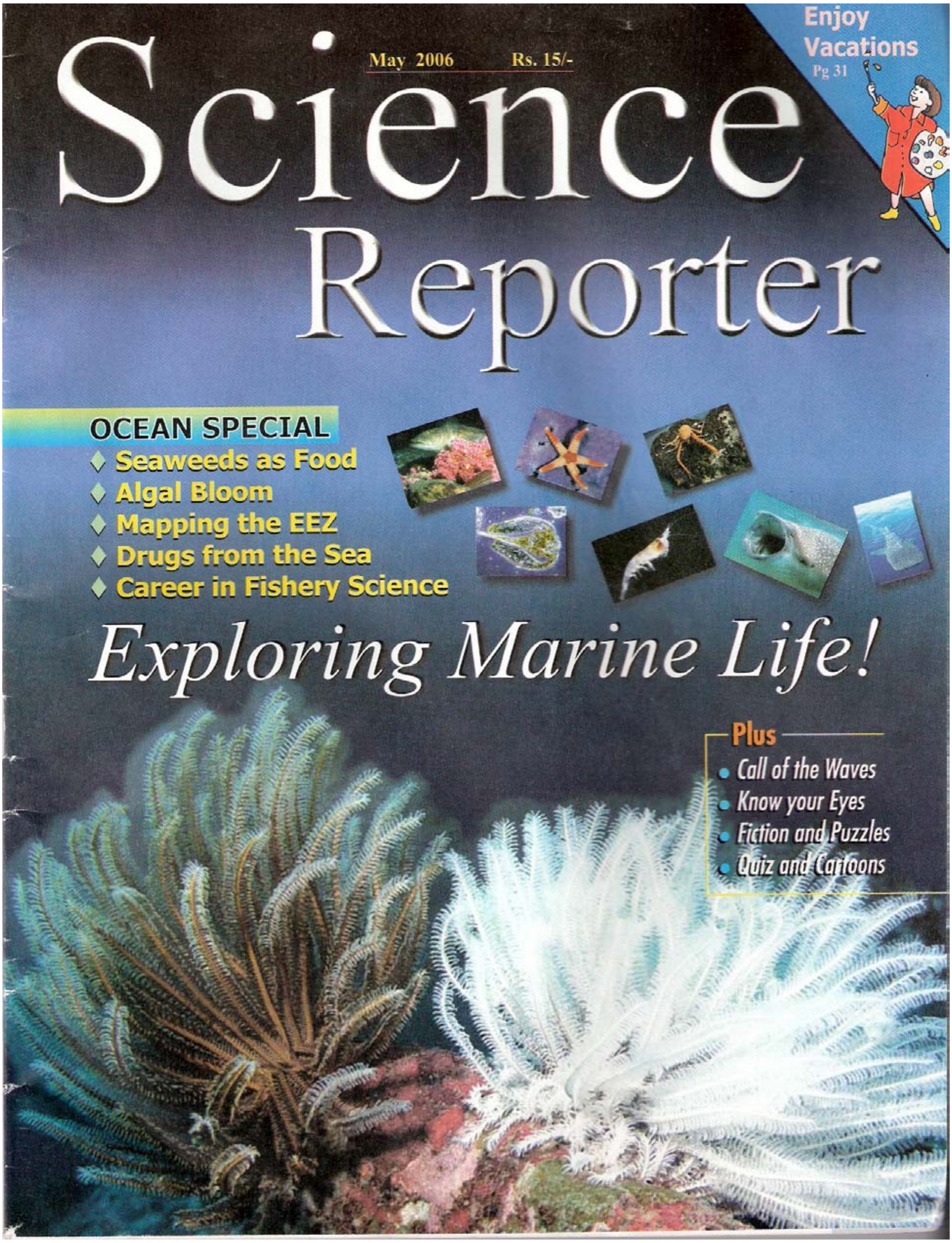
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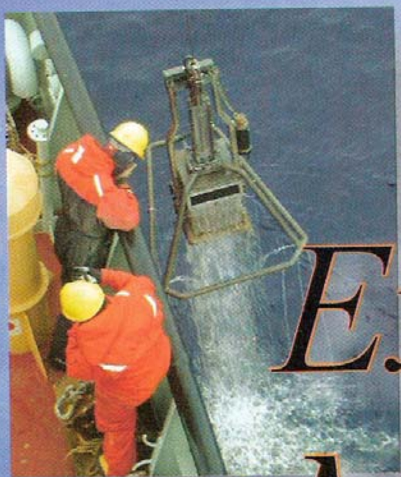


