

Bio-Indications of Sunken Ships and Ship Wrecks

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An evaluation of bottom fauna of ship-wreck sites in estuarine and coastal waters of Goa, revealed an exceptionally high biotic enrichment. In terms of number of species, faunal dispersion, faunal diversity, biomass and productivity, in space and time, the values for richness and heterogeneity in benthic macrofauna were generally higher at ship wreck sites than at close proximity natural sites. Rationale of using biotic factors as indicators of modification of submarine biotopes due to ship-wrecks and other man-made objects is discussed.

INTRODUCTION

Habit and habitat preference in marine biota, both sedentary and mobile, has a direct dependence on the type, location and environmental set-up of an ecosystem. Since the biota of the seafloor, technically referred to as benthos, is largely dependent on the local topographical characteristics, the distribution, abundance, diversity and productivity exhibit changes as the nature of submarine topography is modified (Heirtzler 1982). In the subtidal realm, it has often been observed that besides the natural topographic features like sea mounts, banks and ridges, the man-made structures e.g. artificial reefs, jacked-up platforms, and sunken ships, often support unusually rich and diverse biota (Ranasinghe 1981).

OBSERVATIONS

The causes for extraordinarily high enrichment of subtidal ecosystems have not properly been understood. However, many instances of such modified habitats, both in the inshore and oceanic waters of the Exclusive Economic Zone (EEZ) of India, as elsewhere in the world oceans, are on record.

While studying the bottom fauna of the Arabian Sea Parulekar (1976) reported the unusually high benthic biomass in the environs of continental islands of Karwar group (Lat. 15°43' - 15°55'; Long. 74°00' - 74°10'E) and St Mary Isles (Lat. 13°15' - 13°25'N; Long. 74°40' - 74°47'E). However, the factors causing such an enrichment, could not be properly understood.

Recent surveys on submerged banks in the Arabian Sea, further highlighted the significance of submarine topographical features in the ecology, richness of biota and biological processes. A dredging survey of the Angria Bank (Fig. 1) revealed the high enrichment of flora and fauna at depths of 20-73m in an oceanic environment, with water column of 820m. While the total number of floral species were 57 (Un-

tawale et al 1989), the faunal species, excluding finfishes and other nektonic forms, but including rich representation of sponges, corals, worms and shells, were 89. Similarly, in surveys on other submerged banks in the Arabian Sea (Fig. 2), 73 species of algae (Untawale - personal communication) and 115 species of unique fauna, have been recorded from Sassostris (Lat. 12°59' - 13°13'N; Long. 71°51' - 72°05'E); Bassas de Pedro (Lat. 12°31' - 13°38'N; Long. 72°16' - 72°46'E) and Cora Divh bank (Lat. 13°33' - 13°52'N; Long. 72°04' - 72°15'E). The ecological characteristic of these oceanic banks, in the Arabian Sea, have less varying to stable conditions of temperature, salinity and dissolved oxygen (Nair et al 1966).

A comparison of faunal richness of the oceanic banks, continental islands (Parulekar, *op. cit.*) and submerged rocky basement (Parulekar 1981), with the benthic fauna of the environs of such ecosystems, revealed (Parulekar et al 1982), the magnitude of enrichment, which was manifold more in the modified substratum than in the natural bottom deposits.

A CASE STUDY

Recently, while going through a publication (Rao and Gudigar 1988) on the underwater cultural heritage of the Indian Ocean islands, an illustration showing the sites of ship-wrecks in the coastal waters of Goa (Fig. 3) prompted, the author, to make an attempt to evaluate the ship-wreck sites from a biological angle and to ascertain whether a ship-wreck induced changes in benthic substratum results in the enrichment of biota.

