

Otoliths in Continental Shelf and Slope Surficial Sediments Off Saurashtra, Arabian Sea, India and their Significance

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ABSTRACT

Otoliths are a viable and underutilized paleoceanographic tool. In India a considerable amount of work has been done on otoliths of the fresh water fishes, however no significant report is available for marine otoliths. In the present study, about 89 surficial sediment samples from the shelf and slope region (depth upto 1000 m) off Saurashtra, Arabian sea were examined to study the otoliths. The study revealed the existence of a number of species belonging to 21 genera viz. *Acropoma*, *Apogon*, *Ariosoma*, *Benthoosema*, *Bregmaceros*, *Callionymus*, *Ceratoscopelus*, "*Clupeidarum*", *Diaphus*, *Electrona*, *Epinephelus*, *Gobius*, *Hygophus*, *Morone*, *Myctophum*, *Notoscopelus*, *Pomadasyd*, *Protomyctophus*, *Scopelogadus*, "*Serranidarum*", *Vinciguerria*. The species identification is in progress and will be reported in due course. This preliminary report which is the first report from the northern Arabian Sea on fossil fish otolith may help as an additional tool in the reconstruction of paleoenvironment and in assessing the latitudinal distribution of fish stock in the past. This study may be of some help in deciphering the movement of fishes with respect to global warming associated with Green House Effect.

Key Words : Otoliths, Continental Shelf, Slope, Saurashtra, Arabian Sea, India.

INTRODUCTION

Global variations of sea-level are viewed in the light of their behaviour in the recent past and possible consequence of a future rise that may be accelerated by the Green House Effect. There are evidences of sea-level changes in the past few thousand years not only globally but also along the west coast of India. It is important to analyse the changes that took place over this region after the last glacial maximum (LGM) to understand the present and to anticipate the future. A vast amount of such information is stored in the remains of fishes. In the food chain the fishes form a major contributor to the marine ecology. The west coast of India is not only rich in its mineral resources but also contributes a major portion through fisheries to the economy of our country. A slight change in the climatic conditions will lead to the migration or extinction of these fishes, which would in turn affect the economy of the country. No direct data is available to understand the migratory changes of fishes in the past, but some amount of data has been stored in the hard parts of fishes known as otoliths. Otoliths which are calcified concretions found within the membranous labyrinth of bony fishes have been studied by ichthyologists, micropaleontologists and fisheries biologists for well over a century. Otoliths are typically composed of 99% aragonite contained in an organic matrix (Kalish, 1993). Fishes have three pairs of otoliths. The largest of the three pairs of otoliths, called saggita, typically exhibits a species specific shape (Fitch and Brownell, 1958; Casteel, 1976). Otoliths are useful in determining the age of fishes by counting the growth rings or seasonal bands on its outer surface. Oxygen isotope studies on

otoliths help the paleontologist in determining the paleoclimate/ paleotemperature, and are as useful as foraminifera and other calcium carbonate bearing shells (Nolf 1995; Elder et al., 1996). Like the foraminifera the otoliths are found in a wide spectrum of sedimentary environment and are very common fossils in many marine sediments.

This is the first study to assess the potential for using otoliths as paleoceanographic tool on the west coast of India (Off Saurashtra, Arabian Sea).

MATERIALS AND METHODS

As a part of National Institute of Oceanography's research project "Foraminiferal distribution in surface and subsurface sediment samples along the west Coast of India", a number of surficial sediments were collected using Peterson Grab Sampler during various cruises of R.V.Gaveshini at depths ranging from 50 to 1000 m. These sediment samples were processed in the laboratory by soaking the sediment samples in water along with hydrogen peroxide and sodium hexametaphosphate (few drops) to disintegrate the organic matter and clay particles respectively. The sediment sample was then washed through 63 μ m sieve using a slow shower. The 63 μ m fraction was oven dried at a temperature between 50 and 60°. The dried samples were again passed through a 850 μ m sieve to separate the fine from the coarser fraction. The >850 μ m fraction was scanned thoroughly for larger foraminifera and it is in this fraction that otoliths which have been used in the present study were found.

