

WEALTH FROM THE SEA

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*I must go down to the sea again
To the lonely sea and sky,
And all I ask is an oil rig, an echosounder,
Some drill pipe, a license to explore,
Some straw bales,
And a slick to steer them by*

—With apologies to John Masofield
G.R.S. HAWKINS.

ONE of the well-debated issues in the world today are the ways in which the mineral resources of the oceans, after two-three decades, are going to supplement the rapidly dwindling resources of the land. As time passes, it is becoming increasingly clear that the alternate sources of almost all resources, both living and non-living, will largely come from the sea. The developed countries of the world had, several decades ago, started their quest for resources by undertaking oceanographic exploration of the seas bordering their countries. Today substantive quantities of oil, natural gas, sand, limestones heavy minerals, sulphur, potash are being recovered from the floor of the oceans.

In 1971, 18 per cent of oil (439 million tonnes) and 12 per cent of gas (167 billion cubic metres) of the total world production came from the oceans. More recent figures, although not yet fully established, are indeed far more impressive. Unlike the oil and natural gas, which have a high price per unit volume and which are not so uniformly distributed either on land or in the sea, the metallic minerals are low-priced and are found in varying quantities throughout the world. Despite their world-wide

distribution, the forecast puts an overall limit to many of these minerals on land. To meet the future needs of scarce minerals especially copper, nickel and cobalt, even deeper regions of the oceans (3000 to 5000 m), located thousands of kilometres away from the land mass, are being intensively explored.

Some of the significant mineral resources of the oceans, their methods of exploitation, the overall effect of their mining from the marine environment have been described in this article. The importance of this type of approach can be judged from the fact that India has no less than 2 million sq. km within its exclusive economic Zone of which 4,50,000 sq. km constitutes the continental shelf (Fig. 1).

A cross-section given in Fig. 2 shows the morphological features of the coast up to the deep ocean basin. A systematic scientific study of the vast region is at present being carried out by N.I.O. using the research vessel R. V. *Gaveshani* (Fig. 3).

