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SPACE TECHNOLOGY AND OCEANOGRAPHY

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ABSTRACT

Space Technology has developed modern sensing devices which carried on aircraft and spacecraft platforms can obtain repetitive synoptic data over large oceanic areas. It has also developed aspects of systems-theory, information-theory, data processing methodology etc., which can be applied to the large volumes of data collected over the oceans. This integrated technique of surveying oceans for its resources is known as **Remote Sensing.** Water colour, sea-state, surface winds, temperature, chlorophyll, surface-currents, sediment transport and surface salinity are some of the parameters collected through Remote Sensing. The data so collected have applications to shipping, meteorology, coastal geography and marine biology. It is suggested that it is time for drawing up plans for taking observations over specific sites in the Arabian Sea and the Bay of Bengal from aircraft and ocean-craft platforms simultaneous with the expected overflights of NASA's Earth Resources Technology Satellites, already orbited and to be orbited in future.

Dr. N. K. Panikkar has played a significant role in the development of modern Oceanography in India. This he has done both through his personal scientific contributions of high calibre as well as through his remarkable ability of organising scientific Institutions. Young scientists have been thereby enabled to work in Institutions and find out ways and means of utilising our oceanic resources for the economic betterment of our country. I am happy to associate myself with the Marine Biological Association who is dedicating this special number of their Journal to Dr. N. K. Panikkar, on his Sixtieth Birthday, and to wish him many more years of useful work in his chosen field of Oceanography.

It is well known that the earth is a space ship with no external supplies except solar insolation. Humanity inherited all the terrestrial resources at its birth and we will be supplied with nothing more. The oceans, which constitute about 70% of the earth surface, probably has within them far more resources than the land areas, although tapping them may be more difficult. So far, the oceans have been explored through ship-borne instrumentation and visual observations. Ocean vessels have limited capabilities and are slow moving. Unlike the static ground, the oceans are dynamic— subject to continuous change. The expanse of the oceans coupled with their dynamic nature, make the conventional method of ship observations inadequate. It is here that space technology can be of great help.

Remote sensing

Space technology have developed modern sensing devices which carried on aircraft and spacecraft platforms can collect data on phenomena and features appearing on the ocean surface. These sensing devices include passive and active systems and employ different bands in the visible spectrum, in the near infra-red, in the far infra-red as well as in the centimeter radio waves. Fortunately, the atmosphere is transparent for all these bands when cloud free, and to some even when clouded. The reflectivity and the emissivity of ocean surface in the various bands of the electromagnetic spectrum are quantitatively registered by these sensing devices.

Space technology has also developed aspects of large systems theory, information theory, data processing methodology etc. which can be profitably applied to large volumes of data that can be collected with sensors on aircraft and satellites, particularly the latter. An integrated approach to earth resources studies using all these has now become feasible. Such an approach called Remote Sensing, when applied to oceanographic problems and carried out in conjunction with the conventional methods using ship-borne instrumentation, can be expected to yield substantial economic benefits.

Remote Sensing applied to oceanography, or any other field, produces imagery and analogue data, whose deciphering and interpretation require special skills. When oceanographic data are derived from the imagery, it is also necessary to validate them through independent ship-borne observations. Hence the need to carry out spacecraft and aircraft remote sensing observations in conjunction with conventional, ship-based observations.

Applications To Oceanography

The present state-of-the-art of remotely sensing oceanographic and related parameters from aircraft and satellite platforms has provided tools for collecting data simultaneously over a wide area. This has not been possible with ships. Within the last decade a variety of sensor-mounted spacecraft and aircraft, both manned and unmanned, have provided directly or indirectly oceanographic data on parameters like: water colour, sea-state, surface-winds, temperature, chlorophyll, surface-currents, sediment transport and surface salinity. With these parameters, the anticipated oceanographic applications can be: study of ocean waves and sea conditions; delineation of shoals and mapping of coastal areas; ocean currents, their variations and meanderings; ice surveillance; coastal marine processes with particular reference to erosion in coastal areas; biological phenomena including characterisation of productive and non-productive areas; sea-level and sea-slope and sub-surface structure, etc.

The evaporation from the oceans is the ultimate cause of all clouds and precipitation even over the land areas. The role played by the location of abnormally warm oceanic areas in causing the vagaries of the rainfall (including that of the Indian Monsoon) is gradually being realised by meteorologists. Thus, a survey of the oceans becomes essential for the forecasting of weather over land and sea. As stated in the earlier chapter, on behalf of the World Meteorological Organisation and the International Council of Scientific Unions, a group of meteorological scientists are now involved in the GARP Project. They have realised that the tropical oceans play a large part in the generation of global weather systems. In order to investigate the details of this role, plans are afoot for conducting an experiment in the northern equatorial Atlantic in 1974. The planners have definitely stated that a geosynchronous and a couple of sunsynchronous satellites, for surveying the oceanic area under investigation, are essential requirements for the experiment.

The Gemini Manned Spacecraft Missions, brought several colour photographs of the earth's surface taken during the flights. Made with hand-held cameras, these pictures revealed the potential of surveys of the earth and its resources by means of remote sensing from space. The pictures were remarkably clear, clearer than those taken from aircraft. Their clarity was obviously due to the fact that the camera's lens was many miles away from the atmospheric scattering medium. These pictures covered thousands of square miles at one time, shownig large patterns and formations which cannot be seen in aerial photographs.