RESULT

The results revealed rich otolith fauna composed of 21 genera (Table 1) belonging to 12 families as given below:

Family : Myctophidae Gill, 1893

Genus : 1. *Benthosema* (Plate 1, Figs. 6-12)

2. *Diaphus* (Plate 2, Figs. 3-12)

3. *Electrona* (Plate 3, Figs. 1&2)

4. *Myctophum* (Plate 1, Figs. 13-16;
Plate 2 Figs. 1-2)

5. *Hygophus* (Plate 2, Figs. 13-15)

6. *Notoscopelus* (Plate 2,
Figs. 16-19)

7. *Ceratoscopelus* (Plate 3,
Figs. 5-8)

8. *Protomyctophum* (Plate 3,
Figs. 3-4)

Family : Serranidae Swainson, 1839

Genus : 9. *Epinephelus* (Plate 3,
Fig. 9)

10. *Morone* (Plate 3, Fig. 16)

11. "*Serranidarum*" (Plate
3, Fig. 10)

Family : Gobiidae Bonaparte, 1832

Genus : 12. *Gobius* (Plate 4, Figs. 9-
14)

Family : Bregmacerotidae Gill, 1872

Genus : 13. *Bregmaceros* (Plate 3,
Figs. 12-15)

Family : Apogonidae

Genus : 14. *Apogon* (Plate 3, Figs.
17-20 & Plate 4,
Figs. 1-4)

Family : Clupeidae Cuvier, 1817

Genus : 15. "*Clupeidarum*"
(Plate 1, Figs. 2-3)

Family : Callionymidae Bonaparte, 1832

Genus : 16. *Callionymus* (Plate 4, Fig. 5)

Family : Pomadasysidae Regan, 1931

Genus : 17. *Pomadasys* (Plate 4, Fig. 8)

Family : Photichthyidae Weitzman, 1974

Genus : 18. *Vinciguerria* (Plate 1, Figs. 4-5)

Family : Congridae Kaup, 1856

Genus : 19. *Ariosoma* (Plate 1, Fig. 1)

Family : Melamphidae Gill, 1892

Genus : 20. *Scopelogadus* (Plate 3, Fig. 11)

Family : Acropomatidae Gill, 1891

Genus : 21. *Acropoma* (Plate 4 Figs. 6-7)

The species identification is in progress and will be reported in due course of time. Based upon species

identification from otoliths Fitch and Brownell (1958) have been able to indicate the water depth and characteristics in the area of deposition as well as increases in the ocean temperature indicated by a northward extension of more southerly species along Southern California coast during Pleistocene.

DISCUSSION

The material is composed of otoliths of modern and past origin (Table 2). The observations made indicate that the species *Vinciguerria* belonging to the family *Photichthyidae* found in sample number 150/10 at a depth of 540 m are found as a recent otolith and is completely absent in the old material, a look at the ecology of this specimen shown that is species is a tropical species (Table 1 and Fig. 1) indicating that the temperature must have

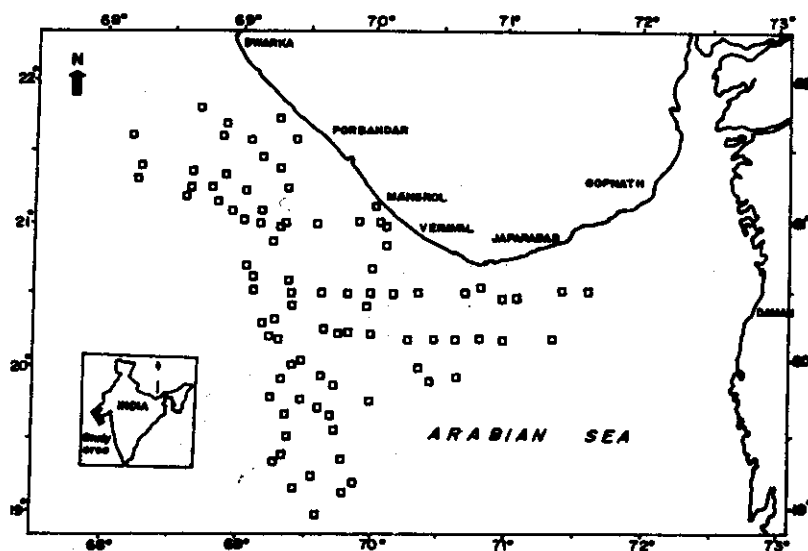


Fig. 1 Location Map Showing Sites of Sample Collection

risen in this area implying that this species must have not existed during the last Glacial Maximum (LGM) when the temperatures were lower than present. Therefore, this can be taken as a change in temperature scenario, whereas reverse is the case with *Acropoma* which is a subtropical species and found only in the old material indicating its existence only at lower temperatures than present.

