# Sediment Traps as a New Tool for Estimation of Longevity of Planktonic Foraminifera

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## Abstract

Sediment trap technique provides time series data of sinking particles [faunal and sediment] from surface to bottom oi the sea .Besides many other applications data can atso be used to estimate life span of planktonic foraminifera. Based on rearing experiments, life spans of lew weeks were proposed for planktonic foraminifera by earlier researchers .Reanalysis of the results of sediment traps deployed in the Arabian Sea [dining 1986- 87] indicated the life spans of planktonic foraminifera to be ~6 months. A fresh approach is required to confirm this hypothesis. If confirmed, the findings will have far reaching implications in paleoclimatic reconstructions.

## Key words

Planktonic foraminifera, Life span Sediment trap, Arabian Sea

## Introduction

The looming danger of global warming associated with green house effect and its several consequences draws attention of scientists, planners and common man alike Since both the natural and anthropogenic causes are supposed to influence the global warming, there is need to quantify both of them. The future furies in nature can be faced with less hardship if they can be predicted, even with certain uncertainties. Prediction is a delicate task and depends on our understanding of paleoclimate. During the last few decades, the microfossils, especially planktonic foraminifera in deeper marine sediments became the prime source to generate paleoclimatic records.

While reviewing the work done on modern planktonic foraminifera Hemleben et al (1988) stated, that "With the increasing interest in the shells of planktonic foraminifera as indictors of the history of the earth, revealed through the sedimentary record and by application of modern isotopic analytical techniques, it becomes ever more important that a comprehensive analysis of

current biological understandings be available to new as well as senior scholars in the earth sciences". However, in a edited book on biology of foraminifera Lee and Anderson (1991) stated " ...it has become clearer to us, from our perspective as editors, that we really know very little about most aspects of foraminiferan biology" and pointed out " Much further research is required on the life - cycles of foraminifera to provide background information essential for classical and molecular genetic research". No significant developments have taken place since this review, as far as life span of planktomc foraminifera is concerned.

In view of the above, an attempt is made to estimate longevity of planktonic foraminifera through sediment traps.

## Status of Life Span Studies

Estimates of life spans of planktonic foraminifers are mostly based on laboratory culture experiments. However, all the attempts, to maintain live specimens in lab culture through their complete life cycle, failed. Therefore, the life span estimates of planktonic foraminifers are based on the observation of time taken to construct last few chambers in lab culture experiments till they attain maturity and undergo gametogenesis, and then back calculating the time taken to construct earlier chambers (Caron and Swanberg, 1990). Similarly, lunar or semi-lunar periodicity in reproduction has also been observed in these culture experiments, thus suggesting life span of two to four weeks for few species like *Hastigerina pelagica* (Spindler et al. 1979). However, in such studies also, discrepancies were noted in laboratory and field observations (Hemleben et al. 1988).

Based on the time taken to build last few chambers and linear extrapolations, life span of planktonic foraminifers were estimated to be of the order of few days to few weeks. However certain observations like differences in isotopic composition of earlier and later chambers of single specimens are difficult to explain considering life spans of few days to few weeks. The differences in isotopic and elemental composition of different chambers in the same test were interpreted to be the result of ontogenetic effects or due to vertical migration of the specimens during different phases of their life cycle (Houstan et al. 1999, Eggins et al.2003). Later on non-linear extrapolations of life span were also proposed, suggesting the life span to be of few weeks (Caron et al. 1981; Caron and Swanberg, 1990) as exhibited in figure 1. The present work is in agreement with these results, favoring longer life span and provides evidences for still longer life spans.

