# Contributions to Marine Biodiversity in India

# coast track

*Issues and Challenges in Coastal Management*


Acropora intermedia


Acropora cytherea


Favia pallida


Montipora foliosa


## Inside.....

- Introduction on Marine biodiversity
- Marine biodiversity in India as today
- Marine biodiversity of India in comparison with global Marine biodiversity
- Summary of Marine biodiversity studies in Indian sea
- Latest News and Titbits

Vol. 16 (2) April 2017 - September 2017

ISSN:2393-8978

For Private Circulation only

# CONTENTS

**Volume 16 (2) April 2017 - September 2017**



Please send your valuable suggestions, comments and queries to:


**ENVIS RESOURCE PARTER**
Centre for Coastal Zone Management and Coastal Shelter Belt
Institute for Ocean Management, Anna University
Chennai - 600 025, Tamil Nadu, India.

**:** iom-env@nic.in

**Visit us at:** www.iomenvis.nic.in
Please send your feedback ( Annexure I)

**Contact :**

+91 (44) 2235 7506 / 8448

+ 91 44 2220 0158

iom-env@nic.in, iom@envis.nic.in,
ponmozhisrini2001@yahoo.com


## CHIEF EDITOR


**Prof. Dr. R. Ramesh**
Institute for Ocean Management,
Anna University, Chennai &
Director, NCSCM,
Anna University Campus, Chennai.


## EDITORS


**Prof. Dr. S. Srinivasalu**
Co - ordinator, ENVIS - IOM,
Director, Institute for Ocean Management &
Additional Controller of Examinations,
Anna University , Chennai.


## ASSOCIATES


**S. Sathya**
Information Officer - ENVIS,
Institute for Ocean Management,
Anna University , Chennai.

**K.Rajalakshmi**
Information Assistant - ENVIS,
Institute for Ocean Management,
Anna University , Chennai.


## IMPORTANT WEBSITES

**Institute for Ocean Management (IOM) -** www.annauniv.edu/iom/home.htm
**IOM ENVIS Centre -**
www.iomenvis.nic.in
www.iomenvis.in
**Land Ocean Interactions in the Coastal Zone -** www.loiczsouthasia.org
**National Centre for Sustainable Coastal Management** - www.ncscm.res.in


**Cover Design & Layout:**
**S. Sathya and K.Rajalakshmi- ENVIS**

**Printed at: KSB Printers, Chennai**

# Our Previous Coast Track Newsletters

1. Vol 6 (1) March 2007 :
**Need for Coastal Management and Interpreting the Plans, Policies and Strategies for Integrative ,Coastal Management Plan of a few Islands in Andaman**

2. Vol 6 (2) December 2007 :
**Coastal Shelter Belts, Overview of Types of Coastal Protection, Shore Protection and Sea Defense**

3. Vol 7 (1) March 2008 :
**Coastal Bioshield**

4. Vol 7 (2) July 2008 :
**Natural Hazards and Disasters**

5. Vol 7 (3 and 4) January 2009 - March 2009 :
**Global Change and the Coastal Zone : LOICZ Science**

6. Vol 8 (1) June 2009 :
**Fisheries and Climate Change**

7. Vol 8 (2 and 3) October 2009 and January 2010 :
**Deltas of the World, A Review of Coastal Science Issues**

8. Vol 8 (4) January 2010 - March 2010 and Vol 9 (1) April 2010 - June 2010 :
**Icelandic Volcanoes**

9. Vol 9 (2) July 2010 - September 2010 :
**Artificial Reefs**

10. Vol 9 (3 and 4) October 2010 - March 2011 :
**Blue Carbon**

11. Vol 10 (1 and 2) April 2011 - September 2011 :
**Ecosystem Services and Human Well Being**

12. Vol 10 (3 and 4) October 2011 - March 2012 :
**Coastal Waste Waters**

13. Vol 11 (1 and 2) April 2012 - September 2012 :
**Coastal Livelihoods in India**

14. Vol 11 (3 and 4) October 2012 - March 2013 :
**India - A Disaster Prone Country**

15. Vol 12 (1 and 2) April 2013 - September 2013 :
**Sand Dunes**

16. Vol 12 (3 and 4) October 2013 - March 2014 :
**Coastal Erosion**

17. Vol 13 (1 and 2) April 2014 - September 2014 :
**Sand Dunes - A natural shelter belt - Status, Legislation and Values**

18. Vol 13 (3 and 4) October 2014 - March 2015:
**Ecologically Sensitive Coastal Areas**

19. Vol 14 (1) April 2015 - June 2015:
**Coastal Ecosystem - Fresh Water Implication**

20. Vol 14 (2) July 2015 - September 2015:
**Coastal Ecosystem Valuation**

21. Vol 15 (1) October 2015 - March 2016:
**Annual Monsoon 2015 in South India - A Nightmare to Chennai City**

22. Vol 15 (2) April 2016 - September 2016 :
**Coral Reefs in India - A Review**

23. Vol 16(1) October 2016 - March 2017 :
**Coastal Cliffs of India**

www.iomenvis.nic.in - Login and download Our Previous Newsletters

# Editorial Note


Biodiversity has three aspects, viz genetics, species and ecosystem. India is recognized to be uniquely rich in all these three aspects. Almost all the bio geographical regions of the world are represented in India, with a mere 2.4 % of the total land area of the world; the known biodiversity of India contributes 8.22 % of the known global biodiversity. India is one of the 12 mega-diversity nations of the world accounting for 7.31% of the global faunal and 10.88% of the global floral total species.

India has 7500km long coastline having (mangroves, estuaries, coral reefs, back waters) rich biodiversity. More than 340 species of corals are found in India. India is rich in Mollusks, Crustaceans, Polychaetes and Corals.

In the issue of coast track, provides an insight about the marine biodiversity in India, as today, which has been summarized in a table of comparison of species with global marine biodiversity, this data has revealed that India contributes 6.78% of marine biodiversity in global scenario. The other table summarizes the studies carried out regarding marine bio-diversity in Indian seas. It is my sincere hope that this issue on contributions to marine biodiversity in India is useful and we value your feedback to our newsletter and the contents.

# Marine biodiversity in India - An Introduction

**K. Venkataraman**
(*Former Director*) - Zoological Survey of India (ZSI)
Senior Scientific Consultant
National Centre for Sustainable Coastal Management
Anna University Campus, Chennai 600 025

Oceans and major seas cover 70.8% or 362 million km$^2$ of the earth with a global coastline of 1.6 million km. Marine ecosystems are tightly connected through a network of surface and deep-water currents and they are among the most productive ecosystems in the world. Coastal and marine ecosystems include sand dune areas where freshwater and seawater mix, nearshore coastal areas, and open ocean marine areas. India is one among 12 mega-biodiversity countries and 25 hotspots of the richest and highly endangered eco-regions of the world. In terms of marine environment, India has a coastline of about 8000 km. The exclusive economic zone (EEZ) of the country has an area of 2.02 million sq km comprising 0.86 million sq km on the west coast, 0.56 million sq km on the east coast and 0.6 million sq km around the Andaman and Nicobar islands. Adjoining the continental regions and the offshore islands and a very wide range of coastal ecosystems such as estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, sandy stretches and coral reefs, which are characterized by unique biotic and abiotic properties and processes. A network of 14 major, 44 medium and numerous minor rivers together with their tributaries cover practically the entire country except for the western arid region of Rajasthan Desert. The total length of the rivers is estimated at over 40,000 km. The dissimilarities between the Indian west and east coasts are remarkable. The west coast is generally exposed with heavy surf and rocky shores and headlands whereas the east coast is generally shelving with beaches, lagoons, deltas and marshes. The west coast is a region of intense upwelling associated with southwest monsoon (May – September) whereas the east coast experiences only a weak upwelling associated with the northeast monsoon (October - January), resulting in marked differences in hydrographic regimes, productivity patterns and qualitative and quantitative composition of fisheries. All islands on the east coast are continental islands whereas the major island formations in the west coast are oceanic atolls.

A serious study of the history of coastal and marine biodiversity needs support of data documented in the past. Historical research into the development of marine biodiversity studies in India during the last 200 years can be done with an insight into the pattern of inventory of biodiversity. The earliest such study on marine biodiversity of India was made by F. H. Gravely' in his address to the zoology section of the eighth session of the Indian Science Congress held in Calcutta (=Kolkata) in 1921. He dealt with the history of marine biodiversity studies in India and Sri Lanka since 1659. In the Silver Jubilee (1938) volume of the Indian Science Congress Association (ISCA) Srinivasa Rao's up-dated the information on the progress of research up to 1938. The aforementioned accounts provided the most vital sources of information documented at different intervals of time. The present account, however, has its own limitations. While an attempt has been made to trace the contribution of the early pioneers of the nineteenth century towards the development of zoology, greater emphasis has been laid in the-study of the progress during the twentieth century on the broader spectrum of the discipline by way of higher education, research and development, and governmental support (Table 1 and 2).

The Marine Survey of India- started its biological studies in 1871 when the Council of the Asiatic Society of Bengal appealed to the Government of India for undertaking investigation in Indian waters, similar to the one done by H.M.S. Challenger, appointed by the British Government, in respect of life and matter of great oceans. The appeal of the Asiatic Society was based on the recommendation of a committee composed of F. Stoliczka, W. T. Blanford, J. Anderson, J. Wood-Mason, and T.Oldham, who opined that deep-sea investigation might lead to the discovery of new animal forms. The proposal was supported by the Royal Society of London and by many of the contemporary leading zoologists. But credit for the first deep-sea biological investigations of the Indian Ocean goes to James Wood-Mason of the Indian Museum, who, with limited facility, collected specimens from shallow water up to about 300 fathoms. In 1875 the post of Surgeon-Naturalist of the Marine Survey of India, was created and filled up by Dr .J. Armstrong, who, without the aid of a ship, had to restrict his work to the shallow water and littoral region. He published in the Journal of the Asiatic Society of Bengal a brief but excellent paper on hydroid zoophytes from Indian coasts and seas. Deep-sea dredging at last took its proper, if secondary, place in the economy of Marine Survey of India. With Surgeon-Naturalist G.M.T. Giles on board the Investigator, several areas were surveyed in 1884-85 and 1886-87 and the collections were studied during the recess season. Giles published a series of papers on marine animals of Indian waters in the Journal of the Asiatic Society of Bengal (1885-90), which constituted the basis of his future work. In 1888 Giles resigned, and at the end of the year Capt. A. Alcock was appointed in his place. The latter was succeeded by Surgeon-Captain A. R. S. Anderson (1893-99). Several areas of the Bay of Bengal, the sea around Sri Lanka, the Andaman, Palk Straits, Lakshadweep, the mouth of the Ganges and the Indus, etc. were extensively surveyed. With the appointment of artists like A. C. Chowdhury and later, S. C. Mondal, a series of twelve plates per year were prepared and published in the 1890sas Illustrations of the Zoology of the Royal Indian Marine Surveying Steamer Investigator. However, the first of the monographs based on collections made by the Investigator was published by Alcock in 1898 on Madreporaria followed by three more volumes, The Deep Sea Ophiuroidea by R. Koehler, The Deep Sea Fishes by Alcock, and The Deep Sea Brachyua by Alcock—all being published in1899.

The foregoing brief account shows certain definite trends of research and investigation. As Gravely noted in 1921: 'In Europe, with its comparatively limited and well-explored fauna, morphology commonly offers much greater scope for investigation than does taxonomy. In India, with its much richer and largely unexplored fauna, this is not so, and thus it happens that all he greater Indian Zoologists have hitherto been taxonomists. But their taxonomic work has been based on careful investigations into anatomy and field biology, thereby establishing for us a fine tradition. The Indian Museum of Calcutta (estd. 1814), the museum at Madras, the colleges at Lahore, Madras (Chennai), and Allahabad were the only other places of worthwhile research and training in the discipline till the start of expansion of education and the growth of institutions in the early years of the twentieth century.

Universities located in the coastal regions like Orissa, Andhra, Tamil Nadu, Kerala, Gujarat, and Maharashtra have established separate departments to study marine sciences including marine biology. The University of Calcutta may be listed as the youngest member in this group.

The National Institute of Oceanography at Goa established in 1963-64 under the Council of Scientific and Industrial Research (CSIR) has during the last twenty years made valuable contributions on biological oceanography involving survey of biological resources, coastal aquaculture, studies in phytoplankton, biology of ecosystem under different environmental stress, marine microbiology and studies on marine fouling and wood boring organism. Zoological Survey of India also established a separate Marine Biological Station at Madras (1973) and published valuable data of research investigation on several aspects of marine biology. Likewise, the Central Marine Fisheries Research Institute at Cochin developed into a national centre for study of not only marine fishesbut also other marine forms like corals, sponges, coelenterates, and turtles. The establishment of the Department of Ocean Development by the Government of India in 1982 later the first successful Indian Antarctic expedition and the current emphasis on oceanographic studies, as seen at the Indian Science Congress in 1983, are a positive index of growth and development of marine biology in India, besides other sub-disciplines of zoology.

The National Institute of Oceanography (NIO) at Goa has been referred to earlier; but NIO scientists' utilization of the country's first research vessel, R.V. Gaveshani, which has made more than 101 cruises in the seas around India and the Indian Ocean, needs special mention. The material collected during these cruises contributed substantially towards our knowledge on primary productivity, planktonology, benthic biology, microbiology and distribution of marine organism and their interaction, etc. The directories on marine research projects, marine scientists and training and education facilities in marine sciences in India, published by NIO, will indicate the development of study and research in marine biology.

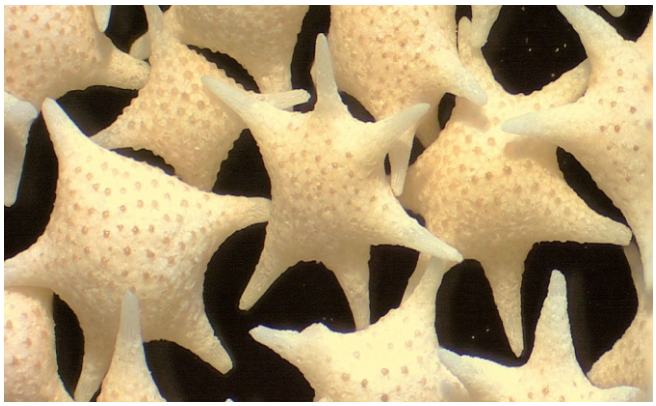
The successful missions to Antarctica carried out by the scientists of NIO and other agencies (1981-84) are landmarks in further research activities. NIO has three regional centres of research at Cochin, Bombay, and Visakhapatnam, each one of which is actively involved in the biological oceanographic studies. The Planning Commission has identified the Central Marine Fisheries Research Institute as the national data centre for marine fishes. As a result, a national workshop on 'Acquisition and Dissemination of Data on Marine Living Resources of Indian Seas' was held at Cochin in 1982, which has opened up the potentiality of data processing by the use of computer and other modern technologies.

Among the Asian countries, India is perhaps the only one that has a long record of biodiversity inventories of coastal and marine biodiversity dating back to at least two centuries. However, these are so diverse in space, time and taxon that it is almost impossible to review all records and reports. The synthesis of what is known of coastal and marine biodiversity in India attempted in this paper relies mainly on systematic accounts, records and reports of two major institutions concerned with surveys and inventories of fauna and flora – the Zoological Survey of India and the Botanical Survey of India as well as other research organizations such as Central Marine Fisheries Research Institute, National Institute of Oceanography and National Centre for Sustainable Coastal Management.

In recent years lack of taxonomists for many groups is evident that comprehensive taxonomic coverage of the marine biota of the entire region remains a monumental task, beyond the capacity of existing local taxonomic expertise. In order to augment the gap on exploration and identification of many faunal components, taxonomists should be encouraged with sufficient funding support.

Currently the Government of India providing limited financial support under the scheme of All India Coordinated Project on Taxonomy (AICOPTAX) to promote the taxonomical research through the Ministry of Environment and Forests and Climate Change. However, other scientific ministries such as Ministry of Earth Sciences and Ministry of Science and Technology should also encourage the taxonomists not only for taxonomical research but also for capacity building on taxonomy. Awareness on the importance of taxonomy of marine biota has to be deliberated at academic level, which will enhance the interest of students upon marine taxonomical studies. The present accout gives an overview of studies sofar made on the marine biodiversity of India.

**Phylum: Protozoa**



https://i.kinjaimg.com/gawkermedia/image/upload/t_original/ot3ao3a1wg7z0atrserm.jpg

**Foraminifera:** Foraminiferans are eukaryotic unicellular organisms with the general characteristics of protists. Their exoskeleton is commonly made of calcium carbonate while the rest have agglutinated shells made up of sediments or shell of dead organisms.Due to their diversity which is the function of their ecological adaptation, each environment is characterized by ecological assemblages. Their small size, sensitivity to small change in the environment and ability to preserve these changes in their hard part, give them an immense applicability in the field of palaeoclimatic reconstruction and environmental monitoring.

It has been estimated that the total number of foraminiferans might be approximately 4000 living species. Forminiferan is one of the relatively well-studied groups, with the earliest descriptions of new species dating back to 18th Century. The most important phase of documentation of foraminiferan fauna began with the Challenger Expedition (1873-1876), giving rise to detailed descriptions of deep and shallow water Foraminifera[47,56]. Contemporary studies began with International Geophysical year in 1958 and the International Indian Ocean Expedition (1962-1965).The major part of the work on this group has been done along the east coast of India. These are by Bhatia and Bhalla[38] (14 benthic species from Puri Beach), Satyavathy[236] (Waltair Coast), Sarojin[233] (Waltair Coast), Subba Rao and Vedantam[261] (distribution of 32 species on the continental shelf off Visakhapatnam at depths of 20–200 m), Bhalla[37] (16 species from beach sand of Visakhapatnam), Bhatt [39] (15 planktonic species off Visakhapatnam), Bhalla[37] (15 species from Madras Marina Beach), Gnanamuthu [107] (47 littoral benthic species from Krusadai Island, Gulf of Mannar) and Ameer Hamsa[20] (description of four new records from the Palk Bay). Comparatively less work has been done on the west coast of India and the Arabian Sea. Mention may be made on the work of Antony [30](description and distribution of 164 species from Kerala coast), Siebold[24] (12 species of benthic foraminifera from Kochi backwaters), Chapman[56] (description of 277 species from bottom samples near Lakshadweep Islands), Chatterjee and Gururaja[57] (unidentified species from 16-20 m depth off Mangalore coast), Chaudhuri and Biswas[64] (12 species from Juhu Beach, Bombay) and Rao[212, 213, 214] (a series of papers describing 84 species from shallow waters of Gulf of Cambay).

The study of Frerichs[94] on the distribution and ecology of benthonic and planktonic forms in the sediments of the Andaman Sea appears to be the only one from the Andaman and Nicobar Islands. The protozoans identified sofar in India is 1122 out of 17855 in the world (Table 1).

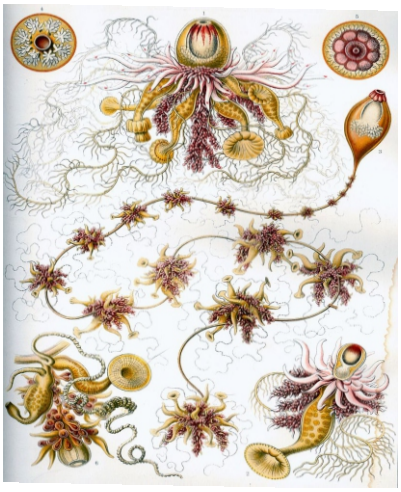
**Phylum: Cinadaria**

http://www.angelfire.com/mo2/animals1/images/jellyfish.jpg

The global estimates of cnidarian diversity vary between 9000 and 12,000 species. In India 178 species of Hydrozoa, 30 species of Scyphozoa, five species of Cubozoa and about 1117 species of Anthozoa have been reported till now (Table 1).

Since all groups of Cnidarians have not received adequate attention of Indian taxonomists, the above figures cannot be taken as final. Except the pioneering works of Annandale[22, 26,27], Leloup[149] and Menon[163] other studies are few and scattered. Comprehensive accounts are available only for siphonophores by Daniel[74], scyphomedusae by Chakrapany[55], scleratinian corals by Pillai [197] and Venkataraman[283, 284.]

**Hydrozoa**: The first description of hydrozoans in India was by Annandale[26] from Chilka Lagoon and subsequently by Menon[160] reporting 35 species under 28 genera and of Mammen[154,1]



https://upload.wikimedia.org/wikipedia/commons/2/23/Mikrofoto.de Blepharisma_japonicum_15.jpg

who has inventorised 116 species belonging to 13 families. Among these forms, species of the orders Milliporina, Stylasterina and Trachylina have received only scant attention so far.

