploitation of the corals, dredging the reef areas and the exploitation of the reef flora and fauna has resulted in the destruction of coral reefs of India. The coral reefs of India face several threats from both natural and anthropogenic origin. Indiscriminate exploitation of corals for various purposes, over exploitation of reefs associated living resource, dredging, reclamation, are important anthropogenic factors in the destruction of corals in India. Pollution, sea erosion, siltation, constructive activities in lagoons also added to this man made cause of destruction of reefs. Global warming, coral bleaching, cyclones, pests like *Acanthaster planci*, white band diseases are some of the natural cause affect mortality of corals.

**1.3 Estuarine ecosystems:** Estuary is a partly enclosed coastal body of brackish water with one end rivers flowing into it and the other end open to the sea. Estuaries are important buffer zones as it is a transition zone between freshwater environments and are subject to marine influences such as tides, waves and influx of saline water, fresh water and sediment. This inflow of both marine and fresh water brings lots of nutrients in both water and sediment makes them most productive habitats in the world. A total of 14 major, 44 medium and 162 minor rivers draining fresh water into the sea through about 53 estuaries in India. Several of Indian estuaries have become danger prone zones (Alok Saxena, 2012). Estuaries are the natural nurseries for many marine animals but their fisheries have declined due to over exploitation of juveniles and anadromous stocks. Estuaries face threats are damming of rivers, construction of barrages, fishing pressure, and pollution are the main cause for biodiversity loss and degradation of the ecosystem. Estuaries face problems of lack of effective planning and coordinated among the different stakeholders in the implementation of management option, lack of critical knowledge on the ecological principles as well as sustainable management of resources, and low level of knowledge on the biodiversity value of goods and services provided by estuary.

**1.4 Lagoon Ecosystem:** A lagoon is a shallow water body along the low lying coast separated from the ocean by a barrier and also connected to the sea by inlets or estuary at one or two places. A total of 17 major lagoons or lakes occur along the coast of India. Important lagoons are Chilka Lake, Gulf of Mannar, Muthupet, Muthukkadu, Nizampatanam, Pennar, Pulikat Lake, Ashtamudi Lake, Ettikulam, Paravur Lake, Murukkanpuzha, Talapdy, Veli Lake, Vembanad Lake, Lagoons of Bombay, and Lakshadweep atolls (Alok Saxena, 2012). The lagoon ecosystems are the most vulnerable ecosystems due to several anthropogenic activities which threatens flora and fauna of the system. Threats include pollution from industries, dumping of city sewages, recreational boating, navigation, dredging, expansion of urban and rural settlements, reclamation, over exploitation of fish stocks, intensive aquaculture practices and pollution from different sources.

Diversion of lake water for use in irrigation and industry, invasions of plant and animal exotic species, and contamination by toxins and nutrients from industry, farms, sewage and urban runoff are the threats to the existence of lake ecosystems of India. In most parts of the world anthropogenic impacts on lakes are spreading geographically and becoming more intense in quantity and quality due to human population increases and the globalization of trade, which has increased deforestation and the use of pesticides and fertilizers, and has spurred the spread of invasive species. Lakes and lagoons that often fringe them provide critical wintering; feeding, resting and breeding habitat for many species of migrating birds, yet one of the largest gaps in biodiversity assessments to date has been bird diversity. One factor not regularly included in assessments of lakes is the present and future degree of water scarcity in the watershed. Water scarcity can be expected to negatively impact lakes due to human reliance on increasing proportions of their water usage for drinking water, irrigation and industrial needs. Chilka and Vembanad lakes are examples of lakes identified using Ramsar criteria that had not been identified by previous prioritization studies. Chilka is a brackish coastal lake separated only by sand flats from the Bay of Bengal, and is home to many important migratory bird, gastropod, bivalve, reptile and mammal populations.

**1.5 Coastal Ecosystems:** Characteristic features of the Indian Ocean are the upwelling, southwest monsoon, northeast monsoon, mud-bank along the southwest coast and high coastal production. Upwelling occurs in the region between Kanyakumari and Karwar during the onset of southwest monsoon. It starts in the southern region first and then extends northwards with the progress of southwest monsoon. Southwest monsoon season is the period when mud-banks are formed in some places along the southwest coast of India especially the Kerala coast. Mud banks of the Alleppey - region is formed by the subterranean mud and Vembanad lake system provides the mud for this. The mud-banks between Parapanangadi and Tanur are the aggregation of coastal mud. The mud-banks at Chellanam, Narakkal, Valappad, Elathur, Quilandy, Muzhuppilangadi, Kottikalam, Anjur, Adakathubali, Kumbala, Uppala and Ullal are formed by the sediments and organic debris discharged from river and estuaries. Mud-banks at Vypeen are formed from dredging operation (Rao *et al.*, 1992). Along the southwest coast in the India maximum production of phytoplankton takes place during the southwest monsoon months. The optimum hydrographic condition in the southwest monsoon mouths, the salinity of water falls from 35% to 30-31%, the temperature decreases from 31-32°C in 23-25°C and abundance of nutrients like phosphate, nitrate and silicate become abundant due to upwelling and river discharges makes maximum phytoplankton production which is higher than some of the fertile seas of the world.

The peak of plankton biomass is observed during peak southwest monsoon and pre-monsoon periods that is during and after upwelling, while the abundance of fish eggs and larvae shows peak during pre-monsoon. Thus it is well known that the intensity of southwest monsoon plays an important role in the fluctuation of the fishery resources especially the pelagic fishes.