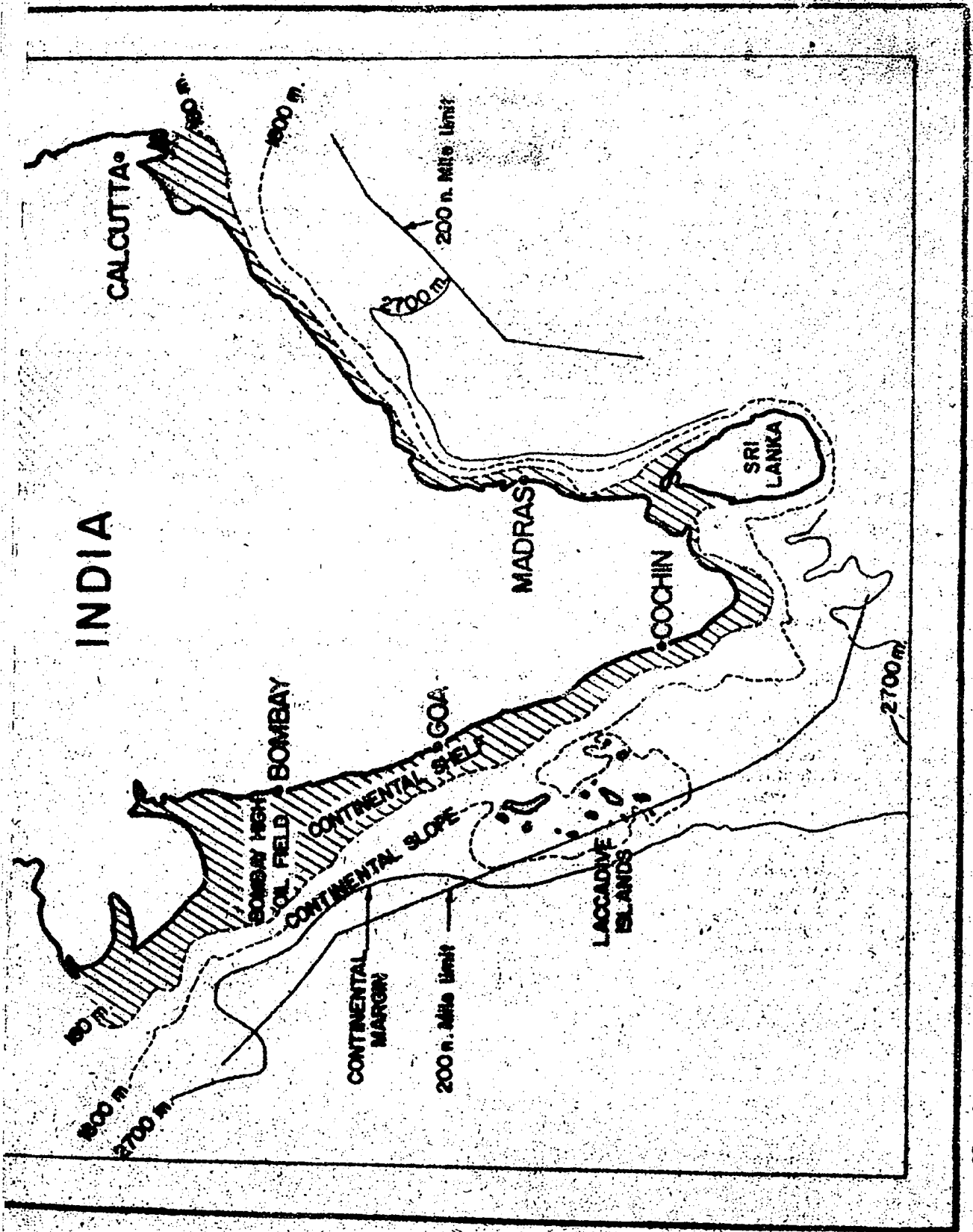
SEA BED RESOURCES

The sea bed contains a variety of mineral resources ranging from beach

sand and gravel, calcium carbonate heavy minerals, such as gold, diamonds, tin, monazite, phosphorus to subsurface resources of oil, gas, sulphur, coal, potash etc. Although this article gives much emphasis to the resources of the sea bed, we must not forget that the 330 million cubic miles of sea water in itself is enormous source of dissolved elements. From the sea water some of the substances such as common salt, magnesium, calcium and potassium compounds are being commercially extracted.

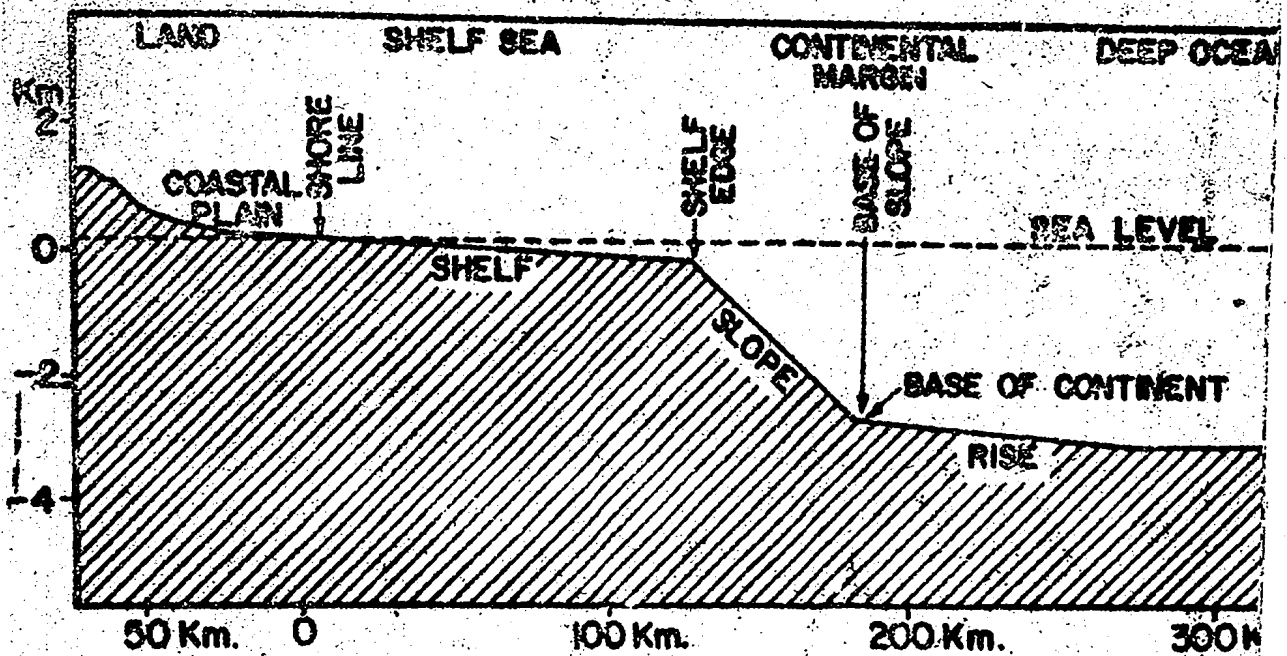
Precious metals like gold, silver etc. are also present in sea water but they are in extremely small quantities. Gold, for example, occurs at average concentration of 0.04 milligrams per ton and cannot be extracted economically at present.