Data, from published (Parulekar 1973; Parulekar and Dwivedi 1974; Parulekar et al 1975; Parulekar et al 1980; Harkantra and Parulekar 1981 and Parulekar et al 1982) and unpublished sources are used here to compare the distribution, abundance, diversity and productivity of benthic or seafloor fauna at and around ship-wreck sites with the clean or natural sites in close proximity. All the ship-wreck sites are indicated (A), (B), (C), (D), and (E) as in Fig. 3, and

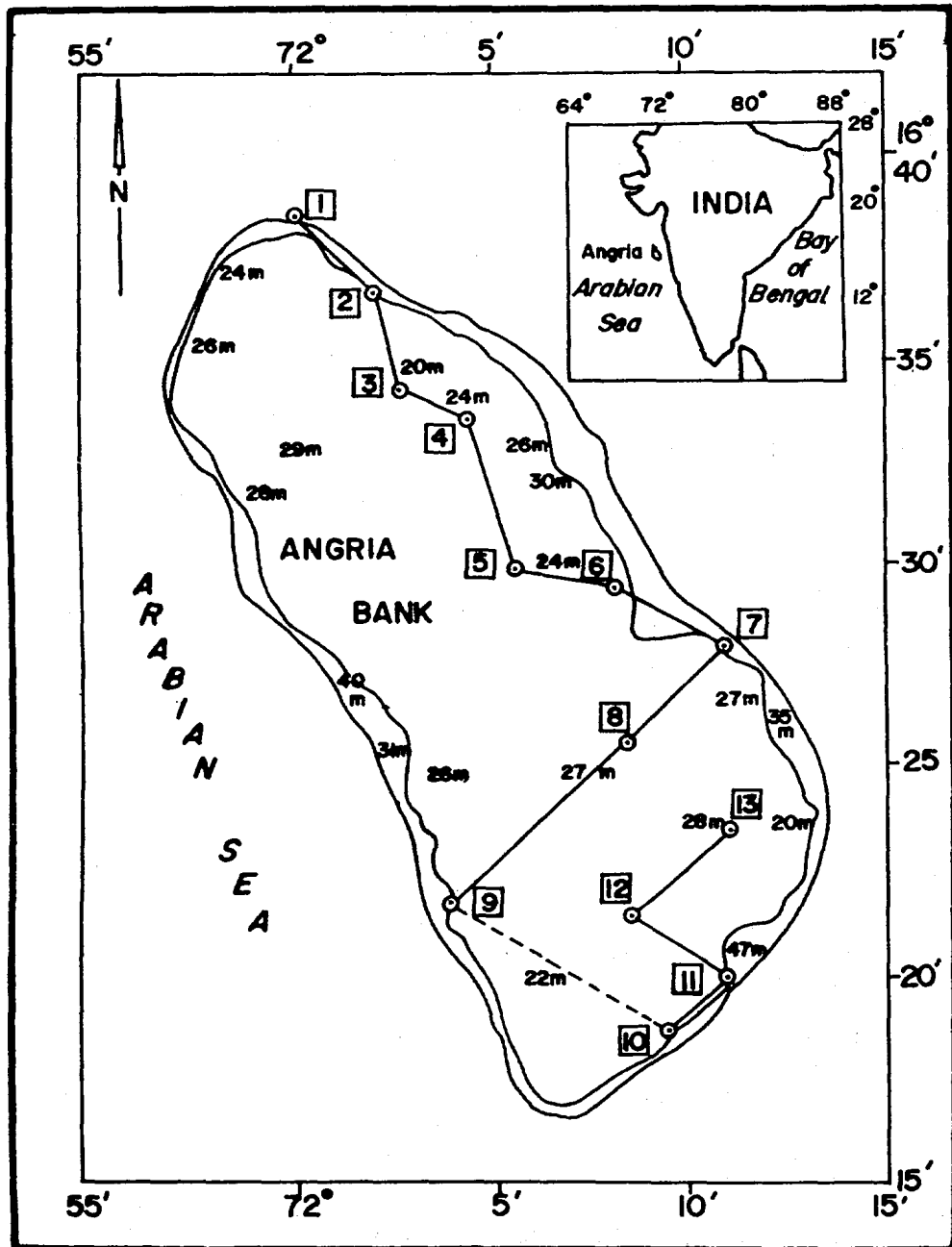


Fig. 1 Angria Bank topography with depth profile and sampling track with stations (box).

