

SEASONAL CHANGES IN THE TEMPERATURE, SALINITY AND PLANKTON VOLUME AT PORT BLAIR, ANDAMANS

K. RANGARAJAN¹ AND R. MARICHAMY²

Central Marine Fisheries Research Institute; Unit, Port Blair

ABSTRACT

The seasonal changes in the temperature, salinity and plankton volume at Port Blair, Andamans, during the period 1964 to 1970 have been investigated and the changes correlated with the meteorological conditions of the locality. The atmospheric temperature exhibited a clear double oscillation in a year, the maxima occurring in April and November. The range of fluctuation was generally less than 10°C. The surface temperature closely followed the atmospheric temperature and exhibited a clear double oscillation. The surface temperature was invariably lower than the atmospheric temperature. The temperature of the surface water steadily increased from January to April registering a sharp fall in May due to the onset of the south-west monsoon. The surface salinity increased steadily from January to April registering a fall in May which coincided with the onset of the monsoon. Higher values were restored during the post-monsoon period. The surface water was fairly rich in plankton during the colder months. An inverse relationship was noticed between the abundance of plankton and temperature/salinity.

INTRODUCTION

The study of the distribution and seasonal variations of temperature and salinity in the marine environment is of great importance since these factors have a pronounced impact on the general distribution and relative abundance of marine organisms. Though much literature is available on the physical conditions of seawater along the east and west coasts of India (Jayaraman, 1951; Prasad, 1952, 1957; Ramamurthy, 1953; Chacko *et al.*, 1954; Varma and Reddy, 1959; La Fond, 1957, 1958), very little information is available about the Andaman Sea (Sewell, 1928, 1929) probably because of the remoteness of the area from the mainland.

The present paper deals with the observations made on the surface temperature, salinity and plankton volume at Port Blair, Andamans, during a period of seven years from 1964 to 1970 and correlates the seasonal changes occurring in the marine environment with local meteorological conditions.

Present address: 1. Central Marine Fisheries Research Institute; Sub-station, Madras-8.
2. Central Marine Fisheries Research Institute; Sub-station, Tuticorin-1.

MATERIAL AND METHODS

The station selected for this study is situated in the entrance channel to the Port Blair harbour (Lat. $11^{\circ} 41' N.$, Long. $92^{\circ} 45' E.$) and the depth of water at the station is about 45 metres. Regular observations have been made at weekly intervals on the surface temperature and salinity of the seawater, usually between 0600 and 0700 hours. The temperature of the surface water was recorded on board with a centigrade thermometer with an accuracy of $0.1^{\circ} C$. The salinity of the seawater was estimated in the laboratory by the Harvey method using standard seawater as reference. The surface plankton was collected by towing a net of half-metre diameter made of organdie silk for fifteen minutes. The sample of plankton was preserved immediately in formalin and the volume of plankton noted after allowing the sample to settle down for 24 hours in a tall measuring cylinder. The meteorological data like the maximum and minimum atmospheric temperature and rainfall at Port Blair for the period 1964 to 1970 have been taken from 'A Statistical Outline of Andaman and Nicobar Islands' published by the Andaman Administration.

RESULTS

Atmospheric temperature

The average maximum and minimum atmospheric temperature recorded at Port Blair during various months are given in Table 1. The highest atmospheric temperature of $35.4^{\circ} C$ was recorded in April 1970 and the lowest of $28.6^{\circ} C$ in August 1967. The annual range in maximum atmospheric temperature for the seven years was more or less steady being about $4.5^{\circ} C$.

During most years three peaks in the average maximum atmospheric temperature were noticed (Fig. 1). The first major peak invariably occurred in the month of April. The second peak, which was not pronounced, occurred during July-August and the third during October-November. However departure from this general trend was noticed during 1967, 1969 and 1970 when the secondary peak during July-August was not noticed.

The general trend of atmospheric temperature based on the total monthly averages for the entire period, however, exhibited a clear double oscillation in the course of a year (Fig. 2). The two maxima were noticed in April and November and the two minima in September and December. It may be stated that April was the hottest month of a year.

The amount of precipitation in the locality appeared to exert an influence on the general trend of atmospheric temperature. After the peak in April, just before the onset of the south-west monsoon, the sharp fall in atmospheric temperature in May coincided with the onset of the monsoon rains. The slight increase in atmospheric temperature noticed during July-August in certain years

TABLE 1. *Average maximum and minimum temperature recorded at Port Blair during 1964-1970*