A vertical view of some coastal areas in Florida, showed shoal areas and underwater detail through colour tones. Sedimentation patterns over large lakes were clearly discernible. Several atolls 60 miles or less in diameter appeared in the central Pacific. Such ocean photographs have already been used to revise hydrographic charts.

Biological productivity of plankton and fish are perhaps the most important oceanic resources. In the years ahead this resource must be surveyed, monitored, conserved and wisely harvested. There is a significant correlation between ocean temperature gradients and the location of large schools of fish, so that information on the ocean temperature through infra-red sensing would prove valuable to the fishing industry. Surface temperature measurements also help to identify locations of highest plankton concentration and therefore possibly locations of high population of fish.

The oceans absorb surplus carbon-dioxide in the atmosphere via phytoplankton which converts it into oxygen. Some scientists feel that the overload of industrially emitted carbon-dioxide might have already saturated the ocean's capacity to effect this conversion. This also makes it necessary to monitor the areas of phytoplankton. Phytoplankton can be killed or their vigour impaired through oil slicks or pollution films. With so many oil tankers the risk of such films is large over the Arabian Sea. With many countries going in for underwater drilling operations for oil, the risk of oil slicks spreading over oceans is on the increase. It is desirable to monitor them. A satellite sensor scanning in the near ultra-violet and thermal infra-red can detect oil slicks, those which are only a few hours old and those which are several days old.

It is not known definitely whether schools of fish create detectable thin films of fish oil. If so, the same technique of ultra-violet sensing may detect schools of fish swimming just below the surface.

Subtle gradations in ocean colour shown in the Gemini photographs correlated well with ocean flora. Hence this technique can be used to indicate areas of high food content where fish are more likely to be found. As already mentioned ocean colour gradation in shallow waters can be used to update hydrographic charts. This is very necessary as the action of tides and currents are continuously changing the contours of the sea bottom, faster than the classical hydrographic surveys. From a space platform, small difference in colour can be detected through the use of multi-spectral photography or scanning imagery, using narrow band filters.

The areas and intensities of the "sunglint"—the area of an ocean surface which reflects sunlight into the observing camera provide data on the surface waves, which can be related to the surface wind. The state of the sea also produces differences in the sea colour when viewed vertically. Remote sensing techniques for these features installed in spacecraft can provide information on the state of the sea. The state of the sea can be inferred more definitely using microwave radiations. The information about the state of the sea can be used for appropriate re-routing of ships along routes offering less resistance to the ship's motion.

The space oceanographers say that they will now strive for data on the following: the surface wind field, wave systems; ocean currents, their boundaries and speeds; eddies and divergences; areas of upwelling; depth of the mixed layer; water temperatures and their gradients; biological productivity; fluxes of heat, moisture and carbon-dioxide.

The following table gives some of the applications of Space Technology to Oceanography:

Application	Type of data	Inference drawn from the data
Shipping	Wave height	State of the sea
	Surface temperature	
	Surface temperature gradients	Currents
	Water colour	
	Temperature anomalies	Hazards like icebergs
	Water/ice inference	
Meteorology	Wave heights	
	Water colour	Winds
	Surface temperature	Evaporation
	Temperature anomalies	Cyclone development
Coastal Geography	Land/water interface	
	Colour tones and contrast	Shore line topography
	Water colour tone	Effluents from rivers and sediment deposits
	Water surface elevation	Sea level and slopes
Marine Biology	Colour tones	Bioluminescence
	Colour tones	Plankton
	Colour tones	Schools of fish and algae
Physical Oceanography	Sea surface temperature gradient	Upwelling
	Water temperature gradient	Current and eddies
	Water colour	
	Wave refraction and colour tones	Bottom topography
	Ultraviolet or other vapour features	Oil slicks of petroleum origin or of fish origin

Earth Resources Technology Satellites

Sensor systems aboard the unmanned ERTS-A (Earth Resources Technology Satellite) flown in July 1972 is providing, and the manned Skylab/EREP (Earth Resources Experiment Package) to be flown in 1973 will provide, thermal and visual imagery applicable to oceanography. The mission of ERTS-A, to be followed by ERTS-B in 1973, is the repetitive acquisition of high resolution multispectral spectra of the earth's surface. The ERTS-A satellite carries two sensor systems one of which is a four channel Multi-spectral Scanner (MSS), while the other is a three-camera Return Beam Vidicon (RBV). Apparently the RBV system has been turned off due to some technical reasons; the performance of the MSS system has been reported as better than anticipated.

However, to use the information gathered from these programmes—ERTS-A, ERTS-B etc.—it is necessary to have data gathered simultaneously from *aircraft and ocean-craft over pre-defined test sites.* The data gathered from spacecraft, aircraft and ocean-craft then should be correlated with one another, so that scientists can draw reliable inferences about the appropriate ocean-craft data given only the spacecraft data. It is only then that the spacecraft data can be used efficiently for fisheries development and utilisation.

It is suggested that the Marine Biological Association take initiative and draw up plans for taking observations over specific sites in the Arabian Sea and the Bay of Bengal from aircraft and ocean-craft platforms simultaneously with the expected overflights of the ERTS-A, ERTS-B, EREP satellites over these areas during the years 1973 and 1974.

References

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