Sathyabama Institute of Science and Technology

Monitoring Aquatic Ecosystem

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1. LIFE BELOW WATER

Oceans cover more than 70% of the planet and are a source of food and income for more than 10% of the world's population. Pollution and climate change continue to have a major impact on the ocean. Countries are working together to protect the marine environment from their effects and achieve United Nations Sustainable Development Goal (SDG) 14, which calls for conserving and sustainably using the oceans, seas and marine resources for sustainable development.

Sathyabama Institute of Science and Technology is focusing to conserve and sustainably use the oceans, seas and marine resources for sustainable development (SDG 14) though its premier research centres like Centre for Ocean Research, Centre for Climate Change Studies, Centre for Remote Sensing and Geoinformatics and Centre for Earth and Atmospheric Sciences. Centre for Ocean Research (COR) was established in 2007 as a joint initiative of National Institute of Ocean Technology (NIOT) Chennai and Sathyabama Institute of Science and Technology to encourage targeted sectors like reduce marine pollution; protect and restore ecosystems; reduce ocean acidification; sustainable fishing; conserve coastal and marine areas; end subsidies contributing to overfishing; increase the economic benefits from sustainable use of marine resources; increase scientific knowledge; research and technology for ocean health; support small scale fishers; and implement and enforce international sea law. The main role of the research centres are to facilitate a platform to the student communities from the Schools and Departments to utilize the high end instrumentation related to ocean science and research as Ocean education is enhanced through scientific cooperation and knowledge at all levels, through the development of research capacity and through the transfer of marine technology.

2. Target 14.1. REDUCE MARINE POLLUTION

(By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution)

As eutrophication, nutrient run off to the ocean and plastic accumulation are the major problem indicated in 14.1, a collaborative work has been carried out with National Institute of Ocean Technology (NIOT) to study the growth response of the diatom Chaetoceros species to the elemental ratios of Deep Ocean waters. As ocean thermal energy conversion project in Indian Ocean is plan to utilize the Deep Ocean Water as one of the resources, the non-utilized Deep Ocean Water with high nutrient content could be used for raising micro algal culture for aquaculture and other marine bio prospecting applications. The sustainable output of the work was published in Estuarine, Coastal and Shelf Science (https://doi.org/10.1016/j.ecss.2020.106812).

To address the heavy metal pollution in estuary environment as the target 14.1 a collaborative study was carried out with P.G. and Research Department of Zoology, Jamal Mohamed College (Autonomous), Tiruchirappalli, Tamil Nadu, 620020, India. Mass mortality of fishes was reported at the Adyar estuary, South India, during November 2017. The probable reasons for fish mortality are analyzed in this paper. Critical assessments on water quality parameters including the metal concentrations, nutrients, and histology of gills and liver of fish (Mugilcephalus) isolated from the impact zone were performed. Among the metals observed, chromium showed levels (3.64 ± 0.001 mg L^{-1}) much above the average permissible limits (0.1 mg L^{-1}). The low salinity could have escalated the toxicity of the metal. In addition, histology of gills and liver showed cellular necrosis, epithelial lifting, hyperplasia, edema, mucous cell proliferation in the gills, cytoplasmic vacuolation of hepatocytes, and degeneration of liver which reveal that chromium toxicity is the most probable cause for mass mortality.The output was reported as publication in the journal Environmental Monitoring and Assessment (https://doi.org/10.1007/s10661-019-7636-4)

As per the SDG Target 14.1 Centre for Ocean Research and Department of Visual Communication, Sathyabama Institute of Science and Technology jointly organized a “National Workshop on the Awareness of Marine Plastic Debris in Indian Seas (Pollution & Solution) — WAMP2020” in partnership with International Union for Conservation of Nature (Commission on

Ecosystem Management & Commission on Education and Communication) on 22nd& 23rd January 2020.The theme of the WAMP2020 was to create awareness on the impact of plastic litters and its alarming accumulation in our surrounding environment. 'Mobile media' is used as the tool to gather young minds. Abstracts are invited fore-posters, awareness videos & scientific cartoons from students, scholars, researchers, post docs, faculties and scientists for best presentation awards. The program highlights the objectives of Swachh Bharat Mission and Digital India Program as per the GOI norms.