Exploring Marine Life

VIJAYALAKSHMI R. NAIR

An exciting project seeks to investigate marine life with census scientists sampling a wide variety of ocean habitats, from coastal regions to the deepest parts of the oceans. The project is expected to lead to a deeper understanding of the diversity of marine life: past, present, and future.

HUMAN curiosity and the urge to unravel the secrets of the sea dates back to time immemorial when they first looked at it as a source of food and also as a mode to travel around. The oceans form a continuous water mass covering about three fourths of the earth's surface. Till recently humans were ignorant of the secrets locked up in its mysterious depths. By about the middle of the 19th century they started exploratory surveys that led to the emergence of a new field of science – Oceanography.

Oceanography is a multi-disciplinary approach to learn all about the biology, physics, chemistry, geology, engineering and meteorology of the ocean. Biological oceanography deals with the hidden animal and plant life in the sea. In the ocean, the first or primary level of production starts with the synthesis of carbohydrates by the microscopic plants termed as phytoplankton, which mainly occupy the lighted water column of the sea.

The secondary level of production is that of zooplankton a general term for the drifting animal population in the water column, which are unable to maintain their position by swimming against water currents and are thus

Advances in technology lift limits for discovery of life that is small, deep, or rare. Census scientists are innovating, refining, and integrating techniques to assess and monitor marine life.

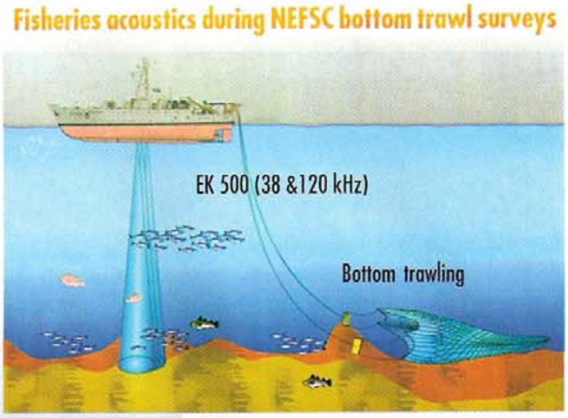
Scientists and crew sort through the massive amount of specimens *(left)*

Submersibles will be deployed for the census *(left)*

A Scallop Dredge on the NOAA research ship, Oregon II, used to sample marine life along sea floor *(left)*

Compared to the known species from different regions of the world, the unknown are thought to be more than the known.

transported passively in the horizontal plane by the flow field. Zooplanktons inhabit all regions of the ocean down to the abyssal depths. The zooplankton community is a heterogeneous assemblage of animals covering many taxonomic groups comprising mostly of invertebrates.



A diagram showing how sampling nets and Multi-frequency Echo Sounders work together to study marine life *(right)*

A large sediment corer being recovered after collecting the sample of deep ocean floor *(left)*

The expected important outcomes are more complete knowledge of biodiversity, new understanding of the functional role of biodiversity in ocean ecosystems and better characterization of global scale patterns of zooplankton biodiversity in the world oceans.

In the zooplankton are included many of the protozoa, especially tintinids, radiolarians and foraminiferans, now termed as micro-zooplankton; a large number of the small crustaceans such as copepods, cladocerans, ostracods, mysids, euphausiids, amphipods and decapods; the medusae, ctenophores and siphonophores; many worms, chaetognaths, a number of molluscs; tunicates like appendicularians, salps, doliolids; and the eggs and larval stages of most of the benthic and nektonic animals. They have special adaptations for a planktonic existence.