Months	1964		1965		1966		1967		1968		1969		1970	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	30.1	22.0	30.1	20.9	30.7	22.9	30.0	22.8	30.4	21.9	30.3	22.0	32.1	17.6
February	31.9	23.2	31.5	22.0	31.7	22.7	31.2	22.0	31.1	21.5	30.8	20.7	33.2	20.2
March	32.7	22.9	31.9	22.0	32.3	21.9	32.0	22.2	32.8	23.6	32.6	22.6	34.1	20.6
April	34.0	24.0	33.0	23.3	33.3	24.2	33.2	23.5	33.2	24.1	33.7	25.0	35.4	22.2
May	30.5	23.4	31.3	23.5	30.8	24.3	30.8	23.9	31.2	24.0	31.8	24.5	33.9	20.9
June	29.5	23.2	29.3	23.7	30.2	24.5	30.0	24.3	29.9	23.8	29.8	24.4	31.4	21.6
July	29.8	23.3	29.4	23.7	29.1	23.6	28.9	23.6	29.0	23.8	29.5	24.1	31.0	21.7
August	29.2	23.3	29.1	22.9	29.7	23.7	28.6	23.7	29.6	24.4	29.5	23.6	30.6	21.2
September	28.9	22.9	28.7	22.9	29.3	23.1	29.3	23.4	29.1	23.4	29.4	23.3	30.9	20.7
October	29.8	22.7	29.9	23.1	30.3	22.9	29.6	22.9	30.5	23.5	30.9	23.2	31.3	21.2
November	29.5	22.5	30.5	23.1	30.2	23.0	30.8	23.3	31.2	23.9	30.3	23.0	31.8	20.7
December	29.9	22.2	29.8	23.7	29.9	23.0	30.2	23.3	30.9	23.5	31.1	23.7	31.3	20.3

coincided with the slight slackening in the monsoon activity noticed generally during this period. As will be shown subsequently there is an outburst of heavy rainfall during September before the south-west monsoon retreats from

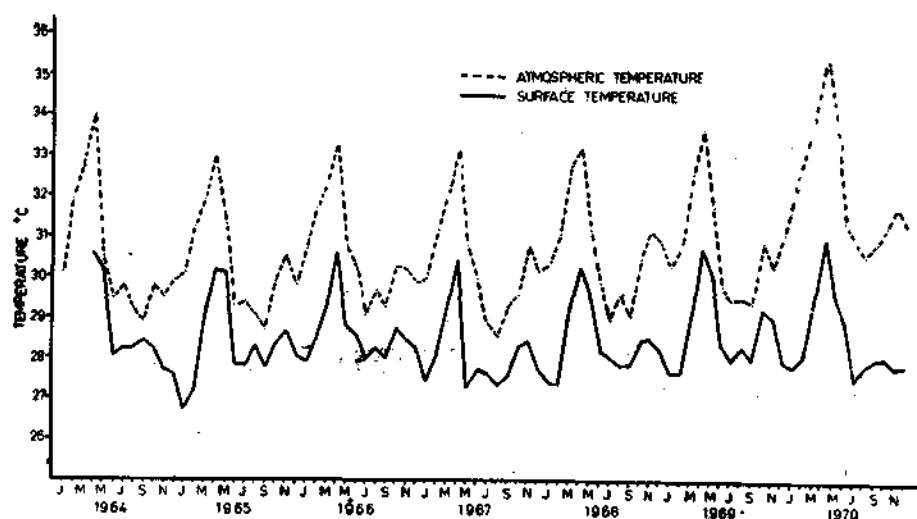


Fig. 1. Relationship between atmospheric temperature and surface temperature at Port Blair, Andamans during 1964-1970.

the Islands. Correspondingly a decline in atmospheric temperature was noticed during this month. Since the rainfall in the Islands during the north-east monsoon was not heavy the amount of precipitation after September gradually tapered off resulting in an increase in atmospheric temperature during this period. The second peak in atmospheric temperature occurred in November.

Temperature of surface water

The temperature of the surface water fluctuated between 26.2° and 31.6° C. The maximum temperature was recorded on 1-5-64 and 30-4-69 and the minimum on 20-1-65 and 27-1-65.

The monthly mean surface temperature ranged from 27.48°C in January to 30.55°C in April. The temperature steadily increased from January to April (Fig. 2) and registered a fall in May due to the onset of the south-west monsoon. The surface temperature continued its downward trend till July. A slight increase in average temperature was noticed in August which coincided with the slight slackening in the monsoon activity during this month. As a result of heavy rainfall during September a slight decrease in surface temperature was noticed in this month. The secondary peak in the surface temperature was noticed in October followed by a gradual decline in the following

months. From this it is clear that the surface temperature was influenced by the atmospheric temperature which in turn was influenced by the amount of precipitation in the locality.

Surface salinity

The salinity of the seawater in a locality, as is well known, is influenced by many factors like tides, currents, mixing, evaporation, precipitation, upwelling etc. It is indeed a very complex phenomenon and no single factor could be attributed to the changes in the salinity. With this limitation in mind only a broad picture of the seasonal changes in the salinity of the surface water at Port Blair is presented here.

