OCEANS IN 21ST CENTURY

Pioneering power research

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The National Institute of Ocean Technology in Chennai has made a successful bid to develop technologies to exploit ocean resources.

BY SPECIAL ARRANGEMENT

The National Institute of Ocean Technology in Chennai.

FOR a country with an extensive coastline like India, tapping the vast resources under the sea requires a `deep' knowledge of the kind that the National Institute of Ocean Technology (NIOT), Chennai, has. With a mandate to develop technologies to understand the oceans, estimate their resource potential, and develop indigenous technology to exploit them without endangering the environment, the NIOT, the technical arm of the Department of Ocean Development (DOD), has grown from a Rs.1-crore set-up with just five scientists in 1993 to a Rs.90-crore organisation having 220 scientists.

According to NIOT director Dr.M. Ravindran (who has been heading the organisation since its inception), the institution was established mainly to develop and demonstrate technology in the field. "India has 2 million sq km of Exclusive Economic Zone (EEZ). But there was absolutely no information about the rich resources available in the vast oceans. Institutions such as the National Institute of Oceanography (NIO) in Goa were doing a lot of work in the fundamental science of oceanography but not any application-oriented work or engineering projects. It was to fill this gap that NIOT was set up in coordination with the Indian Institute of Technology-Madras," says Ravindran. Apart from doing in-house projects, the NIOT identifies sponsors and monitors and executes technology development programmes in coordination with other institutions.

The NIOT has a three-point mission: to develop world-class technologies and applications for sustainable utilisation of ocean resources; to provide competitive, value-added technical services to organisations working in ocean-related areas; and, to provide the knowledge base and enhance the institutional capability to manage ocean resources and environment.

By making tremendous strides in developing, demonstrating and disseminating ocean technology that help India understand and exploit the resources of the oceans, the NIOT has far surpassed its

mandate for the last decade. According to Ravindran, the strength of the NIOT is its multi-disciplinary approach. Its clientele includes the India Meteorological Department, the governments of Indian islands, fishermen, water transport operators and miners.

At any given point of time, the NIOT runs a variety of projects. The major ones include:

Ocean Thermal Energy Conversion (OTEC)

As a tropical country with a long coastline, India has tremendous ocean thermal energy potential. The OTEC technology uses the water temperature difference at the surface (at about 29^0 C) and at a depth of 1,100 metres (at about 7^0 C) to produce electricity.

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The Pichavaram mangrove in Tamil Nadu, a critical coastal habitat. Under the Integrated Coastal and Marine Area Management programme, the NIOT has generated a training capsule for different stakeholders on coastal and marine habitat management, using the Geographic Information System.

The NIOT is implementing the world's first 1 MW floating OTEC technology demonstration project off the Tuticorin coast in Tamil Nadu. The various sub-systems for the plant have been configured, designed and integrated on an OTEC floating barge. A one-kilometre-long cold water pipe has been towed out to the site and deployed vertically with an anchoring system at a depth of 1,200 m. The OTEC plant will be commissioned after the barge is connected during the next fair weather season.

This kind of non-polluting renewable energy source is appropriate for power-starved nation like India. Though it is capital intensive now, improvements in technology and higher rated plants can bring down the unit cost considerably. India's OTEC resource potential is estimated at around 180,000 MW.

For the mainland, the cost of power generation for plants upwards of 25 MW is expected to be comparable to fossil fuel units. But for islands, an OTEC power plant of any size is cheaper than the conventional generation units.

Wave Energy

The DOD set up a National Test Facility off the Vizhinjam fishing harbour near Thiruvananthapuram to demonstrate the conversion of wave energy into electricity. For this purpose, a concrete caisson-based Oscillating Water Column (OSW) type wave energy conversion system was designed, erected and commissioned in 1991. Subsequently, the plant was taken over by the NIOT for carrying out additional research and development (R&D) on the power module. The NIOT developed a special impulse turbine for this.

Since waves are random intermittent sources of energy, the average power is generally low, though a peak power output of over 50 kW was obtained from the plant. The NIOT is now working on floating wave-powered buoys of smaller rating, using the energy conversion technologies already developed. Special control devices with battery back-up will be provided to make for the variations in wave energy availability.

As an offshoot, the NIOT took up another project to use this caisson-based wave energy facility to provide desalinated water to the local community. For this purpose, a commercially available reverse osmosis plant was procured and linked to the wave energy caisson system at Vizhinjam.