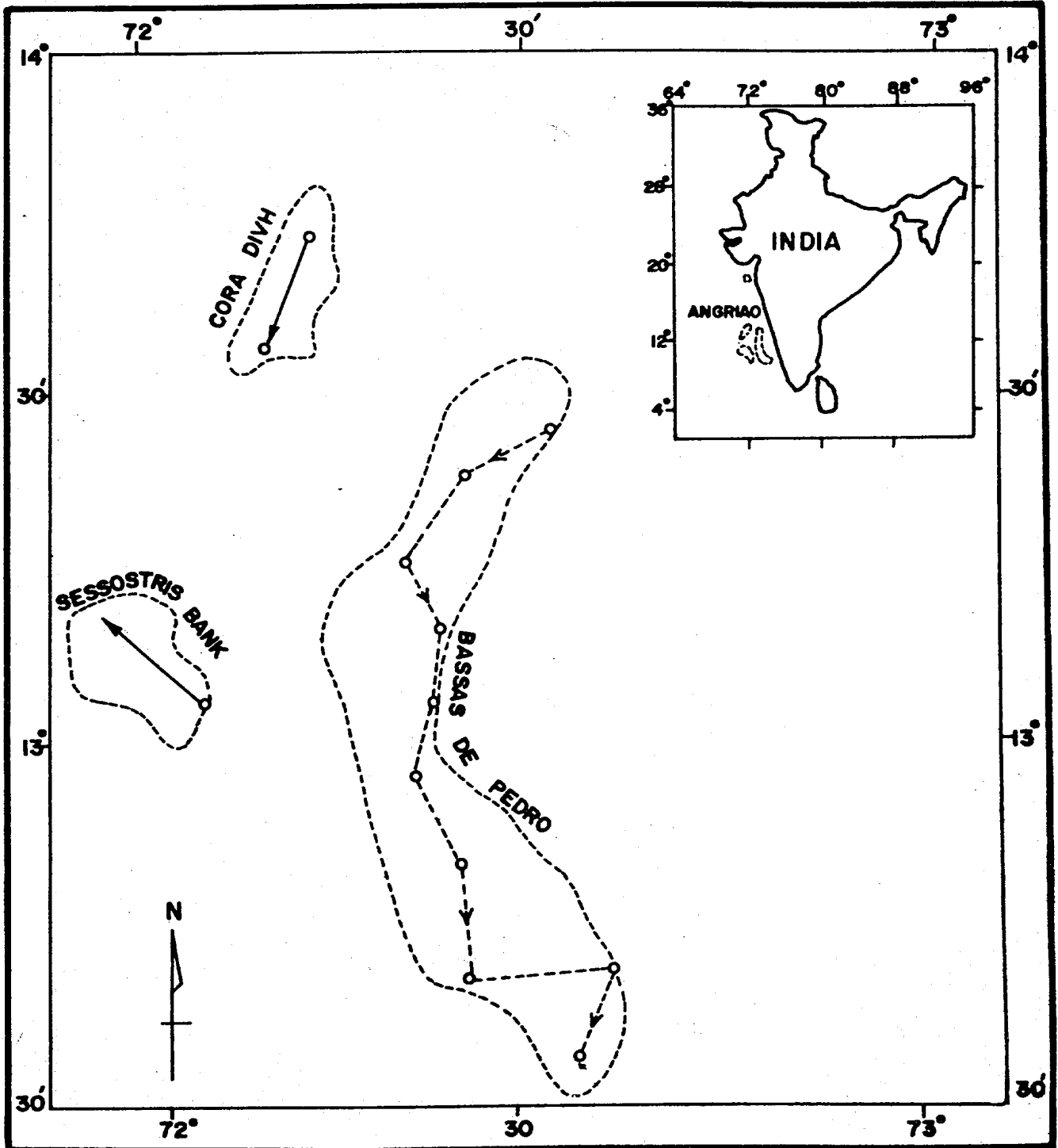


Fig. 2 Location and sampling track at submerged banks in the Arabian Sea.