The lowest salinity recorded during the period of this investigation was 18.32‰ on 27-9-67 and the highest 35.39‰ on 14-4-65 and 21-4-65. The monthly mean surface salinity ranged from 29.73 to 32.81‰ over the year. The surface salinity steadily increased from January to April (Fig. 2), and fell at the onset of the south-west monsoon in May. The decline continued from May to July corresponding to the period of heavy rainfall. The slight increase in August coincided with the slight decrease in rainfall during this month. The surface salinity was again lowered in September as a result of very heavy rainfall. Generally low salinity values occurred during the period of heavy rainfall and

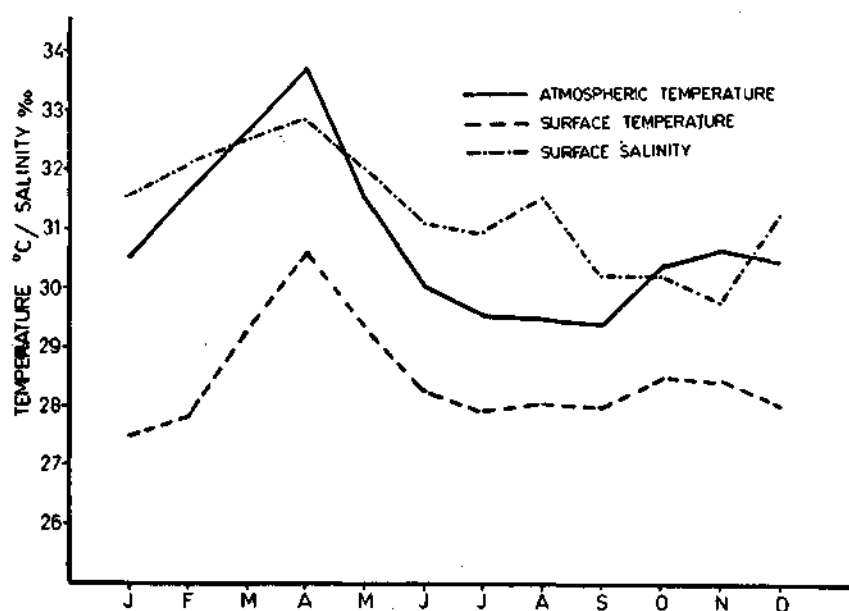


Fig. 2. General trend of atmospheric temperature, surface temperature and surface salinity at Port Blair, Andamans during 1964-1970.

high salinity during the period of low rainfall. However, departure from this general trend was noticed during October and November when the salinity continued to decline although there was a sharp decline in rainfall during this period. The retreat of the north-east monsoon from the Islands generally occurred during December resulting in further decrease in rainfall and consequent increase in salinity.

Wide fluctuations in surface salinity were noticed during the months of May to September roughly corresponding to the periods of heavy rainfall. A maximum fluctuation of 13.31‰ in the surface salinity was recorded during September 1967. Very little fluctuation in salinity was noticed during February to April corresponding to the dry season. On the basis of salinity trend the seasonal changes occurring in the surface waters at Port Blair can be broadly divided into (1) a period of high salinity with very little fluctuation during February to April, the pre-south-west monsoon period, (2) a fairly long period of comparatively low salinity with greater fluctuations during May to November, the period of the two monsoons and (3) a period of recovery during December and January, the post-north-east monsoon period.

Rainfall

The normal and actual rainfall and the percentage departure from normal at Port Blair during the period 1964 to 1970 are given in Table 2. The rainfall was above normal during 1964, 1965, 1967 and 1970 and below normal during the rest of the period.

TABLE 2. *Normal and actual rainfall at Port Blair*

Period	Normal rainfall cm	Actual rainfall cm	Percentage departure from normal
1964	313.25	332.38	+ 6.11
1965	318.05	321.57	+ 1.11
1966	318.05	292.77	— 7.95
1967	318.05	360.46	+ 13.33
1968	318.05	262.00	— 17.62
1969	318.05	268.95	— 15.44
1970	318.05	366.32	+ 15.18

The month-wise rainfall and average number of rainy days during the period are given in Table 3. Maximum precipitation occurred during May to September, which thus forms the period of south-west monsoon. Generally a slight slackening in the monsoon activity (rainfall) was noticed in the month of August. Before the south-west monsoon retreats from the Islands usually there is a heavy outburst of rainfall in September.