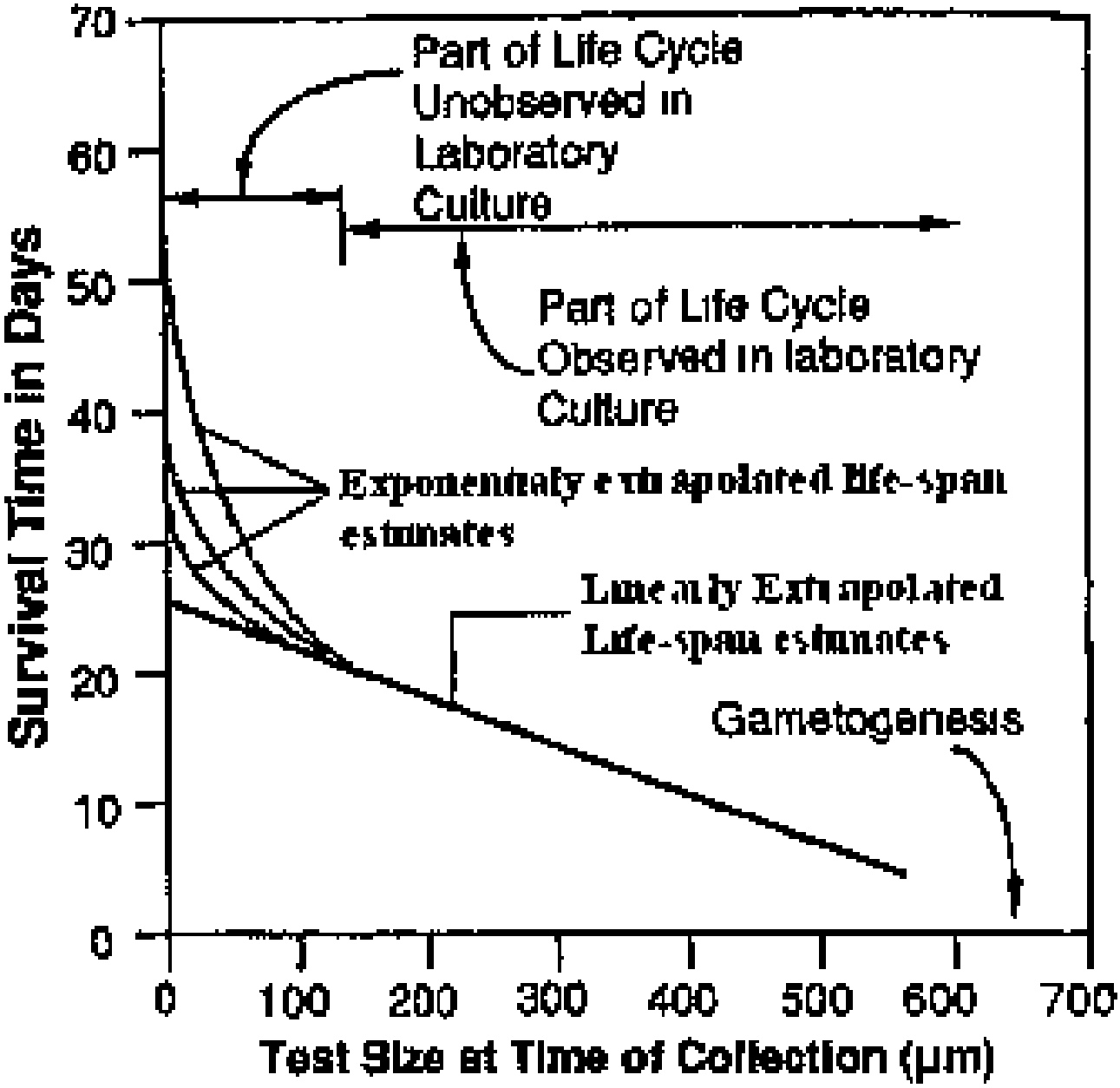


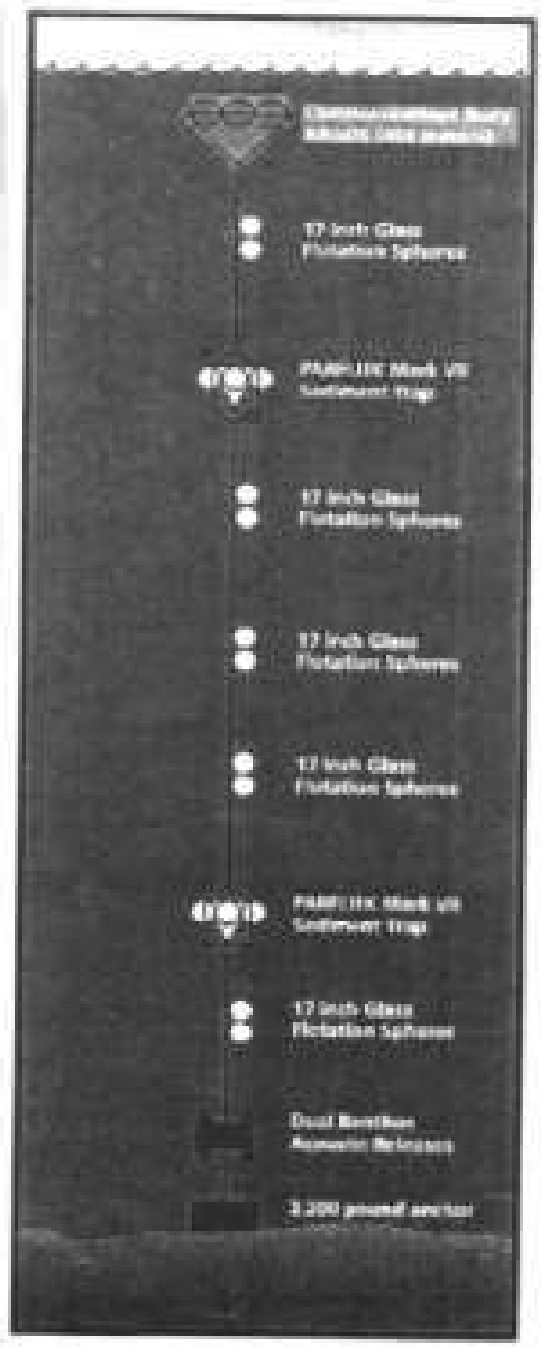

Fig. 1. *Extrapolated life span estimates, of planktonic foraminifera (modified after Caron & Swanberg, 1990).*

The limitation of the estimates of the life span of planktonic foraminifera based on culture studies is the paucity of information on the ecological preferences of juvenile planktonic foraminifera especially of the conditions that promote growth and reproductive maturation.Many of the most significant questions concerning factors regulating life-cycle, species abundance and the productivity of planktonic foraminifera remain to be investigated (Lee et al. 1991) .Time series sediment trap results can help answer most of these questions.

# Equipments and Conceptual Framework

## Sediment traps

In order to trap the particles sinking from surface to the bottom of the ocean Dr Werner Deuser a geochermst from Woods Hole Oceanographic Institution (WHOI) for the first time deployed a huge sediment trap developed by Ken Doherty a senior engineer from WHOI The modified version ot the same was later deployed in all the major oceans including Arabian Sea (Fig 2) as part of the International collaborative oceanographic project




Tig 2 *Schematic diagram of sediment trap mooring*

A sediment tiap consists of a funnel shaped or cylindrical collector affixed to a titanium frame (Fig 3) The lower end of the collector opens in a plastic bottle that keeps on changing with the help of a microprocessor controlled motor at regular intervals The upper end of the collector is covered with a honeycomb baffle to prevent laiger organisms from entering inside the trap