Building material: Sand, gravel and limestone form the backbone of construction work in the industry. In quantity, though not in value, they constitute the largest commodity extracted from the ocean. They occur in the continental shelf throughout the world. Extensive deposits, spread over many thousands of kilometres, are found on the western shelf of India.



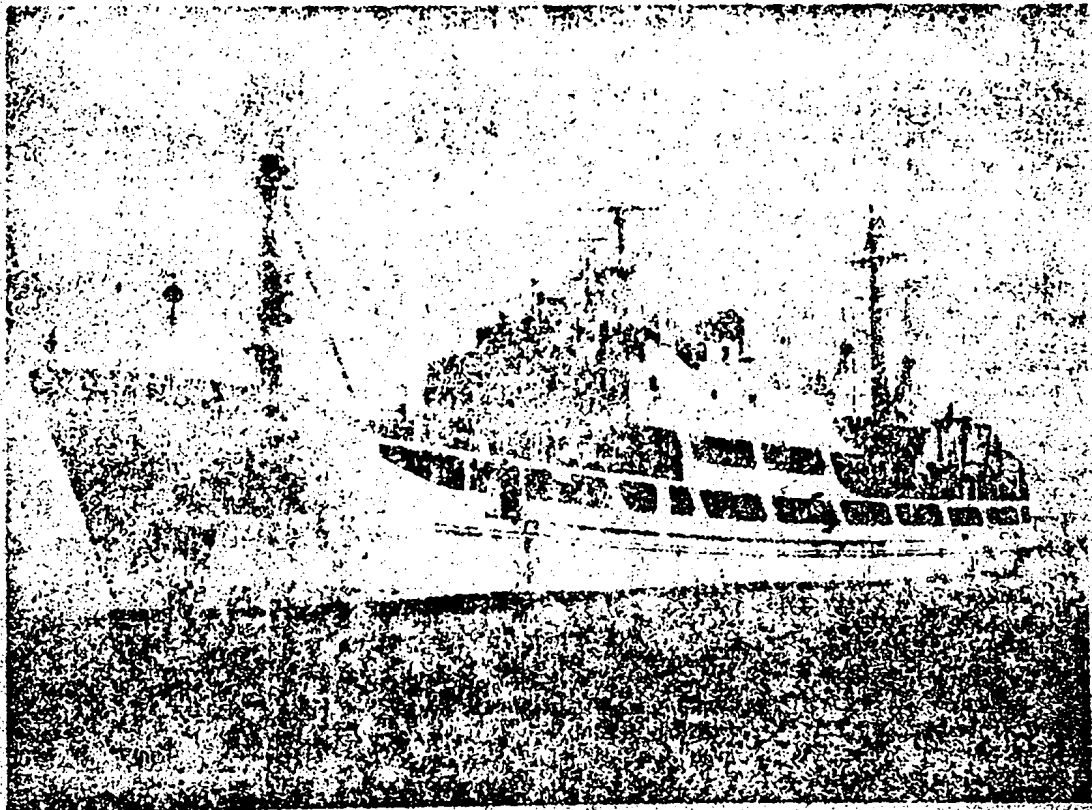
Map showing the continental margin of India which includes the continental shelf and slope off the west and east coast of India. The 200-mile Economic Zone limit from the mainland has also been shown.