Bay of Bengal is much warmer than the Arabian Sea and more numbers of cyclonic storms develop over Bay of Bengal than Arabian Sea. Seasonal mean surface temperature over Arabian Sea is highly variable from one season to alter as compared to the Bay of



Bengal. The lowest sea surface temperature in the Bay of Bengal was about 25 to 28°C during winter season but in other seasons it remains at 28.5 to 29°C. Bay of Bengal is the one of the world's largest submarine fans which comprised of large volumes of sediments discharged by the Ganges and Brahma Putra Rivers. Bengal basin can be divided into Mahanadi – Godavari and Cauvery off shore basins and non-basinal areas such as Vishakhapatnam – Chilka lake shelf and Madras-Pondicherry shelf. Central Bengal Bay has got an average depth of about 3400 m and several turbidity channels are present with a width of 5 to 27 km. South Bay of Bengal is characterized with the presence of a large number of sea mounts and coral Islands. Sea mounts and coral islands are the excellent habitat for biological diversity with the presence of a variety of marine organisms. They not only provide food and protection but also for the breeding grounds for a large number of organisms. Bay of Bengal shows moderate primary production in all the seasons as compared to Arabian Sea (Devaraj, 1996).

A total of 26 stocks is presently exploited from the inshore waters extending up to 50 meters by mechanized craft using gears like trawls, purse seines, gill nets, hooks and lines and a variety of indigenous crafts and gears. A large number of stocks of them are exploited not only by the same gear but by different gears also. Technological advances, increasing fishing effort, multigear-multiday fishing and higher investments kept the production increasing from about 0.6 million tons in fifteen to about 3.6 million tons in 2010 (Rao, 2013).

**1.6 Marine Protected Areas:** In India, there are about 31 Marine Protected Areas (MPA) primarily in marine environments, which cover a total area of 627.2 Km<sup>2</sup> with an average size of 202.1 Km<sup>2</sup>. In order to protect the ecologically important areas Government of India initiated action through the state governments to create a network of MPAs under the Wildlife (Protection) Act, 1972. Recognizing ecological values and importance for biodiversity conservation, the GOI has notified three Biosphere Reserves in 1989 in marine areas *viz*: Great Nicobar Biosphere Reserves in Andaman and Nicobar (885 Km<sup>2</sup>), Gulf of Mannar Biosphere Reserve (10,500 Km<sup>2</sup>) in Tamilnadu and Sundarbans Biosphere Reserve (9,630 Km<sup>2</sup>) in West Bengal (Singh, 2003).

## 2. Status of Marine Resources

The ecosystem goods and services provided by the fauna and flora and the interrelationship between the biodiversity and ecological processes are the fundamental issues in the sustainability and the equilibrium of the ecosystem. Some of the marine resources like seaweeds, sponges, gorgonids, corals, pipe fishes and others are being exploited for the extraction of pharmaceuticals, active chemicals which are known to cure several diseases. While there are reports of over exploitation of certain of these resources, there are also reports of environmental degradation due to anthropogenic influences. Certain fragile and sensitive marine ecosystems will not be available to the posterity if adequate care is not taken to conserve the system. In order to achieve improved returns while protecting the environment, a suitable policy needs to be formulated to exploit the resources on sustainable levels, to extract the drugs indigenously, basically for domestic use and for limited export. It is seen that there is a tendency for intensive exploitation of exportable commodities, but the country cannot lose sight of the need to protect

biodiversity and meet domestic requirements in its bid to increase foreign exchange earnings. Ecosystem goods from the marine realm included the fin fish crustaceans, molluscs and seaweeds. The important flora and fauna falling to the two major kingdoms such as Animal and Plant Kingdom recorded from the Indian region and their present status are discussed below.

## 2.1 Kingdoms: Plantae

**Mangroves:** Mangroves trees up to medium size and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics. Asia has the largest amount (42%) of the world's mangroves (Kathiresan and Rajendran, 2005).

**Sea grasses:** Sea grasses are flowering plants from one of four plant families (Posidoniaceae, Zosteraceae, Hydrocharitaceae, or Cymodoceaceae), all in the order Alismatales grow in marine, fully saline environments. A total of 14 species of sea grasses in six genera are reported from Indian seas (Venkataraman and Wafer, 2005).

**Macro algae (Sea weeds):** Macro algae is large multicellular plants that resemble vascular plants but lack the complex array of tissues used for reproduction and water transport. They are found in red (Rhodophyta), green (Chlorophyta) and brown (Phaeophyta) divisions. The colours of macro algae are due to different pigments that the algae use to convert the sunlight into chemical energy via photosynthesis. A total of 1010 species of macro algae has been reported from India. A large number of seaweed species known from the Indian seas are edible and serve various industrial purposes. They are most abundant along the Gujarat, Kerala and Tamilnadu coasts and around the Andaman and Lakshadweep Islands. The edible seaweeds from 70% of the standing stock of 100,000t, followed by algin (16%), Carrageenan (8%) and agar (6%) yielding seaweeds. The edible seaweeds are known to be rich in protein (20 to 25%) Carbohydrates (16 to 24%), lipids (6 to 11%) vitamins and amino acids.

## 2.2 Kingdom: Animalia

### 2.2.1. Phylum: Porifera (Sponges)

Sponges are multicellular organisms which have bodies have pores and channels allowing water to circulate through them, consisting of jelly-like mesohyl sandwiched between two thin layers of cells. About 519 species of sponges are known to occur in the Indian seas. About 34 species of coral boring sponges have been reported from the Gulf of Mannar and Island system of India (Thomas, 1996 a). Sponges are the major components of the benthic fauna and are distributed from the intertidal to the hadal depths and are a potential source of many new bioactive compounds. In India our knowledge of the identity, biology, availability, population structure and possibilities of commercial exploitation of sponges is meager and requires prioritization.

**Ctenophora (Comb jellies):** Ctenophora are live in marine waters and distinctive feature is the groups of cilia (comb) they use for swimming. They are the largest animals that swim by means of cilia. A total of 20 species of comb jellies has been reported from India.

## 2.2.2 Phylum: Cnidaria

### Class: Scyphozoa (True jelly fish)

Scyphozoa is referred as the true jellyfish. Their stings may cause skin rashes, muscle cramps, or even death. A total of 30 species of Scyphozoans has been reported from India.