Zooplanktons include herbivores, carnivores, detritivores and omnivores, constituting an efficient food chain utilizing the energy transfer from the primary to the secondary level. Thus, zooplankton as secondary producers form a major link in the food chain and are significant in assessing the fertility of the sea. The zooplankton form the food for the next level of producers like fishes. Larval stages of fishes, prawns, crabs, clams, etc., are temporarily included in the zooplankton. The remaining are permanent or holozooplankton members of the zooplankton community.

The German scientist Victor Hansen originally used the term 'plankton'. It is derived from a Greek word meaning 'wanderer' or something that passively drifts about. The concept of passive drifting is true for a majority of zooplankton, but there are certain larger forms such as crabs, lobsters and shrimp, which also have the ability for horizontal as well as vertical movement. The smaller

We have good knowledge on species inhabiting the upper 100-200 m of the oceans where most sampling was conducted. Enormous amount of data and information on zooplankton species and their biogeography are available.

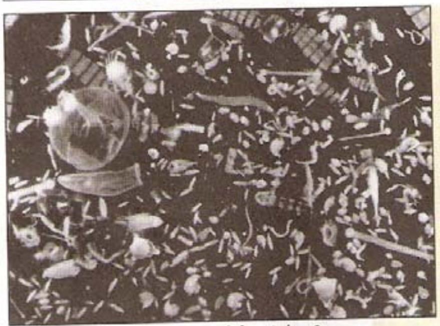
zooplankton undertake vertical migration. Some of the larger medusae and siphonophores are capable of strong swimming movements.

Plankton were first found to be associated with the phenomenon of discolouration of water associated with their swarming. Probably the earliest reference to this aspect was that of Pytheas in the fourth century B.C., who during his voyage to the North Atlantic reported that the sea became sluggish and thick like a jellyfish. Perhaps the most spectacular display resulting from light emitting plankton life was reported as bioluminescence of the sea.

Various expeditions were undertaken to study zooplankton from different parts of the world oceans. In India, institutes like the National Institute of Oceanography, Goa, Central Marine Fisheries Research Institute, Cochin, Universities, etc., are making regular zooplankton collections for quantitative and qualitative evaluation.

Census of Marine Zooplankton (CMarZ)

Census of Marine Life (CoML), a global program launched in 2000 and running through 2010, aims to understand the diversity, geographic distribution and abundance of marine species from pole to pole covering estuarine coastal and



Typical zooplankton community. Catch from Indian Ocean

Enormous amount of data on zooplankton are being accumulated through various expeditions, cruises and site-specific investigations from different parts of the world ocean.

oceanic waters from surface to abyss. By 2010, CoML field projects will integrate and synthesise their discoveries and conclusions and produce a new global view of the diversity of life in the ocean.

Census of Marine Zooplankton (CMarZ) is a project under CoML and aims to take a census of the zooplankton species abounding the world oceans. CMarZ works towards a taxonomically comprehensive assessment of biodiversity of animal plankton throughout the world ocean. Enormous amount of data on zooplankton are being accumulated through various expeditions, cruises and site-specific investigations from different parts of the world ocean. These are not accessible to all and it is necessary to formulate a plan to consolidate the available information in the form of a baseline report for proper dissemination of the results on a global basis.

To implement this, CMarZ was launched in 2004 with project offices in USA, Asia and Europe. CMarZ is led by a Steering Group with 20 members from 17 countries, including India. The Steering Group guides scientific and technical development and ensures close co-ordination. The goal is to produce accurate and complete information on species diversity, biogeographic distribution and genetic diversity of holozooplankton by 2010 focusing on about 6800 currently described species, expecting to add at least this many more species to the database over the next four years.

The Known

Humans have mapped the oceans, charted the currents and faunal boundaries and defined biogeographical provinces like rich fishing grounds since the first sea voyage. The HMS Challenger Expedition during 1873-1876 was one of the earliest attempts to record the global pattern of biological, chemical and physical properties of the oceans. The present knowledge on the global ocean biodiversity results from decades of work by ecologists and taxonomists.

The biogeographical patterns for different taxonomic groups of zooplankton are not equally well known for all regions especially towards coastal waters and exclusive economic zones (EEZ). We have good knowledge on species inhabiting the upper 100-200 m of the oceans where most sampling was conducted. The primary task is to assemble information contributed by taxonomists on species of different taxa. These experts know the described species and can speculate knowledgeably about how many species may truly exist within each taxa.