FIG. 2

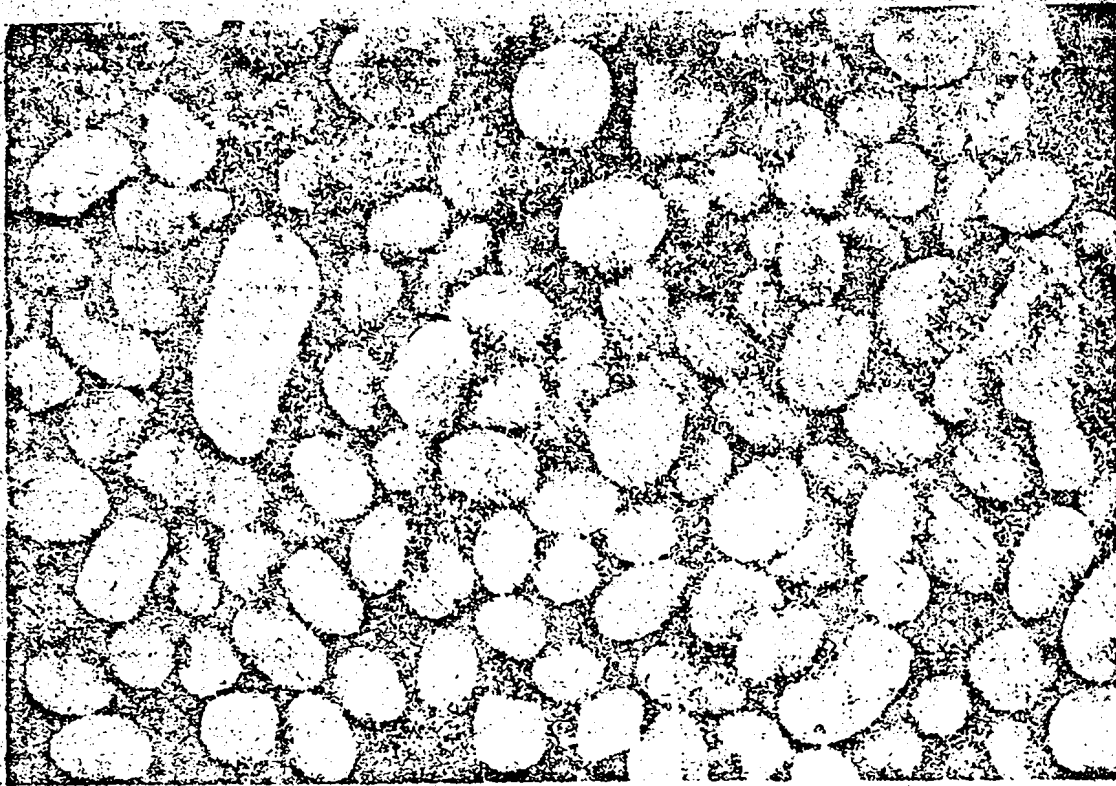


Cross section showing geomorphic features from the coast up to deep sea.

FIG. 3



R. V. Gaveshani, the first oceanographic research ship of India used by NIO for deep sea investigations.



Ooids (chemically precipitated calcium carbonate) from the western continental shelf of India.

These deposits ensure that resources are readily available for construction purposes and when needed in the future. Precipitated calcium carbonate is suitable for the chemical industry and is used in the form of Ooids (Fig. 4). These cover an area of about 50,000 square kilometres on the shelf off the west coast of India.

Heavy minerals: These minerals have a specific gravity greater than 2.5. The heavy mineral deposits of monazite, ilmenite and zircon occur as beach sands. These deposits have been known for a long time and are of considerable value. Extensions of these deposits occur quite commonly in deeper waters of the continental shelf.

One such deposit, which has recently been identified by the National Institute of Oceanography (NIO), is the extension of the ilmenite beach placer into the deeper waters of the various bays along the coast of Andhra Pradesh. The geological exploration in deeper waters of the continental shelf (62 to 109 metres) indicates the widespread occurrence of several heavy

minerals in the shelf regions of Karnataka and Kerala.

Phosphorite: It is mainly composed of calcium phosphate and can be utilized as an important raw material for the manufacture of agriculture fertiliser. Phosphorite is formed as a result of precipitation of phosphate from sea water and is deposited in the form of nodules, slabs, coating on sand grains or as rock fragments. Large areas of the ocean floor are covered with phosphorites and an estimated 300 billion tonnes are found on the continental shelves of the world. Their occurrence usually coincides with such regions where upwelling of oceanic water occurs.