### Class: Hydrozoa (Jelly fish)

Hydrozoans are small, predatory animals, some solitary and some colonial, and marine. The colonies are large, and in some cases the specialized individual animals cannot survive outside the colony. The Portuguese Man of War (*Physalia physalis*) and *Crambionella stulhamani* are important jelly fish species. About 116 species of hydrozoans belonging to 13 families have been reported from India.

### Class: Anthozoa

**Octocorallia (Soft Corals):** Octocorallia belong to a subclass of Anthozoa. It includes the blue coral, soft corals, sea pens, and gorgonians (sea fans and sea whips) within three orders: Alcyonacea, Helioporacea, and Pennatulacea. Their life cycle includes a motile phase as plankton and later a sessile phase. About 300 species of soft corals have been reported from India. Gorgonids are popularly known as the sea fans or sea whips, the gorgonids are available in fishable magnitude in the Gulf of Mannar although distributed almost all along the Indian coasts including Andaman sea. These organisms support a minor export market providing raw material for the extraction of prostaglandins which are claimed to be wonder drugs. About 22 species belonging to 7 families and 15 genera were reported from India (Thomas, 1996 b).

The biomedical versatility of the gorgonids, popularly known as the sea fans, attracted great attention to this resource. Large quantities of sea fans have been exported from India to the USA, France, Germany and Netherlands. Many drugs (e.g. Prostaglandins) have been separated from the sea fans for treatment of various ailments. Owing to very attractive prices in the export markets, there has been indiscriminate exploitation of the sea fans from the Indian seas, particularly the Gulf of Mannar. Based on the color, the gorgonids are named in the trade as 'black', 'red', 'monkey tail' and 'flower'. The four species which have already shown symptoms of depletion include *Echinomuricea indicia*, *Heterogorgia flagellum*, *Echinogorgia complex* and *Gorgonella umbraculum* (Thomas and Ranimary George, 1987). Some of the less exploited grounds off Vizhinjam, Cape Comorin, Visakhapatnam, Okha, Dwaraka, Gulf of Kutch, Ratnagiri, Malwan, Andaman Islands, Rameswaram, Tondi and Point Calimer offer a limited scope of gorgonid exploitation through pruning, where the basal stalk is left undisturbed for regeneration, which takes place at the rate of about 2 cm per year.

**Ceriantharia (Tube - dwelling anemones):** Tube-dwelling anemones which are similar to sea anemones, but belong to the subclass of anthozoans. They are solitary, living buried in soft sediments. Tube anemones live and can withdraw into tubes, which are made of a fibrous material, which is made from secreted mucus and threads of nematocyst-like organelles, known as ptychocysts. The diversity included about 20 species in India.

**Actiniaria (Sea anemones):** The Actiniaria belongs to the class Anthozoa which includes sea anemones. They are water-dwelling, predatory animals. They have large polyps that allow



for digestion of larger prey and also lack a Medusa stage. They are related to corals, jellyfish, tube-dwelling anemones, and *Hydra*. Sea Anemone *Heteractis magnifica* Quoy and Gairmad, 1833 is associated with clown fish. Actinarian diversity included about 30 species in India.

**Corallimorpharia (Coral anemones):** Corallimorpharia is closely related to the true sea anemones (Actiniaria). The tentacles are usually short and arranged in rows radiating from the mouth. They resemble the stony corals, except for the absence of a stony skeleton. They occur in a wide range of marine habitats, and are associated with phase shifts in coral reefs that change from hard-coral dominated to soft-coral dominated. Diversity of Corallimorpharia includes about 10 species along the Indian coast.

**Zoanthidea (Mat anemones):** Zoanthids are commonly found in coral reefs, the deep sea and many other marine environments around the world. They may be in the form individual polyps, attached by a fleshy stolon or a mat that can be created from small pieces of sediment, sand and rock. A total of 8 species of Zoanthids has been reported from India.

**Scleractinia (Reef building corals):** Scleractinia are marine corals that form a hard skeleton. Most of the modern coral reefs are formed by scleractinians. About 200 species Scleractinia from the diversity of India (Pillai, 1996).

**Antipatharia (Black corals):** Antipatharia is treelike corals related to sea anemones and found in deeper depths. There are about 230 known species of black corals in 42 genera of this 10 species occur in India (Pillai, 1996). Though black coral's living tissue is brilliantly colored, it takes its name from the distinctive black or dark brown color of its skeleton.

### 2.2.3 Phylum: Platyhelminthes (Flat worms)

Platyhelminthes are bilaterally symmetrical, unsegmented, soft-bodied invertebrate worms. They don't have body cavity, and circulatory and respiratory systems, which made them to in a flattened shape. Nutrition and respiration are done by simple diffusion. About 100 species of flatworms have been reported from India. Research on the Platy helminthes of India is less as compared to the Annelids of India (Venkataraman and Wafer, 2005).

### 2.2.4 Phylum: Echiura (Spoon worms)

The Echiura are a small group of marine animals. They lack the segmented structure found in other Annelids of this group. Recent studies show they may be included in the phylum Annelida. About 43 species under 14 genera have been reported from India.

### 2.2.5 Phylum: Sipuncula (Peanut worms)

The Sipuncula are bilaterally symmetrical worms and contains about 144-320 species. Recent molecular work suggests that they may belong to phylum Annelida. They live in shallow waters, either in burrows or in discarded as molluscan shells. Some bore into solid rocks to make a shelter for themselves. About 35 species under 10 genera have been reported from India. They are concentrated mainly along the Andaman and Nicobar Islands, Lakshadweep Islands, Gulf of Mannar and Gulf of Kutch.

### **2.2.6 Phylum: Annelida**

#### **Class: Polychaeta (Clam worms)**

The Polychaeta are generally marine, and belong to phylum Annelida. The body has a pair of fleshy protrusions called parapodia that bear many bristles, called chaetae, which are made of chitin. The annelid worm diversity includes about 300 species in India. Extensive research on the Polychaetes of India has been carried out of the Indian Ocean (Venkataraman and Wafer, 2005).