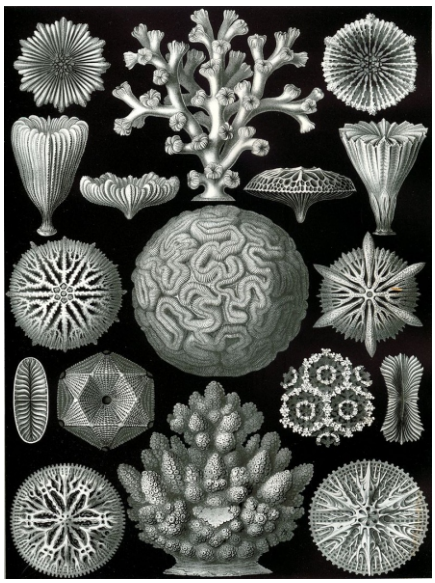
**Siphonophora**: Siphanophora are abundant in the Indian seas and constitute an important part of the marine plankton.

https://upload.wikimedia.org/wikipedia/commons/thumb/c/cb/Haeckel_Siphonophorae_7.jpg/800px-Haeckel_Siphonophorae_7.jpg

The siphanophores from the Indian Ocean have been studied by several workers – Browne[52] from the Seychelles, Mauritius and Chagos Archipelago; Sundara Raj[266], Lelop[149] and Daniel and Daniel[75] from the Madras Coast; Patriti[194] from off South East Coast of Africa and Madagascar; Totton[278] from SE Coast of Africa, South East, North West and South Indian Ocean, Gulf of Aden, Aquaba and Red Sea;

Alvarino[19] from the tropico-equatorial region; Rengarajan[224] from the West Coast of India and Daniel[72, 73] from the West and East Coasts of India and those collected by *R. V. 'Vityaz'* along 90-110$^0$ E longitude down 35$^0$ S latitude.A comprehensive account of Siphanophora of India (1985) shows 116 valid species of which, one variety and three doubtful species known from the Indian Ocean of which 89 occur in the Indian Seas.

**Anthozoa - Scleractinia**:



https://en.wikipedia.org/wiki/Scleractinia#/media/File:Haeckel_Hexacorallia.jpg

Studies on taxonomy of Indian coral reef started in India as early as 1847 by Rink in Nicobar Islands and later in 1988 by Thurston at Gulf of Mannar region. Brook[48] recognized 8 species of *Acropora* from Rameswaram, out of which *A. multicaulia, A. thurstoni* and *A. indica* were described as new. Subsequent contributions to inventory of coral species were made by Alcock[9, 6], Gardiner[96], Matthai[157] Gravely[108 - 110] and Sewell (1935) Contemporary studies on corals are those of Pillai[196] and Venkataraman *et al.*[284] which list a total of 218 species under 60 genera and 15 families. The consecutive surveys made between 2008 and 2013 by Zoological Survey of India resulted with the occurrence of 519 scleractinian corals including two new species from Andaman and Nicobar Islands.

Among the four major reef areas of India, Andaman and Nicobar Islands are rich in coral species diversity whereas those of Gulf of Kachchh is poorer. Lakshadweep Islands have more number of species than those of the Gulf of Mannar. Among the deepwater (ahermatypic) corals so far 720 species belonging to 110 genera and 12 families have been reported from the world of which 227 species belonging to 71 genera and 12 families have been reported from the Indian Ocean region[54, 285]. However, meager attention has been paid so far to inventorise the deepwater corals and as a result, only 44 species are known until now from Indian Seas[284].

**Gorgonians:**

https://en.wikipedia.org/wiki/Gorgonian#/media/File:Iciligorgia_schrammi.jpg

Gorgonians are marine coelenterates of the class Anthozoa, which include sea fan, sea whips, corals, sea anemones and other related species. The gorgonians popularly called as sea fans and sea whips are marine sessile coelenterates with colonial skeleton and living polyps. A total about 135 species of Gorgonians are reported from Indian seas. Venkataraman *et al.*[283] reported 27 species of gorgonians belonging to eight families and 19 genera from India. Among them, 12 species of gorgonians belonging to four families and nine genera have been reported from the northeast coast of India[275].

However in the Andaman and Nicobar Islands, only 10 species under four families and nine genera have been recorded[284]. Recently[294] 51 species belonging to 25 genera, eight families, and three sub - orders. Among them 44 species belonging to 24 genera and seven families are new to India. This paper gives an updated list of all known gorgonian species found in the Andaman and Nicobar Islands.

**Scyphozoa – Scyphomedusae:** The earliest records of Scyphozoa in Indian Seas were made by Browne[49, 50, 51] from Lakshadweep, Maldives, Sri Lanka and Okhamandal Coast of Kattiawar, followed by Annandale[27], Menon[160, 162, 163], Panikkar [186], Nair[167, 168] and Chakrapany[55]

https://upload.wikimedia.org/wikipedia/commons/thumb/8/88/Cauliflour_Jellyfish%2C_Cephea_cephea_at_Marsa_Shouna%2C_Red_Sea%2C_Egypt_SCUBA.jpg/250pxCauliflour_Jellyfish%2C_Cephea_cephea_at_Marsa_Shouna%2C_Red_Sea%2C_Egypt_SCUBA.jpg

In the Indian seas several cruises of the R.I.M.S. 'Investigator' and coastal surveys by the Officers of the Zoological Survey of India have yielded a collection of 24 species, which form the Indian National Collections in the Zoological Survey of India, Kolkata[55]. In addition, several cruises of the R. V. 'Chota Investigator' along the Chennai Coast from 1972 to 1983 revealed the occurrence of 19 species of which 11 were already known from the Indian seas. Thus, out of the 200 species of Scyphomedusae known from the World Oceans, 30 are known from the Indian Seas[55] (Table 1).

Probably since from the description of two new species *Edwardsia jonessi* Seshaiya and Cutress, 1969 from Porto Novo and *Paracondylactis sagarensis* Battacharya, 1979 in India, no species has been added in the sea anemone list of India. The studies on sea anemones of Andaman and Nicobar Islands are *terra incognita* except few reports. The Indian sea anemones listed by Parulekar[193] include *Anthoplerua panikkarii, Bunodactis nicobarica* and *Parabunodactis inflexibilis* from Andaman and Nicobar Islands. Madhu and Madhu[152] reported the occurrence of 10 species of sea anemones at 14 sites from these Islands, followed by[293] reported 19 species of sea anemones from these islands and complied 54 species of sea anemones reported from India.

**Phylum: Ctenophora**

Ctenophores, variously known as comb jellies, sea gooseberries, sea walnuts, or Venus's girdles. They are biradially symmetrical, acoelomate organisms that resemble cnidarians.

http://www.ucmp.berkeley.edu/cnidaria/images/RedLine2.jpg

They are largely planktonic, exclusively marine animals found throughout the world's ocean[10, 44, 51]. Unlike cnidarians, with which they share several superficial similarities, they lack stinging cells.

Instead, in order to capture prey, ctenophores possess sticky cells called colloblasts. In a few species, special cilia in the mouth are used for biting gelatinous prey. They have eight "comb rows" of fused *cilia* arranged along the sides of the animal. These cilia beat synchronously and propel ctenophores through the water. Many ctenophores have two long tentacles, but some lack tentacles completely. Many ctenophores, like various other planktonic organisms are bioluminescent. The phylogenetic position of ctenophores has been, and still is, in dispute. Two species of fossil ctenophore have now been found in the Late Devonian, in the famous Hunsrückschefer slates of southern Germany[73, 74]. Ctenophore includes nine orders with over 200 valid species currently known species from the world[75]. Only 19 species of ctenophores were recorded in Indian waters (Table 1).

**Brachiopoda:** Brachiopoda is a primitive minor phyla in the animal kingdom. They commonly called as lamp-shells which alike bivalve (Mollusca) have two shells and upper shell is smaller than loser one. They are solitary, sessile benthic marine invertebrates, closely related to phylum Phoronida. The brachiopods are classified under eight orders and two classes, based primarily on shell morphology.

https://en.wikipedia.org/wiki/Brachiopod#/media/File:LingulaanatinaAA.JPG

So far 12,000 fossil species recorded and grouped in to about 5,000 genera. The largest modern brachiopods are 100 mm long, a few fossils measure up to 200 mm wide[3]. Among the Brachiopods, genus *Lingula* is considered as one of the most 'Living Fossils' and oldest of all living genera of animals[4]

Brachiopods were flourished in the Palaeozoic but have gradually decreased towards the recent. It is reported that super family Linguloidea originated during early Cambrian and expanded rapidly from medial Cambrian to the beginning of Ordovician[5]. After Devonian time only the family Lingulidae subsists[5]. According to Brachiopod Lingulids are exclusively marine[6] and occur upto the depth of 5000 m[6]. The existing brachiopod species of world oceans is about 391 belonging to 116 genera[3]. About 30,000 species of brachiopods became extinct from Devonian era[6]. Indian brachiopod fauna comprises of four species [7-9](Table 1).

**Phylum: Annelida:**

**Archiannelida**: Pioneering studies on archiannelids of India were made by Aiyar and Alikunhi[4] and Alikunhi[15, 17, 18] along Madras coast from which two species of *Polygordius,* two species of *Protodrilus* and four species of *Saccocirrus* were described as new to science.

https://en.wikipedia.org/wiki/Haplodrili#/media/File:Polygordius_appendiculatus.jpg

Rao and Ganapati[219] recorded 15 species of archiannelids from the beach sands along Waltair Coast. Thus, compared to the vast stretch of Indian coast, the investigations hitherto carried out on Archiannelida are quite limited and any further intensive surveys of the fauna in other areas are quite likely to yield interesting results. The world records of Archiannelida hitherto made fall under five families, 18 genera and over 90 species, of which about 20 species are reported from Indian coasts.

**Polychaeta**: In the phylum Annelida, the Polychaeta have received considerable attention from 1909. Polychaetes form an important component in the marine food chain especially for demersal fishes.

https://pbs.twimg.com/media/DCT0W8aUQAAgmGr.jpg

Approximately worldwide number of polychaetes estimated as 8000 species. Survey of this group actually started in 1921work on "Polychaeta of Chilka Lake" followed by the littoral fauna of Krusadai Island in the Gulf of Mannar by Gravely[108, 109, 110] (nearly 36 species under 11 families) and by Fauvel[90] (119 species under 22 families). Perusal of literature shows that most of the records pertaining to this group are either from the Madras Coast or the Gulf of Mannar[1, 2, 3, 13,14, 15, 16, 17, 33,97,95,111, 139, 101, 138, 263,271]. Central Marine Fisheries Research Institute has listed 200 species under 46 families in the catalogue of types and reference collections. From the collections of Zoological Survey of India and the Indian Museum, Fauvel[91] described 300 species under 30 families and in his later monograph[92] raised this to 450 species. Hartman[120] while dealing with polychaetes of Indian Ocean recorded 244 species of which 116 are considered new to the region. The catalogue of the polychaetous annelids from India lists 883 species.

**Oligochaet**a: Marine Oligochaete fauna is poorly known in India, and most of the species are recorded from littoral zones of small freshwater bodies like ponds, tanks, pools, ditches, etc., all over the country.

http://classconnection.s3.amazonaws.com/633/flashcards/2861633/jpg/earthw11363808846764.jpg

The Enchytraeidae (pot-worms) occur in terrestrial, littoral and marine habitats, being abundant in acidic soils with high organic matter. As compared to the world fauna, only 3% of enchytraeid species have so far been reported from this region, mainly from Orissa.

## Phylum: Sipuncula

The Sipuncula or Sipunculida is commonly called 'peanut worm' because some have the general shape of shelled peanuts.

https://upload.wikimedia.org/wikipedia/commons/thumb/f/f3/Sipuncula.jpg/1200px-Sipuncula.jpg

They are bilaterally symmetrical, un-segmented marine worms. The first species of this phylum was described in 1827 by the French zoologist Henri Marie Ducrotay de Blainville who named it the name *Sipunculus vulgaris*. Sipunculids are relatively common, and live in shallow waters, either in burrows or in discarded shells like hermit crabs. Some bore into solid rocks to make a shelter for themselves. Although typically less than 10 cm long, some sipunculans may reach several times that length.

The sipunculan body is divided into an unsegmented trunk and a narrower, retractable anterior section, called the 'introvert'. Sipuncula is a relatively species poor and generally rarely investigated phylum; nonetheless, it may play an important role in bioturbation of sediments and as a food source for higher trophic levels. The fossils (*Archaeogolfingia* and *Cambrosipunculus*) from the Cambrian Chengjiang biota in China, are belong to the crown group and illustrated that sipunculans have changed little (morphologically) since the early Cambrian, about 520 million years ago[295]. Salina[296] has documented 320 species known from the world ocean. The major areas of species concentration are the Andaman and Nicobar Islands, Lakshadweep Islands, Gulf of Mannar and Gulf of Kachchh. A total of 38 species have been identified from the Indian seas till today (Table 1).

**Phylum: Echiura**

The phylum Echiura comprises of 129 species under 32 genera and five families[257]. Studies on Indian echiuran fauna began only in the early 20th Century when Annandale and Kemp[29] described two new species of the genus *Anelassorhynchus* from Chilka Lagoon. Subsequent studies[79, 80,81,204,205,164] had enriched knowledge on Indian echiuroids so much so that the current inventory of 48 species under 11 genera is fairly rich in comparison with what is known from the Indian Ocean (Table 1).

http://www.wildsingapore.com/wildfacts/worm/echiura/echiura/160511chg7mn1.jpg

Maximum abundance of echiurans is in Gulf of Kachchh, Gulf of Kambath, Lakshadweep, Andaman and Nicobar Islands and Gulf of Mannar.

Mud-dwelling forms are few in numbers and are found in Kerala, West Bengal and Orissa.

**Phylum: Chaetognatha**

Members of Phylum Chaetognatha (bristle-jaws) are commonly known as arrow worms, include of many predatory marine worms, which also be a major component of plankton. Most of them are benthic and attached with algae, dead shells and hard rocks.

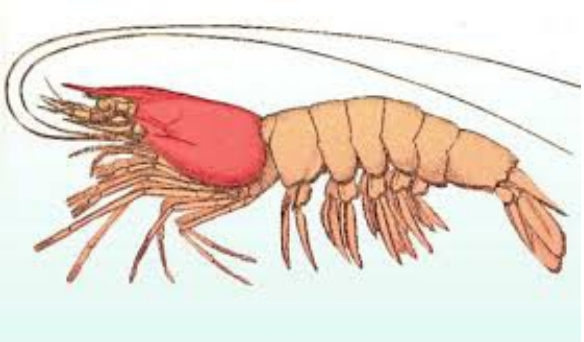
https://upload.wikimedia.org/wikipedia/commons/8/8e/Chaetoblack.png

They are entirely marine but a few species are estuarine and can be found from surface tropical waters and shallow tide pools to the deep sea and Polar region. Most chaetognaths are transparent and are torpedo shaped, but some deep-sea species are orange. They ranged in size from 2.0 - 120.0 mm. There are more than 120 modern species assigned to over 20 genera[27], notwithstanding, the diversity of species is less, the number of individual is large. Due to their soft bodies, chaetognaths fossilize poorly. Even so, several fossil chaetognath species have been described[28]. Chaetognaths appear to have originated in the Cambrian Period. Complete body fossils have been formally described from the Lower Cambrian Maotianshan shales of Yunnan, China i.e., *Eognathacantha ercainella*[29] and *Protosagitta spinosa*[30] and the Middle Cambrian Burgess Shale of British Columbia (*Oesia disjuncta* Walcott[31]. Chaetognaths rank second in terms of abundance after copepods in marine zooplankton and are cosmopolitan in distribution.

Of the 120 species known from the world ocean, about 44 have reported from the Indian seas[32] (Table 1). Recent chaetognath, *Paucijaculum samamithion* Schram, has been described from the Mazon Creek biota from the Pennsylvania of Illinois[27].

**Phylum: Arthropoda**

**Crustacea**: Global estimate of Crustacean species diversity is 150,000 of which 50, 685 have been described so far.

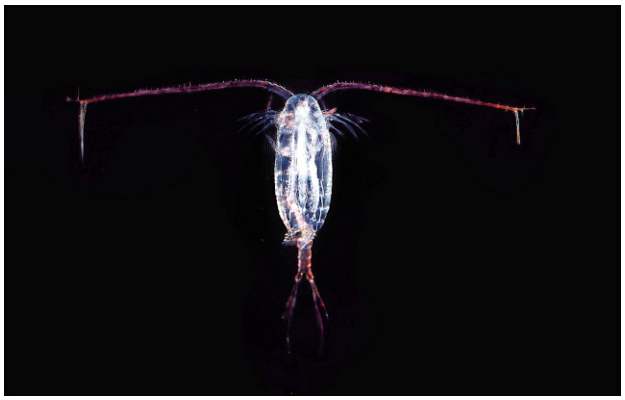


http://www.easybiologyclass.com/crustacea-crustaceans-general haracters-phylum-arthropoda/

Of the 3370 species of Crustacea that have been reported[286, 297, 298,299] (Table 1) so far, marine species (94.85%) contribute maximum to this diversity. In India as many as 139 species of stomatopods (four families and 26 genera), 26 species of lobsters (4 families, 11 genera), 162 species of hermit crabs (three families, 40 genera), 705 brachyuran crabs (28 families, 270 genera), 84 species of shrimps and prawns (7 families, 19 genera) and 159 species of Caridea (15 families, 56 genera) have been recorded so far. Other than these, 540 species of copepods, 104 species of cirripeds, 120 species of ostrocods have also been recorded.

**Copepoda**: Copepods are the most widely studied group among the marine zooplankton. There are approximately 210 described families, 2,280 genera and over 14,000 species in the world. Important contributions to systematics of copepods from Indian waters are those of Sewell[239], Krishnaswamy[140, 141, 142, 143] and Pillai[202].e most dominant group is Calanoida,

Largely as a result of these studies as well as several others since then [153] it is now known that there are 540+ number of copepod species in Indian waters. Among these, with the Cyclopoida and Harpacticoida being relatively less important. Major studies on Cyclopoids are again those of Krishnaswamy[140,141,142].



https://upload.wikimedia.org/wikipedia/commons/thumb/2/28/Copepodkils.jpg/1200pxCopepodkils.jpg

Only very few papers dealing with marine Harpacticoida of India and neighboring seas have been published so far[238, 240]. Studies on sand-dwelling forms are still less: only those of Krishnaswamy[140, 141, 142, 143,] provide an account of 17 sand-dwelling harpacticoids under five families together with discussion on their adaptation as well as their ecology. A total of 106 species belonging to 23 families are known from the east coast estuaries. Among them the calanoids are the dominant, distributed in 16 families, followed by harpacticoids (five families and cyclopoids (two families). The diversity in the west coast estuaries is relatively higher, with 179 species in 31 families. Calanoids are dominant with 20 families. Though the number of families of harpacticoids and cyclopoids are the same (six families), the latter is more diverse, with 22 species compared with seven species of harpacticoids. The present status of copepod identification from the Indian coast is 541 species (Table 1).

**Ostracoda**: Ostracoda commonly called as seed shrimp, falls under Subphylum Crustacea. About 70,000 fossils and recent species reported, in which only 13,000 species conformed as extant[10]. Body is dorso-ventrally flattened grow up to 30 mm and protected with bivalve like shell. Ostracods are grouped together based on gross morphology, but the group may not be monophyletic[11]; their molecular phylogeny remains ambiguous[12]. Marine ostracods are part of zooplankton or benthos, attached with sea floor.

https://upload.wikimedia.org/wikipedia/commons/thumb/9/93/Ostracod.JPG/1200px-Ostracod.JPG

among the 13,000 species, about 2000 species and 200 genera of non-marine ostracods are reported worldwide[13]. However, a large portion of diversity is still un-described, indicated by undocumented diversity hotspots of temporary habitats[14]. Of the known species and generic diversity of non-marine ostracods, half of them (1000 species, 100 genera) belong to family Cyprididae[13]. Only a little more than 125 species of ostracods are known from the Indian coast [15,16] (Table 1).

**Branchiura**: Our knowledge of this group from the Indian region is rather scanty. It is not until 1951, when Ramakrishna contributed to our knowledge of the Indian species of arguulids found parasitic on fishes, that the group received adequate attention. He described four species of the genus Argulus of which three were described as new to science (Table 1).

http://keys.lucidcentral.org/keys/v3/TFI/start%20key/key/crustacea%20key/Media/Images/Crustacea/Maxillopoda/Branchiura/Arguloida/argulus_dorsal.jpg

**Branchiopoda**: This group comprised of fairy shrimp, clam shrimp, Cladocera, Notostraca and the Devonian Lepidocaris. They found in both marine and freshwater ecosystems which feed upon planktons and detritus. Branchipoda can be distinguished by their gills, appendages, compound eyes, carapace, which may be a shell of two valves enclosing the trunk or entirely absent[6]. In the groups where the carapace prevents the use of the trunk limbs for swimming (Cladocera, clam shrimp and the extinct Lipostraca), the antennae are used for locomotion, as they are in the nauplius[6]. There are about 200 species of clam shrimps known all over the world [17]. In which around 35 species have been recognized[18] from Indian coasts. The fossil record of branchiopods found from Upper Cambrian and possibly further.

**Malacostraca - Mysidacea**: Mysids are shrimp-like animals with a shield fused shaped carapace of first three segments. A total number of 780 species are well known worldwide under 120 genera[158]. Mysidaceans, with a total number of about 84 species, are known so far only from the works of Tattersall[272] and Pillai[199,200,201].

https://upload.wikimedia.org/wikipedia/commons/thumb/d/d9/Crustacea.jpg/1200px-Crustacea.jpg

**Cumacea**: A total number of 1300 species of marine cumaceans are reported till now (Jaume and Boxshall[124]). Cumacean species are also little known except for the studies of Calman[53], Kemp[137] and Kurian[145, 146]. Earlier 23 species of Bodotriidae, three species of Disstylidae, four species of Nannastaeidae and one species of Camylaspididae are known from the Indian region. The recent study reveals that, a total of 88 species under eight genera and three families are reported as Indian cumaceans[58,195].

https://upload.wikimedia.org/wikipedia/commons/4/49/Diastylis_bradyi.jpg

**Tanaidacea**: Tanaidacea is an order under crustaceans which includes benthic macro-invertebrates species. A report of 2008 implied that a total of 900 marine tanaidacean species are available worldwide[124]. Tanaidacea is categorized in four suborders such as follows Anthracocaridomorpha, Apseudomorpha, Neotanaidomorpha and Tanaidomorph, while the first one represents the fossil species but the others include a total numbers of 1052 species,

https://upload.wikimedia.org/wikipedia/commons/3/38/Tanaissus_lilljeborgi.jpg

(Apseudomorpha with 457 species under 93 genera, Neotanaidomorpha with 45 species under four genera and Tanaidomorph with 550 species under 120 genera)[41]. Our knowledge of Tanaidacea is rather poor from the Indian region with only three species (Table 1). Chilon[59] contributed a paper dealing with a species of the group from the Chilka Lake.

