

## HETEROTROPHIC BACTERIA AND BIOCHEMICAL ACTIVITIES OFF THE WEST COAST OF INDIA

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### ABSTRACT

Vertical distribution of heterotrophic bacteria and their biochemical activities in the Arabian Sea were studied. Population of bacteria varied from nil to  $10^3$ /ml. Higher counts were invariably encountered at or close to the surface. Biochemical activities in terms of population density of nitrate reducers, ammonia oxidisers, gelatin liquifiers, hydrogen sulphide producers, fat hydrolysers and thiosulphate oxidisers were estimated.

### INTRODUCTION

The populations of heterotrophic bacteria in the sea and in the open ocean is of considerable importance as they play a vital role in various nutrients and energy cycle. Their distribution has been suggested to be a precise tool in the identification of water masses and currents (Kriss, Lebedeva and Mitzkevich, 1960). A comprehensive account of the distribution of heterotrophic bacteria in sea has been given by ZoBell (1946). Little work has been done on the bacterial population in the Indian waters and hence the vertical distribution and biochemical activities of the bacteria from the Arabian Sea are presented here.

### MATERIALS AND METHODS

During the 13th cruise of R. V. *Gaveshani*, water samples were collected from surface, 100, 300, 500, 1000 and 1200 m depths, using Nansen bottles from 18 stations (Fig. 1) after initial flushing of the bottles (Kriss, 1962). The effect of hydrostatic pressure was eliminated by restricting the sampling to less than 2000 m depth (Oppenheimer and ZoBell, 1952). The samples were immediately chilled. They were then brought to the laboratory in ice. Bacterial counts were determined using pour plate technique in ZoBell 2216E medium. In addition to the total viable heterotrophic population, the number of each group of bacteria having the following biochemical activity was estimated either by most probable number (MPN) or by pour plate technique.

1. Nitrate reducers (MPN), 2. Ammonia oxidisers (MPN), 3. Gelatin liquifiers (Pour plate), 4. Hydrogen sulphide producers (MPN), 5. Fat hydrolysers (Pour plate), 6. Thiosulphate oxidisers (MPN).

The plates/tubes were incubated at temperature of  $28 \pm 2^\circ\text{C}$  (Oppenheimer, 1968) and the counts were expressed as No./ml.

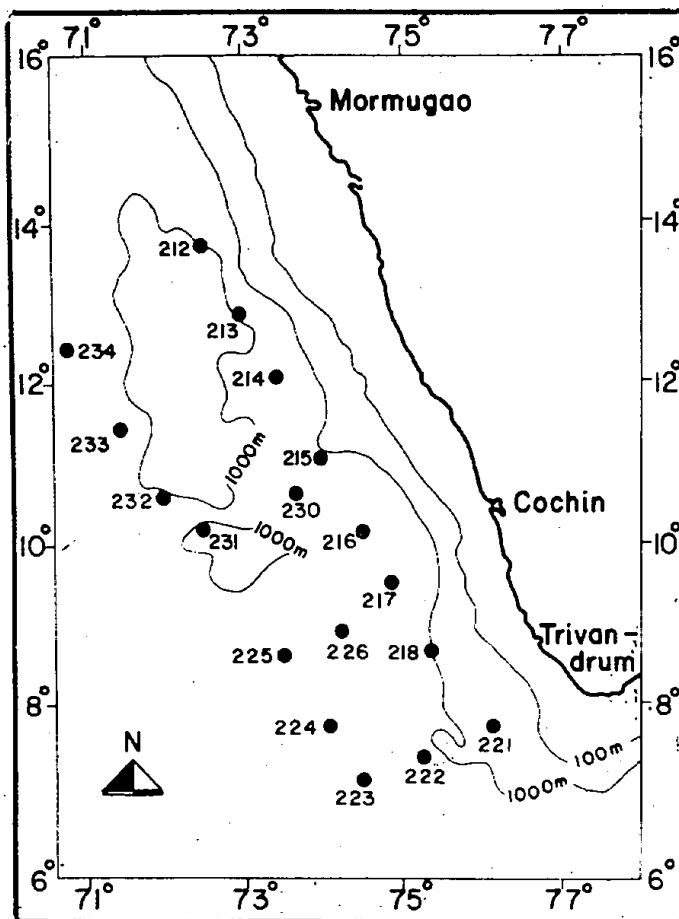


Fig. 1. Location of bacterial sampling stations during the 13th cruise of R. V. *Gaveshani*.