#### **Class: Clitella**

**Oligochaeta (Earth worms):** The Oligochaeta is different types of aquatic and terrestrial worms. Earthworms are semi aquatic or fully aquatic. There are several interstitial marine worms. About 10 species reported from India.

### **2.2.7 Phylum: Nemertea (Ribbon worms)**

Nemertea belongs to the phylum of invertebrate and known as ribbon worms or proboscis worms. They have an unsegmented body, thin and elongated with no differentiated head. Ribbon worm diversity includes about 60 species in India.

### **2.2.8 Phylum: Arthropoda**

#### **Subphylum: Crustacea**

India is endowed with rich diversity of crustaceans and several of them supporting commercial fisheries since ancient times. The recent changes in fishing patterns involving destructive innovations of fishing gears, excessive fishing pressure on some of the traditional stocks and the anthropogenic activities of man, causing damages to the natural habitat and diversity of crustaceans. The number of species entering into the systematic list is on the increase as a consequence of the extension of fishing activities to deeper waters and capture of non conventional species. The marine king crab of the species *Tachypleus gigas* and *Carcinoscorpius rotundicauda* occurs in the detect regions of Ganges and Mahanadi along the northeast coast. They are considered as living fossil and hence care should be taken to preserve them in the nature. Recently because of biotic interference there has been a decline in the numbers of these animals in Orissa. The chemical reagent *list* is produced from the blood of this crab. This medicine has got a wide usage in the treatment of several diseases.

#### **Class: Maxillopoda**

**Cirripedia (Barnacles):** They have a calcareous shell composed of several pieces. They are known as curl footed because of their curved legs. A total of 36 species of cirripedia has been reported from India.

#### **Class: Malacostraca**

#### **Order: Amphipoda (Land hoppers)**

Amphipoda is having no carapace and generally with laterally compressed bodies. Amphipods range in size from 1 to 340 millimeters and are mostly detritivores or scavengers. They live in marine aquatic environments. A total of 132 species of Amphipods belonging to 54 genera have been reported from India.

#### **Order: Isopoda (Pill bugs, sow bugs)**

The Isopoda are small crustaceans with seven pairs of legs in the size of above 300 micrometers. They have dorso-ventrally, flattened body, without carapace. There are about 33 species belonging to 13 genera have been reported from India.

### **Order: Stomatopoda (Mantis shrimp)**

Stomatopods are marine crustaceans and they occur in a variety of different colours, from shades of browns to bright neon colours. These aggressive and typically solitary sea creatures spend most of their time hiding in rock formations or burrowing indicate passageways in the sea bed. Unlike most crustaceans, stomatopods hunt, chase, and kill their prey. Most species live in tropical and subtropical seas although some live in temperate seas. The stomatopod diversity includes about 30 species along the Indian coast.

### **Order: Decapoda**

**Dendrobranchiata (Shrimp, prawns):** Dendrobranchiata are decapod crustaceans, known as shrimp or prawns. There are 540 extant species in seven families. They differ from related animals, such as Caridea and Stenopodidea, from the branching form of the gills and by the fact that they do not brood their eggs, but release them directly into the water. They are widely fished and farmed for human consumption. About 10 species have contributed to the diversity in India.

**Caridea (Caridean shrimp):** The caridean shrimp is an infraorder of shrimp within the order Decapoda. They are found widely around the world in both fresh and salt water. Carideans are found in every kind of aquatic habitat, with the majority of species being marine. The most significant commercial species among the carideans is *Pandalus borealis*. About 150 specimens included in the caridean shrimp diversity of India.

**Palinura (Lobsters):** Lobsters have a cylindrical, sub ovoid or dorso-ventrally compressed carapace and flattened abdomen. The group includes the spiny lobsters and slipper lobsters. The abdomen is flattened.

**Thalassinidea (Ghost shrimps, mud shrimps):** Thalassinidea include crustaceans, which live in burrows in muddy bottoms of the sea. They are characterized by a relatively soft cuticle (shell) in most common forms. Thalassinids typically live in deep and sometimes complex burrows. Shallow water local species typically remain deep in the burrow and suspension feed (filtering plankton and organic particles from the water) by beating their pleopods to create a current. About 20 species of Thalassinides have been reported from the Indian Ocean.

**Anomura (Hermit crabs, sand crabs):** Anomura is a group of decapod crustaceans, including hermit crabs and others. All true crabs are in the sister group to the Anomura. A total of 20 species Anomuran crabs have been reported from India.

**Brachyura (Crabs):** Crabs are decapod crustaceans with a typically very short tail, usually entirely hidden under the thorax. A total of 250 species of crabs has been reported from Indian coast.

### **2.2.9 Phylum: Mollusca**

Molluscs in general had a tremendous impact on Indian tradition and economy and were popular among the common man as ornaments, currency, as a part of spiritual activities even at the inception of human culture and civilization.

**Class: Scaphopoda (Tusk shells)**

The Scaphopoda are commonly known as the tusk shells. They have a tubular shell is open at both ends as compared as other molluscs open at one end. Tusk shells live in seafloor sediment where they feed on detritus, foraminiferans and microscopic animals. Scaphopod diversity includes about 10 species.

**Class: Polyplacophora (Sea cradles)**

Polyplacophorans include about 600 extant species are entirely marine, and inhabit hard bottoms and rocky coasts. Chitons are small to large marine molluscs. These molluscs are also sometimes commonly known as sea cradles. A total of 40 species of polyplacophora has been reported from India (Appukuttan, 1996).

**Class: Gastropoda**

**Prosobranchia (Sea snails):** Prosobranchia includes sea snails, land snails and freshwater snails. *Prosobranch* means *gills in front* (of the heart). In contrast *Opisthobranch* means *gills behind* (and to the right of the heart). Prosobranchs have their gills, mantle cavity and anus situated in front of their heart. Most prosobranchs have separate sexes. The diversity of prosobranchian species was at the tune of 2550 species.