**Isopoda:** Very little is known about the marine isopods when compared to terrestrial isopods of India. Chopra[60] contributed a monumental monograph on the Bopyrid isopods of Indian Macrura wherein 33 species pertaining to 13 genera were described from Andaman Islands, Delta of Ganges and Madras and other areas. Chopra[60] contributed another paper on the Bopyrid isopods on Indian Macrura.

https://upload.wikimedia.org/wikipedia/commons/7/78/Eurydice_pulchra.jpg

The collection included 12 species pertaining to seven genera collected mostly from the Andaman and Nicobar Islands, Delta Ganges, Gulf of Mannar and Bombay.

The contributions on the marine woodborers from 1963 to 1968 by various Indian authors revealed six species of the genus *Sphaeeroma* and nine species of *Limnoria* from the Indian waters.

**Amphipoda:** Studies on the amphipods of the Indian and the neighboring waters received the attention of Zoologists only as late as 1885 when Giles published a paper on the occurrence of two species of amphipods from Bengal. His subsequent works raised the number to 27.

https://upload.wikimedia.org/wikipedia/commons/7/78/Eurydice_pulchra.jpg

Gravely[110] and Sundara Raj[266] reported sixteen species amphipods from Krusadai Island, Gulf of Mannar and the neighbouring waters. Bernard[35] reported amphipods from the collection made from Travancore, Cochin and Bengal coasts by the Zoological Survey of India. Apart from the record of the three species of amphipods off the coast of Mahabalipuram by Giles[105] and a brief note about the occurrence of three species of amphipods at Adyar in Madras. In the last half of the previous century, Sivaprakasam[246] in a series of contributions enriched our knowledge on the amphipods of east coast of India and listed 61 species. Nayar[177, 178] dealt with the amphipods of the Madras Coast and Gulf of Mannar. In his monographs on the Gammaridean amphipods of the Gulf of Mannar he dealt with 78 species, of 26 families. Surya Rao[267] enumerated a detailed account of the intertidal Gammarid amphipods from the Indian coasts and listed 167 species (Table 1).

**Euphausiacea**: The earliest account on Indian euphasids is known through the work of Wood-Mason and Alcock[290], Alcock and Anderson[9,10,].

https://upload.wikimedia.org/wikipedia/commons/thumb/e/e3/Meganyctiphanes_norvegica2.jpg/1200px-Meganyctiphanes_norvegica2.jpg

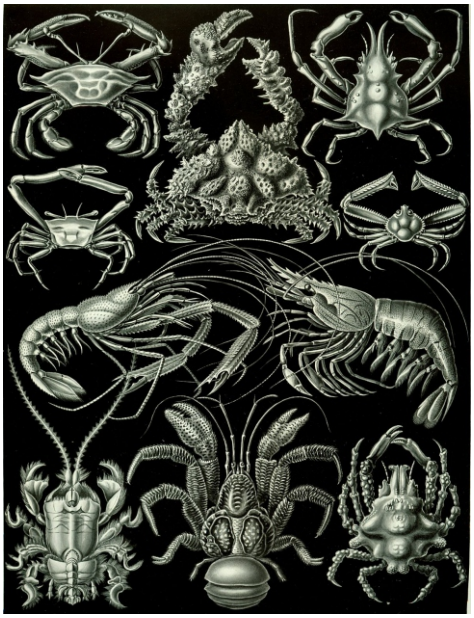
Tettersall [273] gave an account of them from the Indian Ocean. Among the Indian coasts 23 species of euphasids from the Laccadive and Maldive as well as from adjoining regions two species from South West Coast of India have been recorded so far.

**Stomatopoda**: Kemp [135] published a monograph on Indo-Pacific stomatopods comprising of 139 species and varieties known till then. Kemp and Chopra published papers on the stamatopods form collection of the John Murry Expedition (1933 –34) made by Sewell.

http://tolweb.org/tree/ToLimages/Odontodactylus_scyllarus.jpg

Tiwari and Biswas[276] published a paper based on material accumulated since Chopra's work. After a gap of two decades Ghosh[102, 103] and Tiwari and Ghosh[277] have contributed a series of papers highlighting the present knowledge of Stomatopoda in the Indian waters. The study of Stomatopoda of India is, however, far from complete and the total number of species as on today is 93 (Table 1).

**Decapoda - Macrura:** Decapoda as a whole has received a good attention from scientific workers compared to other groups. The recent work ny De Grave et al.[354] states 14 335 species in the world. The earliest to contribute was de Man[85] who, in a series of papers, referred to the Decapod collection from the brackish water ponds of Lower Bengal. The contributions of Kemp to the study of Indian Crustacea are among the most noteworthy of the group.



https://upload.wikimedia.org/wikipedia/commons/thumb/4/44/Haeckel_Decapoda.jpg/220px-Haeckel_Decapoda.jpg

His contributions on decapod crustaceans of the Indian Museum published in 24 parts in the Records of the Indian Museum contains systematic account of various marine and brackish water forms belonging to the families Hippolytidae, Carangonidae, Disciadidae, Palaemonidae, Pasiphasidae, Stylodactylidae, Rhynchocinetidae, Pacdalidae and Anchistodidae in which, species from most varied habitats have been reported. Alcock[7,8] contributed a comprehensive catalogue on the penaeid prawns of India. Since then several Indian researchers have contributed to inventories of this group. Although large number of species of prawns and lobsters are known to occur in and along the Indian coast, work on this group of species is very limited. World over 17 families, 67 genera and 383 species have been recorded as commercially

A total of 55 species of commercial shrimps and prawns have been recorded in India. The East coast of India contributes to about 24.5% and the West coast contributes 75.3% of countries shrimp production.

**Brachyura**: The earliest works on the crabs of Indian Seas were those of Milne Edward[165], Henderson[121] and de Man[86]. The present status of species of brachyurans in the world is 6559[354].

https://invertebrate.w.uib.no/files/2013/03/krabber.j

The first comprehensive study of the crabs of west coast was that of Borradalile[42-45]. Alcock (referred elsewhere) in his contributions entitled "Materials for a carcinological fauna of India" published detailed account of marine and brackish water crabs. Kemp[136] dealt with 38 species under six families collected from the Chilka Lake and in 1923 accounted for crabs collected from the mouth of Hooghly River. Chopra[61] in a series of contributions entitled "Further Notes on Crustacea Decapoda in the Indian Museum" published in seven parts dealt with Hymenosomatid, Dromiacea, Oxystomata, Oxyrhyncha, Brachyrhyncha and Potamonid crabs.

These series were in continuation of Kemp's series entitled "Noters on Crustacea Decapoda in the Indian Museum'. Many other Indian authors added to the earlier works raising the total carcinological fauna to above 250 species. There are about 254 species of crabs belonging to 120 genera under 24 families recorded along the west coast of India. Among these, the names of 100 species have been revised. 22 families and 37 subfamilies represent brachyuran crabs. Family Leucosiidae represented the higher number with 20 species followed by subfamily Thalamitae of family Portunidae (19 species). Family Xanthidae alone is represented by 10 subfamilies of which the subfamily Zosiminae is represented by 14 species. The total number of species identified as on today is 705(Table 1).

**Anomura**: In 2009, a total of 1069 species of anomura species were documented by De Grave *et al.* while recent study represent a checklist 2451[354] species worldwide[159, 354]. Sarojini and Nagabhushanam[234] gave a detailed account on the Porcellanids from the Waltair Coast.

https://upload.wikimedia.org/wikipedia/commons/thumb/a/a9/CoenobitaClypeatus.JPG/250pxCoenobitaClypeatus.JPG

Reddy and Ramakrishna[222] listed twenty species pertaining to the families Paguridae and Coenobitidae. The study on the Anomuran crabs is far from complete and more studies are needed in this group. The total number of species identified so far in the marine ecosystems of India is 120 (Table 1).

**Phylum: Pycnogonida**

The Pycnogonida commonly known as sea spiders as they resemble spiders and other arachnids in aspect of their morphology and anatomy with small bodies and relatively long, hinged legs[300].

http://www.discoverlife.org/IM/I_PA/0000/320/Seaspider,I_PA2.jpg

The body is variable in general shape, discoid to elliptic, degree of separation. The body of the pycnogonid is always much reduced and sometimes appears to be only connector between each pair of legs; thus, the digestive and reproductive organs have migrated to the legs[301]. Generally they feed on sessile fauna e.g. coelenterates, cnidarians, bryozoans andascidians, sometimes on slow-moving organisms e.g. molluscsfg and polychaetes[302,303]. The oldest fossil record of pycnogonids is dating back to the Upper Cambrian from Hunsruck Shale of western Germany[304]. According to recent classification of Bamber[305], a total of 1330 species of pygnogonid belonging to four orders, 15 families and 85 genera were recorded from the world oceans. Indian pycnogonid fauna comprises of 36 species under 16 genera in nine families based upon Daniel and Sen[306] and Veena[307].

## Phylum: Bryozoa

Byozoans were originally called 'Polyzoa', but this name was soon replaced by Ehrenberg's term Bryozoa[308, 309]. It comprises with about 16,000 fossil species, of which 5,000 living species under three groups, Phylactolaemata (freshwater), Stenolaemata (marine) and Gymnolaemata (mostly marine) reported worldwide. They commonly called as moss animals and are entirely aquatic (both marine and freshwater), lives in colonial and sessile. They have wide range of growth forms such as branching, encrusting, fan like, net like and few forms sub massive colonies, mostly grow on any hard substratum as incrustations. Bryozoan colonies consist of few individuals to millions of them and the colony range forms millimetres to few meters[310].

http://www.seawater.no/fauna/bryozoa/images/IMG2010_2369.jpg

Almost all bryozoans are colonial, composed of anywhere from a few to millions of individuals. Each individual, or zooid, is enclosed in a sheath of tissue, the zooecium[311], in which many species secretes a rigid skeleton of calcium carbonate. The Bryozoa are the only animal phylum with an extensive fossil record that does not appear in Cambrian or late Precambrian rocks. The oldest known fossil bryozoans, including representatives of both major marine groups, the Stenolaemata (tubular bryozoans) and Gymnolaemata (boxlike bryozoans), appear in the early Ordovician.

In India, Satranarayana Rao[312] summarized about 200 species. The total number of species inventorised till today is 272 (Table 1).

## Phylum: Phoronida

Members of Phoronida is superficially resembles burrowing polycheate worms (*Sabella* sp.) and they are commonly called as horseshoe worms. These organisms are exclusively occurring in marine environment. They live in upright chitin tubes made by their own to protect soft bodies. Phoronids found through-out the world ocean between the intertidal zone and about 400 meters down except Antarctica[313]. Phoronids consist of a crown of tentacles (Lophophore) at the upper end of stalk to filter-feed and the stalk decent in to the tube. Most adult phoronids are 2.0 cm long and about 1.5 mm wide, although the largest are 50 cm long.

http://ecoreserves.bc.ca/wpcontent/uploads/2011/11/phoronidss.jpg

Some species occurs separately in vertical tubes embedded in soft sediments. Others form tangled masses of many individuals buried in or encrusting rocks and shells. The actinotroch larva of phoronids is familiar among plankton[314], and sometimes account for a significant proportion of the zooplankton biomass[315]. No phoronid fossils have been recorded so far[316]. Temereva[315] described the larvae of *Phoronopsis albomaculata* and *Phoronopsis californica* and also summarized there are 12 undisputed adult phoronid species, 25 morphological types of larvae.

Only three species of phoronids reported from Indian coast especially from Digha coast in West Bengal and Andaman Islands.

**Phylum: Entoprocta**

Phylum Entoprocta is also called as Kamptozoa. Entoprocta resembles hydroids and bryozoans as these organisms have thin stalk and branched tips. Main body of this animal has a cup-like calyx that has a ring of 6-36 ciliated tentacles, which attached on its dorsal surface to the substrate by long and thin stalk like hydroids[317].

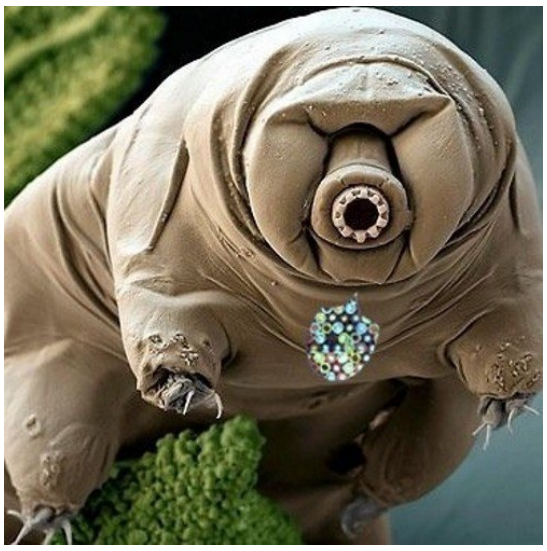
https://sites.google.com/site/124070g4lophotrochozoa/home/classification/entoprocta

The calyx and stalk are covered by a thin, collagenous cuticle, which does not extend over the tentacles, and is under-laid by a cellular epidermis[316]. These organisms are functionally acoelomate, lacking a fluid-filled body cavity. Entoprocts are very small, with individual zooids size measuring from 0.1 to 7 mm in length[318]. Phylum Entoprocta includes 170 undisputed species, classified under 4 families[316] of sessile, solitary (family Loxosomatidae) or colonial (families Loxokalypodidae, Pedicellinidae and Barentsiidae) primarily marine organisms, although two freshwater species, *Loxosomatoides sirindhorne* and *Urnatella gracilis* have been identified. Marine species are found throughout the world's oceans, and *Urnatella gracilis* is found on all continents except Antarctica[317,319].

The majority of entoprocts live in coastal, marine environments throughout the world[320, 321].However, only 10 species of Entoprocta recorded from the rivers around India. So far only four species are known from Indian seas (Table 1).

**Phylum: Tardigrada**

Phylum Tardigrada is a part of the super phylum Ecdysozoa. The tardigrades are bilaterally symmetrical micrometazoans with four pairs of lobopod legs terminating in claws. Members of this phylum are often referred to as "water bears" because of their bear-like appearance and slow lumbering gait. Tardigrades were first described by German zoologist Johann August Ephraim Goeze[323] in 1773. Of the three orders of the phylum Tardigrada, the only one found in marine, freshwater and high-altitude mountain habitats is the Heterotardigrada.



http://i58.servimg.com/u/f58/17/30/76/23/28619910.jpg

They range in size from 50 mm to 200-250 mm, but some giants can reach 1,700 mm. Tardigrades can withstand 1,000 times more radiation than other organisms, and are able to survive in extreme environments that would kill almost any other animal. Tardigrades are the first known animal to survive in space[324, 325].Some have a cosmopolitan distribution, while others are endemic.

About 1150 species under five families and 20 genera have been described from the world[322, 326]. However, in India only 10 species under two families and three genera have been reported and all are as meiofauna of the marine region[327, 328]. Tardigrades feed on plant or animal cells, algae, decaying plant matter. It is an ancient group, with fossils dating from 530 million years ago, in the Cambrian period[329].

**Phylum: Nematoda**

The nematodes or roundworms constitute the phylum Nematoda. They are a diverse animal phylum inhabiting a very broad range of environments. The group was originally defined by Karl Rudolphi in 1808 under the name Nematoidea.

http://www.angelfire.com/mo3/invertzoo/images/ascaris.gif

Nematodes have successfully adapted to nearly every ecosystem from marine to fresh water, to soils, and from the Polar region to the tropics, as well as the highest to the lowest of elevations. Nematodes are considered the most abundant metazoan taxon with 90% in composition[330]. Recently, it has been claimed that nematodes are one of the three major radiations that have produced most of the world's multicellular species[331, 332]. Lambshead[333] estimated that there may be as many as $1 \times 10^8$ nematode species in the deep sea, but the number of described species of nematodes is only about 20,000, of which more than 4000 are free-living marine organisms Gerlach [334].Six species and one genus of free-living marine nematodes belonging to two orders and seven families were recorded from Indian waters from intertidal sediments of Pichavaram mangrove of Southeast Coast of India[335]. A total of 356 species are currently known from Southeast continental self of India[336] (Table 1).

**Phylum: Platyhelminthes**

The flatworms that comes under Phylum Platyhelminthes and comprise a very diverse group of worms, with over 10,000 species described. Included within this large phylum are parasitic flatworms, such as tapeworms and liver flukes.They are bilaterally symmetrical and triploblastic and have no body cavity other than the gut and lack anus. The lack of a cavity also constrains flatworms to be flat; they must respire by diffusion. Platyhelminthes are divided into four classes: Turbellaria, free-living marine species; Monogenea, ectoparasites of fish; Trematoda, internal parasites of humans and other species. The most common marine flatworms belong to a different group, called polyclads (or Polycladida).

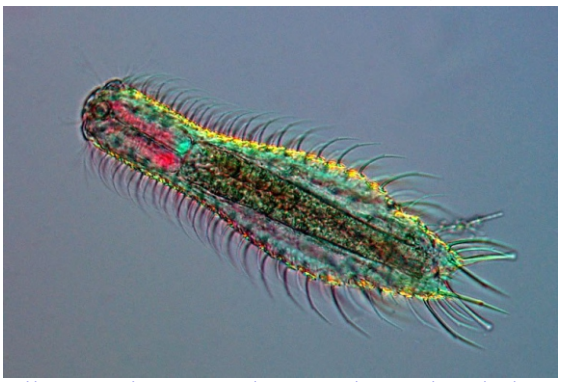
https://sharon-taxonomy2009p2.wikispaces.com/Platyhelminthes

Triclads and polyclads are all free-living (i.e. they are not parasites). Polyclads are found in most marine habitats, usually on the sea floor among algae, corals, or on rocky reefs. However, they are often hidden in tiny crevices and can be hard to find. Platyhelminths have practically no fossil record.

A few trace fossils have been reported that were probably made by platyhelminths[337]. Newman and Cannon[338] reported 15000 species of polyclads in the world. Recently, studies conducted by the Zoological Survey of India (Table 1) have found 46 species of polyclad from the Andaman and Nicobar Islands[72].

**Phylum: Gastrotricha**

The gastrotrichs commonly referred to as hairybacks, are a group of microscopic (0.06-3.0 mm), worm-like, pseudocoelomate animals, and are characterized by a meiobenthic life style. In marine habitats they are mainly interstitial, whereas in fresh waters they are ubiquitous component of periphyton and benthos. In marine sediments, gastrotrich density may reach 364 individuals/10 $cm^2$; typically they rank third in abundance following Nematoda and Copepoda (Harpacticoid), although in several instances they have been found to be first or the second most abundant meiofaunal taxon. In aquatic environments the ecological role of the gastrotrichs is realized within the microphagous, detritivorous, benthic community.



https://i0.wp.com/invorma.com/wpcontent/uploads/2015/06/Gastrotricha.jpg

The phylum is cosmopolitan with about 765 species grouped into two orders: Macrodasyida, with 310 strap-shaped species, all but two of which are marine or estuarine, and Chaetonotida with 455 tenpin shaped species, three-fourth of which are freshwater. Macrodasyida include eight families and 32 genera, whereas Chaetonotida count eight families and 31 genera[339]

India, only 61 species are identified so far (Table 1). Most recent studies based on molecules (18S rRNA and EST) indicate Gastrotricha as members of the Platyzoa[340].

**Phylum: Kinorhyncha**

The kinorhyncha are a smallest phylum of marine worms. They are recognized by the five or six rings of recurved spines on their heads and the segmented appearance of their bodies. The segmented nature of their bodies is a reflection of the rings of cuticular plates that surround the body; it is not homologous with the segmentation of Annelid worms or Arthropods. The kinorhynchan body is comprised of a head, a neck, and a trunk, the trunk has 11 segments or zonites each with a single dorsal plate (tergite), and two ventral plates (sternites)[341].

https://encryptedtbn0.gstatic.com/images?q=tbn:ANd9GcQ8ECotjI9rjB0m4xywirT4R8T9qzN8XsaO7ACWWxf4HrLcMefi

They live in marine sediments ranging from coastal to depths of up to 5000 m and have been found in all the world seas and oceans. They cannot swim, and move by pushing their heads forward into the mud. They feed on diatoms and other organic matter they find in the mud. No kinorhyncha fossils have yet been found.

According to Sorensen[342], kinorhyncha includes 196 valid species, distributed on two orders, nine families and 21 genera, however, recently, Neuhaus[343] describes the world list of kinorhyncha, which is assigned as class under phylum cephalorhyncha. The class kinorhyncha includes 186 species, distributed in two orders, nine families and 21 genera. In India only 10 species ar known till today (Table 1).