Well-known areas of substantial deposits of phosphorite are off South Africa, north-west Africa, east and west coast of North and South America. Phosphorite is a mineral, particularly valuable to India because a large part of its requirements is met at present through imports. Deposits of offshore phosphate are being actively explored by NIO, particularly off the west coast of India

which is well-known as a region of upwelling.

Manganese nodules: These nodules are composed largely of manganese, copper, nickel and cobalt. Much of the interest on manganese nodules in recent years has been due to their copper, nickel, and cobalt content which are in short supply in the world. The nodules are found in deeper regions of the ocean at depths of 3,000 to 6,000 metres. Like phosphorites, they are formed as a result of precipitation from sea water and their occurrence in the nodular form is most common in the sea, although slabs and coating of these are also found on the sea bed.

At the sea bottom, the nodules continue to grow but very very slowly, at the rate of 2 to 8 mm per million years. Of all the three major oceans, the Pacific Ocean is known to be the richest source of nodules and this ocean alone has been estimated to contain as much as 1,600 billion tonnes of manganese nodules.

A typical nodule from the Pacific is composed of Mn: 13 to 30 per cent

by weight, Co: 2000 to 7000 ppm, Cu: 700 to 10000 ppm, Ni: 1200 to 12500 ppm. Though potentially very attractive in view of the availability of nodules in very large quantities, there is a large variation in their density in the sea, i.e. weight of nodule per unit area of the ocean floor. There is also a wide variation in the chemical composition of the nodules from one region to the other.

These features make the commercial exploitation of nodules a somewhat risky venture. Added to these are the constraints of unsolved problem of ownership of these deposits as they are found far outside the economic zone of most countries.

The large occurrence of these polymetallic nodules in the Central Indian Ocean, is of much interest to India on a long-term basis. In composition, the Indian Ocean nodules are similar to those of the Pacific equatorial nodules. In view of this, an extensive programme of nodule exploration is presently being formulated by NIO.

Petroleum: In many ways, oil and natural gas form the most spectacular mineral wealth of the sea. However, highly sophisticated engineering technology and vast sums of money are required for the recovery of petroleum from the offshore areas. The prevailing regional imbalance in the location of major oil fields (the giant oil fields are mostly located in West Asia, South America and the USSR), and an ever-increasing rate of consumption of oil and gas in the world, have resulted in a concerted effort by many nations, including India to search for oil and gas in deeper areas of the sea. As the depth of water increases, the marine environment becomes more and more hostile for the exploitation of these resources.

In 1976-77, about 160 offshore wells were drilled in the world at water depths greater than 200 metres. In 1977-78, the record of water depth for drilling was 456 metres. This was increased to 600 metres by the use of semi-submersible rigs. With the discovery of Bombay High and Bassein oil fields, a promising beginning has been made in India. When fully developed these oil fields would become a major source of oil for the country. Both these oil fields are found in the shallow waters of the shelf.

Exploration cost of oil in the sea is less than that on land but drilling cost in offshore areas is much higher. Thus the total development of an offshore well may cost as much as 3 million dollars. By 1980, the offshore production of oil in the world is expected to reach 20 million barrels per day. The rate of production in the future will further increase substantially as it is estimated that about 25 per cent of the world's prospective oil basins lie offshore in water depths of less than 300 metres.