#### RESULTS AND DISCUSSION

##### *Vertical distribution of heterotrophic flora*

The total heterotrophic population in ZoBell 2216E medium did not show any particular trend in its horizontal distribution. However, some similarity was seen in the vertical distribution of these bacteria. At many stations, maximum population was seen either at the surface or at 100 m depth. Only at very few stations, heterotrophic flora were maximum below this depth (Fig. 2). Population count varied from nil to  $10^3$ /ml. It was relatively small at 500 m and most of the deeper stations were virtually sterile. At times, no population was observed at some intermediate stations also. However, there were a few exceptions such as stations 221 to 223 where the counts at and below 1000 m varied between 140 to 190/ml. Although their vertical abundance was moderate between Stns. 212 to 225, beyond Stn. 225, it was either very low or completely absent except at the surface of Stn. 230 where the count was 230/ml.

It has been recognised by several authors that the heterotrophic population declines with depths (ZoBell, 1959; Kriss, Lebedeva and Mitzkevich, 1960; Sieburth, 1971; Sorokin, 1971) and that the lowest counts occur below 1000 m depth (ZoBell, 1963). The highest population was observed by Sieburth (1971) in the upper 100 m of water column whereas ZoBell (1959) and Paul, Morita and Jones (1972) noted the

highest population at, or very close to the surface. The high bacterial biomass in the euphotic zone (Kriss, Lebedeva and Mitzkevich, 1960; Whittle, 1977) may be due to the recycling of the organic matter from primary production within this zone and this presumably leads to the decline in their population at greater depths (Steele, 1972; Menzel, 1974). Crow, Ahearn, Cook and Bourquim (1975) are of the opinion that the bacterial biomass of the surface layer is 100 times greater than in subsurface layers. However, in the present investigation, the results obtained were somewhat different. The biomass obtained was not always high within the euphotic zone. At some stations, it was of the order of  $10^2$ /ml even at 1000 m and below (Fig. 2). Nevertheless, ZoBell (1968) has indicated that bacteria are widely and unevenly distributed in deeper waters. One of the reasons for this high population at greater depths may be because these depths were closer to the sea bottom where the population is known to be very rich (Ezuras Daiku, Tajima, Kimura and Sakai, 1974; Nair, Bharathi and Achuthankutty, 1978),