**Phylum: Nemertea**

Nemertea is also known as 'ribbon worms' or 'proboscis worms'. Alternative names for the phylum have included Nemertini, Nemertinea and Rhynchocoela. The typical nemertean body is very slim in proportion to its lengthThe smallest are a few millimeters long; more are less than 20 cm, and several exceed 1.0 m[344]. The longest animal ever found, at 54 m long, may be a specimen of *Lineus longissimus*[353]; many have patterns of yellow, orange, red and green coloration. In 1555, Olaus Magnus wrote of a marine worm which was apparently 17.76 m long. All nemerteans move slowly, using their external cilia to glide on surfaces on a trail of slime, while larger species use muscular waves to crawl, and some swim by dorso-ventral undulations.

https://nwccinvertebrates.wikispaces.com/file/view/Nemertine.jpg/595386520/287x368/Nemertine.jpg

A few live in the open ocean while the rest find or make hiding places on the bottom. Most nemerteans are carnivores, feeding annelids, clams and crustaceans. A few species are scavengers and a few species live commensally inside the mantle cavity of molluscs.

The Middle Cambrian fossil *Amiskwia* from the Burgess Shale has been classed as a nemertean based on a resemblance to some unusual deep-sea swimming nemerteans[345]. Traditional taxonomy divides the phylum in two classes, Anopla and Enopla with two orders each. A total of 1,362 species had been described and grouped into 285 genera[346, 351]. India harbours only six species of Nemertea from the entire coastal and marine Habitat[352].

**Phylum: Rotifera**

The rotifers, commonly called wheel animals, are microscopic and near-microscopic pseudocoelomate animals. It was first described by Rev. John Harris in 1696, and other forms were described by Anton van Leeuwenhoek[347] in 1703. Most rotifers are around 0.1–0.5 mm long (although their size can range from 50 µm to over 2.0 mm[348], and are common in freshwater environments throughout the world with a few marine species;

http://www.ansp.org/research/systematicsevolution/collections/rotifera/

for example, those of genus *Synchaeta*. Some rotifers are free swimming and truly planktonic, others move by inch worming along a substrate, and some are sessile, living inside tubes or gelatinous hold fasts that are attached to a substrate. About 25 species are colonial (e.g. *Sinantherina semibullata*), either sessile or planktonic. Rotifers eat particulate organic detritus, dead bacteria, algae, and protozoans.

They eat particles up to 10 µm in size. About 2200 species of rotifers have been described. Their taxonomy is currently in a state of flux. The phylum Rotifera is grouped with three classes: Seisonidea, Bdelloidea and Monogononta[349]. The largest group is the Monogononta, with about 1500 species, followed by the Bdelloidea, with about 350 species. There are only two known genera with three species of Seisonidea[350]. However, in India only 47 species are reported so far (table 1)..

**Phylum: Mollusca**

The number of species of molluscs recorded from various parts of the world varied from 80,000 to 1,50,000. The history of malacological study in India is immense and interesting. Studies on Indian molluscs were initiated by the Asiatic Society of Bengal (1784) and the Indian Museum, Kolkata (1814). Benson in 1830 was perhaps the first author to publish a scientific paper on Mollusca. Between the years 1830 and 1865 he published a total of about 90 papers dealing with the land and freshwater molluscs of the Indian subcontinent.

https://lh6.googleusercontent.com/cfqMDCF22AY/UxUEYFpgq1I/AAAAAAAAAQIs/rspaM2lib2Y/s400/snail-1f.jpg

The beginning of the 20th century is the most productive and significant period in the history of Indian Malacology, with the Zoological Survey of India, Central Marine Fisheries Research Institute and several maritime universities contributing immensely to the knowledge of the molluscan fauna.

In India, till today, 5100 species of Mollusca have been recorded from freshwater (22 families, 53 genera 183 species), land (26 families, 140 genera and 1487 species) as well as from marine habitats (242 families 591 genera, 3400 species)[258,259,260]. From the available data, it is possible to identify certain areas having rich molluscan diversity. Andaman and Nicobar Islands have a rich molluscan diversity, which include over 1000 species from the marine region[260] Gulf of Mannar and Lakshadweep have 428 and 424 species respectivel[283]. Eight species of Oysters, two species of mussels, 17 species of clams, six species of pearl oysters, four species of giant clams, one species of window-pane oyster and other gastropods such as Sacred chank, *Trochus, Turbo* as well as 15 species of cephalopods are exploited from the Indian marine region.

**Opisthobranchia**: The Opithobranchs or sea slugs are shell less molluscs. About 4000 species of opisthobranchs were reported from world. The earlier works on opithobranchs were initiated during 1880s [11]. The first report on opithobranchs was made by Eliot (1910) which deals with 42 species belonging to 10 families.

https://nl.wikipedia.org/wiki/Opisthobranchia

Presently a total of 260 species of opisthobranchs are reported till now form Indian waters whereas a maximum number of 200 species are recorded from Andaman and Nicobar Islands[208].

## Phylum: Echinodermata

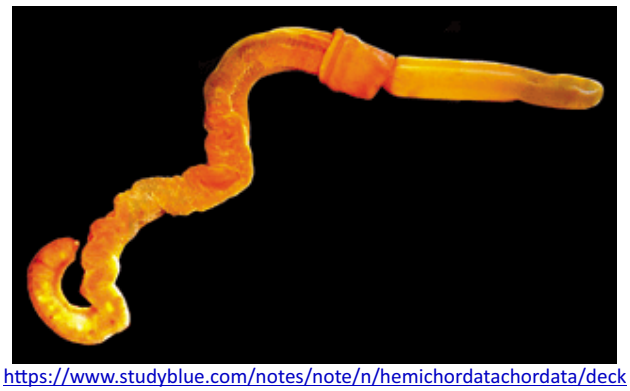
Plancus and Gualtire made the first report on Indian echinoderms from Goa in 1743 and the next one in 1830 was by Collier (1830) on the *beche-de- mer*.[150, 151] Subsequently, the accounts of Lutken and Marktanner-Turneretscher[156] included a few new species from the Bay of Bengal. Most of what we know of the echinoderm fauna is from examination of the collections from expeditions such as Investigator, Challenger, Valdivia and John Murray. India has 765 species (Crinoidea: 13 families, 43 genera 95 species; Astereroidea: 20 families, 81 genera and 180 species; Ophiuroidea: 15 families, 67 genera 150 species; Echioidea: 28 families, 79 genera 150 species; Echioidea: 28 families, 79 genera 150 species; Holothuroidea 14 families, 62 genera 160 species) recorded until today and about 257 species are known from Andaman and Nicobar Islands[235, 125]. The recent investigation on echinoderms stated that 12 species of echinoderms such as five species of crinoids, six species of ophiuroids and one species of Astereroids were newly record to India reported from Andaman and Nicobar Islands[226-229] with updates the total Indian echinoderm database at 777 species. Lakshadweep has 77 species and the Gulf of Mannar, 112 species.

https://maxanimalclassificationproject.weebly.com/uploads/5/2/3/1/52314537/3065915_orig.jpg

Economically, only Holothuroidea are exploited on a commercial scale for export. Twelve species of Holothurians belonging to the genera *Actinopyga, Bohadschia, Holothuria, Stichopus* and *Thelenota* are known to be of commercial importance in India. However, only three species *Bohadschia marmorata, Holothuria scabra and H. spinifera* are being exploited to a large extent in the Gulf of Mannar. All holothurians are now included under Schedule 1 of the Wildlife Protection Act, 1972.

## Phylum: Hemichordata

Phylum Hemichordata is divided into three classes, *i.e.* Enteropneusta, Pterobranchia and Planctosphaeroidea. Of the four families known from the world only three families are recorded from India. So far, 238 species are recorded from the world of which 14 are known from India[88, 225,291] (Table 1).



https://www.studyblue.com/notes/note/n/hemichordatachordata/deck/13178208

Genera such as the, *Ptychodera, Glossobalanus, Glandiceps* have been collected from the Gulf of Mannar, Gulf of Kachchh, Andaman Islands, Lakshadweep and Maldive Seas, the Tamil Nadu coast upto Cape Comerin and the *Saccoglossus* has been recorded from the high saline marshy areas of Sunderbans in West Bengal. The only commonly available enteropneust worm in India is *Ptychodera flauva.*

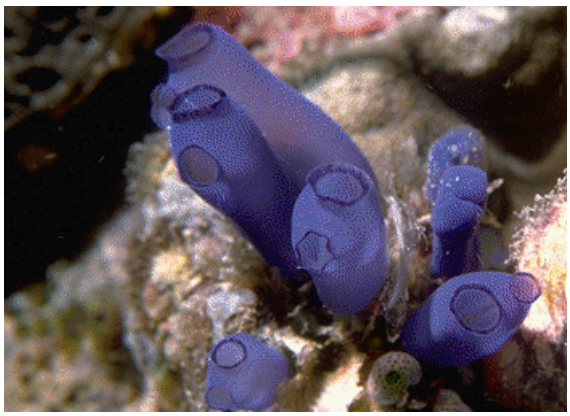
## Phylum: Protochordata

This phylum includes two subphylum Cephalochordata and Urochordata. Worldwide the diversity of cephalochordates includes two families, two genera and 24 species and in India six species are reported under two families and two genera.

https://upload.wikimedia.org/wikipedia/commons/thumb/f/ff/Enteropneusta.png/220pxEnteropneusta.png

The subphylum Urochordata is divided into class Ascidiacea (sea squirts) that are sessile or benthos attached to substratum on the coral reef, Class Thaliacea (= salps) and Class Larvacea that are planktonic. About 2000 species of ascidians are reported from all over the world of which 47 are reported in India (nine families, 21 genera). Out of 57 species of Thaliacea reported from the world, 48 species (four families and 19 genera) occur in India and out of 25 species of Larvacea reported from the world 18 (two families 14 genera) are reported from India[89, 22]. The total number of species identified till today is 522 (Table 1).

**Urochordata**: Tunicates or sea squirts are well known as Urochordates and represent the taxon Protochordata. The most important feature of this group is presence of notochord during the early developmental stage. The animals lost their myomeric segmentation during the adult life stage. These marine animals are usually sessile and well recognized filter feeders. The structures of these animals are just like sac.



http://www.ucmp.berkeley.edu/chordata/urochordata.gif

Till now 2150 species were record worldwide while 281 species from India. There are 516 species identified in India (Table 1). The close proximity with the chordates gives enormous scopes to the researchers to work with this group of animals for knowing their life processes.

## Phylum - Vertebrata

**Fishes:** The history of ichthyology in India is colossal and interesting. Brief histories of Indian Ichthylogy may be found in Day[82, 83] and Whitehead and Talwar[289]. Among the books published on Indian fishes, Day's[82] treatise "The fishes of India" is of greatest importance.

https://msb.unm.edu/divisions/fishes/_img/208-cyprinodon-pecosensis.jpg

The publications on "Commercial sea fishes of India" by Talwar and Kacker[270] and "Fishes of the Laccadive Archipelago" by the Jones and Kumaran (1980) are noteworthy in our knowledge of fish faunal resources of India besides many other research publications by other scientists. Fishes comprise about half the total number of vertebrates. The number of estimated living fish species might be close to 18196 in the world. Day[83-84] has described 1418 species of fish under 342 genera from the British India. Talwar[269] has described 2546 species of fish belonging to 969 genera, 254 families and 40 orders. The distribution of marine fishes is rather wide and some genera are common to the Indo-Pacific and the Atlantic regions. Fifty seven percent of the Indian marine fish genera are common to the Indian Ocean and to the Atlantic and Mediterranean.

The exact number of species associated with coral reefs of India is still to be found, however the number of fishes in coastal and marine ecosystems of India is 2618 species of which Chondricthyes (cartilaginous fish) is 154 species and Actinopterigii (bony fishes) is 2275+. The Lakshadweep Islands have a total of 603 species of fishes[127]. Recent studies stated that the database of Indian fishes increased up to 2618 (Table 1). Over 1000 species are found in the Andaman and Nicobar Islands and about 538 in the Gulf of Mannar Biosphere Reserve.

The categories of fishes occurring in coral reef ecosystem of India includes groups such as the damselfishes (76 species), butterfly fishes (40 species), parrot fishes (24 species), sra basses, groupers and fairy basslets (57 species), cardinal fishes (45 species), jacks and kingfishes (46 species), wrasses (64 species), combtooth blennies (58 species), gobies (110 species), surgeonfishes, tangs, unicornfishes (40 species). Another 20% are composed of cryptic and nocturnal species that are confined primarily to caverns and reef crevices during daylight periods.

**Reptiles**: A total of 32 species of marine reptiles are reported from Indian seas including 26 species of sea snakes belonging to the family Hydrophiidae, five species of sea turtles and one species of saltwater crocodile *Crocodylus porosus* have been reported from seas around India. All the sea snakes, four species of turtles and a crocodile are also found to be occurred in the marine environment are known from islands of Andaman and Nicobar. Studies on sea turtles occurring in the coastal waters of India and their nesting grounds were neglected till Smith[247] focused our attention on these giants among the sea reptiles. Seven species of sea turtles are found in the world's warm oceans of which five species are reported in India of these Leatherback sea turtle, *Dermochelys coriacea* is the sole representative of the family Dermochelyidae and is a rare species.

https://qph.ec.quoracdn.net/main-qimg9cd56264
18025c7f2f52968de23954a0-c

The remaining four species namely the Green turtle (*Chelonia* mydas), the Olive Ridley (*Lepidochelys olivacea*), the Hawksbill (*Eretmochelys imbricata*), and the Loggerhead (*Caretta caretta*) are contained in a single family, Cheloniidae.

**Seabirds**: The marine ecosystem offers a variable feeding and breeding ground for a number of birds. Although not exhibiting spectacular diversity, a number of seabirds are found regularly in marine and estuarine ecosystems.

There are some special species, which are exclusively dependent on coral reef ecosystem, while a few are generalists without much dependence on it. Some of the pelagic seabirds notably boobies (Sulidae), shearwaters (Procellariidae) and terns (Sternidae) which were reported, rarely nest on Andaman and Nicobar Islands. Smaller numbers of waders and other seabirds are also found on or near coral reefs. These include sandpipers, oystercatchers, turnstones and plovers.

https://fthmb.tqn.com/r2XjsGzqF3rSFTY2selo2BEZu4=/960x0/filters:no_upscale()/australasiangannet5761d9a65f9b58f22e144a6b.jpg

Birds of pray including ospreys and sea eagles are likewise occasional visitors of the marine region. Gulf of Kachchh Marine Park area 123 species of waterfowl and 85 species of terrestrial birds have been reported in 2002. Waterfowl with moderately good population have been found in Kachchh are the Lesser Flamingo, Kentish Plover, Ruff, Crab Plover, Black tailed Godwit and Avocet. From Gulf of Mannar Marine National Park are in 1985-1988 a total of 187 species of birds were recorded of which 84 were aquatic and the remaining terrestrial. At Manali and Hare Islands 23 species of migratory birds were found to be over summer every year. The waders uncommon to India such as knot Calidris canuta, eastern knot Calidris tenuirostris, curlew Numenius auquata, Whimbrel Numenius phaeopus and bar tailed godwit Limosa lapponica were recorded as regular winter visitor to this area[32].

**Marine Mammals:** Marine mammals are classified under three major orders namely, Cetacea (whales, dolphins and porpoises), Sirenia (manatees and dugong) and Carnivora (sea otters, polar bears and pinnipeds).

Order Cetacea consists of two suborders namely, Mysticeti (baleen whales) and Odontoceti (toothed cetaceans). Mysticeti represents four families of 14 species, while Odontoceti represents ten families of 73 species. Totally 130 marine mammal species have been recognized in the world oceans[126]. The Indian seas support 33 species of marine mammals, which include Delphinidae, Physeteridae, Kogiidae, Ziphiidae, Phocoenidae and Platanistidae[144, 287] (Table 1). Of the 33 species of cetaceans five are baleen whales, and the rest are Odontoceti, which includes Delphinidae, Physeteridae, Kogiidae, Ziphiidae, Phocoenidae and Platanistidae[144].

http://www.visualdictionaryonline.com/images/animal-kingdom/marine-mammals/examples-marine mammals_1.jpg

However, a majority of these are oceanic forms and occasionally a few individuals may get stranded on the shore.Standing and sighting records reported that the Indian seas is a habitat for only 20 species of cetaceans and one species of sirenian[287]. Sea cow, *Dugong dugon* occurs in near shore waters of Gulf of Mannar, Gulf of Kachchh and Andaman and Nicobar Islands. The information on species distribution and abundance of marine mammals in marine regions of India remains scanty. Vivekanandan and Jeyabaskaran[287] published the results of marine mammal surveys conducted in Southern Ocean.

# Marine biodiversity in India as today

The current inventory of coastal and marine biodiversity of India is summarized in Table 1. It indicates that a total of 16366 species of faunal and floral communities were reported from seas around India. The data revealed that India contributes 6.78% of marine biodiversity in global scenario.

## Table 1: Marine biodiversity of India in comparison with global marine biodiversity

| Taxon/Group | Species in India | Species in World |
|---|---|---|
| Bacteria | *** | 4800 |
| Seaweeds | 1058 | 18826 |
| Cyanophyta | 9 | 1,000 |
| Chlorophyta | 216 | 3052 |
| Phaeophyta | 191 | 1,600 |
| Rodhophyta | 434 | 8174 |
| Xanthophyta | 8 | *** |
| Bacilliariophyta (Diatoms) | 200 | 5000 |
| Seagrass | 14 | 60 |
| Mangroves (True) | 69 | 73 |
| Other Protoctista | *** | 23,000 |
| Protozoa | 1122 | 17855 |
| Dinophyceae (Dinoflagellates) | 90 | 2000 |
| Euglenophyta | *** | 250 |
| Chrysophyceae | *** | 500 |
| Dinomastigota | *** | 4,000 |
| Radiolaria | *** | 550 |
| Porista | 532 | *** |
| Foraminifera | 500 | 10,555 |
| Porifera | 476 | 8339 |
| Cnidaria | 1406 | 12616 |
| Actinaria | 75 | 1109 |
| Hydrozoa | 178 | 3662 |
| Scyphozoa | 30 | 250 |
| Cubozoa | 5 | 45 |
| Staurozoa | 1 | 50 |
| Anthozoa (Scleractinian nd Octocorallia) | 1117 | 7500 |
| Ctenophora | 19 | 197 |
| Platyhelminthes (Polyclads) | 46 | 1500 |
| Arthropoda: Crustacea | 3370 | 50685 |
| Copepoda | 541 | 14000 |
| Ostracoda | 125 | 5930 |
| Branchiopoda | 4 | 100 |
| Branchiura | 4 | 47 |
| Thecostraca | 74 | 1768 |
| Cirrepedia | 104 | 1,445 |
| Malacostraca : Mysidacea | 84 | 780 |

| Taxon/Group | Species in India | Species in World |
|---|---|---|
| Cumacea | 88 | 1300 |
| Tanidacea | 3 | 900 |
| Isopoda | 33 | 4500 |
| Amphipoda | 167 | 8089 |
| Euphausiacea | 23 | 83 |
| Stomataopoda | 93 | 480 |
| Brachyura | 705 | 6793 |
| Anomura | 120 | 1106 |
| Achelata | 38 | 149 |
| Penaeidea and Caridea | 343 | 3215 |
| Nemertea | 6 | 1362 |
| Gnathostomulida | 4 | 97 |
| Gastrotricha | 61 | 497 |
| Rotifera | 47 | 172 |
| Ciliata | 218 | 2668 |
| Kinorhyncha | 10 | 188 |
| Acanthocephala | 229 | 600 |
| Entoprocta | 4 | 181 |
| Nematoda | 356 | 6833 |
| Phornida | 3 | 11 |
| Brachiopoda | 8 | 419 |
| Mollusca | 2000 | 42579 |
| Bryozoa | 272 | 6148 |
| Siponcula | 38 | 147 |
| Echiura | 48 | 197 |
| Annelida | 584 | 11,712 |
| Polychaeta | 520 | 8000 |
| Tardigrada | 10 | 212 |
| Echinodermata | 742 | 7,000 |
| Chaetognatha | 44 | 131 |
| Protochordata | 522 | 3087 |
| Urochordata | 516 | 3057 |
| Cephalopchordata | 6 | 30 |
| Hemichordata | 14 | 130 |
| Vertebrata | 3166 | 18900 |
| Pisces | 2618 | 18196 |
| Reptiles | 32 | 74 |
| Birds | 33 | **** |
| Mammalia | 33 | 130 |
| Fungi | 450+ | 500 |
| **Total** | **16366**** | **241222** |

*Bouchet[46]; Groombridge and Jenkins[112].
** After Venkataraman and Wafar[297]; Venkataraman and Raghunathan[299]. *** Original inofmation available.