Desalination

A process of removal of salts from seawater and brackish water of inland seas, highly mineralised groundwater (for instance, geothermal brines) and municipal wastewater, desalination renders potable water that is otherwise unusable. Desalinated water is also used for irrigation, industrial applications and other purposes. A number of technologies have been developed for desalination - such as reverse osmosis, distillation, electro dialysis, and vacuum freezing. In India, the availability of freshwater is falling at an alarming rate. Many island communities depend on rainwater. The NIOT has, therefore, initiated experimental studies on seawater desalination to meet the drinking water needs of people, particularly of the coastal areas and island groups.

The ocean thermal gradient can be effectively used for desalination of saline water. The NIOT is working on two technologies - low temperature thermal desalination, which uses flash evaporation of seawater under low vacuum and temperature conditions, and dew point condensation, which utilises cold seawater to condense saturated vapour in the atmosphere. A laboratory model of a low temperature thermal desalination plant with a capacity of 20 litres a day was designed in association with IIT-Madras.

The experimental results have provided valuable inputs for the design of a plant with a capacity of 100 cubic metres a day for the Lakshadweep group of islands. This is a technology demonstration-cum-utility project with vast potential.

Deep Sea Technology and Ocean Mining

The prime objective of this project is to develop and acquire technology that will lead to commercial mining of polymetallic nodules - potato-like structures containing cobalt, nickel and copper - in the central Indian Ocean basin. An underwater mining system consisting of a crawler, a crusher and a collector, capable of operating at depths of 6,000 m, is to be designed and developed for mining polymetallic nodules. The NIOT is developing the technology with help from the Institut fur Konstruktion (IKS), University of Siegen, Germany.

As part of the project, measurement of *in situ* (in the original place) soil properties of the seabed at a depth of 6,000 m is also being undertaken. The other areas of research under this project include the development of deep and shallow water mining systems, underwater thrusters, and remote-operated boat.

Marine Archaeology

When the side scan sonar of a survey ship read signals from something that looked like man-made structures 40 m under the sea, detailed surveys were done on a 13 km by 7 km area between October 2002 and January 2003. The NIOT thus stumbled upon an archaeological site 30 km off the Gujarat coast in the Gulf of Cambay. During subsequent cruises, more than 2,000 artefacts including geometrically shaped articles, broken pottery, semi-precious stones, possibly stone tools and some ornaments were collected by grab dredges. Some of the structures located earlier were

found to be covered by sand waves while some other areas could not be surveyed owing to the presence of hydrocarbon production platforms erected recently. However, the surveys found an excellent collection of microlithic tools of different typology made up of hard materials such as chert, agate, jasper, chalcedony, opal and corundum.

All this and much more of the NIOT's activities are the responsibility of key groups.

The Technology Groups

It broadly includes engineering design, assembly and integration teams, provides technical and design support for all the projects and also maintains a data bank of underwater components and materials. It is actively involved in the development of technologies relating to OTEC, remote-operated vehicles, deep-sea mining, hyperbaric chamber, and high-power underwater thrusters.

The Coastal and Environmental Engineering Group

This group develops application-oriented technologies in coastal and envi<147,2,7>ronmental areas. Its prime goal is to enhance the marine infrastructure of the country. It mainly focusses on mathematical modelling of thermal dispersion, dredge soil disposal, sediment transport, storm surge projection and so on; coastal engineering studies including hydrographic, oceanographic, geophysical and geotechnical investigations to design, assess and conduct feasibility studies of marine infrastructure development; and environmental engineering to assess and monitor the impact of development on coastal areas, manage water quality through water load allocation, and study waste assimilation in estuaries.

The group has state-of-the-art data processing centres and one of the most sophisticated environmental and geophysical laboratories in the country.

Marine Instrumentation and Control Group

This group focusses on the design and development of acoustic-based underwater instruments such as the acoustic tide gauge (ATG) and underwater transducers. The group has a modern acoustic test facility comprising an acoustic tank with a fully automated transducer positioning and calibration system for characterisation and calibration of underwater acoustic instruments. It has indigenously developed and installed ATGs with a patented built-in calibration facility at various locations in India and Vietnam. Several other hi-tech instruments are at various stages of development.