References:

https://harnessingnatureblog.wordpress.com/home/

https://harnessingnature.wordpress.com/2019/10/16/national-workshop-on-the-awareness-of-marine-plastic-debris-in-indian-seas-pollution-and-solution/

https://vigyanprasar.gov.in/wp-content/uploads/Vigyan-Samachar-MoES-News-1-24-Jan-20.pdf

3. Target 14.2. PROTECT AND RESTORE ECOSYSTEMS

(By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans)

A collaborative research was carried out between with National Institute of Ocean Technology and Indian Institute of Technology, Chennai towards the Target 14.2 through the assessment of wetland change dynamics of Chennai coast, Tamil Nadu, India using satellite remote sensing. The coastal wetlands of Chennai are increasingly being affected by anthropogenic factors, such as urbanization, residential, and industrial development. This study helps to monitor and map the dynamics of the coastal wetlands of Chennai using Landsat satellite images of 1988, 1996, 2006, and 2016 by following a supervised classification method. Post-classification wetland change detection was done in three temporal phases, that is, 1988 1996, 1996 2006, and 2006 2016. Change detection matrix analysis was performed to identify theform of changes. Ground truthing was carried out to validate the wetland classes. The overall accuracy of the classified image was 79.29% and the kappa coefficient was 0.7600. These results were imported into a GIS environment for further analysis. It was found that the wetlands have decreased to an alarming extent in the past 28 years from 23.14% in 1988 to 15.79% in 2016 of the total study area, owing to conversion of wetlands into industrial development, urban expansion, and other developmental activities.The sustainable output of the work was published in Indian Journal of Geo-Marine Sciences (IJMS) (http://nopr.niscair.res.in/handle/123456789/49703).

To address the ecosystem based solution for the protection of marine ecosystem, Sathyabama Institute of Science and Technology has contributed to the Learning Solutions from Nature on

International Day for Biological Diversity, with IUCN Commission on Ecosystem Management South Asia. A small movement from Commission on Ecosystem Management to learn more from nature, go sustainable, on the celebration of Biodiversity day was documented as video and broadcasted in CEM_SA IUCN Youtube channel (https://youtu.be/JELjclhMZ_M?t=766)

4. Target 14.3. REDUCE OCEAN ACIDIFICATION

(Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels)

Aquaculture is one of dominating seafood production sector in India, which is facing the global climate challenges for the sustainable and progressive production. Aquaculture is majorly threatened by changes in temperature, salinity, ocean acidification and extreme climatic events that affect infrastructure and livelihoods which can impact aquaculture both negatively and positively. The role of environmental stress such as temperature fluctuations, salinity changes, low pH and low dissolved oxygen to stress the host and suppress its immune system have been recognized long back. As a consequence, the incidence of disease outbreaks and rates of pathogen transmission often increase during changes in the environment.

To address the Target 14.3, this research project is being carried out with the support of National Initiative on Climate Resilient Agriculture (NICRA), Indian Council of Agricultural Research. The impact of temperature anomalies on infectivity pattern of Vibriosis in Litopenaeusvannamei and to develop suitable dietary interventions (functional feed) to mitigate the disease outbreaks due to temperature anomalies stress has been addressed in this ICAR project (Ref. 2-13(8)/20-21/NICRA 30.04.2020).

Products developed in this ICAR project: Nano-based functional feed for mitigate the temperature stress and disease incidence.

Seaweed aquaculture, the fastest-growing component of global food production, offers a slate of opportunities to mitigate, and adapt to climate change. Seaweed farms release carbon that maybe buried in sediments or exported to the deep sea, therefore acting as a CO_2 sink. The crop can also be used, in total or in part, for biofuel production, with a potential CO_2 mitigation capacity, in terms of avoided emissions from fossil fuels, of about 1,500 tons CO_2 km^{-2} $year^{-1}$. Seaweed aquaculture can also help reduce the emissions from agriculture, by improving soil quality substituting synthetic fertilizer and when included in cattle fed, lowering methane emissions from cattle. Seaweed aquaculture contributes to climate change adaptation by damping wave energy and protecting shorelines, and by elevating pH and supplying oxygen to the waters, thereby locally reducing the effects of ocean acidification and de-oxygenation.