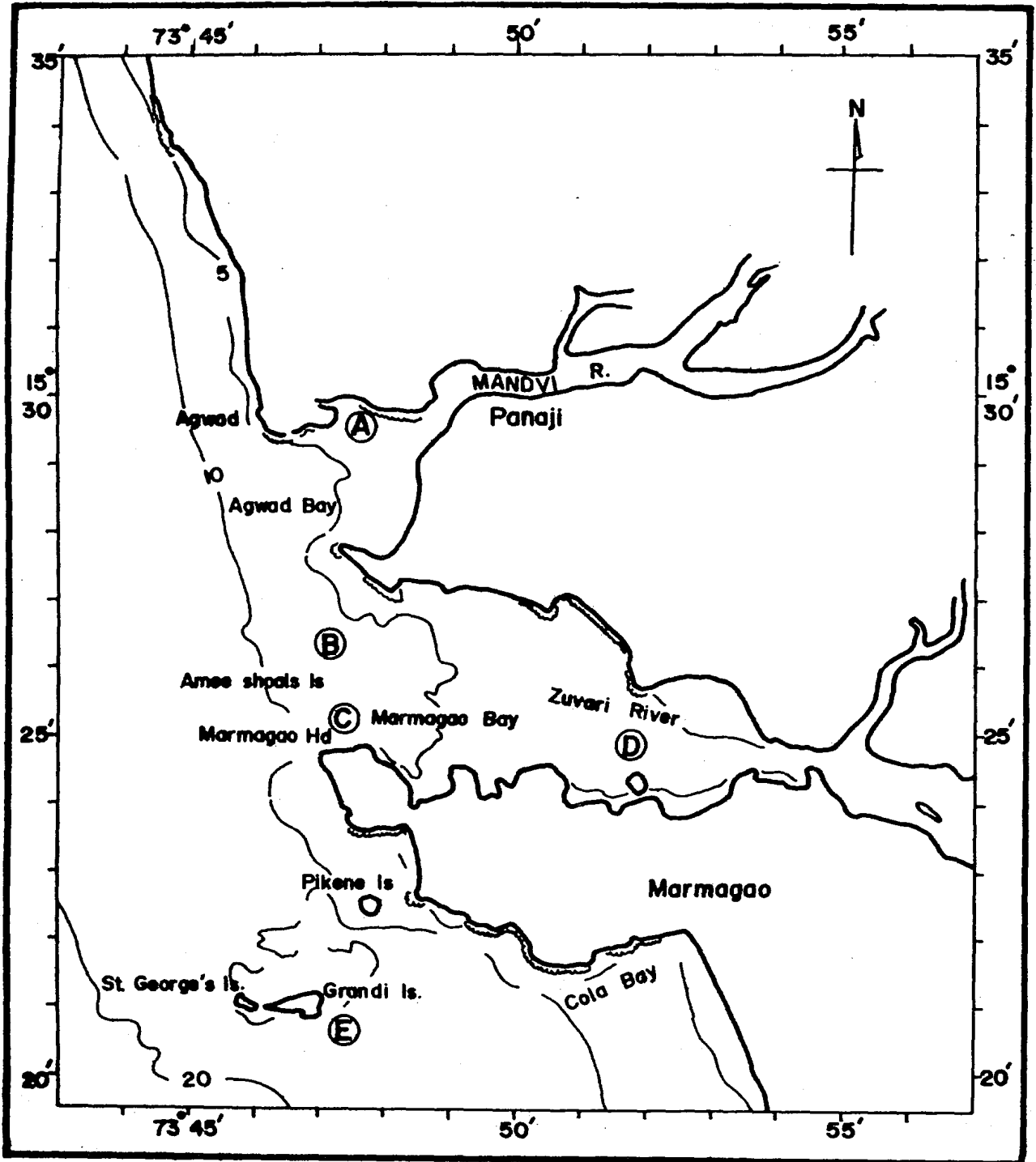


Fig. 3 Observation points (A to E) in Goa waters.