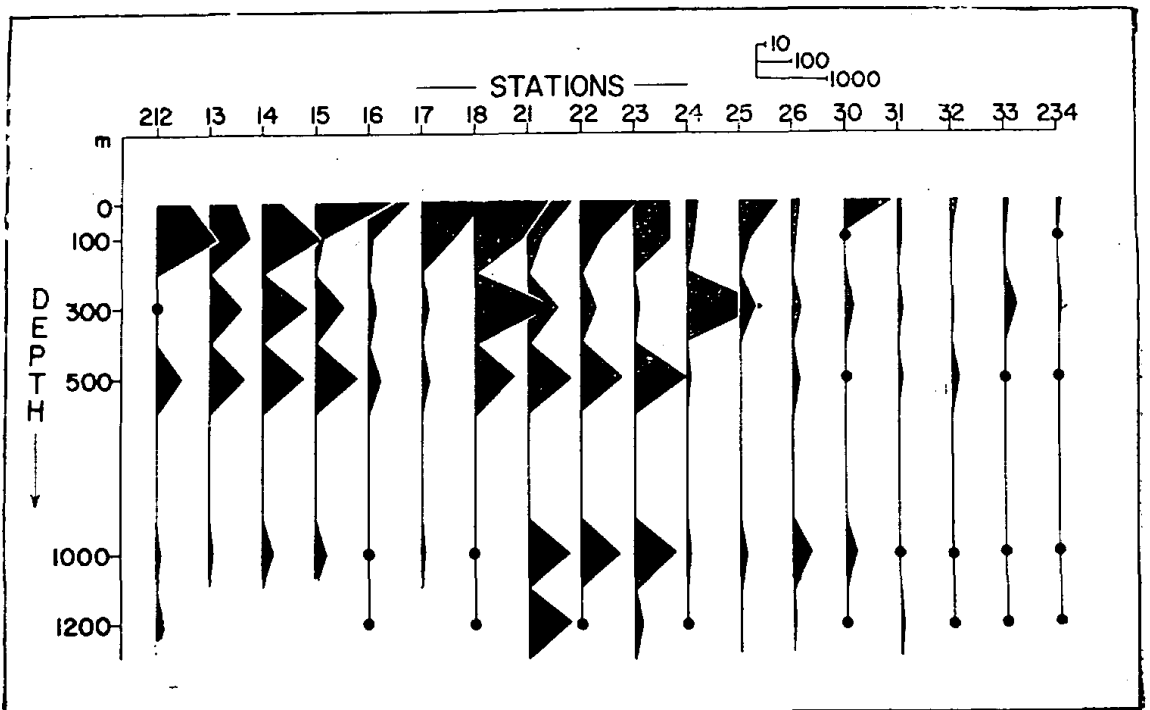


Fig. 2. Distribution of heterotrophic flora (No./ml). Closed circles indicate no population.

The availability of organic matter (ZoBell, 1972; Dale, 1974) susceptible to degradation (Ituriaga and Hoppe, 1977) has a definite role to play in the proliferation and distribution of bacteria. But variation in their vertical distribution and abundance may be controlled by the availability of easily assimilable organic matter (ZoBell, 1963). However, the uneven distribution noted in the euphotic zone may largely be because of differences in primary production (Sieburth, 1971) which gives rise to organic matter essential for their survival and growth.

#### *Physiological groups*

Among the various physiological groups of bacteria, the most important ones are the nitrate reducers and ammonia oxidisers as the nitrogen cycle plays an important

role in the productivity of the sea. Hence, the bacteria were tested for these activities. Nitrate reducers occurred in 22 samples. Of this, 15 samples were from or below 100m depth and the rest were from the surface. The counts of these bacteria ranged from nil to 140/ml. Generally, their population was very poor ( $\leq 2.5$ /ml). Only in one sample, the population was 140/ml and in two samples, it was 15/ml. High counts were encountered at deeper waters (Figs. 3 a-d). The station 221 alone had these bacteria in small numbers throughout the water column. Ammonia oxidisers occurred in 21 samples. Of these, 7 were from the surface and the rest from 100 m depth and below. As in the case of nitrate reducers, the counts of ammonia oxidisers were also  $\leq 2.5$ /ml in most of the samples except at the stations 215 and 216 where the populations both at surface and 100 m were 140/ml. Only at station 218, a low population was seen throughout the water column (Figs. 3 a-d).

According to Gundersen, Mountain, Taylor, Ohye and Shen (1972), the low population of nitrifiers in the surface waters is due to their inability to compete with phytoplankton for the small amount of ammonia available in this region and hence they could be detected only below 200 m. But the explanation provided by Spencer (1956) for the failure to demonstrate these bacteria in the upper and middle layers of