# Table 2. Summary of Marine Biodiversity Studies in Indian Seas

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| **PLANT KINGDOM** | | | | | | | | |
| 1 | Micro algae (Diatom) | 1930-till date | East and west coasts, Madras Coast | Coastal and Offshore waters | Hauling | University of Madras Andhra University, Botanical Survey of India, Annamalai University | Sankara Menon (1931), Gopala Iyer *et al*. (1936), Venkataraman (1939), Subrahmanyan (1946), Desikachary and Ranjithadevi (1986) | Studies going on till today |
| 2 | Macro Algae (Seaweeds) | 1940-till date | East and west coasts, Andaman and Nicobar Islands | Intertidal rocky shore of west and east coasts, Coral reef areas in Gulf of Mannar, Gulf of Kachchh, and Andaman nd Nicobar islands | Intertidal surveys on seaweed meadow | Botanical Survey of India, Forest Survey of India, Zoological Survey of India, National Institute of Oceanography, Central Salt and Marine Chemical Research Institute, Central Marine Fisheries Research Institute. | Krishnamoorthy and Joshi (1970), Iyengar (1984), Jagtap (1985, 1992), Umamageshwara Rao (2000). | Studies going on till today. Large amount of harvesting going on for commercial purposes. |
| 3 | Sea grasses | 1980 – till date | Gulf of Mannar, Andaman and Nicobar Islands and Gulf of Kachchh | Near shore area | Underwater surveys on seagrass meadow | Botanical Survey of India | Jagtap (1985, 1992, 1996), Ramamurthy *et al.* (1992), Silas and Fernando (1995) | Studies incomplete. And going on till today. Associated fauna not worked out |
| 4 | Mangroves | 1980 – till date | East and west coasts, Sunderbans and Andaman and Nicobar Islands | Littoral Forest | Remote sensing and ground truth surveys | Botanical Survey of India, Forest Survey of India, Zoological Survey of India, National Institute of Oceanography, Annamalai University, MSSRF | Jagtap (1985), Kathiresan (1992, 1993, 2001, 2009, 2013), Kathiresan and Quasim (2005), FSI (2009, 2011), MSSRF (2002), | Studies going on till today. Associated fauna is still to be done. Conservation efforts are on. |

| Protista | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sl. No** | **Taxonomic Group** | **Period** | **Study/survey Region** | **Habitat** | **Mode of assessment** | **Institutions involved** | **Major contributors** | **Remarks/Gap areas** |
| 5 | Foraminifera | 1798-till date | East and west coasts, Andaman and Nicobar Islands, Lakshadweep | Benthic and pelagic | Core and grab sampling of sediment | Indian museum, Geological Survey of India, Zoological Survey of India, Indian Institute of Science, Agarkar Institute | Fichtel and Moll (1798), Challenger Expedition (1873-1876), Brady (1884) Chapman (1895), Hofker (1927-1951), Gnanamuthu (1943), International Indian Ocean Expedition (1962-1965), Satyavathy (1954), Bhalla (1970), Ameer Hamsa (1974), Antony (1968), Rao (1970, 1971a, 1971b), Frerichs (1967), Rajshekhar (2013), Mohan *et al.* (2013) | National Institute of Oceanography and a very few universities studying. Very little study conducted and very few scientists working |
| **ANIMALIA** | | | | | | | | |
| **Porifera** | | | | | | | | |
| 6 | Porifera (Sponges) | 1894 – till date | East and west coasts, Andaman and Nicobar Islands | Intertidal, coral reef areas | Surveys in intertidal zone and subtidal area | Indian Museum, Zoological Survey of India, Central Marine Fisheries Research Institute. | Schulze (1894-1904), R.I.M.S. Investigator (from 1884 to 1900), Annandale (1915), Dendy and Burton (1926), Burton (1928), Burton and Rao (1932), Thomas (1977 nd 1979), Tikader *et al.* (1986), Pattanayak (2006), Venkataraman *et al.* (2013 in press) | Very few scientists working. |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| **Cnidaria** | | | | | | | | |
| 7 | Cnidaria(All group) | 1907-till date | Gulf of Mannar, Palk Bay, Gulf of Kachchh, Andaman and Nicobar Islands, Lakshadweep | Coral reef | Underwater surveys | Indian Museum, Zoological Survey of India, Central Marine Fisheries Research Institute. | Annandale (1907, 1915, 1916), Leloup (1934) and Menon (1931), Daniel (1985), Chakrapany (1984), Pillai (1991) | Very few scientists working. Capacity building needed for underwater studies. Status survey required. Conservation efforts are on. |
| 8 | Hydrozoa | 1915-1965 | East coast | Chilka lagoon | Underwater surveys | Indian Museum, Zoological Survey of India | Annandale (1915), Menon (1931), Mammen (1963, 1965) | Study incomplete. Very few scientists working. Capacity building needed for underwater studies |
| 9 | Siphonopora | 1927-1985 | East and west coasts, Madras coast | Nearshore waters | Trawling and fishing nets | Zoological Survey of India | Sundara Raj (1927), Lelop (1934) and Daniel and Daniel (1963), Rengarajan (1974), Daniel (1966, 1974) | Study incomplete. Very few scientists working. Capacity building needed for underwater studies. |
| 10 | Anthozoa Scleractinia | 1847-till date | Gulf of Mannar, Palk Bay, Gulf of Kachchh, Andaman and Nicobar Islands, Lakshadweep | Coral reef | Underwater surveys | Asiatic Society of Bengal, Indian Museum, Zoological Survey of India, Central Marine Fisheries Research Institute | Rink (1847), Thurston (1888), Brook (1893), Alcock (1893, 1898), Gardiner (1903-1906), Matthai(1924) Gravely (1927) and Sewell (1935), Pillai (1967-1988), Ramakrishna *et al.*(2010),Venkataraman *et al.* (2003 - 2013) | Study incomplete. Very few scientists working. Capacity building needed for underwater studies. Status survey required. Conservation efforts are on |
| 11 | Gorgonians | 1903-till date | Gulf of Mannar, Palk Bay, Kerala coast, Andaman and Nicobar Islands | Coral reef | Survey by Royal Indian Marine Survey Ship *Investigator* (1909),Under water surveys and through fishing nets. | Indian Museum, Zoological Survey of India | Pratt(1903), Thompson and Crane, (1909), Thomson and Simpson (1909), Thomas *et al.* (1995), (Venkataraman *et all., on* 2004), Venkataraman *et al.* (2003 – in press) | Very few scientists working. Capacity building needed for underwater studies. Status survey required. Conservation efforts are on |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| 12 | Scyphozoa Scyphomedusae | 1905-1983 | Entire Indian Seas including Lakshadweep, Andaman and Nicobar Islands, Madras coast | Open ocean and near shore waters | Surveys by Royal Indian Marine Survey Ship *Investigator* (1905) and through fishing nets | Indian Museum, Zoological Survey of India | Browne (1905, 1906, 1916), Annandale (1916), Menon (1930, 1931), Panikkar (1944), Nair (1945, 1954), Chakrapany (1915). | Study incomplete. |
| 13 | Ctenophora | 1915-1939 | Indian seas including Andaman and Nicobar Islands | Open ocean and nearshore waters | Surveys by Royal Indian Marine Survey Ship *Investigator* (1915) | Indian Museum, Zoological Survey of India | Annandale and Kemp (1915), Varadarajan (1934) and Devanesan and Varadarajan (1939). | Study incomplete. Very few scientists working. Capacity building needed for underwater studies. Status survey required. |
| 14 | Actinaria | 1907-till date | East and west coasts of India especially from West Bengal (Port Canning), Orissa (Chilka lake), Tamil Nadu (Adyar backwaters and Gulf of Mannar), Kerala (Cochin backwaters and Ashtamudi), Gujarat (Gulf of Kachchh), Maharashtra (Mumbai, Malvan), Goa, northern Karnataka and Andaman and Nicobar Islands. | Intertidal rocky shores in west coast, sandy shores in east coast and coral reefs in Andaman and Nicobar Islands | Intertidal and underwater surveys | Indian Museum, Zoological Survey of India, National Institute of Oceanography | Annandale (1907 nd 1915), Panikkar (1936, 1937a-c, 1939) and Parulekar (1966, 1967, 1968, 1969a,b, 1971, 1990), Raghunathan *et al*.(2013- in press) | Study incomplete. Very few scientists working. |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| 15 | Polyclads | 1902-till date | Andaman and Nicobar Islands, Lakshadweep and Gulf of Mannar | Coral reef | Intertidal and underwater surveys | Indian Museum, Zoological Survey of India. | Laidlaw (1902), Sreeraj and Raghunathan (2011; 2013), Apte and Pitale (2011), (Venkataraman *et al*., 2013 in press) | Study incomplete. Very few scientists working. |
| 16 | Archiannelida | 1944-1968 | East coast (Madras coast and Waltair coast) | Intertidal and nearshore waters | Inertidal surveys and benthos samples | University of Madras, Andhra University | Aiyar and Alikunhi (1944), Alikunhi (1946, 1948) | Study incomplete. |
| 17 | Polychaeta | 1921-1963 | East coast (Chilka lake, Andhra Coast, Madras coast, Gulf of Mannar) | Intertidal and nearshore waters | Inertidal surveys and benthos samples | Zoological Survey of India, University of Madras, Andhra University, National Institute of Oceanography | Southern(1921), Gravely (1927), Fauvel (1930, 1932, 1953), Hartman (1947), (Aiyar, 1924, 1931), Subramaniam (1938), Aiyar and Alikunhi,(1940),Gravely (1942), Alikunhi (1941, 42,1946-1948), Krishnan (1946), George (1905), Ganapati &Radhakrishna (1958), Ghosh (1963), Banse(1959), Krishnamoorthi (1963), Tampi and Rangarajan (1963), Parulekar (1982), Rao (2002), Ajmal Khan and Murugesan (2005) | Study incomplete. |
| 18 | Oligochaeta | 1983-till date | Andaman and Nicobar Islands | Intertidal and nearshore waters | Inertidal surveys and benthos samples | Zoological Survey of India | Rao (1983) | Study incomplete. No recent studies on this group |
| 19 | Sipuncula | 1903-1979 | Andaman and Nicobar Islands, Lakshadweep Islands, Gulf of Mannar and Gulf of Kachchh | Intertidal and coral reefs | Intertidal surveys | Indian Museum, Zoological Survey of India | Shipley (1903), Gravely (1927), Prashad (1936), Johnson (1964, 1969, 1971), Haldar (1975 to 1978, 1985a&b) Cutler (1977) and Cutler (1979) | Study incomplete. Very few scientists working. Capacity building needed |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| 20 | Echiura | 1915-1964 | Eastcoast(Chilka lagoon, Gulf of Mannar, West Bengal &Orissa), West coast (Gulf of Kachchh, Gulf of Kambath, Kerala coast), Lakshadweep, Andaman and Nicobar Islands | Intertidal and reef areas | Intertidal surveys | Indian Museum, Zoological Survey of India | Annandale and Kemp (1915) (Prashad, 1919, 1935), Menon *et al.,* (1964); Dattagupta, (1967, 1976), Dattagupta and Menon (1963, 1964) | Study incomplete. Very few scientists working. Capacity building needed |
| 21 | Chaetognatha | 1936-till date | Coastal and marine areas of India and Indian Ocean Region | Pelagic ecosystem | Surveys of MV Sagara Sampatha | National Institute of Oceanography, Central Marine Fisheries Research Institute, National Institute of Oceanography, Zoological Survey of India, Andhra University, Madras University | Lele and Gae (1936), Subramaniam (1937), Varadarajan and Chacko (1943), Pillai, (1944), Menon, (1945), George, (1952), Prasad (1956), Sudarsan (1963), (Rao, 1958, 1966) Rao and Ganapati (1958), Rao and Kelly (1962), Srinivasan (1977, 1980), Nair *et al.,* (1981), Vijayalaxmi *et al.,*(2008), Nair (1967, 1971, 1973, 1974, 1975), Nair and Rao, (1973), Nair and Selvakumar (1979), Silas and Srinivasan, (1968, 1969, 1970), Srinivasan (1972, 1979, 1996). | Study incomplete. Very few scientists working. Capacity building needed |
| 22 | Tardigrada | 1998 – till date | Intertidal and interstitial areas of Tamil Nadu coast | Free living | Meiofaunal samples of benthos | Zoological Survey of IndIA | Venkataraman (1998), Sivaleela (2006) | Study incomplete |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| **Crustacea** | | | | | | | | |
| 23 | Copepoda | 1924-till date | Entire Indian coastal and marine ecosystems of India | Pelagic environment of nearshore and oceanic waters | Surveys by Research vessels of India viz, RIMS Investigator, Sagar Sampada, Sagar Kanya, Sagar Pachmi, SagarPoorvi, Sagar Manjusha, Sagar Nidhi | Zoological Survey of India, National Institute ofOceanography, Central Marine Fisheries Research Institute, National Institute of Ocean Technology | Sewell (1924, 1929, 1940), Krishnaswamy (1950, 1952, 1953) and Pillai (1967), Madhu Pratap (1979) | Considerable studies have been made |
| 24 | Parasitic Copepods | 1985 | Coastal and marine and interstitial waters in general | Pelagic | Parasitic copepods in marine fishes | Kerala University | Krisha Pillai (1985) | Study incomplete |
| 25 | Ostracoda | 1975 – till date | West coast of India | Pelagic environment of nearshore and oceanic waters | Surveys by Research vessels of India viz, Sagar Sampada, Sagar Kanya, Sagar Pachmi, Sagar Poorvi, Sagar Manjusha, Sagar Nidhi | National Institute of Oceanography, Central Marine Fisheries Research Institute | George *et al.,* (1975), George and Nair (1980) | Study incomplete. |
| 26 | Branchiura | 1983-till date | Andaman and Nicobar Islands | Intertidal and nearshore waters | Inertidal surveys and benthos samples | Zoological Survey of India | Rao (1983) | Study incomplete. No recent studies on this group |
| 27 | Cirrepedia | 1894-till date | East coast of India | Intertidal rocky shores | Intertidal surveys | Indian Museum, ZSI, University of Madras Annamalai University | Weltner](1894),Borradaile (1903), Annandale (1907, 1909&10, 1913, 1924), Nilsson (1938), Panikkar and Aiyar (1937), Daniel (1952, 1953, 1956, 1958, 1962, 1963, 1971, 1974, 1975), Fernando (2006) | Study incomplete |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| 28 | Mysidacea | 1922-till date | East and west coasts | Pelagic ecosystem | Surveys by Research vessels of India viz, Sagar Sampada, Sagar Kanya, Sagar Pachmi, Sagar Poorvi, Sagar Manjusha | National Institute of Oceanography, Central Marine Fisheries Research Institute, Zoological Survey of India. | Tattersall (1922), Pillai (1964, 1968, 1973). | Study incomplete |
| 29 | Cumacea | 1904-till date | East coast | Pelagic ecosystem | Samples collected through International Indian Ocean Expedition | Indian Museum, Zoological Survey of India, University of Madras | Calman (1904) Kemp (1916) and Kurian (1954, 1965), Chatterjee and Pesic, 2010; Petrescu and Chatterjee, 2011) | Study incomplete |
| 30 | Tanaidacea | 1923 | East coast – Chilka lake | Lagoon ecosystem | | Zoological Survey of India, | Chilon (1923) | Study incomplete |
| 31 | Isopoda | 1924 - 1968 | Andaman and Nicobar Islands, Delta Ganges, Gulf of Mannar and Bombay | Pelagic waters | Coastal waters and sediment samples | Zoological Survey of India, | Chopra (1924) | Study incomplete |
| 32 | Amphipoda | 1888-till date | Gulf of Mannar, Travancore, Cochin, Madras and West Bengal coasts, | Pelagic waters | Coastal waters and sediment samples | Indian Museum, Zoological Survey of India, | Giles (1888, 1890), Gravely (1927), Sundara Raj (1927), Bernard (1935), Sivaprakasam (1966, 1967, 1968, 1970), Nayar (1959, 1966) Surya Rao (1974) | Study incomplete |
| 33 | Euphausiacea | 1891-till date | East and west coast, Lakshadweep, Andaman and Nicobar Islands | Pelagic waters | Through oceanographic surveys conducted by *RIMS Investigator* | Zoological Survey of India, National Institute of Oceanography, Central Marine Fisheries Research Institute. | Alcock (1891) Alcock and Anderson (1893, 1894). Tettersall (1911), Silas (1967), Mathew (1971, 2000) | Study incomplete |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| 34 | Stomatopoda | 1913-till date | East and west coasts | Pelagic and demersal waters | John Murry Expedition (1933 –34) made by Sewell | Indian Museum, Zoological Survey of India,, National Institute of Oceanography, Central Marine Fisheries Research Institute, Annamalai University | Kemp (1913), Tiwari and Biswas (1952), Ghosh (1975, 1976), Tiwari and Ghosh (1975) | Study incomplete |
| 35 | Decapoda Macrura | 1901 - 1906 | East and west coasts | Pelagic and demersal waters | Oceanographic surveys by research ships. | Indian Museum, Zoological Survey of India | Alcock (1901, 1906) | Study incomplete. No recent studies on this group |
| 36 | Brachyura | 1834-till date | East and west coasts | Coastal waters | Trawling surveys by survey ships as well as fishing boats | Indian Museum, Zoological Survey of India,, Central Marine Fisheries Research Institute, Annamalai University | Milne Edward (1834-1837), Henderson (1893), de Man (1887, 1895, 1896, 1898, 1899, 1900, 1901). Kemp (1915), Chopra (1930, 1931, 1933, 1935, 1939), Ajmal Khan (2000-2010) | Considerable studies are made |
| 37 | Anomura | 1972 – till date | East and west coasts | Coastal waters, estuaries | Intertidal surveys | Zoological Survey of India, Annamalai University | Sarojini and Nagabhushanam (1972), Reddy and Ramakrishna (1972), Ajmal Khan (2000-2010) | Study incomplete |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| **Mollusca** | | | | | | | | |
| 38. | Mollusca | 1784-till date | Throughout the Indian coast especially Gulf of Mannar, Palk Bay, Gulf of Kachchh, Andaman and Nicobar Islands, Lakshadweep Archipelago | Intertidal to nearshore waters and deep sea | Intertidal surveys and sampling through fishing trawlers | Zoological Survey of India, National Institute of Oceanography, Central Marine Fisheries Research Institute, Madras Government. Museum, Bombay Natural History Society. and all Universities dealing with marine studies | Hornell (1905), Thomas Satyamurthy (1956), Subba Rao, (1991, 1998, 2000), Venkataraman (2004), Ramakrishna (2010) | Considerable studies are made |
| 39. | Opisthobranchia | 1980-till date | Throughout the Indian coast especially Gulf of Mannar, Palk Bay, Andaman and Nicobar Islands, Lakshadweep Archipelago | Intertidal to nearshore waters | Intertidal and undersea surveys in coral reef areas | Zoological Survey of India, Bombay Natural History Society. | Alder and Hancock (1864), Eliot (1910), Ramakrishna *et al*., (2010), Raghunathan *et al*. (2010), Sreeraj *et al*. (2013) | Study incomplete |
| 40. | Bryozoa | 1970-till date | East and west coasts, Gulf of Mannar | Intertidal to deep sea | Intertidal surveys in coral reef areas and deep sea sampling by grabs | Cochin University of Science and Technology, Zoological Survey of India, | Satynarayana Rao, (1998), Soja *et al*. (2006) | Study incomplete |
| 41. | Ectoprocta | 1908 - 1915 | East coast | Coastal waters | ------ | Zoological Survey of India, | Annandale (1908, 1916) and Harmer (1915) | Study incomplete |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| **Echinodermata** | | | | | | | | |
| 42 | Echinodermata | 1743-till date | Throughout the Indian coast especially Gulf of Mannar, Palk Bay, Gulf of Kachchh, Andaman and Nicobar Islands, Lakshadweep Archipelago | Coastal and nearshore waters | Intertidal and undersea surveys in coral reefs | Zoological Survey of India,, Central Marine Fisheries Research Institute | Collier (1830), Muller (1849) Lutken (1865, 1872) and Marktanner-Turneretscher (1887), (Sastry, 1998; James, 1986), Raghunathan *et al.* (2013) | Considerable studies are made in nearshore waters. Knowledge on deep water echinoderms is lacking |
| **Vertebrates** | | | | | | | | |
| 43 | Hemichordata | 1994-till date | Gulf of Mannar and Palk Bay | Coastal and nearshore waters | Intertidal and undersea surveys in coral reefs | Zoological Survey of India, | Ruppert and Barnes, 1994; Dhandapani, 1998; Zang, 2011 | Study incomplete |
| 44 | Protochordata | | Gulf of Mannar and Palk Bay | Coastal and nearshore waters | Intertidal and undersea surveys in coral reefs | Zoological Survey of India, | Renganathan (1986), Dhandapani (1998) | Study incomplete |
| 45 | Urochordata | 1986-till date | East and west coast of India, Gulf of Mannar, Palk Bay and Andaman and Nicobar Islands | Coastal and nearshore waters | Intertidal and undersea surveys in coral reefs | Zoological Survey of India, Manonmaniam Sundaranar University, Annamalai University | Renganathan (1986), Meenakshi (1996), Ananthan *et al*. (2011) | Study incomplete |
| 46 | Pisces | 1875-till date | Throughout Indian Seas | Coastal, nearshore and offshore waters | Oceanographic Research vessels, Fishing trawlers | Zoological Survey of India, Fisheries Survey of India, Central Marine Fisheries Research Institute, National Institute of Oceanography and all the Universities dealing with marine sciences | Day (1875-1878, 1889), Whitehead and Talwar (1976), 1991), Talwar and Kacker (1984), Day (1889), Kumaran (1980), Rao (2003), Venkataraman *et al.* (2003), Ramakrishna *et al.* (2010) | Considerable studies are made |

| Sl. No | Taxonomic Group | Period | Study/survey Region | Habitat | Mode of assessment | Institutions involved | Major contributors | Remarks/Gap areas |
|---|---|---|---|---|---|---|---|---|
| 47 | Reptiles | 1931-till date | Throughout the Indian coast especially Gulf of Mannar, Palk Bay, Gulf of Kachchh, Andaman and Nicobar Islands, Lakshadweep Archipelago and other turtle nesting sites | Coastal and nearshore waters | Oceanographic Research vessels, Fishing vessels and surveys in coral reef areas | Zoological Survey of India,, Indian Institute of Science, Wild Life Institute of India | Smith (1931), Venkataraman and John Milton (2003), (Murthy (2007) | Sporadic studies are available. Comprehensive study is lacking |
| 48 | Seabirds | 1985-till date | Throughout the Indian coast especially Gulf of Mannar, Palk Bay, Gulf of Kachchh | Coastal and nearshore waters | Coastal and oceanographic surveys | Bombay Natural History Society, Zoological Survey of India, | Balachandran (1995), Venkatraman (2009) | Study incomplete |
| 49 | Mammals | 1852-till date | Entire Indian coasts including Gulf of Mannar, Andaman and Nicobar Islands | Coastal, nearshore and offshore waters | Survey by Indian research vessels | Central Marine Fisheries Research Institute, Zoological Survey of India,, National Institute of Oceanography. | Blyth (1852), Silas (1960), Daniel (1963, 1966), Alagarsawamy *et al*. (1973), Jefferson *et al.* (1993), Agrawal and Alfred, (1999), Alfred *et al*., (2002), Kumaran (2002) George *et al*. (2011), Vivekanandan and Jeyabaskaran (2012). Raghunathan *et al.* (2011, 2013) | Sporadic studies are available. Comprehensive study is lacking |