EXTRACTION TECHNOLOGY

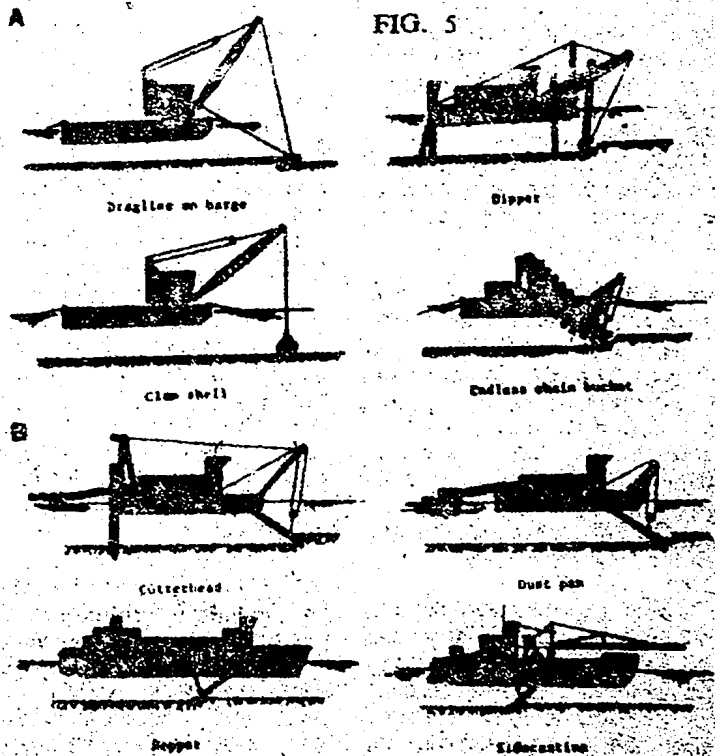
The technology of offshore mining of unconsolidated mineral deposits such as sand, limestone, tin, phosphorite, diamond is essentially based on the principle of dredging. Some of the dredges have been designed in such a way that they dig and scoop the sediment at the same time, while the others use hydraulic pumping or air-lift systems (Fig. 5). Continuous line-bucket systems are used for the recovery of manganese nodules.

Shallow water (less than 50 metre in depth) and protected bays in coastal areas offer the best opportunities for safe mining operations. Deeper

waters, on the other hand, require extensive and very reliable meteorological and oceanographic data planning and implementing an efficient and safe operation. The importance of these vital oceanographic data is well appreciated when it is known that a dredging plant operated at the sea surface undergoes various forms of movements such as heave, pitch, roll, sway, yaw and surge.

Such movements and the associated stresses and strains on the plant may say the least of persons on board impose severe limitations on the work carried out at sea.

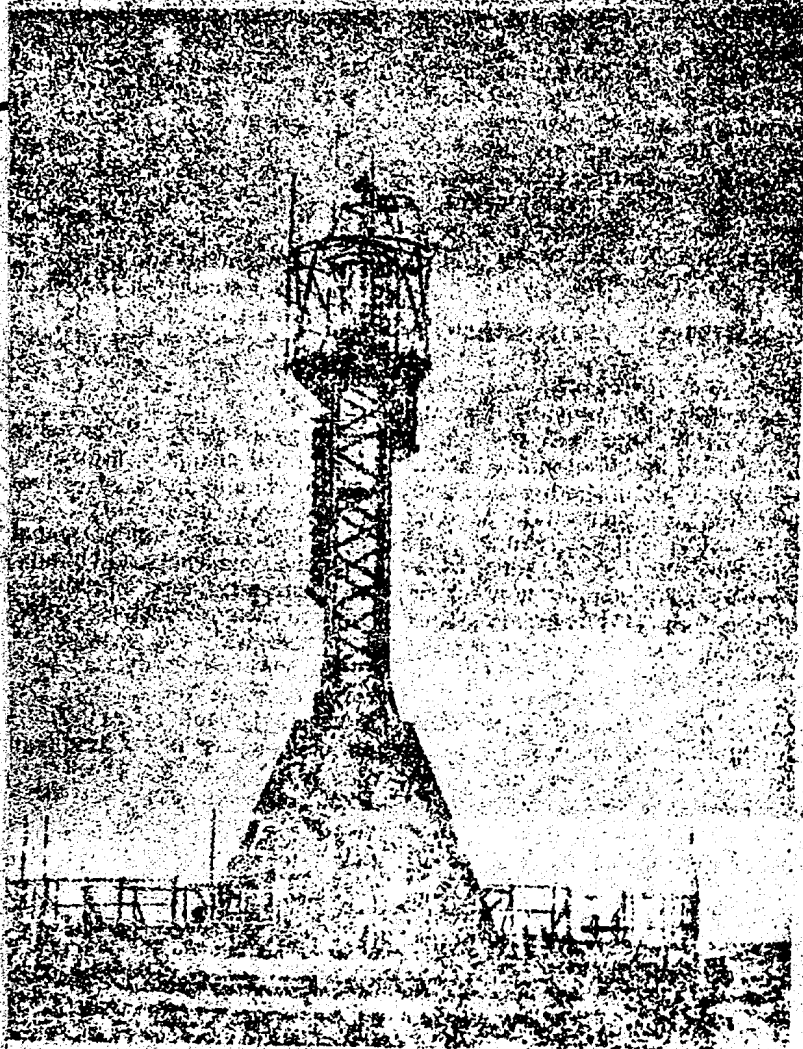
Dredging for the maintenance of navigational channels, prevention of harbour siltation and several other aspects are being intensively undertaken in India and a similar technology at an advanced level could be adopted for offshore mineral mining. Detailed environmental data, meteorological and oceanographic conditions can easily be obtained from the India Meteorology Department (IMD) and NIO as has been done in the case of offshore exploration and production of oil. Long term collection and transmission