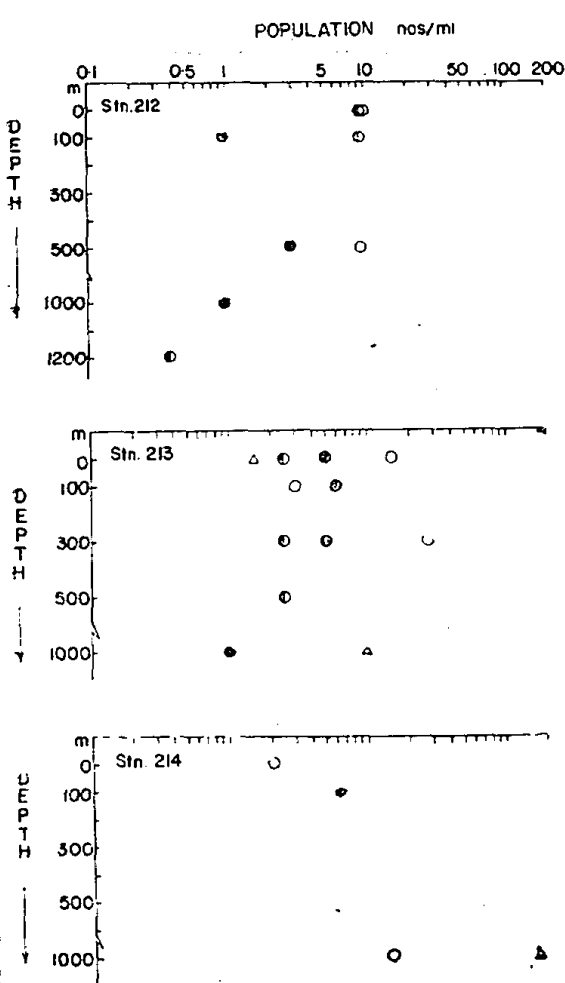


Fig. 3a

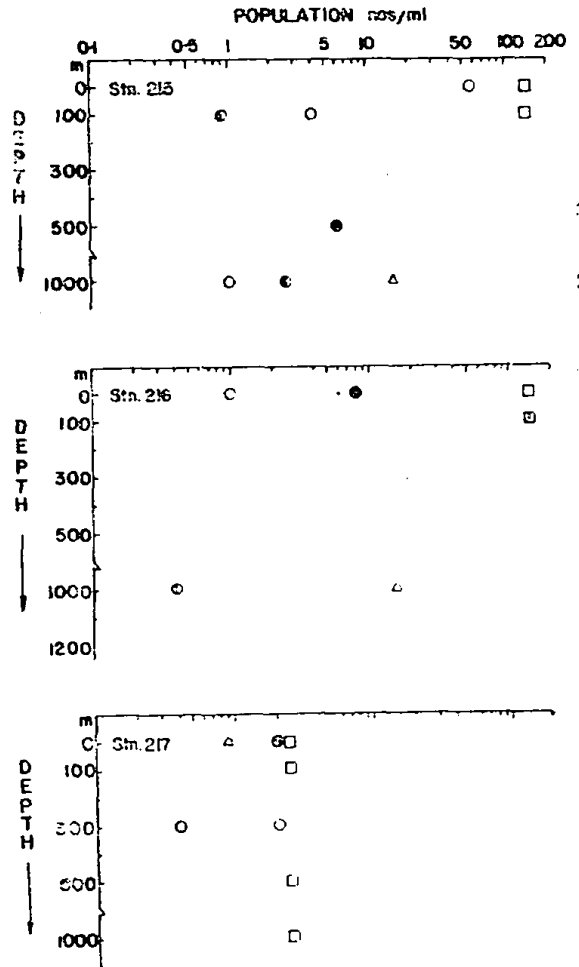


Fig 3b

open oceans is that the water column may not be containing sufficient concentration of iron which is essential for growth of these bacteria. In his opinion, Carey's observation in 1938 on large populations of ammonia oxidisers in waters rich in phytoplankton may be due to the relatively higher iron content in phytoplankton. But in the present investigation, small populations of ammonia oxidisers occurred at the surface and at intermediate depths of some stations. Whether it is the low concentration of iron or the abundance of phytoplankton or some other factor which limits the growth of nitrifiers