In general the old material shows the presence of Cosmopolitan species or subtropical species whereas the recent material shows either cosmopolitan or truly tropical species.

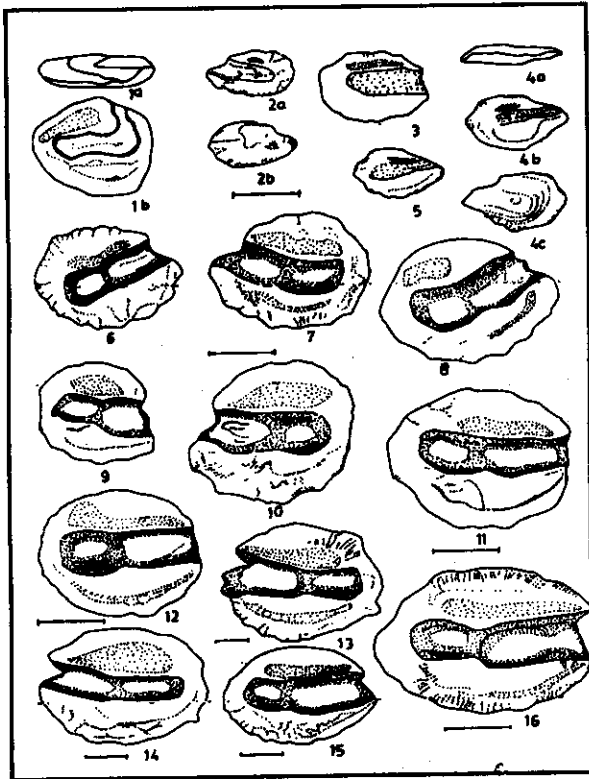


Plate 1

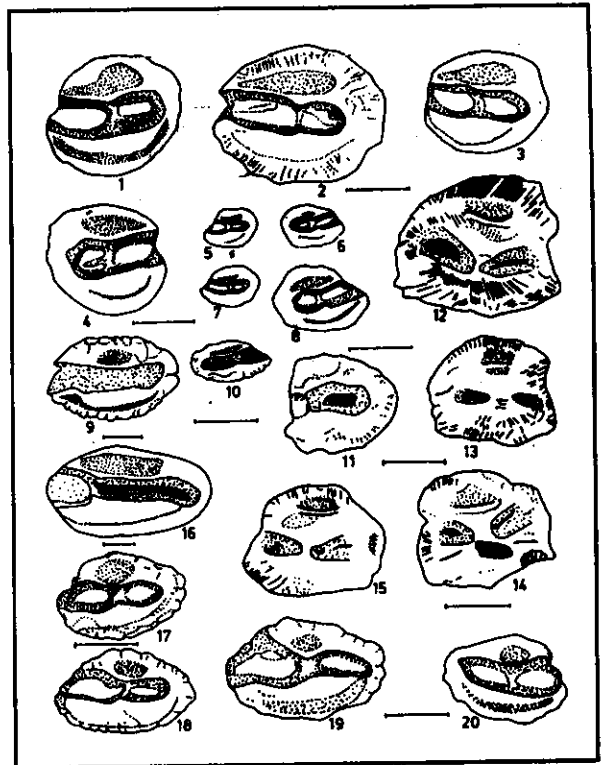


Plate 3

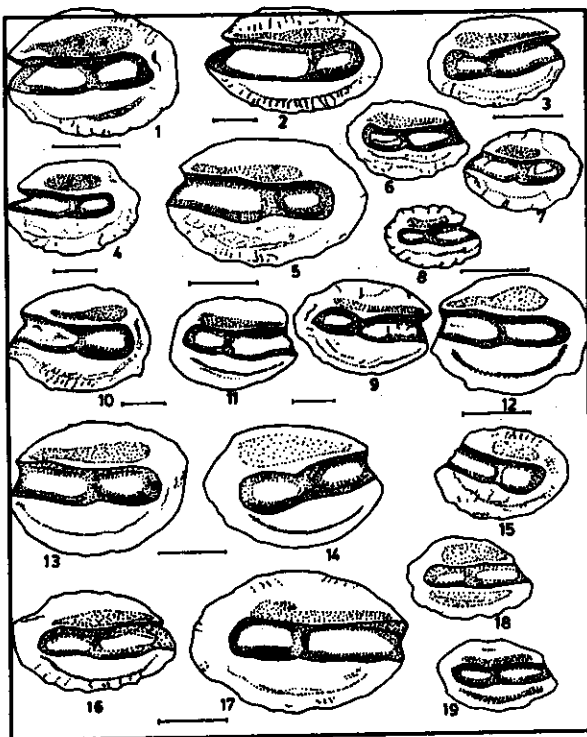


Plate 2

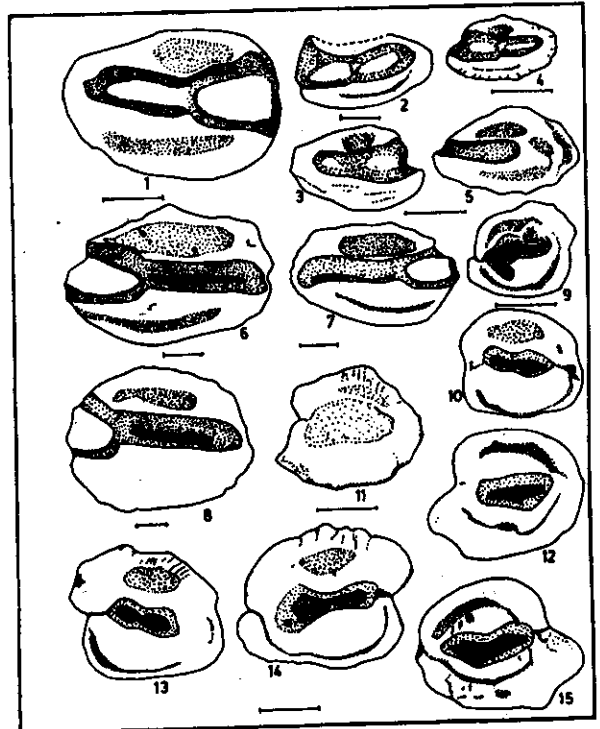


Plate 4

Table 1

General Species	Bathymetry								Climate		
	Benthic				Pelagic				Tropical	Sub-Tropical	Temperature
	Neritic	Littoral shallow sub Litt.	Deep sub-Litt.	Shallow Bathyal	Deep Bathyal	Epi-pelagic	Meso-pelagic	Bathy pelagic			
Ariosoma sp.	**	**	**	**	**	P	P	**	P	P	**
Clupeidarum	**	**	**	**	**	P	P	**	P	P	**