Enormous amount of data and information on zooplankton species and their biogeography are available. The global census of marine zooplankton will make use of these existing data and archived zooplankton collections maintained at different Marine Biological Institutes around the world. The CMarZ database will also eventually contain records on new species yet to be identified.

Analysis of the current database records reveal that near-surface records account for 50 percent of observations of ocean life, less than 0.1 percent are from the bottom half of the water column. A specimen collected below 2000 meters could be 50 times likely to be new to science than one found at 50 meters.

The Unknown

A taxonomically comprehensive global scale summary of the present status of biodiversity of marine zooplankton is yet to be formulated. Though studies on zooplankton started by the middle of the 19th century, worldwide distribution patterns have been made for less than 10% of the species described. Also, for most of the zooplankton groups many more species remain to be discovered. This is especially true of gelatinous forms that have never been properly sampled and for species living in unique and isolated habitats like hydrothermal vents and seeps.

Deep-sea regions are certain to yield many new species. It appears many morphologically defined zooplankton species will include genetically distinct population having many cryptic species. Compared to the known species from different regions of the world, the unknown is thought to be more than the known.

The Unknowable

The huge expanse of the world oceans makes the completeness of information an enduring challenge. Efforts using traditional techniques or modern versions have their own limitations in yielding complete knowledge on zooplankton biodiversity. The world oceans may remain unknowable because of their sheer size and due to the interplay of time/space scale of variability in a complex environment. Even with technological advances, it will be difficult to obtain a synoptic top-to-bottom and pole-to-pole view of the world oceans within the time frames of environmental variability. Also the accuracy of zooplankton species diversity can be influenced by human errors and inevitable inconsistencies between observations and analyses made by different scientists.

Scientific Rationale

We do not have a clear picture on how differences in the diversity of marine zooplankton communities affect flow of energy and matter through the marine food web. The need for a taxonomically comprehensive global scale census of marine zooplankton biodiversity has its origin in some of the most critically important questions that drive ecology, oceanography and evolutionary biology today. The conceptual basis and need for CMarZ are realized from the importance of zooplankton biodiversity to the ecosystem.

One such important aspect is the functional consequences to marine ecosystems. Changes in zooplankton diversity can have significant consequences for functioning of marine ecosystems. Shifts in the relative abundance of important species can be propagated through the food web. For instance, altered copepod species composition can dramatically alter the biological pump, or transport of carbon from surface waters into the ocean's interior.

Global elemental cycles can be influenced by zooplankton. Marine zooplankton are significant mediators of fluxes of carbon, nitrogen and other important elements in ocean biogeochemical cycles. Long-term changes in fluxes into the deep sea may be related to zooplankton species composition in overlying waters.

Marine bioinvasion is a recently observed phenomenon. Species invasions are occurring with ever-increasing frequency, especially in coastal waters. Non-indigenous gelatinous species have negatively affected ecosystems throughout the world. A glaring example of this phenomenon is the inadvertent introduction of the ctenophore *Mnemiopsis leidyi* into the Black Sea and now in the Caspian Sea presumably by transport through ballast water. This leads to devastation of fisheries. Blooms of gelatinous zooplankton can also clog the water intake point of industrial establishments.

Food web stability is another important aspect influenced by biodiversity. Theoretical ecologists observed that food web containing many species with weak trophic interactions exhibit greater ecological

Zooplankton is a general term for the drifting animal population in the water column, which are unable to maintain their position by swimming against water currents.

stability than those having few species with strong interaction. Recent research findings indicate that rare species may play an important role in stabilizing communities over time.

Finally, a baseline biodiversity assessment can provide a contemporary benchmark against which future changes can be measured.

Executing the Global Census

To begin with, a comprehensive assessment of current knowledge on global biodiversity of zooplankton needs to be made. This will help in identifying gaps in knowledge and for setting priorities for future advances. Existing collections and specimens provide a cost-effective means to obtain wide distributional coverage for many groups of zooplankton. Large-scale studies of zooplankton are needed to evaluate patterns of biodiversity at scales appropriate to dispersal ability of ocean currents.