Mechanical and hydraulic dredges used for the extraction of unconsolidated minerals (sand, tin, heavy minerals, diamond, phosphorite, manganese nodules etc.) from the sea bed.

FIG. 6

SEAN METEOROLOGICAL DATA AND MAJOR NAVIGATIONAL BUOYS



A typical data buoy for the collection and transmission of oceanographic and meteorological data.

data are being carried out using oceanographic data buoys (Fig. 6).

Offshore drilling technology for oil and natural gas is considerably more complex than the dredging used in the exploitation of unconsolidated sediments from the sea bed. The basic drilling rig, similar to that used on land, is either installed on fixed platforms constructed on piles driven into the sea floor or on a jack-up rig which, when drilling is completed, is moved to another location.

Alternatively, the drilling rig is mounted on a ship called "drill ship" (Fig. 7) which is provided with dynamic positioning systems to hold the ship in position very accurately during the course of drilling. Multiple 10 tonne anchors are also used for stabilising such ships. After the drilling is over and if the well is found productive, permanent production platforms (surface or underwater, depending on the water depth) are installed. The oil and gas is then piped through submarine pipelines, either laid at the surface of the sea

floor or buried a few metres in the sea bed up to the shore terminal where refining of the offshore crude is directly undertaken. A submarine pipeline more than 160 km. long from Bombay High oil field to Bharat Refinery in Bombay has been laid by the Oil and Natural Gas Commission (ONGC). The survey and alignment work of this pipeline were conducted by NIO.

Ecological impact of offshore activity: Marine environment is highly dynamic and has considerable built-in resistance.

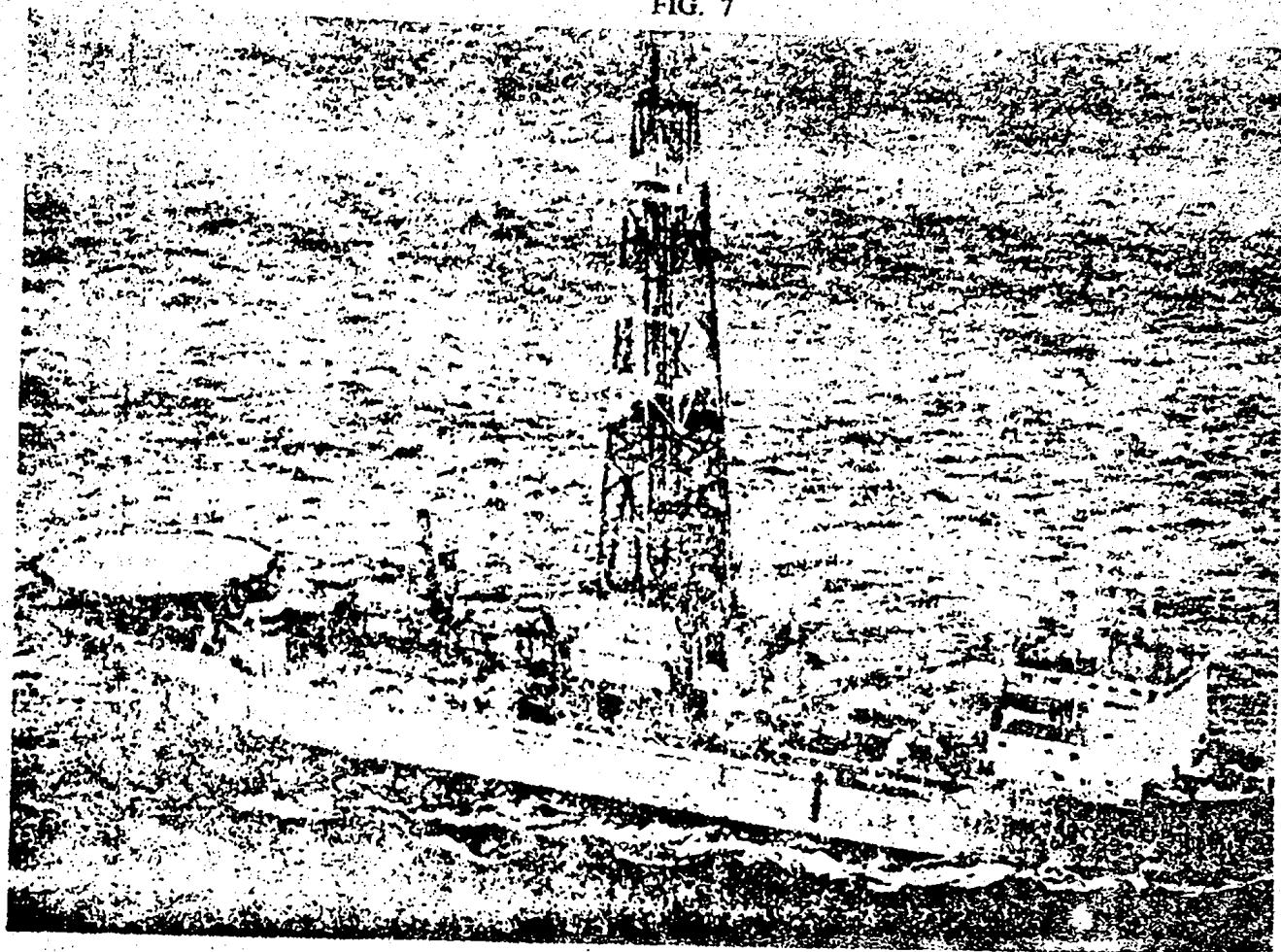
Nevertheless, because of the increase in various kinds of offshore activities—several of which could be mutually conflicting in nature—a great deal of concern has been shown in recent years regarding the health of the sea. The problem of protection of marine environments is being discussed in various national and international bodies and numerous recommendations and regulatory measures are being developed to ensure that the oceans do not suffer adversely.