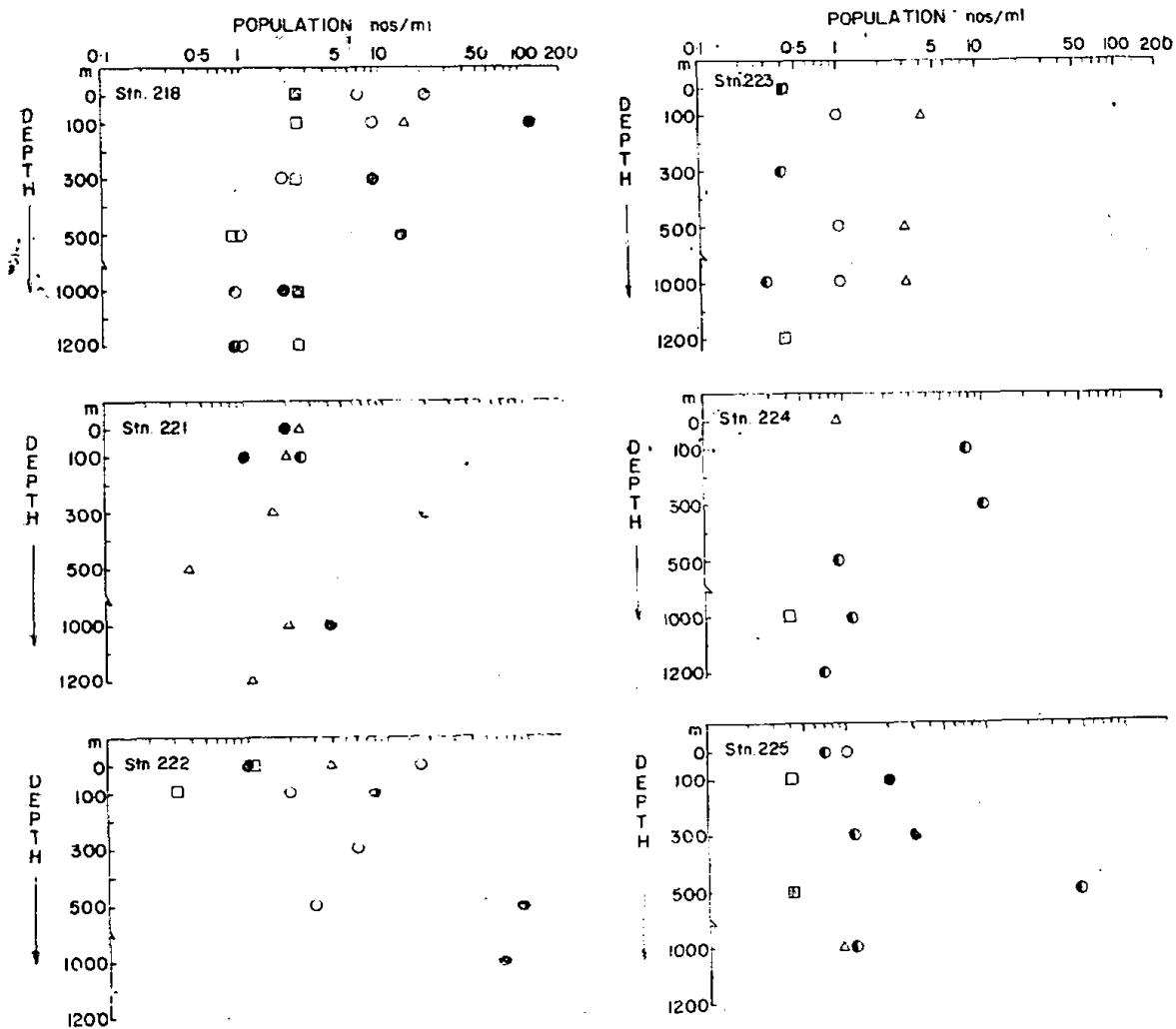


Fig. 3c

Fig. 3 a-d. Distribution of physiological groups at different stations. Open squares—ammonia oxidisers; open triangles—nitrate reducers; open circles—gelatin liquifiers; closed circles—fat hydrolysers; half closed circles thiosulphate oxidisers.

Fig. 3d

at the surface and at mid depths of the ocean is not properly known. However, Carey (1938) has reported a poor population of these bacteria in the open ocean. Even nitrate reduction in the surface layers is being done mainly by phytoplankton (Wada and Hatlori, 1971) and hence this would lead to an insignificant population of nitrate reducers in this region. However, these bacteria may be present at any depth where the water is rich in organic matter (Gundersen, Mountain, Taylor, Ohye and Shen, 1972).

The overall proteolytic activity was low. Hydrogen sulphide producers occurred only in 5 samples from 3 stations [stations 214 (500 m), 215 (surface, 300 and 500 m) and 224 (300 m)]. The counts in all the samples were  $\leq 2.5$ /ml. The other proteolytic bacteria, viz. gelatin liquifiers, also had a small population. Their horizontal or vertical distribution had no particular trend. They were present at many stations but were 10/ml and above only in 6 samples with a maximum of 56/ml at the surface at station 216 (Figs. 3 a-d).

The population of fat hydrolysers was also sparse. Only at station 218, these were distributed throughout the water column with their highest population at 100 m (120/ml) followed by the station 222 at 500 m (91/ml) and 1000 m (65/ml). In most of the samples, the count was  $\leq 5$ /ml (Figs. 3 a-d).

Thiosulphate oxidising bacteria play an important role in the sulphur cycle of marine environment (Devendran, Chandramohan and Natarajan, 1975). These bacteria were often detected in the plankton sphere because their growth is influenced by the organic matter supplied by the abundance and decomposition of plankton (Fujita and Zenitani, 1971). However, they were absent in a large number of samples and occurred occasionally at the surface and often at middle and deeper waters. Their counts generally varied from 0.3 to 2.5/ml. Only two samples had a population of 10/ml or above (Figs. 3 a-d).

The absence of any physiological group of bacteria beyond station 226 can be attributed directly to the very poor heterotrophic population. The availability of organic matter susceptible to degradation (Ituriaga and Hoppe, 1977) and the sources of organic matter are the two important factors which determine the activity of various groups of bacteria. But at the same time, some of the hydrographic factors are also possibly influencing the proliferation of these physiological groups (Sugahara, Sugiyama and Kawai, 1974).

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