**Acronyms:** BNHS – Bombay Natural History Society; BSI – Botanical Survey of India; CMFRI – Central Marine Fisheries Research Institute; CSMCRI – Central Salt and Marine Chemicals Research Institute; FSI – Fishery Survey of India, GSI – Geological Survey of India, IISc – Indian Institute of Science, MSSRF – M.S. Swaminathan Research Foundation; NIO – National Institute of Oceanography; WII – Wildlife Institute of India; ZSI – Zoological Survey of India

## REFERENCES


1. Aiyar R G, *Proc 11th Indian Sci Congr,* (1924) 112.
2. Aiyar R G, *Proc 18th Indian. Sci. Congr,* (1931) 244.
3. Aiyar R G nd Alikunhi K H, *Rec Indian. Mus Calcutta,* 42 (1940) 89-107.
4. Aiyar R G nd Alikunhi K H, *Proc Nat Inst Sci,* 10 (1) (1944) 113-140.
5. Alcock A, *J Asiat Soc Beng,* 62 (2) (1893) 138-149.
6. Alcock A, *Mem Indian Mus,* (1898) 1-29.
7. Alcock A, *A descriptive catalogue of the Indian deep-sea Crustacea, Decapoda: Macrura and Anomura in the Indian Museum being a revised account of the deep-sea species collected by the Royal Indian Marine Survey Ship, "Investigator". Calcutta, India* (1901) 1-286.
8. Alcock A, *Trustees of the Indian Museum, Calcutta*, (1906) 1-55.
9. Alcock A W nd Anderson R S, *Ann. Mag Nat Hist,* 3 (7) (1893) 1-27; 278-292.
10. Alcock A, nd Anderson R S, *J Asiat Soc Beng ,* 43 (1894) 141-185.
11. Alder J nd Hancock A, *Trans Zool Soc Lond*, 5 (1864) 117-147.
12. Alder E, A world of neighbours: UNEP's Regional Seas Programme (UNEP) 2003 [www.unep.ch/seas/Library/-neighbours.pdf]
13. Alikunhi K H, *Proc Indian Sci Congr,* 27 (1941) 152; *Proc Indian. Acad. Sci, B,* 13 (3) : 193-238.
14. Alikunhi K H, *Proc Indian. Sci Congr,* 28 (1942) 173; 29 (1943) 149-150.
15. Alikunhi K H, *Curr Sci,* 15 (1946) 140.
16. Alikunhi K H, *Proc Nat Inst. Sci India,* 13 (3) (1947)105- 127.
17. Alikunhi K. H, *J Roy Asiat Soc Bengal,* 14 (1) (1948) 17-25.
18. Alikunhi K H, *Proc Nat Inst Sci India,* 14 (8) (1948) 373-383.
19. Alvarino A, *J mar biol Ass India*, 14 (2) (1974) 713-722.
20. Ameer Hamsa K M S, *J mar biol Ass India,* 14 (1974) 418-423.
21. Annandale N, *Proc Asiatic Soc Bengal* N S, III, No. 2, (1907) 79-81.
22. Annandale N, *Rec Indian. Mus,* 1 (1907) 197-205.
23. Annandale N, *Rec Indian Mus*, 2 (1908) 24-32 .
24. Annandale N, *Mem. Indian. Mus*., 2 (1909) 61-137.
25. Annandale N, *Rec Indian Mus*, 5 (1910) 115-116; 5 (1910) 145-155; 9 (1913) 227-236; 10 (1914 ) 273-280; 8 (1924) 61-68
26. Annandale N, *Mem Indian Mus,* 5 (1915) 65-114.
27. Annandale N, *Mem. Asiat Soc Bengal,* 5 (1916) 18-24.
28. Anandale N nd Kemp S, *Mem Indian Mus,* 5 (1915) 55-63.
29. Annandale N nd Kemp S, *Mem Indian Mus,* 5 (1915) 519-558.
30. Antony A, *Bull Dept Mar Biol Oceanogr*, 4 (1968) 11-154
31. Apte D nd Pitale RD, *J Bombay Nat Hist Soc,* 108(2) (2011) 109-113.
32. Balachandran S, *J Bombay nat. His Soc,* 92 (3) (1995) 303-313.
33. Banse K, *J mar biol Ass India,* 1 (2) (1959) 165-177.
34. Barman R P, *Pisces* In: *Faunal Diversity In India Zool Surv India* , Kolkata (1998) 418-426.
35. Bernard K H, *Rec Indian. Mus,* 37: (1935) 279-319.
36. Bhalla S N, *Bull geol Soc India*, 5 (1) (1968) 13-15.
37. Bhalla S N, *Contr Cushman. Fdn. Foramin. Res*, 21 (4) (1970) 156-163.
38. Bhatia B nd Bhalla S N J, *J. Paleont Soc India,* 4 (1959) 78.
39. Bhatt D K, *Contr Cushman Fdn Foramin Res*, 20 (1969) 30.
40. Bhatt J R, Ramakrishna, Sanjappa M, Remadevi O K, Nilaratna B P and Venkataraman K, Mangroves of India- their biology and uses, published by Zoological Survey of India (2013), 640pp.
41. Blazewicz-Paszkowycz M, Bamber R nd Anderson G, *PLoS ONE,* 7(4) (2012) e33068. doi:10.1371/journal.pone.0033068
42. Borradaille L A, *Proc Zool Soc Lond,* (1900) 568-596.
43. Borradaile L A, *Marine Crustaceans. IV. Some remarks on the classification of the crabs. In: J. St. Gardiner, The Fauna and Geography of the Maldive and Laccadive Archipelagoes,* 1(4) (1903) 424-429.
44. Borradaille L A, *The fauna and geography of the Maldives and Laccadive Archipelagoes, being the account of the work carried on and of the collections made by an expedition during the years 1899*

*and 1900 by J. Stanley Gardiner, Marine Crustaceans.* I on varieties II Portunidae 1 (2) (1902) 191-208; (3) 237-271.
45. Borradaile L A, *In:* (*Ed.*) J. S. Gardiner, The fauna and geography of the Maldive and Laccadive archipelagoes 1 (3) (1903) 199-208; (1906) 431.
46. Bouchet, P, The Magnitude of Marine Biodiversity. In: The Exploration of Marine Biodiversity, Scientific and Technological Challenges (Ed. Duarte, C M), Fundacion BBVA, (2006)
47. Brady H B, *Rep Sci Res Voyage CHA LLENGER Zool,* 9 (1884) 21.
48. Brook G, *The genus Madrepora. Catalogue of the Madreporarian Corals in the British Museum (Nat. Hist.),* I (1893) 1-212.
49. Browne E T, *Rep Govt Ceylon Pearl oyster*, 4 (1905) 131-166.
50. Browne E T, *Trans Linn Soc London (Zool)*, 10 (1906) 163-187.
51. Browne E T, *Trans Linn Soc London (Zool)*, 17 (1916) 169-210.
52. Browne E T, *Trans Linn Soc (Zool) London*, 2 (1926) 55-86.
53. Calman W T, *Rep Ceylon Pearl oysters Fish. Gulf of Mannar,* 2 (1904) 159-180.
54. Cairns SD nd Kitahara MV, *ZooKeys*, 227 (2012): 1–47, doi: 10.3897/zookeys.227.3612.
55. Chakrapany S, *Studies on Marine Invertebrates. Scyphomedusae of the Indian and adjoining seas. Ph D Thesis submitted to the Univ. of Madras*, (1984) 206 pp.
56. Chapman F, *Proc Zool Soc,* (1895) 4.
57. Chatterjee B P nd Gururaja M N, *Bull natn Inst Sci India*, 38 (1967) 393.
58. Chatterjee T nd Pesic V, *Cahiers de Biol Mar,* 51 (2010) 289-299.
59. Chilton C, *Mem Indian. Mus,* 5 (1923) 877-895
60. Chopra B, *Rec Indian Mus,* 25 (1923) 411 – 550.
61. Chopra B, *Rec Indian Mus*, 32 (1930) 413-429: 33 (1931) 303-324; 35 (1) (1933) 25-32; 35 (1) (1933) 77-86; 37 (4) (1935) 463-514;
62. Chopra B, *J Bombay nat. Hist Soc*, 41 (2) (1939) 221-234.
63. Chopra B nd Das K N, *Rec Indian Mus*, 39 (4) (1937) 337-343.
64. Choudhuri A nd Biswas B, *Micropaleontology*, 8 (1954) 30.
65. Collier C, *Edinburgh New Phil. J.,* 8 (1830) 46- 52.
66. Cutler E B, *Steenstrupia,,* 4 (12) (1977) 151-155.
67. Cutler E B nd Cutler N J, *Bull Mus nat Hist Paris,* 4 (1) (1979) 941-990
68. *Daniel A,* Ann. Mag Nat Hist , *(12)5 (1952) 400-403.*
69. Daniel A, *J Zool Soc India,* 5 (2) (1953) 235-238.
70. *Daniel A,* Bull Madras Govt Mus N S *( N H)* Sec, *6(2) (1956) 1-39.*
71. *Daniel A,* Ann Mag nat. Hist , *(13)1 (1958) 305-308; 755-757 (1962) (13) 5 193-197; (1963) 641-645.*
72. Daniel R, *Ann Mag Nat Hist,* 9 (13) (1966) 689-692.
73. Daniel R, *Mem Zool Surv India,* 15 (2) (1974) 865-868.
74. Daniel R, *Zool Surv India,* (1985) 440 pp.
75. Daniel R nd Daniel A, *J mar biol Ass India,* 5 (2) (1963) 185-220.
76. Daniel A, *J mar biol Ass India,* 13(1) (1971) 82-85.
77. Daniel A, *Proc Indian nat. Sci Acad.* 38 (3 nd 4) (1974) 179-189.
78. Daniel A, *J mar biol Ass India*, 16(2) (1975) 182-210.
79. Dattagupta A K, *Bull natn Inst Sci,* 34 (1967) 365-370;
80. Dattagupta A K, *Proc Intrnat Symp Biol of Sipuncula and Echiura Kotov* 2 (1976) 111-118; *Symp Modern trends of Zoological Researches in India* (1976) 68.
81. Dattagupta A K, nd Menon P K B, *Ann Mag Nat Hist,* 6 (1963) 57-63; 7 (13) (1964) 57-63.
82. Day F, *In*: The of India: being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon. (1875-1878) 778. *Reprinted William Dawson and Sons Ltd*., London.
83. Day F T, *In*: *The fauna of British India, including Ceylon and Burma. Fishes, Vol.II. Taylor and Francies Ltd., London*. (1989) 509. pp.
84. Day F, *The fauna of British India, including Ceylo and Burma. Fishes* 1, (1889) 548 London, Taylor nd Francis.
85. de Man J G, *Rec Indian Mus,* 2 (1908) 211-231.
86. de Man J G, *Zool Jahrb* (Syst), *2* (1887) 639-689; 64 (2) (1895) 157-289; 65 (2) (1896) 134-296; 67 (2) (1898) 67-233; 68 (2) (1899) 1-104; 68 (3) (1899) 123-169; 68 (1900) 11-119; 69 (3) (1901) 279-486;

87. Devanesan D W nd Varadarajan S, *Curr Sci,* 8 (4) (1939) 157-159.
88. Dhandapani P, *Hemichordata* In: *Faunal Diversity In India Zool Surv India*, Kolkata (1998) 406-409.
89. Dhandapani P, *Protochordata* In: *Faunal Diversity In India Zool Surv India*, Kolkata (1998) 412-415.
90. Fauvel P, *Bull Madras Govt Mus,,* I (2) (1930) 1-72.
91. Fauvel P, *Mem Indian Mus,* XII, 1, (1932) 1-262.
92. Fauvel P, *Fauna of India including Pakistan, Ceylon, Burma and Malaya. Annelida, Polychaeta. The Indian Press, Allahabad,* (1953) 507 pp.
93. Fichtel L Von nd Von Moll J P C, *Testacea microscopica, aliaqua minuta ex generibus Argpmauta et Mautilus and naturam pieta et descripta,* 7 (1798) 123; Second Edn, 1803.
94. Frerichs W E, *Diss. Abstr,* 28B (1967) 940-941.
95. Ganapati P N nd Radhakrishna Y, *Andhra Univ Mem Oceanogr,* 2 (1958) 210-237.
96. Gardiner J S, In J. S. Gardiner (*Ed.*) *The fauna and geography of the Maldive and Laccadive Archipelagoes. Cambridge*, 2, 1 (1903-1906) 1679.
*97.* George A I, *Proc Indian. Acad. Sci Sec B*, 32 (1950) 215-221.
98. George P C, *Proc Nat Inst Sci India*, 18 (1952) 657-689.
99. George J, Purushan K S nd Madhu Pratap M, *Indian J Mar Sci* 4 (1975) 201-202.
100. George J nd Nair V R, *Mahasagar Bull Natn Insat Oceanogr,* 13 (1) (1980) 29-44.
101. Ghosh A, *J mar biol Ass India,* 5 (1963) 239-245.
102. Ghosh H C, *Crustaceana*, 28 (1 ) (1975) 33-36.
103. Ghosh H C, *Rec zool Surv India*, 71 (1976) 51-55.
104. Giles G M, *J Asiat Soc Beng*, 54 (1885) 69-71; 56 (1887) 212-229.
105. Giles GM, *J Asiat. Soc Beng,* 57(1888) 220-255; 59 (1890) 63.
106. Giriffiths, C L, *Indian J Mar Sci*, 34(1) (2005) 35-41
107. Gnanamuthu C P, *Bull. Madras Govt. Mus. New Ser Nat Hist Section,* 1(2) (1943) 21.
108. Gravely F H, *Bull Madras Govt Mus New Ser*, 1(1) (1927) 41-51.
109. Gravely F H, *Bull Madras Govt Mus,* 1 (1) (1927) 123-124.
110. Gravely F H, *Bull Mad Govt Mus (N S) N H,* 1(2) (1927) 123-128.
111. Gravely F H, *Bull Madras Govt Mus N S (N H)*, 5(2) (1942) 104 pp.
112. Groombridge, B nd Jenkins, M D, eds. Global biodiversity: Earth's living resources in the 21 st Century. Cambridge: World Conservation Press (2000).
113. Haldar B P, *In*: *Proc Internat.Symp Biol Sipuncula and Echiura Kotor,* 1(1975) 51-92.
114. Haldar B P, *Rec zool Surv India,* 70 (1) (1976) 12-13.
115. Haldar B P, *Newsl Zool Surv India,* 3 (3) (1977) 120-123.
116. Haldar B P, *Bull zool Surv India,* 1 (1) (1978) 37-42.
117. Haldar B P, *In*: *State of the Art Report: Estuarine Biology, Workshop, Berhampore (Orissa)*, 9 (1985a) 13 pp.
118. Haldar B P, *In*: *Second National Seminar o Marine Intertidal Ecology, Waltair,* Abstract 26 (1985b).
119. Harmer S, *Siboga Expedition Monogr*, 28 a (1915) 565 pp.
120. Hartman O, *J mar biol Ass India,* 16 (2) (1974) 609-644.
121. Henderson J R, *Tans Linn Soc Lond Zool,* 5 (2) ( 1893) 325-458.
122. Heywood V H nd Watson R T (Eds.). Global biodiversity assessment (Cambridge University Press, New York), 1996.
123. Hofker J, *SIBOGA Exped,* Part 1 (1927); Part II (1930); Part III (1951); Mon IV (Leiden).
124. Jaume D nd Boxshall GA, *Hydrobiologia*, 595 (2008) 225–230.
125. James D B, *In*: *P S B R James,* (Ed.) *Recent Advances in Marine Biology*, *Today and Tomorrow's Printers and Publishers,* New Delhi (1986) 569-591.
126. Jefferson TA, Webber MA nd Pitman RL, Marine mallals of the world:A comprehensive guide to their identification, Academic Press, (2008)592 pp.
127. Jones S nd Kumaran. M, *In* : *Fishes of the Laccadive archipelago. Kerala : The nature conservation and Aquatic Sciences Service, Trivandram,* (1980 ) 760. pp.
128. Johnson P, *Ann Mag nat Hist*, 7 (13) (1964) 331-335.
129. Johnson P, *J Bombay nat Hist. Soc,* 66 (1) (1969) 43-46.
130. Johnson P, *J Bombay nat Hist Soc,* 68 (3) (1971) 596-608.
131. Kaladharan P nd Kaliaperumal N, *NAGA,* 22 (1) (l999) 11-14.
132. Kalimuthu S, Kaliaperumal N nd Ramalingam J R, *Jmar biol Ass India,* 33 (1nd2) (1991) 170-174.
*133.* Kannan L, Thangaradjou T nd Anantharaman P, *Seeweed Res Utiln,* 21 (1 nd 2) (1999) 25-33.

134. Kathiresan K, *Mangrove atlas and Status of species of India*. (1999) 235 pp.
135. Kemp S, *Mem. Indian Mus*, 4 (1913) 10-17.
136. Kemp S, *Mem Indian Mus*, 5 (1915) 199-325.
137. Kemp S, *Rec Indian Mus,* 12(8) (1916) 386-405.
138. Krishnamoorthi B, *J mar Boil Ass India,* 5 (1963) 97-102.
*139.* Krishnan G, *Studies on the polychaetes from Madras* Thesis University of Madras (1946).
140. Krishnaswamy S, *Rec Indian Mus*, 48 (1950) 117-120; 50 (1952) 324.
141. Krishnaswamy S, *Rec Ind Mus,* 49 (1951) 321-336; 54 (1956) 23-28, 54 : 29-32.
142. Krishnaswamy S, *J Madras Univ,* 23 B (l nd 2) (1953) 61-75.
143. Krishnaswamy S, *Studies on the Copepoda of Madras* Ph D thesis, University of Madras (1957).
144. Kumaran PL, *Curr Sci*, 83 (10) (2002) 1210-1220.
145. Kurian C V, *Rec Indian Mus*, 52 (2-4) (1954) 275-311.
146. Kurian C V, *J mar biol Ass India*, 2 (1965) 630-633.
147. Laidlaw FF, *Fauna and Geology of the Maldive and Laccadive Archipelagoes* 1 (1902) 282-312.
148. Lele S H nd Gae P B, *J Univ Bombay,* 4 (1936) 105 –113.
149. Leloup E, *Bull Mus Hist Nat Belg, Bruxelles,* 10 (9) (1934) 1-5.
150. Luetken C, *Vidensk Meddr dansk naturh. Foren*., 1864 (1865) 123-169.
151. Luetken C, *Overs k danske Videns. Selsk. Forh* 77 (1872) 75-178.
152. Madhu R nd Madhu K, *J. Mar. Biol. Ass. India*, 49 (2) (2007) 118-126.
153. Madhu Pratap M, *Indian J mar Sci,* 8 (1) (1979) 1-8.
154. Mammen T A, *J mar biol Ass India*, 5 (1) (1963 ) 27-61.
155. Mammen T A, *J mar biol Ass India*, 5 (1) (1965) 1-57.
156. Marktanner –Turneretscher G, *Annln Naturh Mus Wein*, 2 (1887) 291-316.
157. Matthai G, *Mem. Indian Mus*, 8 (1924) 1-59.
158. Mauchline J, *Adv Mar Biol* 18 (1980) 1-369.
159. Mc Laughlin PA, Komai T, Lemaitre R nd Rahayu DL, *Raf Bul Zool, Suppl No*. 23 (2010) 5–107.
160. Menon K S, *Rec Indian Mus,* 33 (1931) 489-516.
161. Menon M A S, *Proc Indian Acad Sci,* 22 (1945) 31-62.
162. Menon M G K, *Bull Madras Govt Mus N S (N H),* 3 (1) (1930) 1-28.
163. Menon M G K, *Bull Madras Govt Mus,* (NH) III. 2 (1931) 32 pp.
164. Menon P K B, Dattagupta A K nd Johnson P, *Ann Mag Nat. Hist,* 7 (1964) 49-57.
165. Milne – Edwards H, *Historie naturelle des Crustaces* . Parts I –II (1834-37) 532 pp.
166. Myers N, Mittermeier R A, Mittermeier C G, da Fonseca G A B nd Kent J, *Nature,* 403 (2000) 853-858.
167. Nair K K, *Proc Indian Sci Congr 32nd Sess*, 3 (1945) 97.
168. Nair K K, *Bull Cent Res Inst Univ Travancore*, 2 (1) (1954) 47-75.
169. Nair R V, *Proc Symp Indian Ocean Bull N I S I,* 38 (1967) 747-752.
170. Nair R V, *J mar biol Ass India*, 13 (2) (1971) 226-233.
171. Nair R V, *I O B C Hand Book,* 5 (1973) 87-96.
172. Nair R V, *J mar biol Ass India*, 16 (3) (1974) 721-730.
173. Nair R V, *Mahasagar,* 8 (1nd2) (1975) 81-86.
174. Nair V R, Achuthankutty C T, Nair S S R and Madhupratap M, *Indian J mar Sci*, 10 (3) (1981) 270-273.
175. Nair R V nd Rao T S S, *In:* Zeitschel, B. (Ed) *The biology of Indian Ocean, Chapman and Hall, London* (1973) 1-549.
176. Nair R V nd Selvakumar R A, *Magasagar Bull Nat Inst Oceanogr,* 12 (1979) 17-25.
177. Nayar K N, *Bull Madras Govt Museum (NH),* VI (3) (1959) 59.
178. Nayar K N, *Proc Symp on Crustacea MBAI,* 1 (1966) 133-168.
179. Nilsson Cantell C A, *Mem. Indian Mus*, 13 (1938) 1-81.
180. Oza, R. M. nd Zaidi, S. H. 2001 A revised checklist of Indian Marine algae, CSMCRI Bhavnagar, 296pp.
181. Panikkar NK, *Proc Zool Soc London,* 106 (1936) 39-52.
182. Panikkar NK, *Zool Jahb Abt Anat,* 3 (1937a) 62-71.
183. Panikkar NK, *Proc Indian Acad Sci,* 5(2) (1937b) 33-41.
184. Panikkar NK, *Rec Indian Mus,* XXXIX (1937c) P.IV
185. Panikkar NK, *Proc Zool Soc London,* 108 (1939) 4-7.
186. Panikkar N K, *Curr Sci,* 13 (1944) 238-239.
187. Panikkar N K nd Aiyar R G, *Proc Indian Acad Sci*, 6 (5) (1937) 284-336.
188. Parulekar A, *J Bombay Nat Hist Soc,* 64(3) (1967) 524-529.