Vinciguerria	**	**	**	**	**	P	P	**	P	P	**
Bregmaceros	P	**	**	**	**	P	P	**	P	**	**
Benthoema	**	**	**	**	**	**	P	**	P	P	P
Myctophum	**	**	**	**	**	**	P	**	P	P	**
Diaphus	**	**	**	**	**	P	P	P	P	P	**
Hypophus	**	**	**	**	**	**	P	**	P	P	**
Electrona	**	**	**	**	**	**	P	**	P	P	**
Notoscopelus	**	**	**	**	**	**	P	P	P	P	**
Protomyctophum	**	**	**	**	**	**	P	**	P	P	**
Ceratoscopelus	**	**	**	**	**	**	P	P	P	P	**
Scopelogadus	**	**	**	**	**	**	**	P	P	**	P
Epinephelus	**	**	**	**	**	P	P	**	P	**	**
Morone	**	**	**	**	**	P	**	**	P	**	**
Acropoma	P	**	**	**	**	**	P	**	**	P	**
Pomadasy	P	**	**	**	**	P	**	**	P	**	**
Callionymus	**	P	P	**	**	P	**	**	P	**	**
Gobius	P	P	P	P	P	P	**	**	P	**	P
Apogon	**	**	**	**	**	P	**	**	P	P	P