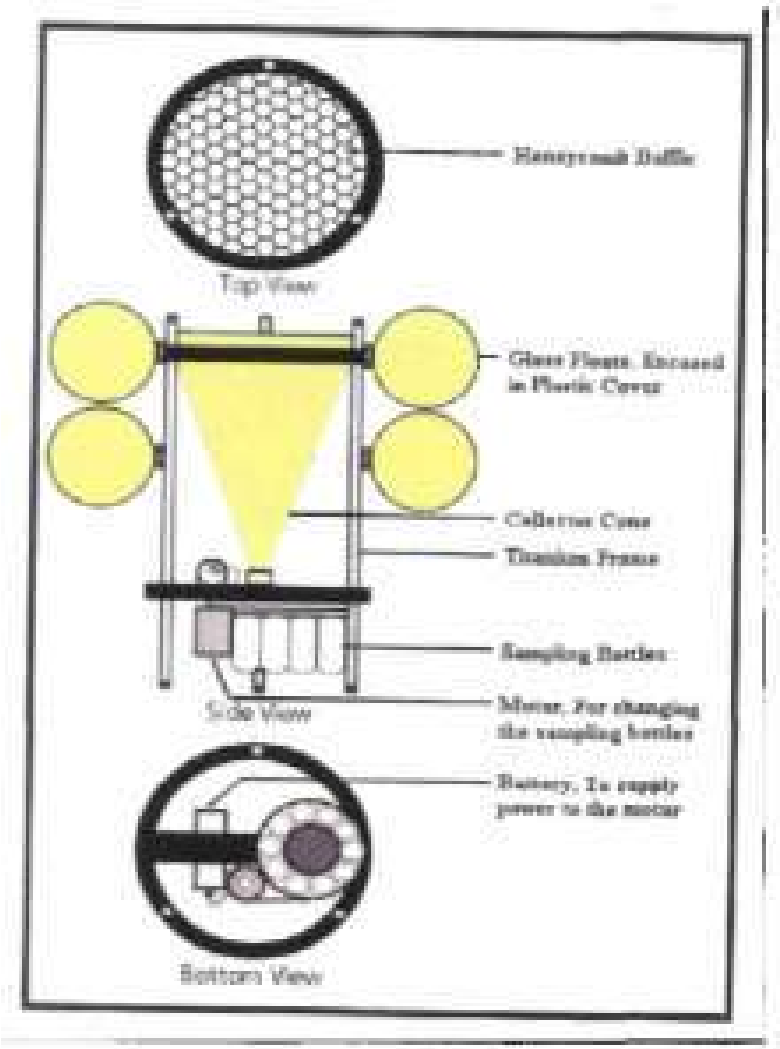


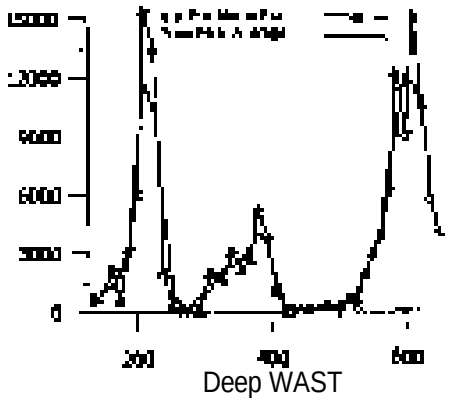

Fig 3 *Collector cone of the sediment trap*

The collector is maintained in a vertical position with the help of a senes of hollow glass spheres encased m thick plastic covering, capable to withstand enormous pressure

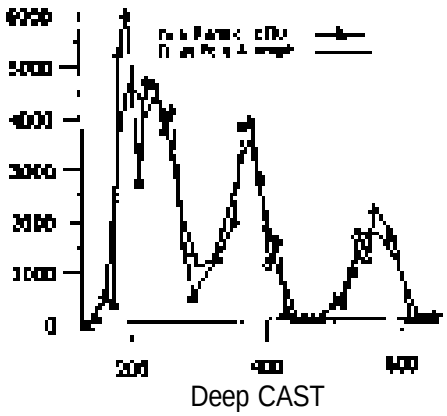
## Conceptual framework

Irrespective of at what depth planktomc foramimfers reproduce during their life cycle, dead tests start sinking to bottom soon after the death of foramimfers If life span of the organism is of the order of few weeks, every cup or at least alternative cups [collection cups automatically changed every ~13

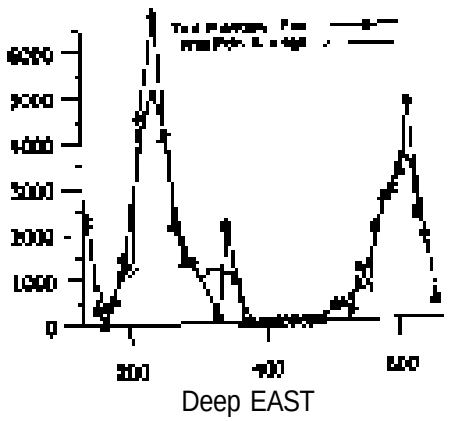
days] should contain considerable number of large planktonic foraminiteral tests .It is possible that their frequency may vary depending upon fluctuations in various ecological parameters .But under any condition it is not possible to miss large tests for longer time. If planktonic forarminiferal tests are not recovered from a series of successive cups [Fig. 4] it may indicate that tests are not sinking and thus that the planktonic foraminifers are not going through regular reproduction. In that case assumptions made to decipher shorter life span need alternative explanations.




**(A)**




**(B)**




**(C)**

Fig.4. *Long nill flux periods in the abundance of planktonic foraminifera reported at all three trap locations*

## Source of Data

Number of papers has been published on seasonal and inter-annual variation of foraminiferal flux in sediment traps deployed in the Arabian Sea [Fig. 5]. The data for the present study about the longevity of planktonic foraminifera is taken from the published records (Nair et al. 1989; Curry et al. 1992). Dr. Curry and Dr. Guptha made the original raw count presented in these papers (personal communication).