**Opisthobranchia (Gastropods):** Opisthobranchs are a large and diverse group of specialized complex marine gastropods previously united under Opisthobranchia within the Heterobranchia, but no longer considered to represent a monophyletic grouping. About 400 species of gastropods have been reported from India.

**Pulmonata (Snails, slugs):** The Pulmonata, or pulmonates, are an informal group of snails and slugs characterized by the ability to breathe air, by virtue of having a pallial lung instead of a gill, or gills. The group includes many land and freshwater families, and several marine families. A total of 20 species of pulmonates was recorded from India.

**Class: Bivalvia (Clams, oysters):** Bivalvia are mollusks with laterally compressed bodies in a shell in two hinged parts. They include clams, oysters, mussels, scallops, and numerous other families of shells. They are filter feeders and most often bury themselves in sediment on the seabed and lie on the sea floor or attach themselves to rocks or other hard surfaces. The bivalve diversity includes about 667 species in India.

**Class: Cephalopoda (Squids, cuttlefishes, octopuses):** Cephalopods are marine animals are characterized by bilateral symmetrical body with a head, and a set of tentacles. They have the ability to squirt ink. About 20 species of cephalopods were found in India. Cephalopod ink contains chemical substances of vast nutraceutical value.

**2.2.10 Phylum: Echinodermata****Class: Echinoidea (Sea urchin)**

Sea urchins move slowly, feeding mostly on algae. Sea otters, wolf eels, triggerfish, and other predators feed on them. A total of 60 species of sea urchins was showed occurrence in the Indian seas.

**Class: Holothuroidea (Sea Cucumbers)**

Sea cucumbers are marine animals are found on the sea floor Total number of holothurians species is 1,250 in the world and maximum number being in the Asia Pacific region. Many of these are utilized for human consumption and some species are used in aquaculture systems. Sea cucumbers serve a useful purpose in the marine ecosystem as they help recycle nutrients, breaking down detritus and other organic matter

after which bacteria can continue the degradation process. About 150 species of sea cucumber have been reported from India. About 12 species of sea cucumber are economically important and have commercial value (James, 1996). Increasing demand has led to massive exploitation of sea cucumbers often resulting in the removal of undersized animals.

**Class: Asterozoa (Star fish)**

The starfish is among the most familiar and diversity of marine invertebrates. They have a central disc and five arms, and some species have more than five arms. They ochre sea star (*Pisaster ochraceus*) and the reef sea star (*Stichaster australis*) are widely known as examples of the keystone species concept in ecology. A total of 180 species of starfishes belonging to 81 genera have been reported from India.

**Class: Ophiurozoa (Brittle Stars)**

They have a disk and generally have five long slender, whip-like arms which may reach up to 60 centimeters in length on the largest specimens. A total of 150 species of brittle stars belonging to 79 genera have been reported from India.

**Class: Crinozoa (Sea lilies)**

They live both in shallow water and in depths up to 6,000 meters. Sea lilies in their adult form are attached to the sea bottom by a stalk. They have a mouth on the top surface that is surrounded by feeding arms. Crinoids usually have a stem used to attach them to a substrate, but many live attached only as juveniles and become free-swimming as adults. A total of 95 species belonging to 43 genera have been reported from India.

**2.2.11 Phylum: Phoronida (Horseshoe worms)**

They live in most of the oceans and seas including the Arctic Ocean but excluding the Antarctic Ocean, and between the intertidal zone and about 400 meters down. About 5 species of phoronids were reported from India.

**2.2.12 Phylum: Brachiopoda (Lamp shells)**

They have hard shells on the upper and lower surfaces, unlike the left and right arrangement in bivalve molluscs. There are two types are recognized, articulate and inarticulate. Articulate brachiopods have toothed hinges and simple opening and closing muscles, while inarticulate brachiopods have untoothed hinges and a more complex system of muscles used to keep the two halves aligned. About 5 species of Brachiopods were found in India.

**2.2.13 Phylum: Bryozoa (Moss animals)**

They are known as Polyzoa, Ectoprocta or moss animals are aquatic invertebrate animals. Size range from 0.5 millimeters long, and are filter feeders. Most marine species live in tropical waters, but a few occur in oceanic trenches, and others are found in polar waters and few prefer brackish water. Over 4,000 living species are known. One genus is solitary and the rest colonial. There is a rich biodiversity in India with about 500 species are reported so far. Several collections and descriptions in the past enriched the knowledge about the Bryozoans occurring along the Indian coast (Venkataraman and Wafer, 2005).



#### **2.2.14 Phylum: Hemichordata (Acorn worms)**

Acorn worms are solitary live in burrows and are deposit feeders, and species are filter feeders. About 12 species of hemichordates have been reported from India as compared to global species of 102.

#### **2.2.15 Phylum: Chaetognatha (Arrow worms)**

Arrow worms are predatory marine worms that form a major component of plankton worldwide. About 20% of species are benthic, and can attach to algae and rocks. They are marine and occur in surface tropical waters and shallow tide pools to the deep sea and Polar Regions. They range in size from 2 to 120 millimeters. A total of 30 species have been reported from India. They are abundant all along the Indian coast. Chaetognaths of Indian seas have been studied extensively along the Malabar Coast, Vishakhapatnam Coast, Andhra coast and Indian Ocean during the sixties (Venkataraman and Wafer, 2005).

#### **2.2.16 Phylum: Chordata**

##### **Class: Thaliacea (Pelagic tunicates)**

Thaliaceans are free-floating for their entire lifespan. They include both solitary and colonial species. Thaliaceans have 30% carbon by mass. Therefore their dense bodies sink to the bottom of the oceans when they die and this may be a major part of the worldwide carbon cycle. A total of 40 species was reported from India.