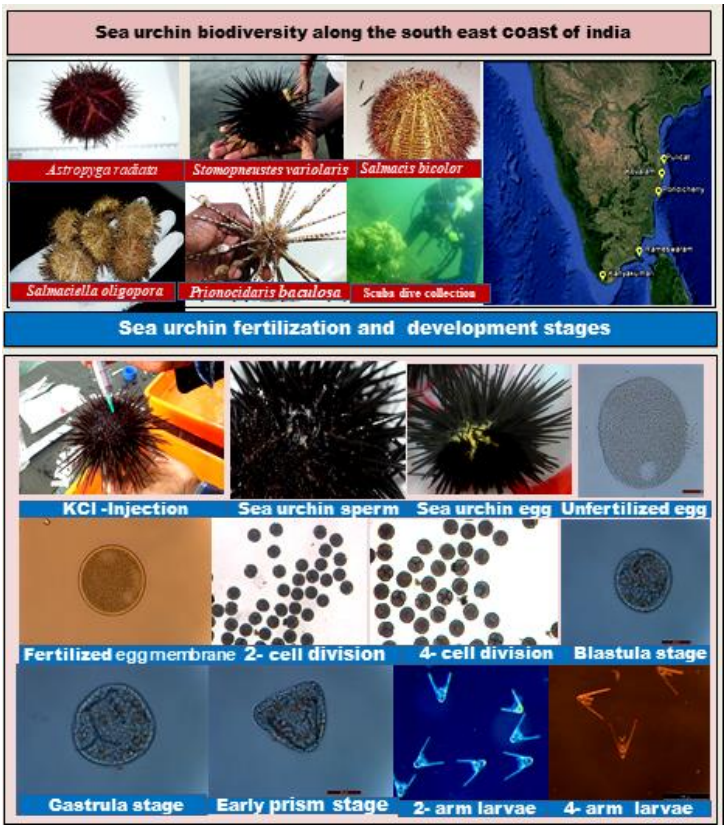
To address the Target 14.3, this research project is being carried out with the support of Science and Engineering Research Board, Department of Science and Technology. Contribution of Seaweed towards a sustainable future by playing a role in climate change mitigation and adaptation has been addressed in this SERB project (Ref: ECR/2017/002894)

A collaborative study was carried out with Center of Villa Dohrn Ischia – Benthic Ecology, Department of Integrative Marine Ecology, StazioneZoologica Anton Dohrn, P.ta S. Pietro, Ischia, Naples, Italy, Department of Biology and Evolution of Marine Organisms, StazioneZoologica Anton Dohrn, Villa Comunale, Naples, Italy, Department of Pharmacology and Toxicology, College of Pharmacy, King Saud University, Riyadh, 11451, Saudi Arabia, Bioproducts Research Chair, Zoology Department, College of Science, King Saud University, Saudi Arabia, Botany and Microbiology

Department, Faculty of Science, Beni-Suef University, Beni-Suef, Egypt, Integrated Molecular Plant Physiology Research Group (IMPRES) Department of Biology, Belgium to report the impact of ocean acidification to support the Target 14.3. The study utilized volcanic CO_2 vents at CastelloAragonese off Ischia Island as a natural laboratory to investigate the effect of lowered pH/elevated CO2 on the bioactivities of extracts from fleshy brown algae Sargassumvulgare C. Agardh. They analysed the carbohydrate levels, antioxidant capacity, antibacterial, antifungal, antiprotozoal, anticancer properties and antimutagenic potential of the algae growing at the acidified site (pH ~ 6.7) and those of algae growing at the nearby control site LaccoAmeno (pH~8.1). The results of the present study show that the levels of polysaccharides fucoidan and alginate were higher in the algal population at acidified site. In a snapshot they performed bioactivity assays but did not characterize the chemistry and source of presumptive bioactive compounds. Nevertheless, the observed improvement in the medicinal properties of S. vulgare in the acidified oceans provides a promising basis for future marine drug discovery. The outcome of this work was published in Environmental Pollution journal (https://doi.org/10.1016/j.envpol.2019.113765)

5. Target 14.3. SUSTAINABLE FISHING

(By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics)



Sea urchin gonads are considered a delicacy in many cultures, especially Japan, which is by far the largest consumer. About 9,000 tons of sea urchin gonads are consumed in Japan every year. Keeping this market demand on mind and to provide sustainable solution for echinoderm fishing, sea urchin aquaculture program is undertaken in collaboration with National Institute of Ocean Technology with the support of Ministry of Earth Sciences. A land-based grow-out of sea urchins, *Salmacisbicolor* species has been developed. The suitable output of the aquaculture program resulted on sea urchin brood stock conditioning, sea-cage nursery methods, diet and nutrition, and grow-out to market.