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the natural sites denoted as A1, B1, C1, D1 and E1 (Table 1) were less than 750 m in one or other direction from the shipwreck site. Thus, A1 was 500 m east of (A); B1 was 650m north of (B); C1 was 600m west of (C); D1 was 500m west of (D) and E1 was 700 m east of (E).

The comparison (Table 1) was made by evaluating the annual mean at ship-wreck site and adjoining natural sites in respect of the following biological parameters pertinent to benthic macrofauna:

- Total number of species in space and time
- Dispersion of species and biota in space and time
- Diversity of macrofaunal species
- Population density of macrofauna in space and time
- Biomass or standing crop in space and time
- Rate of production of macrofauna in unit area and in unit time

A perusal of data in Table 1, reveals that at ship-wreck site, the biotic-enrichment, as measured in terms of distribution, dispersion, diversity, abundance and productivity of benthic or bottom macrofauna is many times more than at clean sites, where presumably, the submarine features are in their natural and unaltered state. On all counts of six parameters taken for comparison (Table 1), the sites with modified substratum due to the sitting of ship wreck can distinctively be delineated on the basis of biological indications relevant to richness, heterogeneity and productivity of bottom living macrofauna. The preference for submarine substratum, as assessed from the dispersion values, which explains the distribution, similarity and association of biota, was more specific in relevance to ship-wreck sites than the natural sites. The spatial variability in the availability, abundance and variety of benthic macrofauna, as observed at ship-wreck site (Table 1), further reflects on the importance and significance of substratum in natural and modified benthic ecosystems.

RELEVANCE

What attracts marine organisms to natural and man-made submarine topographical features still remains unanswered, inspite of numerous studies (Ransinghe *op. cit.*). Some of the earlier studies assumed that it is the food production which acts as an important factor for aggregation and overall biotic enrichment. However, habitat enhancement is one of the important causes of biotic enrichment of submarine substratum (Walton 1962).

A wide variety of environmental factors play an important part in attracting biota to submerged structures such as sunken ships, artificial reefs and jacked-up offshore platforms (Okamoto 1983). Many factors like light, temperature, water motion, sedimentation, substratum size and rugosity, depth, sand scour, presence of microflora, species composition and cover of the attached community, grazing/cropping

Table 1: Comparison of biotic Enrichment, Between ship-wreck site (A to E) & Natural sites (A1 to E1) In respect of Distribution, Dispersion, Diversity, Abundance and production of Bottom Macrofauna. (Annual Mean Values)

Parameter	A	B	C	D	E	Shipwreck site
	A ₁	B ₁	C ₁	D ₁	E ₁	Natural site
Species (nm ⁻²)	47→ 16	45→ 18	23→ 8	20→ 6	29→ 12	
Dispersion (l)	4.9	2.3	6.8	3.1	4.8	
	2.1	1.4	3.8	1.7	2.7	
Diversity (d)	6.46	4.82	4.13	3.76	3.09	
	3.76	2.47	2.78	1.81	1.78	
Population						
Density (nm ⁻²)	3901	2211	4382	1350	2242	
	1169	1201	2242	523	1087	
Biomass(gm ⁻²)	170.19	30.02	138.17	32.57	34.16	
	44.50	17.11	34.16	17.97	22.64	
Production (gCm ⁻²)	12.20	3.18	6.61	2.87	3.01	
	5.40	1.95	2.54	1.92	2.54	