##### **Class: Ascidiacea (Sea squirts)**

Ascidians are found all over the world, usually in shallow water with salinities over 2.5‰ the members of the Thaliacea and Larvacea swim freely like plankton, sea squirts are sessile animals. A total of 50 species belonging 21 genera have been reported from India against 2000 species of Asidian in the world.

##### **Class: Pisces**

**Fin fishes:** Recent analysis indicates that 18 resource groups fall under the abundant category, five fall under less abundant category and one each fall under declining, depleted and collapsed category. The 18 stocks resource groups under the abundant category or less abundant category indicating good condition of their stock. The less abundant category includes elasmobranchs, threadfins, ribbon fishes, mullets and flat fishes. Big-jawed jumper under the declining category flying fishes under depleted and unicorn cod is in the collapsed category. While certain stocks such as those of Mackerel, Lesser Sardines, White bait, Seer fish, Coastal and oceanic tunas, Croakers, Pig face bream, Groupers, Snappers, Catfish, Lizard fish, Silver bells and Goat fishes are exploited all along the Indian coast. Bombay duck is caught mainly along the Gujarat and Maharashtra coast and to a lesser extent along certain pockets of Andhra, Orissa and West Bengal coasts. Hilsa is harvested mainly along the West Bengal coast and Gujarat coast.

**Elasmobranchs:** The elasmobranchs consists of sharks, sawfishes, rays, skates and guitar fishes. They are fished using different types of gears and in recent years have assumed great significance in the export market. They are exploited by a variety of fishing gears like gill

nets, long lines and trawls along the Indian coast by both traditional and mechanized sector (Raje *et al.*, 2002). Though there is no directed fishing for elasmobranchs in certain places of Tamilnadu, large meshed bottom set gill nets called as 'thirukkuvalai' are operated for fishing the rays. They are all predatory feeding on a wide range of zooplankton to benthic invertebrates, bony fishes, other sharks, turtles, seabirds and marine mammals (Joshi, 2012).

In India, we have listed out about 110 species of elasmobranch which includes 66 species of sharks and 44 species of batoides. The recent description of new records and new species may lead to this figure to about 150-170 species from Indian coast alone. The whale shark is huge, sluggish, pelagic filter-feeder, often seen swimming on the surface. Viviparous and gravid female have 300 young ones of several stages of development. The protected elasmobranchs as per the Wildlife (Protection) Act, 1972, Schedule I are *Rhincodon typus* (Whale shark), *Anoxypristis cuspidate* (Pointed saw fish), *Pristis microdon* (Largetooth sawfish), *Pristis zijsron* (Longcomb sawfish), *Carcharhinus hemiodon* (Pondicherry shark), *Glyphis gangeticus* (Ganges shark), *Glyphis glyphis* (Spear tooth shark), *Himantura fluviatilis* (Gangetic sting ray), *Rhincobatus djiddensis* (Giant guitarfish) and *Urogymnus asperimus* (Thorny ray).

**Ornamental fish:** The Gulf of Mannar, Palk bay, Gulf of Kutch, South West coast and the Lakshadweep and Andaman group of Islands are known to be rich in Ornamental fishery. The Wrasses, damsel fish, Surgeon, Butterfly fish, Moorish idol, Squirrel fish, Trigger fish, Rabbit fish, Parrot fish, Angels, Goat fish and Puffer fish are the major aquarium fishes represented by about 180 species (Murty *et al.*, 1989; Murty, 2002). As the majority of these fishes is associated with coral reefs and those in great demand are not very abundant, their exploitation may disturb the habitats and result in depletion of stock, if a suitable mechanism for sustainable exploitation using for example sample traps and monitoring the exploitation and export is not developed. The sea horses and pipe fishes are known to live sea grass beds, mangroves and reefs in shallower coastal waters of the temperate and tropical regions, about 300 species of about 30 genera are known (Vincy, 1995). CITES have listed all the sea horse in the Appendix I stop the trade of these organisms. Indian wild Life Act 2002 also protects the sea horse by putting them on Schedule list I. Dried sea horse has got a high demand in Singapore and China for making soup and for medicinal purposes.

### **Class: Reptilia**

**Marine reptiles:** Marine reptiles are air-breathing, ectothermic, poikilothermic vertebrates. Their skin is covered with dry scales and lays their egg on land. Out of the 700 living species only few species of snakes, turtles, and crocodiles are seen in the ocean.

### **Order: Chelonia**

**Sea Turtles:** Five species of sea turtles were reported In India which include, Olive Ridley (*Lepidochelys olivacea*) Green Turtle (*Chelonia mydas*), Leather back (*Dermochelys olivacea*), Hawksbill (*Eretmochelys imbricate*) and Loggerhead (*Caretta Caretta*). Sea turtles have an armor-like shell, as carapace and that is fused to the backbone. Unlike their terrestrial counterparts sea turtles cannot retract their heads into the shell. Their legs especially forelimbs are modified into flippers for swimming. Green turtles (*Chelone mydas*) are found in coastal water and feed mainly as sea grasses and seaweeds. The hawksbill turtle (*Eretmochelys imbricata*) feed on encrusting animals like sponges, sea quirts, barnacles and sea weeds. The largest sea turtle the leather back (*Dermochelys coriacea*) have a series of

shells and an oceanic species. They have scissor-like jaws for capturing and they feed on jellyfish. Other species feed on soft, bottom invertebrates like sponges, soft corals, jellyfishes and crabs. Prey-predator relationship in the ecosystem is one of the important factors in limiting as well as the proliferation of organisms due to the decline of the one of the components in the trophic relations. A recent spurt of the Jellyfish biomass in different parts of the coastal ecosystem can be attributed to the decline of turtle populations in the ecosystems. Except green turtles all other turtles feed heavily on Jelly fishes and prevent the proliferation of the population. All species of marine turtles are in the endangered category, and are therefore, protected under the Indian Wildlife Act, 1972. In view of their endangered status and total ban on the trade of sea turtles and their products under CITES, proper identification of the species and information on their biology are essential for monitoring the resource.