To address the overfishing, illegal, unreported and unregulated fishing in Target 14.4, a research project is being carried out with the support of Ministry of Earth Sciences.Land based closed cycle culture of Indigenous sea urchin species and development of post-harvest protocols for preservation of roes has been addressed in this MOES project (Ref: MoES/36/OOIS/Extra/39/2014)

6. Target 14.4. CONSERVE COASTAL AND MARINE AREAS

(By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information)

As per the SDG* 1, 5, 13, and 14 Centre for Ocean Research, Sathyabama Institute of Science and Technology have initiated cultivation of red sea weed (Kappaphycusalvarezii), by imparting rigorous entrepreneurship trainings to fisherwomen in the field research station at Col. Dr.Jeppiaar Fishing Harbor, Kanyakumari Dt. Self-help groups were formed at Muttom fishing harbor vicinity in Tamil Nadu, making seaweed as an alternative source of income generation. On an average per capita, a woman generates Rs. 8000 by selling fresh seaweed. More than 100 trained fisher women are engaged in deploying about 500 rafts made out of bamboo and started harvesting about 15 tonnes of the Kappaphycusalvarezii seaweed once in 35 days from sea.

This initiative is funded by Sathyabama Institute of Science and Technology, Chennai. This social relevance activity was highlighted by Harnessing Nature, the official blog of International Union for Conservation of Nature - Commission on Ecosystem Management, South Asia.

https://harnessingnatureblog.wordpress.com/2019/02/24/creating-opportunities-for-women-through-seaweed-farming/

7. Target 14.5. END SUBSIDIES CONTRIBUTING TO OVERFISHING

(By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation)

To enhance the public conservation awareness on illegal fishing as per the Target 14.4, Centre for Ocean Research, Sathyabama Institute of Science and Technology, has taken up the task of investigating the preliminary landing data, biological characteristics and diversity of elasmobranchs along the coast of Tamilnadu such as Chennai, Nagapattinam and Tuticorin. One problem that has been identified to disadvantage conservation efforts in this region is the lack of knowledge on endangered species among the fishermen populations engaged in fishing activity. Public awareness and involvement is critical to conserve sharks and rays in the coastal waters of Tamil Nadu. Thus, the Centre for Ocean Research is carrying out an awareness campaign since 2017 to till date for conservation of sharks and rays, with the support of Rufford foundation – where fishermen are the key agents of change. In this project, species identification flyers prepared in local language (Tamil) is circulated among fishermen, boat owners and other stakeholders to create awareness on the red listed species and their importance in the ecosystem. This social relevance activity was highlighted by Harnessing Nature, the official blog of International Union for Conservation of Nature - Commission on Ecosystem Management, South Asia.

(https://www.iucn.org/sites/dev/files/content/documents/newsletter_eg_january_2019.pdf)

8. Target 14.A. INCREASE SCIENTIFIC KNOWLEDGE, RESEARCH AND TECHNOLOGY FOR OCEAN HEALTH

(Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries)

The molecular taxonomic work underlying species discoveries lays the foundations for all subsequent biodiversity-based research. To know how many species exist provides valuable information about progress in the rate of discovery of life on Earth. Moreover, species richness the number of different species in an area is one of the key metrics for estimating species diversity, which is the basis for many comparative ecological, biogeographic and conservation studies. We are doing one of important marine conservation project from Ministry of Earth and Science (MoES) entitled "Characterization and DNA barcoding of polychaetes from the South East Coast, India" Project No. MoES/36/OOIS/Extra/53/2016, Dated: 09/07/2019.

In details, polychaetes represent a well-defined community among the total macrofaunal groups in most marine environment in terms of numbers and individuals. Distribution of polychaete species is mainly linked to the sediment particle size in which they are residing and constitute the largest faunal assemblage on earth and the biomass in these sediments. To date, traditional taxonomy relies mostly on diagnostic morphological characters, In this regard, DNA barcoding has proved to be a useful alternative method for rapid global biodiversity assessment, providing an accurate identification system for living organisms

Generation of Induced Pluripotent Stem Cells from Endangered/Threatened/Vulnerable Fish Species for Ex-Situ Conservation