Table 2

Species	Locality	Length (mm)	Width (mm)	Old	New	Total
Ariosoma sp.	150/10	0.92	0.85	1	0	1
Clupeidarum* sp	150/10, 1883, 2237	0.65 - 1.32	0.40 - 0.98	2	1	3
Vinciguerria sp.	150/10	0.70 - 0.80	0.40 - 0.47	0	2	2
Benthoema sp.1	150/22, 1882, 1885, 1875	1.12 - 1.37	0.87 - 1.10	7	3	10
Benthoema sp.2	1885, 150/25	0.92 - 1.12	0.85 - 1.24	2	2	4
Benthoema sp.3	150/30, 1883	1.25 - 1.35	1.07 - 1.20	3	0	3
Myctophum sp.1	1889, 1881, 1858, 1850, 1882, 150/30, 1875 1858, 1884, 150/23, 150/20, 150/32, 1885, 1886, 1883	1.25 - 2.40	1.10 - 1.95	90	16	106
Myctophum sp.2	1886, 1882, 1883	1.67 - 1.88	1.27 - 1.36	5	3	8
Diaphus sp.1	1879, 1890, 150/30, 2238, 1875, 1858, 1884, 2252, 150/26, 150/32, 150/18, 150/1, 150/22 1887, 1883, 1886, 1885	1.72 - 2.04	1.24 - 1.60	160	34	194
Diaphus sp.2	150/30, 150/3, 2270, 2267, 150/28, 180/29A, 150/22, 150/10, 1886, 1882, 1883, 1885	0.72 - 1.00	0.90 -	20	18	38
Diaphus sp.3	150/10, 1883	1.15 - 1.68	1.00 - 1.40	25	14	39
Hypophus sp.	1858, 1885, 1883, 1890, 1875, 1882, 2238	0.95 - 1.25	0.75 - 1.07	50	20	70
Electrona	150/10, 1885, 1887, 150/18	0.97 - 1.40	0.87 - 1.57	6	2	8
Notoscopelus	150/18, 150/32, 1861, 1885, 150/30, 150/3 2238, 1875, 1884, 150/1, 2270, 2259, 2257 2245, 2237, 150/27, 150/23, 150/4, 150/28 150/25, 150/32, 150/29A, 150/31, 150/22 1887, 1882	0.87 - 1.57	0.60 - 1.17	75	41	116
Protomyctophum	1885, 1875, 1886, 150	0.70 - 0.97	0.65 - 0.92	5		6
Ceratoscopelus	1886, 150/25, 2257, 150/10, 2245, 150/27	0.42 - 0.77	0.35 - 0.67	6	7	15
Bregmaceros	150/18, 150/30, 150/22, 150/23, 2238, 2271, 1886, 1882, 2237	0.85 - 1.30	0.82 - 1.20	8	7	15
Scopelogadus	150/18	0.9	0.87	1	0	1
Epinephelus	1883	2.1	1.45	1	0	1
Morone sp.	1886	2.65	1.55	1	0	1
Apogon sp.1	150/32, 150/28, 150/30, 2237, 2259	0.75 - 0.87	0.62 - 0.87	6	0	6
Apogon sp.2	2271, 2238, 2270	1.07 - 1.77	0.70 - 1.25	3	0	3
Apogon sp.	2238	0.77	0.52	1	0	1
Acropoma sp.	1882	0.88 - 1.72	1.40 - 2.20	2	0	2
Pomadasy sp.	1886	3.1	2.4	1	0	1
Callionymus sp.	1886	0.22	0.75	1	2	3
Gobius sp.	150/30, 1876	0.62 - 0.87	0.77 - 1.12	0	3	3
Gobius sp. 2	1888, 1886		0.90 - 1.22	0	1	1
Gobius sp. 3	150/30	0.25	1.02			