**Class: Reptilia**

**Order: Squamata**

**Sea Snakes:** Sea snakes occur in the tropical and sub-tropical waters of the Indian Ocean from the east coast of Africa to Australia. They occur in shallow coastal waters, estuary, lakes and fresh water in the rivers away from the sea. They feed on fish, fish eggs, crustacean and tuna. The genus *Laticauda* is oviparous and all other sea snakes are viviparous. The sea snake bite is dangerous and it is neurotoxic like terrestrial snakes like karate and cobra. Sea snakes are mainly exploited for their skin, poison and meat. Most of the sea snake fisheries in Indian Ocean have not been reported and no data available on it. There are about 80 species sea snakes belonging to three families inhabiting the world oceans and estuaries. In Indian waters, about 22 species of marine snakes belonging to three families have been documented. Twenty species are represented in the family Elapidae, of which 18 belong to sub-family Hydrophiinae (true sea snakes) and two belong to sub-family Laticaudinae (sea kraits); one species belong to the sub-family Homalopsinae under family Colubridae, and a single species are represented in the family Acrochordidae.

**Order: Crocodylia**

**Salt water crocodiles:** Salt water crocodile, *Crocodylus porosus* (Schneider, 1801) is the largest reptile in the present world with about six meter lengths and up to one metric ton weight. They can live in salt water but usually occurs in mangrove swamps, estuaries, deltas, lagoons and lower stretches of rivers. The historical geographical range of these species is from Cochin to Sunder bans and up to the Andaman Islands. They can travel 1000 km by sea. Due to hunting and loss of habitat these animals do not exist in Kerala and Tamilnadu. They spent the tropical wet season in freshwater swamps and rivers, moving downstream to estuaries in dry season and sometimes to sea. Juveniles feed on smaller insects, amphibians, crustaceans, reptiles and fish. The larger animals feed on monkeys, mammals, birds, domestic livestock, pets, buffalo, sharks and humans. The species is endangered due to hunting, loss of habitat and breeding sites. Marsh crocodile or Indian swamp crocodile is *Crocodylus palustris* (Lesson, 1831) found in rivers, swamps, lakes and saltwater lagoon. Indian Gharial is *Garialis gangeticus* (Gmelin, 1789) are found mainly in the river Ganga, Brahma Putra and Mahanadi. The crocodile Bank located in Chennai to conserve the endangered reptiles like crocodile and alligators.

**Class: Aves**

**Sea birds:** Sea birds are long lived, with very low natural mortality. They are also characterized by being late to mature and slow to reproduce and some cases, they will start breeding at the age of ten years old. Most of them lay a single egg each year. These biological traits and human induced adult mortality potentially damaging population decreases and collapse of the population. Also most of the tropical sea bird species fell in association with tuna stocks which derive their prey to the surface thereby bringing within the reach of the sea birds. The depletion of the tuna stocks could therefore have impacts on their dependent species like sea birds. The cascade effects of reduce tuna or shark on the ecosystem is not known.

Common birds are Grey heron (*Ardea cinerea*), Pond heron (*Ardeola grayii*), Large egret (*Egretta alba*), Little egret (*E. garzetta*), Painted stork (*Ibis leucocephalus*), Spoon bill (*Platalea leucocordia*), Flamingo (*Phoenicopterus roseus*), Parian kite (*Milvus nigra*), Golden plover (*Pluvialis dominica*), Black headed Gull (*Larus ridibundus*), Gull billed Tern (*Geolchelidon nilotica*), Caspian tern (*Hydroprogne caspia*), Little tern (*Sterna abilfrons*) and Sandwich tern and (*Sterna sandvicensis*), Three species of Albatross are endanger (IUCN) two species near threatened and one is critically endangered (IUCN). Sea birds occur along the Gulf of Kutch, Gulf of Mannar, Chilka Lake, Coringa Wild life Sanctuary and the Sundarbans, Islands of Laccadive such as Pitti and Batapari are the colonies of sea birds. Sundarbans are important staging and wintering area of gulls and terns.

**Class: Mammalia**

**Marine Mammals:** All marine mammals belonging to the whales, dolphins, porpoises and dugong are rare and endangered, and are listed under CITES. They migrate to the tropical seas for feeding and breeding and often get entrapped in the tide and washed ashore or entangled in the fishing gears. Dugongs get entangled in fishing gears while feeding on the sea grass beds along the Gulf of Mannar. Often there has been clandestine fishing for the dugongs along the Gulf of Mannar. The meat is highly relished by the local people and hence the dugongs are often exploited. This has led to a drastic decline in their population. The destruction of seagrass beds due to trawling has further aggravated the situation. The possible occurrence areas of digging are the Gulf of Mannar and Palk Bay, Gulf of Kutch, Andaman Islands. As the dugong inhabits the narrow Palk Strait and the contiguous Gulf of Mannar between India and Sri Lanka, conservation requires international understanding and cooperation (Vivekanadan and Jeyabasker, 2013). Marine mammals come under the class Mammalia; globally 130 species were so far recorded. They included in three orders namely Cetacea (whales, dolphins, and porpoises), Sirenia (manatees and dugong), Carnivora (sea otters, polar bears and pinnipeds like seals and walrus). In India, 31 species of marine mammals (30 species of Cetacea and one species of Sirenia) are documented accounting to one fourths of the world's marine mammalian fauna and almost 8% of the total Indian mammalian fauna.

**Conclusion**

The exploited marine fisheries resources from the coastal area have been reached maximum from the present fishing grounds up to 200 m depth. The coastal fisheries faces several threats such as indiscriminate fishing, habitat degradation, pollution, social conflicts, the introduction of highly sophisticated fishing gadgets, need management

measures and conservation of marine biodiversity to maintain sustainable use of marine biodiversity. Human activities are the major causes for the loss of biodiversity and degradation of marine and coastal habitats, which needs immediate attention and comprehensive action plan to conserve the biodiversity for living harmoniously with nature. Some of the measures such as control of excess fleet size, control of some of the gears like purse seines, ring seines, disco-nets, regulation of mesh size, avoid habitat degradation of nursery areas of the some of the species, reduce the discards of the low value fish, protection of spawners, implementation of reference points and notification of marine reserves for protection and conservation of marine and coastal biodiversity.