by herbivores and omnivores (Carter et. al. 1985) can singly or jointly cause the enrichment or defaunation of the submarine substratum. While studying the effects of substrate rugosity, percent substrate cover and vertical relief on resident fauna of varying substrates, Chandler et al (1985) inferred that midwater structures help to attract greater number of species than the natural sea bottom. Small coral patches, rocky outcrops or oyster rocks and man-made objects provide structural complexity to the substrate as wave patterns get altered, redirecting waves into ecologically sensitive sites (Burchmore et al 1985) and generating a localized eddy circulation, which helps in concentrating the nutrient supply and thus supporting an exceptionally high biological productivity. Buckley and Hueckel (1985), while studying the rate of development of biota on an artificial reef observed that the algal colonization was a major contributor to the physical structure followed by increased habitation by small invertebrates.

While the submarine features, viz. banks, mounts, ridges, natural and artificial reefs increased availability and abundance of biota, no enhancement in net production was observed in studies on artificial reefs in France (Beguery 1974). Similarly, Burchmore et al (*op. cit.*), did not find any significant difference in species richness, evenness and heterogeneity between the artificial and natural sites, though values for richness and heterogeneity were generally higher at artificial sites. Walton (*op. cit.*) found about four times the population density and nine times the biomass of biota on artificial reefs relative to open bottom areas.

In the present study, the magnitude of richness as assessed from number of species, dispersion pattern, diversity index, abundance, standing crop or biomass and rate of production

was twice as high in shipwreck than at the natural sites. Conclusively, it can be recorded that modification of submarine substratum due to sunken ship, induces and supports biotic enrichment.

A point that emerges from the results of the present case study is whether, the biotic enrichment can serve as a valid indicator of shipwreck sites and, if yes, how precisely?

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DISCUSSION

Q: Dr. Gangadharam: Biota are nutritionally dependent and temperature dependent; to what extent can these two factors interfere in projecting backward their relative population and applying it to wreck identification and location?

A: Parulekar: The biota is definitely food dependent. They always display different food habits and a preference for particular food, but as regard the temperature dependence, specially in the tropical marine biota, they seem to have an upper limit of withstanding temperature variations. They can withstand 24-34° temperatures but the upper critical limit is 42°C. The reasons which we want to give for enrichment of submarine ridges, banks, seamounts and shipwrecks with that particular structure, in a particular environment is that it alters the natural physiochemical set up and gives rise to local eddy circulation wherein all organic matter comes into a small gyre. This concentration of organic matter is manifested in high values of C that we find. Daily productivity 450mg/day when in the near vicinity and less 30mg C/day. Trigger fish and Scorpion fish cannot eat this phytoplankton but they feed on herbivores which feed on the phytoplankton; otherwise these animals are only found in pockets. This is a cursory observation without much scientific thought. Future data collected should provide indicators for biological phenomena.

Q: In the 1st Marine Archaeology Conference a paper on the 'Risdan shipwreck', pictures were shown of timbers taken

from the same wreck in which the timbers were perforated by wood borers but the tusks were not perforated by wood borers. Within the same wreck there was a difference could, you explain it?

A: Parulekar: Dr Shantakumaran (Wood Preservation Group N.I.O.) could explain it better. Perhaps in some tusks the activity was at a minimum because conditions for the wood borers to operate were not optimum.

COMMENTS

Shantakumaran: In the same wreck if some timber is damaged i.e. if some timbers are attacked and others are

not, it only indicates the pressure of larger organisms on the timber. Or the timber may be buried in some silt.

Sila Tripathi: Has the use of seaweed for medicinal purposes been mentioned in ancient literature?

A: Parulekar: The main objective of our underwater studies is application to the biomedical field, Now as history goes I am not so sure about the seaweeds. As early as 3000 years ago the Arabs used a Nereid worm as an efficient anti-helminth (round worm). This impairs human health though. Secondly in Japan the seaweeds are eaten especially the variety which is rich in protein. It has an abnoxious taste. They are however rich in halogenated compounds. Iodine controls proper function of thyroid and deficiencies can be controlled.