An essential feature for a global census of zooplankton biodiversity will be an international partnership coordinated through a network of regional centres. Each centre has to identify opportunities for cooperative cruises to obtain zooplankton samples from many ocean regions. This should also include biodiversity hotspots where the ratio of unknown and known species is the greatest. Collaboration among scientists will involve sharing of samples and conducting multiple analyses.

Sampling will be done using traditional nets, remote detection by optical sensors and integrated sensor systems deployed on towed, remotely operated or autonomous vehicles and submersibles. The manned submersible carries investigators to deep-sea hydrothermal vents to observe the biodiversity of this unique and rich habitat and collect samples with its robotic arm. In short, advances in technology lift limits for discovery of life that is small, deep, or rare. Census scientists are innovating, refining, and integrating techniques to assess and monitor marine life.

Traditional morphological analysis of zooplankton samples will remain as the base in processing of new and existing zooplankton collections. Once samples are analysed, a reference specimen collection will be made for all the species or groups identified. It is necessary to put the available taxonomic information into CD-ROMs and web-based sites for greater accessibility.

A number of taxonomic manuals have been published for coastal seas; such efforts will be encouraged. Development of digital taxonomic tools for training and research is a high priority for CMarZ. Laboratories associated with CMarZ equipped for molecular analyses including DNA sequencing will coordinate to ensure storage, archiving and molecular systematic analysis of specimens sent to CMarZ. Voucher specimens and voucher DNA will be permanently maintained by the molecular laboratory and will be accessible for researchers.

Database

A primary product of CMarZ will be a distributed database of species names, collection of information, vouchers and specimen locations, DNA sequences, images and other information. Dissemination of data and information resulting from CMarZ is accessible through the CMarZ data management system. CMarZ data will be fully integrated with and searchable from the Ocean Biogeographical Information System (OBIS) Portal.

The CMarZ Network is an association of zooplankton taxonomists, ecologists, oceanographers and others who are committed to working towards the goal of completing a global biodiversity of the animals that drift with ocean currents throughout their lives or the holozooplankton by 2010. Researchers, students, technical staff and interested others are welcome to join CMarZ Network. Network provides a portal to the CMarZ database and species pages and also provides useful information on project activities to the general user.

Oceanography is a multidisciplinary approach to learn all about the biology, physics, chemistry, geology, engineering and meteorology of the ocean.

The species page database is set up to make summary presentations of taxonomic, morphological, ecological, biogeographical and molecular information for zooplankton species. Information from expert taxonomists and para-taxonomists needs to be collected for preparing species pages. All information will be examined by a CMarZ species page editor, but it is the responsibility of the provider to confirm the accuracy of all information. CMarZ maintains a list of research cruises, fisheries resources and environmental surveys, ships of opportunity, and commercial fishing or shipping vessel tracks. Laboratories associated with CMarZ and equipped for molecular analyses coordinate to ensure storage, archiving, and molecular systematic analysis of specimens sent by CMarZ researchers, who are focused on taxonomic, morphological, or ecological studies.

Education, professional training and capacity building are major objectives of CMarZ considering the dwindling number of taxonomic experts in zooplankton. CMarZ is committed to the generation of new sampling technologies, new analytical tools, and new global-scale understanding when the project ends in 2010. The expected important outcome are more complete knowledge of biodiversity, new understanding of the functional role of biodiversity in ocean ecosystems and better characterization of global scale patterns of zooplankton biodiversity in the world oceans.

But, above all, CMarZ will lead to greater public appreciation for the value of marine biodiversity.

Dr. Vijayalakshmi R. Nair is a retired Senior Scientist, National Institute of Oceanography (NIO), Goa, and continues to work at the Regional Centre, NIO, Kochi as a consultant. Recognising her expertise in zooplankton she has been selected as a member of the Steering Group of CMarZ to represent India from 2005-2010. Address: HB/50, "Vijaya", South Bridge Avenue, Panampilly Nagar, Kochi-682036
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