Always humankind has viewed the ocean as an infinite resource for food. Its vast size and depth and unexplored frontiers made the ocean appear invulnerable to over exploitation. But the truth is that the populations of many species are decreasing at an unsustainable rate, and the number of species listed as endangered from marine life families like whales, dolphins, salmon and sharks are on the rise and as such the conservation of these species is an immediate priority. The research team at Centre for Ocean Research is working to conserve these species by using the generation of induced pluripotent stem cells (iPSC) technology, i.e. to preserve genetic material of these species. iPSCs are generated from somatic cells by direct reprogramming using Yamanaka factors or using small compounds and they are capable of unlimited expansion and differentiation into multiple cell types. Previously iPSC technology has been successfully implemented in endangered species of mammals like Prairie voles (Microtusochrogaster), Rhesus macaque (Macacamulatta), Drill (Mandrillusleucophaeus), Snow leopard (Pantherauncia) and Northern white rhinoceros (Ceratotheriumsimumcottoni) and provided a novel approach in conservation biology. So far this approach has been dealt only with mammalian systems and none has reported the use of iPSC technology for conservation in India. The possibility of producing iPS cells from endangered/threatened/vulnerable fish species will provide an infinite source of undifferentiated stem cells, as iPSCs are immortal and can be continually expanded and easily frozen, which can be differentiated into sperm or oocytes that can be banked and thus act as a promising tool for preserving genetic material and also protecting the species from extinction.

Fish Embryonic Stem (ES) Cells for the Production of Transgenic Fish

The research team at Centre for Ocean Research is also working on Fish Embryonic Stem (ES) Cells to produce transgenic fish for aquaculture and for generation of surrogate breeders for species with reproduction problems. Embryonic stem cells (ES) are unique cell populations derived from early embryos with the ability to undergo both self-renewal and differentiation. Upon transplantation into early embryos they can differentiate into various cell lineages including cells of the

germ line and can be propagated in unlimited quantity for clinical applications. ES cells are also a promising tool towards the generation of transgenic animals. When ES cells colonize germ cells in chimeras, transgenic animals with customized phenotypes are produced and used for functional genomics studies. While until recently ES cell approaches have been mostly limited to mammalian systems, but there has been a growing interest to develop ES cells from fish for research purposes (e.g., to produce transgenic fish for aquaculture and for generation of surrogate breeders for species with reproduction problems). The research team at Centre for Ocean Research has successfully concluded the project on developing embryonic stem (ES) cells from Zebrafish for transgenic applications during the year 2019.

Supporting documents:

Development and characterization of a skin cell line (SGA) from the Mosquito fish, Gambusiaaffinis and its susceptibility to fish Betanodavirus (https://doi.org/10.1016/j.aquaculture.2019.734778)

Isolation, culture and differentiation of blastema cells from the regenerating caudal fin of zebrafish (https://doi.org/10.3390/fishes5010006)

Cells isolated from regenerating caudal fin of Sparusaurata can differentiate into distinct bone cell lineages (https://doi.org/10.1007/s10126-019-09937-3)

EARTH SCIENCE AND TECHNOLOGY CELL(Marine biotechnological studies) has been established at Col. Dr.Jeppiaar Research Park, Centre for Ocean research supported byMINISTRY OF EARTH SCIENCES (MoES), Government of India.

The aim of the MoES-ESTC is to promote research and development **towards the SDG 14 targets** such as reduce marine pollution; protect and restore ecosystems; reduce ocean acidification; sustainable fishing; conserve coastal and marine areas; end subsidies contributing to overfishing; increase the economic benefits from sustainable use of marine resources; increase scientific knowledge; research and technology for ocean health; support small scale fishers; and implement and enforce international sea law.

The objectives of the MoES-ESTC at Sathyabama Institute of Science and Technology is also in agreement with the sustainable develop goals, such as to augment marine living resources and marine biotechnology in collaboration with CMLRE and NIOT; to identify the R&D requirements and to fulfill the gap to develop potent marine bioactive products; to establish collaboration between National and International Institutions; and to create infrastructure facilities related to advanced research in marine biotechnological studies. (Ref: MoES/11-MRDFIESTC-MEB(SU)/2/2014 PC-III)

https://www.moes.gov.in/content/research-projects-2

https://twitter.com/gopiye/status/1050596989816070145?lang=en

Healthy oceans and seas are essential to our existence.They cover 70 % of our planet and we rely on them for food, energy and water. Yet, we have managed to do tremendous damage to these precious resources. We must protect them by eliminating pollution and overfishing and immediately start to responsibly manage and protect all marine life around the world. The world's oceans drive global systems that make the Earth habitable for humankind. The sea regulates everything from rainwater, weather and climate to our food and the air we breathe. The first method of travel between continents, the ocean continues to be used in travel and transportation today.

We need to carefully manage this essential global resource in order to achieve a sustainable future. Despite this, there is a continuous deterioration of coastal waters due to pollution and ocean acidification, which is directly impacting marine ecosystems, biodiversity and even small-scale aquaculture operations. The fragility of the world's oceans are strongly connected to global socio-economic issues, and can contribute to health, safety and financial risks.