189. Parulekar A, *J Bombay Nat Hist Soc,* 65(1) (1968) 138-147.
190. Parulekar A, *J Bombay Nat Hist Soc,* 66 (1) (1969a) 57-62.
191. Parulekar A, *J Bombay Nat Hist Soc,* 66(3) (1969b) 590-595.
192. Parulekar A, *J Bombay Nat Hist Soc,* 68(1) (1971) 291-295.
193. Parulekar A, *Marine Bio fouling and Power Plants* (Eds. K.V.K. Niltil and V.P. Venegopalan) (1990) 218-228.
194. Patriti G, *Marsielle Fac ser suppl*, 10 (1970) 285-303.
195. Petrescu I nd Chatterjee T, *Zootaxa,* 2966 (2011) 51-57.
196. Pillai C S G, *Bull Cent Mar Fish Res Inst*, 7 (1967) 23-30.
197. Pillai C S G, *Zool Surv India*, 1 (1991) 41-47.
198. Pillai N K, *Proc Indian Sci Congress,* 31 (1944) 99.
199. Pillai N K, *J mar biol Ass India,* 6(1) (1964) 1-40.
200. Pillai N K, *J Zool Soc India*, 20 (1968) 6-24.
201. Pillai N K, *Mysidacea of the Indian Ocean. International Indian Ocean Expedition. Handbook of Zooplankton collection*, 6 (1973) 1-126.
202. Pillai P P, *J mar boil Ass India,* 13 (1967) 162-172
203. Poulsen E M, *Dana Report,* 65 (1965) 1-484; 84 (1969) 1-224
204. Prashad B, *Rec Indian Mus,* 16 (1919) 399 - 402.
205. Prashad B, *Rec Indian Mus,* 37 (1935) : 39-43.
206. Prashad B, *Rec Indian Mus,* 38 (1936) 231-238.
207. Prasad P R, *Indian J Fish,* III (1956) 1-42.
208. Ramakrishna, Sreeraj CR, Raghunathan C, Sivaperuman C, Yogesh Kumar JS, Raghuraman R, Immanuel T. and Rajan, P.T., *Guide to Opisthobranchs of Andaman and Nicobar Islands*, (2010) 196 pp.
209. Ramalingam J R, Golden jubilee Celebrations Souvenir 2000, Mandapam R C of CMFRI, Mandapam Camp (2000) 81-83.
210. Rana S S, Nigam R nd Panchang, *Indian J Mar Sci,* 36(4) (2007) 355-360.
211. Rao G C nd Ganapati P N, *Proc Indian. Acad Sci Sec B (1)*, 67 (1968) 24-29.
212. Rao K K, *J. Bomnay nat Hist Soc* 66 (1970) 584; 67 (1970) 259.
213. Rao, K. M, *Proc Indian Acad Sci ,*73 (1971a) 155.
214. Rao, K. M, *J Bombay nat. Hist. Soc*, 68 (1) (1971b) 9 -19.
215. Rao K L, Orient Longman, New Delhi, (1975) 255.
216. *Rao, MU,* Nat Symp Mar Plants Parangipettai *(2010) 5-6pp*.
217. Rao T S S, *Andhra Univ Mem Oceanogr,* 2 (1958) 137-146 (1958) 164-167.
218. Rao T S S, *J Bombay Nat Hist Soc,* 62 (1966) 544-548.
219. Rao T S S nd Ganapati P N, *Andhra Univ Mem Oceanogr,* 2 (1958) 147-163.
220. Rao T S S nd Kelly S, *J Zool Soc India,* 14 (1962) 219-225.
221. Reaka-Kudla M L, The global biodiversity of coral reefs: /A comparison with rain forests, In: Biodiversity II: Understanding and protecting our biological resurces, edibted by Reaka-Kudla M L, Wilson D E nd Wilson E O, (Joseph Henry Press, Washington DC) 1998, pp.36-50
222. Reddy K N nd Ramakrishna G, *Rec zool Surv India*, 66 (1-4) (1972) 19-30.
223. Renganathan T K, *Studies on the Ascidians of South India, Ph. D. Thesis, Madurai Kamaraj University* (1986) 249 pp.
224. Rengrajan K, *J mar biol Ass India*, 16 (1974) 280-286.
225. Ruppert EE and Barnes RD, *Invertebrate Zoology*. (1994).
*226.* Sadhukhan K nd Raghunathan C, *World J Zool*, 6(4) (2011) 334-338.
227. Sadhukhan K nd Raghunathan C, 2012a. *Int J Plant, Ani Env Sci,* 2(1) (2012a) 183-189.
228. Sadhukhan K nd Raghunathan C, *Int J Biol Phar All Sci,* 1(1) (2012b ) 44-55.
229. Sadhukhan K nd Raghunathan C, *Int J Sci Nat,* 3(1) (2012)167-169.
230. Salinas JIS, *J Nat Hist*, 27 (3) (1993) 535-555. DOI: 10.1080/00222939300770301
231. Salm R, Marine biodiversity of the western Indian Ocean: Status and conservation framework, pp. 101–130. In: Linden, O. (ed.) Workshop and Policy Conference on Integrated Coastal Zone Management in Eastern Africa including the Island States. C.M.C. Conference Proceedings. (1995)371pp. Metro Manilla, Philippines.
232. Sanyal A K and Das A K, *Zool Surv India* (1998) 133-144.
233. Sarojini D, *Studies on littoral foraminifera in the Bay of Bengal. M. Sc. Thesis, Andhra University* (1958).
234. Sarojini R nd Nagabhushanam R, *Rec Zool Surv India*, 66 (1972) 249-272.

235. Sastry D R K, Echinodermata In: *Faunal Diversity In India Zool Surv India*, Kolkata (1998) 398-403.
236. Sathyavathy R, *Bull Res Inst Univ Kerala,* 6 (1954) 1-88.
237. Satyanarayana Rao K, Bryozoa In: *Faunal Diversity In India Zool Surv India*, Kolkata (1998) 371-377.
238. Sewell R B S, *Mem Indian Mus* 5 (1924) 771-852
239. Sewell R B S, *Mem Asiat Soc Bengal*, 9 (1929) 133-205.
*240.* Sewell R B S, *Scient. Rep John Murray Exped,* 7 (1940) 117-382.
241. Shipley A E, *In*: Gardiner J S, *Fauna and Geography of the Maldive and Laccadive Archipelagoes* , 1 (1903) 131-140, pl.7
242. Siebold I, *Revta esp Micropaleontology,* 7 (1974) 175.
243. Silas E G nd Kalimuthu S, *CMFRI Bull*, 41 (1997) 55-59.
244. Silas E G nd Srinivasan M, *J mar biol Ass India,* 9(1) (1968) 84-95; 10 (2) (1969) 1-33.
245. Silas E G nd Srinivasan M, *Proc Indian Acad Sci,* 71 (5) (1970) 177-192.
246. Sivaprakasam T E, *J mar biol Ass India,* 12 (1nd2) (1966) 81-92: (1967) 372-383; (1968) 34-51; (1968) 274-282; (1970) 81-92; (1970) 93-96.
247. Smith M A, In: *Fauna of British India, etc. Reptiles and Amphibia. 1. Loricata. Testudines, London (Taylor and Francis Ltd.)* (1931) xxviii+185 pp.
248. Sournia A, Dinet M J C nd Richard M J, *Planktin Res,* 13(5) (1991) 1093-1099.
249. Southern R, *.Mem Indian Mus,* 5 (1921) 563-659.
250. Sreeraj CR, nd Raghunathan C, *J Mar Biol Ass UK*, 4 ((2011) e73; doi:10.1017/S1755267211000819.
251. Sreeraj CR, nd Raghunathan C, *Proc Int Acad Ecol Env Sci*, 3(1) (2013) 36-41.
252. Srinivasan M, *J mar biol Ass India,* 13 (1) (1972 ) 130-133 (1972) 173-181; 16 (3) (1976) 126-143.
253. Srinivasan M, *J mar biol Ass India.,* 16 (3) (1977) 836-838.
254. Srinivasan M, *Zool Surv India, Techn Monogr*, 3 (1979) 1- 47
255. Srinivasan M, *Bull Zool Surv India.,* 3 (1980 ) 55-61.
256. Srinivasan M, *Results of FOR V Sagar Sampada* (1996) 139-148.
257. Stephen AC nd Edmonds SJ. 1972. *The Phyla Sipuncula and Echiura.* Trustees of the British Museum (Natural History), London.
258. Subba Rao N V, *Mollusca*. In: *Animal Resources of India* (1991) *Zool Surv India* 125-147.
259. Subba Rao N V, *Mollusca*, In: *Faunal Diversity in India* (1998) *Zool Surv India* 104-117.
260. Subba Rao N V nd Dey A, *Rec zool Surv India, Occ Paper No.* 187 (2000) 1-323.
261. Subba Rao M nd Vedantam D, *Bull natn. Inst Sci India*, 38 (1968).
262. Subramaniam M K, *Curr Sci,* 6 (1937) 284-288.
263. Subramaniam M K, *Proc Indian Acad Sci Sec B,* 7 (1938) 270-276.
264. Sudarsan D, *Indian J Fish.,* 8 (2) (1963) 364-382.
265. Sundara Raj B, *Bull Madras Govt Mus, (N H),* 1 (1927) 21-23.
266. Sundara Raj B, *Bull Madras Govt Mus,* 1(1) (1927) 125-128.
267. Surya Rao K V, *Proc Indian natn Sci Acad*, 38 (1974) 190-205.
268. Sewell R B S, *Mem Asiatic Soc Beng,* 9 (1935) 461-540.
269. Talwar P K, *In* : *Pisces, Animal Resources of India: Protozoa to Mammalia. Zool. Surv. India, Calcutta*, 1 (1991) 577-630.
270. Talwar P K nd Kakkar R K, *Commercial sea fishes of India, Handbook*, *Zool Surv India,* Kolkata (1984) 997 pp.
271. Tampi P R S nd Rangarajan K, *J mar biol Ass India,* 5 (1) (1963) 108-112.
272. Tattersall W M, *Trans Linn Soc Lond.,* 15 (1) (1911) 119-136.
273. Tattersall W M, *Rec Indian Mus,* 24 (1922) 445-504.
274. Thomas P A, *ENVIS ZSI* Kolkata, (1998) 27-36.
275. Thomas PA, George MA nd Lazarus S, *J Mar Biol Ass India* 37 (1995) 134-142.
276. Tiwari K K, nd Biswas S, *Rec Indian Mus*, 49 (1952) 349-363.
277. Tiwari K K nd Ghosh H C, *Proc zool Soc Calcutta,* 26 (1975) 33 -37.
278. Totton A K, *Disc Rep Cambridge*, 27 (1954) 161.
279. Varadarajan S, *Curr Sci,* 8 (1934) 3-6.
280. Varadarajan S nd Chacko P I, *Proc Nat Inst Sci India,* 9 (1943) 245-248.
281. Venkataraman G, *Proc Indian Acad Sci,* 10 (B) (1939) 293-368.
282. Venktaraman K, *In*: *Faunal Diversity in India* , Alfred J R B, Sanyal A K and Das A K, (Ed) *Zool. Surv India,* Kolkata (1998) 391-395.

283. Venkataraman K, Jeyabaskaran R, Raghuram K P and Alfred J R B, *Bibliography and checklist of Corals and coral reef associated organisms of India, Rec Zool Surv India, Occ Paper* 226 (2004) 1-648 pp.
284. Venkataraman K, Satynarayanan Ch, Alfred J R B nd Wolstenholme J, *Handbook on Hard Corals of India* (Director, *Zool Surv India* Kolkata) (2003) 266 pp.
285. Venkataraman K, and Satynarayana Ch , *Corals Identification manual,* (2012) 1-136.
286. Venktaraman K and Krishnamoorthy P, (*In*) *Faunal Diversity in India* (Ed) Alfred J R B, ENVIS Centre, *Zool. Surv. India,* Calcutta, 1998. 133 – 144.
287. Vivekanandan E nd Jeyabaskaran R, Marine mammal species of India, Central Marine Fisheries Research Institute, Kochi, (2012) 228 pp.
288. Weltner W, Zwei neue Cirripediea aus dem Indischen Ocean *S.B. Ges Natur Fr Berlin* (1894).
289. Whitehead P J P nd Talwar P K, *Bull Br Mus Nat Hist (Sr.*), 5 (1976) 1-189.
290. Wood Mason J nd Alcock A, *Ann. Mag Nat Hist,* 7 (1891) 1-19, 186-202, 258-272.
291. Zhang Z.-Q, *Zootaxa,* 3148 (2011) 7–12.
292. Zoological Survey of India, *Protected species of Mollusca,* (2011).
293. Choudhury, S., Raghunathan, C., Raghuraman, R. and Venkataraman, K. 2015. Actiniarian Sea anemones of India. *In*: Venkataraman, K., Raghunathan, C., Mondal, T., Raghuraman, R., ( *Eds.*), Lesser known marine animals of India. *Zool. Surv. India,* Kolkata, 113-134.
294. Raghunathan, C., Raghuraman, R., Yogesh Kumar, J. A., and Venkataraman, K. 2014. Gorgonian diversity of Andaman and Nicobar Islands, *Souv. U. P. Biodiv. Board,* 14-24.
295. Huang, D. Y., Chen, J. Y., Vannier, J. and Saiz Salinas, J. I., *Proc. the Royal Soc. B: Biol. Sci.,* 2004, 271 (1549), 1671. doi:10.1098/rspb.2004.277
296. Salina, J.I.S., *J. Nat. Hist.,* 1993, **27**(3), 535–555. **doi:**10.1080/00222939300770301.
297. Venkataraman, K. and Wafar, M., *Indian J. Mar. Sci.,* 2005,**34**(1), 57-75.
298. Wafar, M., Venkataraman, K., Ingole, B., Ajmal Khan, S. and LokaBharathi, P., *PLOS one*, 2011, **6**(1), e14613.
299. Venkataraman, K. and Raghunathan, C. 2015. *In*: Venkataraman, K., Raghunathan, C., Mondal, T., Raghuraman, R., (*Eds.*), *Lesser known marine animals of India*. *Zool. Surv. India,* Kolkata, 1-47.
300. Dunlop, J.A. and Arango, C.P., *J. Zool. System. Evol. Res.,* 2005**, 43**, 8-21.
301. Arango, C.P., *Org., Diver. Evol.,* 2002, **2,** 107-125.
302. Arnaud, F. and Bamber, N., *Adv. Mar. Biol.,* 1987, **24**, 1-96.
303. Miyazaki, K., *Proc. Arthropod Embryol. Soc. Japan,* 2002, **37**, 43-44.
304. Waloszek, D. and Dunlop, J.A., *Palaeontology,* 2002,**45**(3), 421-446.
305. Bamber, R. N., *Zootaxa*3148, *Magnolia Press*, 2011, 100-111.
306. Daniel, A. and Sen, J.K., *J. Mar. Biol. Assoc. India*, 1975, **17**(2), 160-167.
307. Veena, S., Kaladharan, P., Rohit, P. and SydaRao, G., *India. J. Mar. Biol. Assoc. India*., 2008, 50: 17-22.
308. Mayr, E., *Systematic Zool*., 1968, **17** (2), 213–216. doi: 10.2307/2412368. JSTOR 2412368
309. Beatty, J. and Blackwelder, A., *Syst. Zool.,* 1974,**23** (4), 545–547. doi: 10.2307/2412472. JSTOR 2412472.
310. Rich, T.H., Fenton, M.A. and Fenton, C.L., *The fossil book. Dover Publications*., 1997, pp. 142–152.
311. Ruppert, E.E. and Barnes, R.D., *Invertebrate Zoology Sixth Edition*.,*Saunders College Publishing, Harcourt Brace and Comp.,* Orlando, Florida. Hardcover., 1994, pp. 1100.
312. SatyanarayanaRao, K., In: *Faunal Diversity in India.* Kolkata: Zoological Survey of India., 1998, Pp. 371–377.
313. 313. Temereva, E.N., Malakhov V.V., Yakovis E.L., Fokin M.V., *Doklady Biol. Sci.,* 2000, **374**, 523–525.
314. Emig, C., In Bernhard Grzimek, Devra G. Kleiman, Michael Hutchins. *Grzimek's Animal Life Encyclopedia.* 2: Protostomes (2ed.). Thompson Gale., 2003, pp. 491–495. ISBN 0-7876-5362-4. Retrieved 1 March 2011.
315. Temereva, E.N., *Invertebrate Zoology,* 2009, **6** (1): 47–48.
316. Ruppert, E.E., Fox, R.S. and Barnes, R.D., *Invertebrate Zoology* (7ed.). Brooks/Cole., 2004.
317. Brusca, R.C. and Brusca, G.J., *Invertebrates* (2nd Edition), *Sinauer Associates,* 2003.
318. Ramel, G., The Goblet Worms (Phylum Entoprocta) (On-line). *Earthlife*. Accessed April 30, 2013 at http://www.earthlife.net/inverts/entoprocta.html

319. Appeltans, W., Bouchet, P., Boxshall, G., De Broyer, C., de Voogd, N., Gordon, D., Hoeksema, B., Horton, T., Kennedy, M., Mees, J., Poore, G., Read, G., Stohr, S., Walter, T. and Costello, M., "WoRMS - World Registry of Marine Species", 2012, *Accessedat* http://www.marinespecies.org
320. Wood, T., *Hydrobiologia*, 2005, **544**, 27-31.
321. 321. Schwaha, T., Wood, T. and Wanninger, A., *Frontiers in Zoology*, 2010, **7,** 7.
322. Zhang, Z., *Zootaxa*, 2011, **3148**, 7-12.
323. Ontario, B., http://www.eoearth.org/view/article/156414., 2010.
324. Simon and Matt, (http://www.wired.com/wiredscience/2014/03/absurd-creature-week-waterbear/), *Wired (magazine)*., 2014.
325. Courtland and Rachel, Water bears are first animal to survive space vacuum"(http://www.newscientist.com/article/dn14690-water-bears-are-first-animal-to-survive-space-vacuum.html). *New Scientist*., 2008.
326. Degma, P., Bertolani, R. and Guidetti, R., Actual checklist of Tardigradaspecies., 2009–2011.
327. Ganapati, P.N. and Radhakrishna, Y., *Andhra Univ. Mem. Oceanogr.* 1958,**2**, 210–237.
328. Venkataraman, K., In: Alfred, J.R.B., Sanyal, A.K. and Das, A.K. (Eds.) *Faunal Diversity in India* Kolkata: Zoological Survey of India., 1998, Pp. 391–395.
329. www.biodiversityexplorer.org**.**
330. Jairajpuri, M. S., and Ahmad, W., *Oxford nd IBH Publishing,* New Delhi., 1992.
331. May, R., *Science,* 1998,**241**, 1441- 1449.
332. Gaston, K. J., *Conser. Biol*., 1991, **5**, 283-296.
333. Lambshead, P. J. D., *Oceanis,* 1993, **19**(6), 5-24.
334. Gerlach, S., *Veroffentlichungen des Instituts fur Meeresforschung* in Bremerhaven, 1980, **18**, 249-255.
335. Chinndurai, G. and Fernando, O.J., *Estu., Coast. and Shelf Sci.,* 2007, **72**, 329-336
336. Ansari, K.G.M.T., Lyla, P.S. and Ajmal Khan, S., *J. Mar. Biol. Ass. India.,* 2012, **54**(2), DOI:10.6024/jmbai.2012.54.2.01716-0x.
337. Alessandrello, A., Pinna, G. and Teruzzi, G., *AttidellaSocietaItaliana di ScienzeNaturale e StoriaNaturale, Milano*, 1988, **129**(2-3), 139-145.
338. Newman, L. J. and Cananon, L.R.G., *J. Mar. Biol. Ass. India*.,*The World of Polyclads.,* Melbourne: *CSIRO Publishing*., 2013, **54**(2).
339. Vannier, J., Steiner, M., Renvoise, E., Hu, S. X., Casanova, J. P., *Proc. Royal Soc. B: Biol. Sci.,* 2007, **274** (1610), 627–633.
340. Todaro, M. A., *University of Modena and Reggio Emilia*., 2014.
341. Barnes, R. D., *Invertebrate Zoology*. *Philadelphia, PA: Holt-Saunders International.*, 1982, pp. 286–288.
342. Sorensen, M.V., *Zootaxa,* 2013, **3703**, 63–66.
343. Neuhaus, B., *In: Neuhaus, Birger World list of Kinorhyncha. Accessed through: World Register of Marine Species* at http://www.marinespecies.org/aphia.php?p=taxdetailsndid=101060, 2014.
344. Walker, J.C. and Anderson, D.T., In D.T. Anderson. *Invertebrate Zoology* (1 ed.). Oxford, 1998.
345. Schram, F.R., *J. Paleont.* (SEPM Society for Sedimentary Geology), 1973, **47** (5), 985–989. JSTOR 1303083.
346.Gibson, R., *J. Natu. Hist.*, 1995, **29**(2): 271–561. doi:10.1080/00222939500770161
347.Harmer, S. F. and Everett. S.A., *The Cambridge Nat. Hist.*, The Macmillan Company., 1896, p. 197. Retrieved 2008-07-25
348. Howey, R. L., *Micscape Magazine*., 1999.
349. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I., *The Invertebrates: a synthesis*, Oxford; Malden, MA: Blackwell, ISBN 978-0-632-04761-1, 2001, p. 98.
350. Baqai, A., Guruswamy, V., Liu. J. and Rizki, G., *University of California Museum of Paleontology,* 2000.
351. Worms, 2016. World register of Marine Species at http://www.marine species.org/aphia.php?p=taxdetailsndid=18390n2016-09-08.
352. Shrinivaasu, S., Venkataraman, K. and Venkataraman, C. 2015. In *Lesser Known Marine Animals of India* (Eds. K. Venkataraman and C. Raghunathan, T. Mondal and R. Raghuraman) Pub. Director, *Zool. Surv. India* Chapter 10: 173-175.
353. Rupport, E. E., Fox, R.S. and Barnes, R. D. 2004. *Invertebrate Zoology* (7 ed.) Brooks/Cole., 963 pp.
354. De Grave, S., Pentcheff, N.D., Ahyong, S.T., Chan, T.-Y., Crandall, K.A., Dworschak, P.C., Felder, D.L., Feldmann, R.M., Fransen, C.H.J.M., Goulding, L.Y.D., Lemaitre, R., Low, M.E.Y., Martin, J.W., Ng, P.K.L., Schweitzer, C.E., Tan, S.H., Tshudy, D. and Wetzer, R. 2009. *A classification of living and fossil genera of decapod crustaceans.* The Raffles Bulletin of Zoology, Suppl. 21, 1–109.