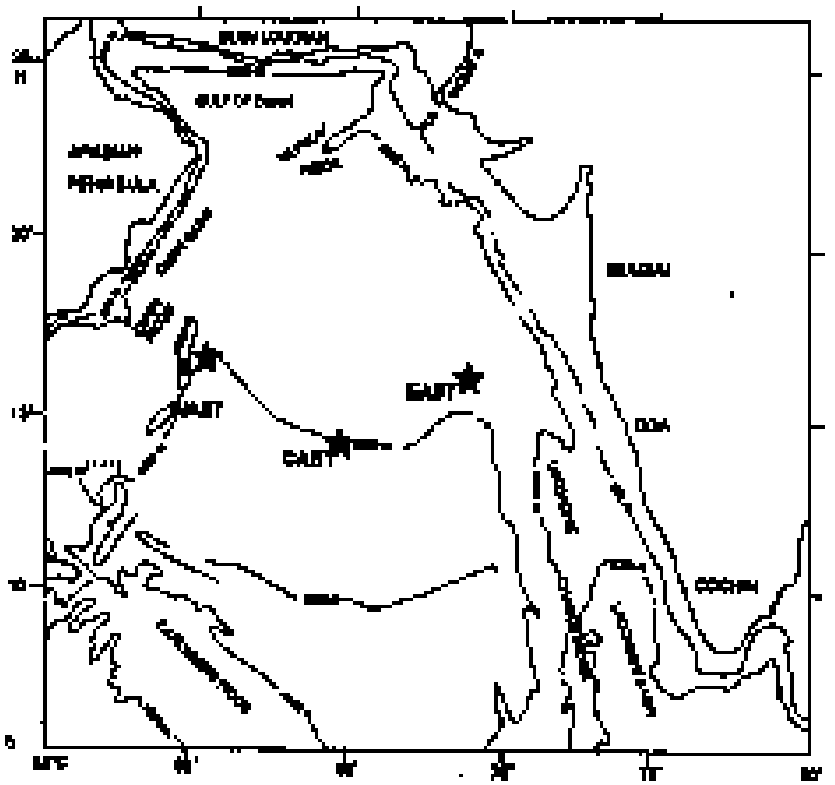



Fig. 5. *Location of the three traps deployed in the Arabian sea, the results of whose are used in the present study.*

## Results and Discussions

The results of sediment traps deployed in the Arabian Sea [during 1986-87], and other world oceans provide new insights for more accurate estimate of life span of planktonic foraminifera. The time series sediment trap data from the Arabian Sea and elsewhere show periods as long as 34 to >130 days during which total planktonic foraminiferal flux becomes almost zero and in certain cases zero. This long nil flux period is not possible with short life spans, as if the life spans are of the order of few days to few weeks then traps should receive a continuous supply of planktonic foraminiferal tests throughout the

year. The malfunctioning of traps is not applicable here because, (i) such periods of zero or near zero flux have not been observed for only one trap or at one location, but from almost all parts of the world oceans, and also (ii) all the traps can not stop functioning simultaneously and that too for the same time of the year for consecutive years. The chances of horizontal transport of planktonic foraminiferal tests away from the trap locations are remote as these trap locations are far away from the boundary of zone of occurrence of planktonic foraminifers from where they can escape the trap while sinking down. The possibility of dissolution of tests during sinking, because of changed physico-chemical conditions of ambient seawater is ruled out as per the observations, that there is none or very little dissolution of tests during settlement through water column. Therefore, by eliminating above reasons, the most convincing explanation could be longer life spans of planktonic foraminifers.

In addition to above, there is a rhythmic pattern of seasonal variation in abundance of larger and smaller fractions of same species, with peaks of larger fraction (150 m to >500 m) slightly preceding that of smaller fraction (125 m to 150 m). All these observations indicate that the life spans of planktonic foraminifers are longer than as reported earlier, most probably of six months, with a marked dormancy period and occurrence of reproduction during favourable conditions associated with monsoons.

## Consequences

Since the inception of mass spectrometers over a century ago, the field of mass spectrometry has grown into an important and indispensable tool in variety of areas including geology and oceanography. The growth of this technique is phenomenal during the last few decades mainly due to the improvements in the electronics. Now it is possible to use solitary specimen or few specimens of planktonic foraminifera to obtained isotopic ratios to reconstruct paleoclimate. In this scenario it is very important to find out the longevity of the foraminifera, as that will decide the physicochemical parameters at which the planktonic foraminifcr had incorporated isotopic signals. This understanding will have far reaching consequences for planktonic foraminifera based paleoclimatic reconstructions.

## Future Strategies

There are several methodologies through which this hypothesis can be tested. First, a new laboratory experiment can be designed in which the complete life cycle can be seen. This will involve expertise from biology as well as geology. Another possible way of testing this hypothesis is through continuous water sampling of the upper 200 m water column for more than a year. If larger tests are found throughout the year, this hypothesis will fail. However, if the

flux of different size fractions is found to vary in accordance with monsoons, it will support the findings. But sampling in open ocean is very expensive and it is not possible to get the research vessels every 15 days .This difficulty can be over come by deploying moored sampling equipments which should be able to filter huge quantity of water on regular intervals and store the filtrates separately .Efforts has been started to setup such an experiment on trial basis by collaborating with different agencies involving engineers and geologists. If succeeded findings will be published in due course.

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