## References

- Alok Saxena 2012. Marine Biodiversity in India, Status and Issues. Marine Biodiversity Uttar Pradesh State Biodiversity Board. pp. 127-134.
- Appukuttan, K. K. 1996. Marine Molluscs and their Conservation. In Marine Biodiversity Conservation and Management (Eds: N. G. Menon and C.S.G. Pillai ), Central Marine Fisheries Research Institute , Cochin, pp. 66-79.
- Devaraj, M, V. Sriramachandra Murthy, R. Sathiadhas and K. K. Joshi. 1998. The new Economic policy and perspective for marine fisheries research and development in India . *Fishing Chimes*, 18 (5): 18-29.
- Devaraj, M. 1996. Coastal biodiversity conservation and sustainable management. In Marine Biodiversity Conservation and Management (Eds: N. G. Menon and C.S.G. Pillai ), Central Marine Fisheries Research Institute , Cochin pp. 172-197.
- Faith, D.P, and A. M. Basker, 2006. Phylogenetic diversity (PD) and biodiversity conservation. Some bioinformatics challenges. *Evolutionary Bioinformatics* online -2001 70-77.
- Faith, D. P, Reid C. A. M. and Huntar, J. 2004. Integrating Phylogenetic Diversity, complementarily and endemism for conservation assessment. *Conserve Biol.* 18.255-261.
- Gopinathan, C.P. and G. S. D. Selvaraj, 1996. The Mangroves-importance, conservation and Management. In Marine Biodiversity Conservation and Management (Eds: N. G. Menon and C.S.G. Pillai ), Central Marine Fisheries Research Institute , Cochin, pp. 4-15.
- James, D.B. 1996. Conservation of Sea cucumbers. In Marine Biodiversity Conservation and Management (Eds : N. G. Menon and C.S.G. Pillai ), Central Marine Fisheries Research Institute , Cochin PP 80-88.
- Joshi, K. K. 2012. *Marine biodiversity and the conservation of the important marine organisms*. In: Marine biodiversity status, opportunities and challenges. Ramachandran, A and Joseph, Aneykutti, (Eds.) CUSAT, Kochi, pp. 35-78.
- Kathiresan, K. And N. Rajendran. 2005. Mangrove ecosystem of the Indian Ocean region. *Indian Journal of Marine Sciences*, 34 (1) 104 -113.
- Murty. V.S., M. Kumaran and R. S. Lalmohan, 1989. Resource of ornamental fishes in Marine Living Resources of the Union Territory of Lakshadweep an indicative survey with suggestions for development. Bull. Central Marine Fisheries Research Institute, 43: 46-64.
- Murty, V. Sriramachandra. 2002. *Marine ornamental fish resources of Lakshadweep*. CMFRI Special Publication, 72. pp. 1-134.
- Pillai, C. S. G. 1996. Coral reefs of India Their conservation and Management in Marine Biodiversity Conservation Management ( Eds. Menon N. G. and C. S. G. Pillai CMFRI, pp. 16-31.



- Raje, S. G. and Joshi, K. K. 2003. *Elasmobranchs*. In: Status of Exploited Marine Fishery Resources of India. Mohan Joseph, M and Jayaprakash, A. A, (eds.), CMFRI, Cochin, pp. 92-101. ISBN 81-901219-3-6
- Raje, S. G. and Mathew, Grace and Joshi, K. K. and Nair, Rekha J and Mohanraj, G. and Srinath, M and Gomathy, S and Rudramurthy, N. 2002. *Elasmobranch fisheries of India - An appraisal*. CMFRI Special Publication, 71. pp. 1-76.
- Raje, S. G. and Sivakami, S and Mohanraj, G and Manojkumar, P. P. and Raju, A and Joshi, K. K. 2007. *An atlas on the Elasmobranch fishery resources of India*. CMFRI, Special Publication, 95. pp. 1-253.
- Rao Syda, G. 2013. Way forward for enhancing Indian Marine Fish Production. *Fishing Chimes*, 33 (1& 2): 57-64
- Rao, D. S., C. P. Ramamritham , A.V. S. Murthy , S. Muthusamy, N. P. K. Unnikrishnan and L. R. Khambadkar , 1992. Oceanography of the Arabian sea with particular reference to the south west monsoon. *Bull. Central Marine Fisheries Research Institute*, 45:4-8.
- Singh, H.S. 2003. Marine protected areas in India. *Indian Journal of Marine Sciences*, 32 (3): 226-233.
- Thomas, P. A. 1996 a. An appraisal of the biological and biochemical diversity in the sponges. *Marine Fisheries Information Service T & E Series* 142: 1-5.
- Thomas, P.A. 1996 b. The Gorgonid resources and their Conservation in India. In *Marine Biodiversity Conservation and Management* (Eds: N. G. Menon and C.S.G. Pillai ), Central Marine Fisheries Research Institute , Cochin PP 32-40.
- Thomas, P. A. and Ranimary George. 1987. Gorgonid resources of India. *Marine Fisheries Information Service T& E Series*, 74: 1-13.
- Venkataraman , K. and Mohideen Wafar, 2005. Coastal and marine biodiversity of India. *Indian Journal of Marine Sciences*, 34 (1): 57-75.
- Vincy , C. J. 1995. Exploitation of sea horses and pipe fishes. Naga. *The ICLARAM quarterly* 18 (1): 18-19.
- Vivekanandan, E and Jeyabaskaran, R. 2012. *Marine Mammal Species of India*. Central Marine Fisheries Research Institute, Kochi, 221 pp.

\*\*\*\*\*