## THE HANS INDIA, 2017

## Conservation of Biodiversity

Conservation and sustainable use of biodiversity have been an integral part of Indian ethos. The varied eco-climatic conditions coupled with unique geological and cultural features have contributed to an astounding diversity of habitats, which harbor and sustain immense biological diversity at all levels.

With only 2.4% of world's land area, India accounts for 7-8% of recorded species of the world. In terms of species richness, India ranks seventh in mammals, ninth in birds and fifth in reptiles. In terms of endemism of vertebrate groups, India's position is tenth in birds with 69 species, fifth in reptiles with 156 species and seventh in amphibians with 110 species. India's share of crops is 44% as compared to the world average of 11%.

India also has 23.39% of its geographical area under forest and tree cover. Of the 34 globally identified biodiversity hotspots, India harbor 3 hotspots, i.e., Himalaya, Indo Burma, Western Ghats and Sri Lanka. Western Ghats are recently included in World Heritage list. It is very rich in flora and fauna and serves as cradle of biodiversity. One of the most pressing environmental issues today is the conservation of biodiversity. Many factors threaten the world's biological heritage.

The challenge is for nations, government agencies, organisations and individuals to protect and enhance biological diversity, while continuing to meet people's needs for natural resources. Efforts have been initiated to save biodiversity both by ex-situ and in-situ conservation.

### Biodiversity Act 2002

The Biological Diversity Act, 2002 is a federal legislation enacted by the Parliament of India for preservation of biological diversity in India, and provides mechanism for equitable sharing of benefits arising out of use of traditional biological resources and knowledge. The Act was enacted to meet the obligations under Convention on Biological Diversity (CBD), to which India is a party.

The National Biodiversity Authority (NBA) was established in 2003 to implement India's Biological Diversity Act (2002). The NBA is a Statutory, Autonomous Body and it performs facilitative, regulatory and advisory function for the Government of India on issues of conservation, sustainable use of biological resources and fair and equitable sharing of benefits arising out of the use of biological resources.

### Levels of biodiversity

Marine Biodiversity refers to 'Life in the Seas and Oceans. The marine environment has a very high biodiversity because 32 out of the 33 described animal phyla are represented in there. Marine organisms contribute to many critical processes that have direct and indirect effects on the health of the oceans and humans. Forest biological diversity is a broad term that refers to all life forms found within forested areas and the ecological roles they perform.

As such, forest biological diversity encompasses not just trees, but the multitude of plants, animals and micro-organisms that inhabit forest areas and their associated genetic diversity. Genetic diversity, refers to the total number of genetic characteristics in the genetic makeup of a species. Genetic diversity serves as a way for populations to adapt to changing environments. With more variation, it is more likely that some individuals in a population will possess variations of alleles that are suited for the environment. The population will continue for more generations because of the success of these individuals.

Species Diversity is the effective number of different species that are represented in a collection of individuals (a dataset).

Species diversity consists of two components: species richness and species evenness. Ecosystem Diversity refers to the combination of communities of living things with the physical environment in which they live. There are many different kinds of ecosystems like deserts, mountain slopes, the ocean floor, Antarctic etc,. Each ecosystem provides many different kinds of habitats or living places. Agriculture Biodiversity includes all forms of life directly relevant to agriculture: rare seed varieties and animal breeds (farm biodiversity), but also many other organisms such as soil fauna, weeds, pests, predators, and all of the native plants and animals (wild biodiversity) existing on and flowing through the farm.

**Biospheres and biodiversity reserves**

The Indian government has established 18 Biosphere Reserves in India, which protect larger areas of natural habitat and often include one or more National Parks and Reserves, along buffer zones that are open to some economic uses. Protection is granted not only to the flora and fauna of the protected region, but also to the human communities who inhabit these regions, and their ways of life. Animals are protected and saved here.

**Hotspots**

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is under threat from humans. Around the world, 25 areas qualify under definition of hotspots. These sites support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a very high share of endemic species. The biodiversity hotspots hold especially high numbers of endemic species, yet their combined area of remaining habitat covers only 2.3 percent of the Earth's land surface. Each hotspot faces extreme threats and has already lost at least 70 percent of its original natural vegetation.

Over 50 percent of the world's plant species and 42 percent of all terrestrial vertebrate species are endemic to the 34 biodiversity hotspots.

**UNO efforts**

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was signed in Washington, DC, on 3 March 1973. In August 2000, 152 States were parties to this Convention. The aim of CITES is to put a ban on international trade in wildlife. The World Conservation Union IUCN brings together States, government agencies and a diverse range of non-governmental organizations in a unique world partnership.

IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and sustainable use of natural resources. International Treaty on Plant Genetic Resources for Food and Agriculture was adopted in Rome in November 2001 to create a legally binding framework for the protection and sustainable use of all plant genetic resources for food and agriculture.

The United Nations Convention on Biological Diversity (CBD), 1992 known informally as the Biodiversity Convention, is a multilateral treaty. The Convention has three main goals like conservation of biological diversity (or biodiversity); sustainable use of its components; and fair and equitable sharing of benefits arising from genetic resources.

The most significant feature of 1972 World heritage Convention is that it links together in a single document the concepts of nature conservation and preservation of cultural properties. The Convention recognizes the way in which people interact with nature

and fundamental need to preserve the balance between the two. The law of sea 1982, envisaged by UNO aims at protecting marine biodiversity and to control marine pollution.

**Desert National Park**

Desert National Park is a unique biosphere reserve for conservation and development of biodiversity in India. It is situated in the West Indian state of Rajasthan near the town of Jaisalmer. This is one of the largest national parks, covering an area of 3162 $km^2$. The Desert National Park is an excellent example of the ecosystem of the Thar Desert. Sand dunes form around 20% of the Park.

**Role of wildlife corridors in biodiversity conservation**

A habitat corridor, wildlife corridor or green corridor is an area of habitat connecting wildlife populations separated by human activities such as roads, development, or logging. This allows an exchange of individuals between populations, which may help prevent the negative effects of inbreeding and reduced genetic diversity that often occur within isolated populations.

**Wetlands repositories**

Wetlands are complex ecosystems and encompass a wide range of inland, coastal and marine habitats. They include flood plains, swamps, marshes, fishponds, tidal marshes natural and man-made wetlands. The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

**Benefits of real life biodiversity**

Biodiversity provides food from crops, livestock, forestry and fish. Biodiversity is of use to modern agriculture as a source of new crops, as a source material for breeding improved varieties and as a source of new biodegradable pesticides. Biodiversity is a rich source of substances with therapeutic properties.

Several important pharmaceuticals have originated as plant-based substances, which are of incalculable value to human health. The industrial products like timber, oils, lubricants, food flavours, industrial enzymes, cosmetics, perfumes, fragrances, dyes, paper, waxes, rubber, latexes, resins, poisons and cork can all be derived from various plant species. Biodiversity is a source of economical wealth for many areas, such as many parks and forests, where wild nature and animals are a source of beauty and joy, attract many visitors. Ecotourism in particular, is a growing outdoor recreational activity. Biodiversity has also great aesthetic value. Examples of aesthetic rewards include ecotourism, bird watching, wildlife, pet keeping, gardening, etc. Biodiversity is also essential for the maintenance and sustainable utilization of goods and services from ecological systems as well as from the individual species. These services include maintenance of gaseous composition of the atmosphere, climate control by forests and oceanic systems, natural pest control, pollination of plants by insects and birds, formation and protection of soil.

**Threats to biodiversity**

The destruction of habitats is the primary reason for the loss of biodiversity in terrestrial and coastal ecosystems. Habitat loss could be attributed to conversion, habitat degradation and fragmentation. When people cut down trees, fill a wetland, plough grassland or burn a forest, the natural habitat of a species is changed or destroyed. Introduction of invasive species may cause disappearance of native species through biotic interactions.

Invasive species are considered second only to habitat destruction as a major cause of extinction of species. Communities are affected by natural disturbances, such as fire, tree fall, and defoliation by insects.

Man-made disturbances differ from natural disturbances in intensity, rate and spatial extent. For example, man by using fire more frequently may change species richness of a community. Exploitation, including hunting, collecting, fisheries and fisheries by-catch, and the impacts of trade in species and species' parts, constitute a major threat for globally threatened birds (30% of all), mammals (33% of all), amphibians (6% of those assessed), reptiles and marine fishes (Baillie et al. 2004). Trade affects 13% of both threatened birds and mammals. Extinction is a natural process. Species have disappeared and new ones have evolved to take their place over the long geological history of the earth.

It is useful to distinguish three types of extinction processes. Over-fishing, habitat destruction, widespread marine pollution and human induced climate change threaten the survival of marine biodiversity. Pollution, oil and gas drilling and oil spills may increase the risks of extinction by increasing mortality of marine organisms. The Silent Valley Project in Kerala was abandoned because it was considered as a threat to biodiversity in the region.

**Biodiversity and food security**

In a recent estimate it was speculated that over 25 per cent of the world's plant species might be lost by the year 2025 AD, if the current rate of plant genetic erosion continues. Preserving this germ pool is an integral part of food security. It is evident that preservation of wide range of germ pool is an integral part of breeding programme.

If we are unable to combat the problems of genetic erosion, it may lead to losing sources of resistance to pests, diseases and climatic stress and, finally, leading to crop failure in future.

It is well-known that out of over 20,000 edible species only a few dozen of plants are domesticated and now feed most of the people. All types of protected area constitute over 12% of the total forest area of the country. This network of protected areas covers most of the representative habitat types in the country and affords protection both to the wild flora and fauna.

*(SOURCE:http://www.thehansindia.com/posts/index/Hans/2017-05-24/Conservation-of-Biodiversity/302161)*

## THE HINDU, 2016

# Kerala to map marine biodiversity

The Kerala State Biodiversity Board (KSBB) has initiated a programme to prepare a Marine Biodiversity Register (MBR) documenting the underwater ecology of the inshore areas and the traditional knowledge systems of fishermen in the State.

The pilot phase will cover a 20-km stretch of the Thiruvananthapuram coast from Valiathura to Puthukurichy. The KSBB has taken up the project in association with Protsahan, a Thiruvananthapuram-based NGO. The project is expected to help demarcate marine protected areas, reconstitute the areas undergoing habitat destruction, and formulate ecosystem-based fishing management policies. It will also suggest measures to protect the marine ecology in the biodiversity - rich coastal waters.

"The conservation measures will be relevant for the large number of traditional hook-and-line fishermen in Thiruvananthapuram," says Chairman, KSBB, Oommen V. Oommen.

"Unlike the Panchayat Biodiversity Register which is prepared by local-level Biodiversity Management Committees, the MBR requires the expertise and involvement of fishermen."

### Reefs and rocky areas

The project seeks to create a biodiversity register of ecologically important reefs and rocky areas. It will record the demersal (fish living and feeding on or near the bottom of the sea) species around the reef areas. The MBR will document traditional knowledge on navigation, bottom configuration of the seabed, ocean currents, and wind patterns. It will also provide indicators to overfishing and marine resource depletion.

The pilot phase involves the preparation of a map of natural reefs in the region and documentation of the kinds of seasonal fishing.

It will cover a depth of up to 25 fathoms of inshore waters. The reefs and their characteristics will be documented with the help of GPS and the details plotted on a map. Charts of important fish species with local and biological names will be prepared.

"Much of the available information on marine biodiversity of the region is based on secondary data generated by the Central Marine Fisheries Research Institute, National Institute of Oceanography, Fishery Survey of India, Department of Aquatic Biology, University of Kerala, and NGOs," says K.P. Laladhas, member secretary, KSBB.

"This project is all about generating baseline data. In the next phase, we hope to cover the area up to the international waters using scuba divers and better equipment," he said.

Protsahan has proposed the documentation of reefs with underwater images and filming of flora and fauna in the next phase.

The core group including fishermen has made several scouting trips in the coastal waters.


*(SOURCE:http://www.thehindu.com/news/national/kerala/kerala-to-map-marine-biodiversity/article4519526.ece)*

# Biodiversity centre in Airoli, Navi Mumbai

The state mangrove cell is set to throw open the much-awaited Coastal and Marine Biodiversity Centre at Airoli along the Thane Creek on April 30, 2017. A first of its kind centre on the western coast, the Rs. 15-crore project in its first phase will have multi-sensory and mechanical exhibits of animals, besides audio-visual presentations.

One can see how a crab looks like from different angles and hear what a bird sounds like in the marine interpretation centre. Mangroves can be experienced through multi-sensory and mechanical exhibits. Besides, turtles, crabs and flamingos can be seen in the backyard of the centre.

According to officials, the marine museum which is part of the second phase of the project will be the first museum dedicated to preserving skeletal remains of marine mammals. The marine museum, which will be set up in the centre premises, will have skeletons of two dolphins and a 29 feet whale in the second phase of the project soon.

Divisional Forest Officer Makarand Godke said, "Besides interactive display of coastal marine species, visitors can also see two live flamingos and two turtles."

Original mangrove nursery, crab pond, board walk can be viewed adjacent to the centre located underneath Airoli-Mulund Bridge. The project is funded by Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ), an international agency and the state government.

"Mumbai Metropolitan Region Development Authority(MMRDA) has sanctioned Rs.10 crore which could be spent for the second phase of the project. A flamingo sanctuary has also been planned here," said MS Bothe, Range Forest Officer.

State forest minister Sudhir Mungatiwar inaugurated the centre.

The centre will house several features related to green cover and marine life. Some of them include coastal interpretation room, marine interpretation room, interactive display, souvenir shop. The outdoor atrractions will have mangrove nursery, crab pond, board walk, creek view, flamingos.

*(SOURCE: https://timesofindia.indiatimes.com/city/navi-mumbai/biodiversity-centre-in-airoli-to-open-this-sun/articleshow/58423693.cms)*

# Hot spots of marine biodiversity most severely impacted by global warming

A new study aimed at identifying areas of highest conservation priority in the world's oceans found six "hot spots of marine biodiversity" that are severely impacted by climate change and fishing pressures.

While human activities are known to drive environmental changes that may lead to ecosystem collapse, previous research has not examined the overlap between global species distribution in our oceans and marine areas most at risk from climate change.

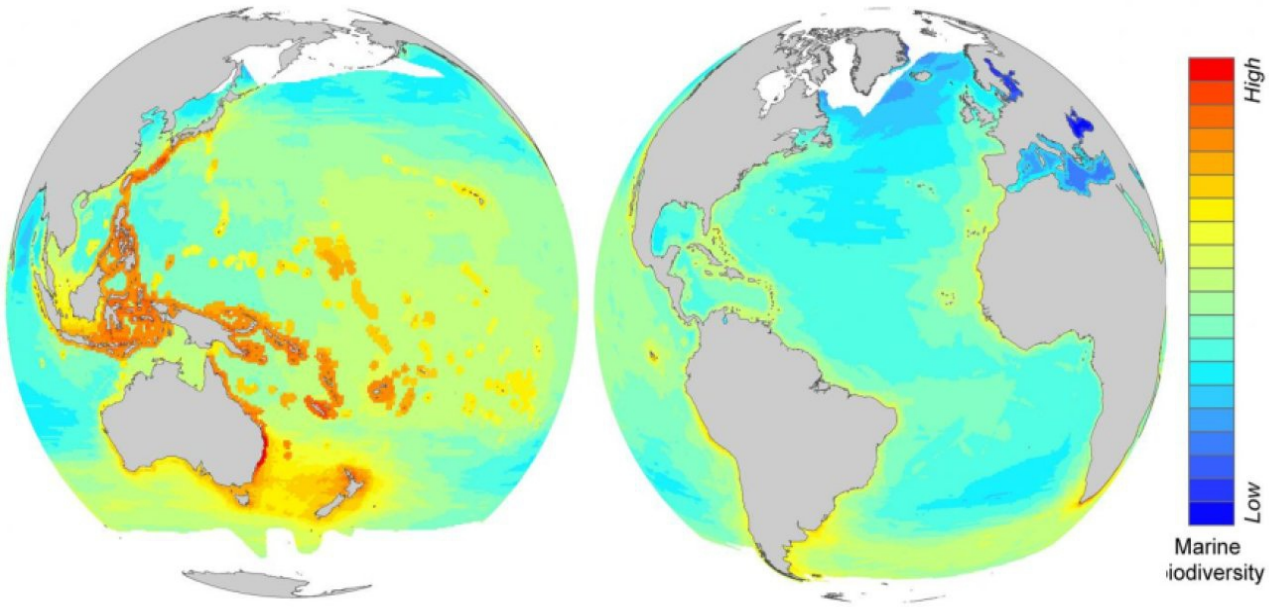
Francisco Ramírez and colleagues compiled a database of 2,183 marine species and over three decades worth of information on sea surface temperatures, ocean currents and marine productivity. They also evaluated industrial fishing data from the last 60 years.

The environmental data showed an uneven distribution of changes to Earth's oceans, with the most striking shifts at the poles and the tropics.

The researchers identified six areas of high biodiversity, including marine areas in temperate and tropical regions of the Atlantic, Indian and Pacific Oceans. While environmental changes have affected ocean temperatures, nutrient availability and currents in these species-rich areas, industrial fishing has also reduced global fish stocks. The analysis of fisheries data showed that harvest pressure will continue and further exacerbate pressure on fish populations in these areas.

Climate and industrial fishing impacts should be considered concurrently for conservation, the authors say, and they call for the international community to conserve biodiversity through fishing policies, similar to the ways in which climate change is being addressed on a global scale.

*(SOURCE:https://www.sciencedaily.com/releases/2017/02/170222152737.htm)*




Global distribution of marine biodiversity is shown. Colors denote the number of species, with red colors indicating areas with the highest biodiversity.

*(SOURCE: https://www.sciencedaily.com/releases/2017/02/170222152737.htm)*

# WORLD OCEAN DAY 2017






Our ENVIS Centre for Coastal Zone Management and Coastal Shelter Belt, Institute for Ocean Management, Anna University , Chennai celebrated the "World Ocean Day - 2017" on 08.06.2017 by arranging awareness programme on our "oceans our future", on an action plan for "Encouraging solution to plastic pollution and preventing marine litter for a healthier ocean and a better future" for the students of Arignar Anna Government Higher Secondary School, Besant Nagar, Chennai - 90

# WORLD OZONE DAY 2017


Our ENVIS Centre for Coastal Zone Management and Coastal Shelter Belt, Institute for Ocean Management, Anna University , Chennai celebrated the " World Ozone Day 2017" on 16.09.2017 at NCSCM, Anna University Campus. The programme starts with welcome speech by Dr. Ramesh, Director, NCSCM, followed by special speech given by Prof. Sutton, Honorary Professor, University of Edinburgh, School of Geosciences on the role of anthropogenic nitrogen (N) in the present day environment.

# WORLD OZONE DAY 2017




Students from various departments of Anna University and Madras University participated in the quiz completion. Various physical oceanography equipment are displayed at the exhibition for visitors.