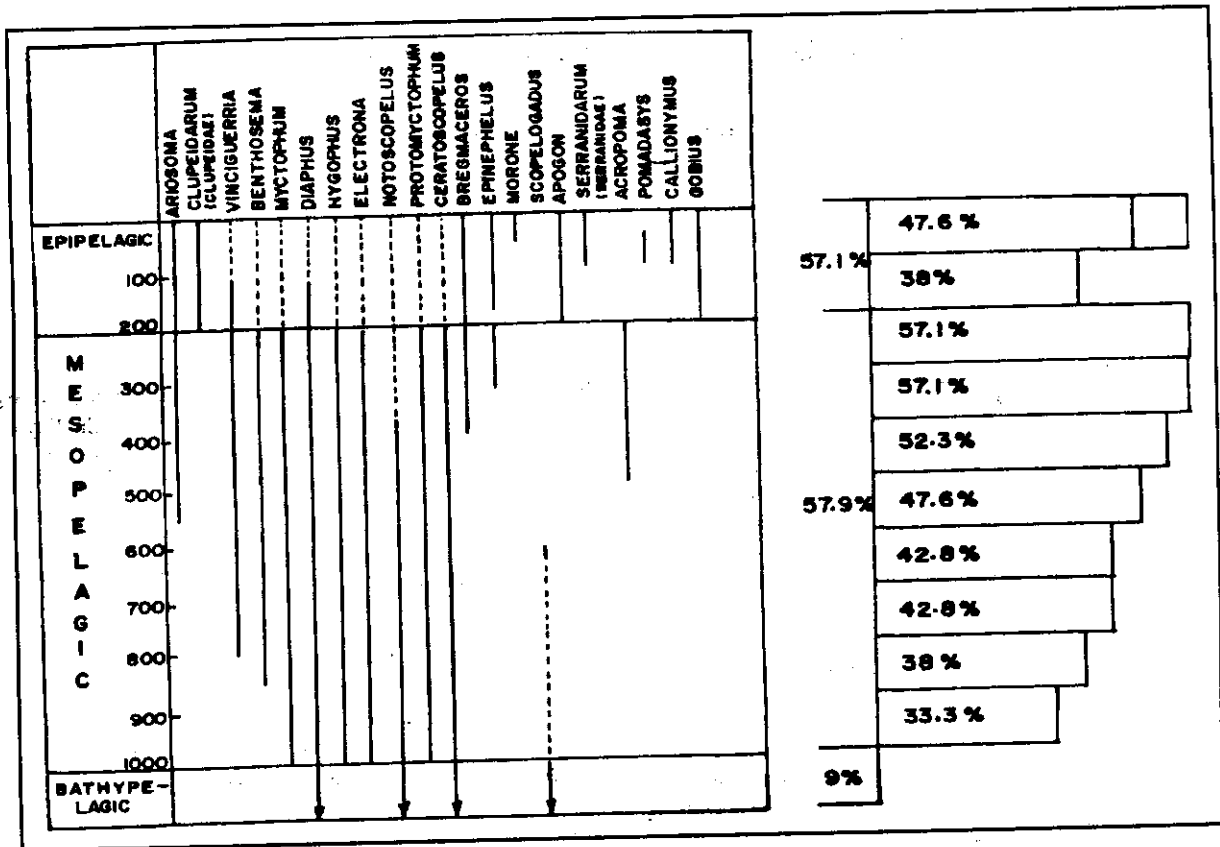


Fig.2 Bathymetric Representation of Teleost Data From the Arabian Sea. Dotted Line Represent the Nightly Presence at Some Mesopelagic Species at the Surface.

Just as the fauna indicate fluctuations in temperature showing the presence or absence of some species based upon its tolerance limits to lower or higher temperatures, the otolith fauna also indicates fluctuations in depth eg. *Morone* is an epipelagic species occurring in many areas in modern environment at depths between 0-50 m (Fig.2) showing its presence in the study area as extinct fauna, now occurring at a depth of 162 m. Similarly, *Pomadasys* found in modern environment at depths between 50-100 m (Fig.2), shows its presence in the study area as extinct species but presently occurs at a depth of 162 m. This indicates that the sea-level probably fluctuated in this area anywhere between 50-100m. The results are in general agreement with the observations made by many authors for the sea-level fluctuations since the Last Glacial Maximum (LGM). The species identification (which is in progress) may help in arriving at a better resolution of the paleoclimate.

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