The Operational Group

It broadly consists of Vessel Management Cell (VMC): This group has been formed to manage and maintain four crafts - Sagar Paschimi, Sagar Purvi, A.A. Sidorenko and Sagar Shakthi - to harness ocean energy and for coastal research. The vessels are being used for coastal ocean monitoring and pollution studies (COMAPS) and the integrated coastal and marine area management programme (ICMAM). The vessels have undertaken 54 cruises for 12 institutions along the eastern and western coasts of India.

Sagar Paschimi was deployed for archaeological survey in the Gulf of Cambay. Used as a support platform for the deployment of OTEC pipeline, it has collected vital baseline data at the site. The vessel has circumnavigated Sri Lanka on study trips for users on the east coast of India. It has also rendered services to various private agencies and government organisations.

Sagar Purvi has carried out a multi-beam survey at Ennore port and the coast off Chennai. For the NIOT's "study of sedimentation patterns" at Haldia for the Kolkata Port Trust, the vessel went into uncharted waters. It collected multi-beam, chemical and physical oceanographic data and seabed

sediment samples and carried out multi-beam bathymetry for more than 200 km. It was the first vessel to circumnavigate Sri Lanka for survey, for clients on India's west coast.

Ocean Science and Technology for Islands

Islands are peculiar in several aspects. They are vulnerable to natural and environmental disasters and have a limited capacity to respond to and recover from them. Further, islands have limited freshwater resources, or facilities to dispose of the increasing quantities of waste and hazardous substances, which threaten the island ecosystem. Sustainable development of islands depends largely on coastal and marine resources. Since island ecosystems are isolated and small in area, they are fragile.

This group provides scientific and technological help to island communities. One of the projects of the group is enhancing marine resources through breeding, rearing and sea ranching for commercial purposes. One of the technologies developed and disseminated to enhance the income of islanders is in the fattening of Indian spiny lobsters and mud crabs.

National Data Buoy Programme: This operational project was to deploy and maintain moored data buoys to collect and process oceanographic and meteorological data on a real-time basis. It also provides data throughout the day to the IMD, ports, the Coast Guard, the National Hydrographic Department, the National Research Laboratories and the scientific community at large. The project helps in predicting weather, monitoring marine environment, validating satellite data, providing sailing notification for ship movement and so on. This group has indigenised all the components of moored data buoys, of which 20 are deployed; the number will soon be doubled.

According to Ravindran, the time series data obtained from this operational project are extrapolated and used in the construction of ocean structures and to study water tranquillity levels, crucial for ocean operations.

The data are also used by the international community, which studies temperature and salinity profiles of seawater to understand the relative wave/current circulation pattern in oceans. The data are fed to the Paris-based Global Ocean Observation System, a part of the Inter-Government Ocean Committee. Under this project, help is provided to Vietnam, Myanmar and Bangladesh to deal with cyclones and hazard mitigation.

Infrastructure Development: The NIOT's R&D laboratory is equipped with sophisticated high-precision instruments to carry out biochemical studies related to culture and technology development activities for living marine organisms. They include ultraviolet (UV), Visible and Near Infrared (NIR) spectrophotometers, fluorimeter, liquid scintillation counter, Gamma counter, phase contrast and fluorescence microscope, stereo-zoom microscope, electrophoresis and gel documentation systems, high-speed centrifuges, ultrasonicator, lyophiliser, deep freezers, DNA sequencer, total organic carbon analyser, and so on.

A seafront laboratory at the Tamil Nadu Fisheries Department campus at Neelankarai (near Chennai) is well equipped to support lobster-fattening and larvae-rearing programmes under controlled environmental conditions. The laboratory is equipped with a seawater intake system and an algal culture facility to support the programmes.

According to Ravindran, while NIOT's performance has surpassed its mandate, it could have done even better but for two main problems - poor infrastructure and a small weather window (provided by the weather conditions) to work in the sea. The costs of projects such as the one for producing thermal energy are higher than those of conventional plants because the technology is completely indigenised, involving a lot of research. Says Ravindran: "Scientists are constantly working to bring the costs down. Once the technology is in place, putting up power plants will become cheaper, bringing down the cost per unit power."

Having completed nearly 100 projects and having contributed immensely to understanding, measuring and exploring the resources of the oceans, the institution can be proud of its progress. Dr. Ravindran attributes the success to the 220 dedicated scientists and their interdisciplinary approach to unravel the secrets of the sea.