Some of the more obvious results of offshore mining by dredging or similar activities are the disturbances caused to the bottom fauna. Many of these bottom animals have considerable commercial value. The increase in the turbidity of water caused by the stirring up of sediments or by the release of dredged material at the surface during the course of mining operation, may lead to a reduction in biological productivity of the water column.

However, it is unlikely that these effects can cause significant damage to the environment because most mining operations are highly localised and the disturbance at times tends to be beneficial since more nutrients are released to the water column from the freshly re-suspended sediments.

The production and transportation of oil has created some serious environmental problems in the sea. The much publicized Torrey Canyon disaster which spilled about 1,00,000 tonnes of crude oil in the near shore water of Britain and France is frequently cited by ecologists as a rule rather than an exception. The Ekofisk Bravo incident in the North Sea spilling less than a quarter of the Torrey Canyon spill was set right without any lasting damage to the environment.

FIG. 7



A drill ship for drilling of oil in offshore areas.

TABLE 1

NATURAL AND ARTIFICIAL SOURCES OF OIL IN THE SEA

Ballast and wash water from tankers	
(a) non-load on top	670,000 tonnes
(b) load on top	120,000 ..
Machinery space bilges	24,000 ..
Accidents to ships	
(a) tankers	135,000 ..
(b) other vessels	23,000 ..
Effluents from shore/mainland	500,000 ..
Offshore drilling & production	34,000 ..
Natural sources	500,000 ..

Random accidents of this nature are bound to happen but some of these appear to have been far too exaggerated. A realistic evaluation given in Table 1 clearly indicates that out of the 2,000,000 tonnes of oil finding its way into the sea every year as a result of various human activities, only 2 per cent (30,000 tonnes/year) can be attributed to offshore drilling and production. The rest (about 1.4 million tonnes/year) is because of other activities associated with shipping. Nevertheless, contingency plans for tackling accidental oil spills during production and transportation are very necessary.

Innovative technology appropriate to Indian conditions to safeguard the seas around India is being developed by NIO under the sponsorship of ONGC. These include theoretical investigations of spilled oil movement on the seas during various seasons under different weather conditions and the evaluation of efficiency of various dispersants for the removal of oil.