TABLE 3. *Month-wise average number of rainy days, rainfall and volume of plankton at Port Blair*

Months	Number of rainy days	Rainfall mm	Volume of plankton ml
January	3	51.14	95
February	1	9.47	68
March	0.3	9.99	62
April	4	39.33	46
May	19	436.24	48
June	18	419.37	65
July	20	514.11	44
August	20	415.19	67
September	20	533.96	59
October	16	282.07	80
November	14	268.36	82
December	8	169.99	85

Although the Andaman Islands receive rains during both the south-west and north-east monsoons the maximum precipitation occurs during the south-west monsoon. There is no complete cessation of rainfall after the retreat of the south-west monsoon and before the setting in of the north-east monsoon, and the long period of rainfall extends from May to December. This has a marked influence on the temperature and salinity conditions of the locality, as shown already.

Plankton volume

Only a brief mention is made here about the seasonal fluctuations in volume of plankton. Full details about the composition of plankton, and the abundance and seasonal fluctuation of the various components will be dealt with elsewhere.

The volume of plankton for a fifteen minutes surface haul varied widely during the course of this study. The lowest volume of 4 ml was recorded on 14-5-69 and the highest volume of 790 ml on 28-9-66. The month-wise average volume of plankton for the entire period is given in Table 3. The average volume varied from 44 ml to 95 ml, the highest being in January. High volumes were noticed during May-June, and October to January roughly corresponding with the period of decreasing rainfall. Generally an inverse relationship was noticed between the volume of plankton and temperature/salinity. During the period of high temperature and salinity the volume of plankton was generally low, while it was high during the period of moderate salinity and low

temperature. During the colder months the surface water was rich in planktonic organisms and often phytoplanktonic blooms consisting of species of *Thalassiosira*, *Thalassiothrix*, *Biddulphia*, *Bacteriastrum*, *Ceratium*, *Chaetoceros*, *Rhizosolenia* etc. were observed during this period.

DISCUSSION

Sewell (1929) has stated that the air temperature over the open waters of the Indian seas exhibited a clear double oscillation in the course of the year, there being two maxima (one in April and the other in September-October) corresponding to the two dry hot seasons and two minima during the periods of south-west and north-east monsoons. The temperature of the surface water also follows a similar course and exhibits a clear double oscillation. A similar double oscillation in surface temperature has been observed by Chidambaram and Menon (1945) off West Hill, Calicut, Ramamurthy (1953) along the Madras coast, Chacko *et al.* (1954) in the Kundugal Gut, Gulf of Mannar, and Prasad (1957) at Mandapam, Gulf of Mannar.

During the present investigation also the same pattern has been observed. The first major peak of air temperature was in April and the second minor peak in November. A slight increase in atmospheric temperature noticed during July-August in some years was not a constant feature. Similarly the trend of surface water temperature also exhibited a double oscillation. The slight increase noticed in August might be due to the proximity of the station to the land and in the open sea this feature is quite likely to be absent.

An interesting feature that emerged from this investigation was that the average atmospheric temperature was always higher than the mean surface temperature. Prasad (1957) has observed that the average atmospheric temperatures were above the mean surface temperatures mostly in the months of May, June and July at Mandapam. During most months the atmospheric temperature was below the surface temperature and the longest continuous period when such a situation existed was about ten months. The atmospheric temperature at Mandapam was, however, never above the surface temperature continuously for more than four months. Such a phenomenon was not noticed at Port Blair, possibly due to the markedly different meteorological conditions prevailing at Port Blair.

In the course of this investigation a close relationship was noticed between the surface temperature and salinity, the peaks in the surface temperature generally coinciding with the peaks in the surface salinity (Fig. 2). However, a deviation from this general trend was noticed during the month of December when the surface temperature registered a decline but the surface salinity exhibited an increase. This increase was probably due to the transport of high salinity water towards the Andaman coast during the post-north-east monsoon

period. An examination of the current chart of Bay of Bengal during December revealed that there was a strong north-westerly current from the Straits of Malacca flowing towards the Andaman coast. The retreat of the north-east monsoon from the Islands and the changed pattern of circulation during the month of December probably accounted for the increase in surface salinity during this period.

Regarding the seasonal changes in the volume of plankton it should be borne in mind that quantitative calculations based on tow net catches, as pointed out by Bigelow and Sears (1939), can only be approximation to the truth and great reliance cannot be placed on these data. However it is reasonable to assume that the fluctuations in the volume of plankton from a tow net may give a general picture of the gross changes that take place from month to month.

Information on the plankton production in the Bay of Bengal has been mainly confined to the inshore waters along the east coast of the mainland (Prasad, 1956; Ganapati and Murthy, 1955). Recently some observations have been made on plankton production in Andaman Sea during the International Indian Ocean Expedition. During the 33rd cruise of *R. V. Vityaz* in October 1960 to April 1961 maximal total quantity of phytoplankton was observed in the Andamans Sea (Zernova, 1962). Zernova and Ivanov (1964) have found that the Andaman Sea is a region of highest production of phytoplankton in the northern Indian Ocean. Prasad (1966) has also mentioned that moderately high plankton production is found in the Andaman Sea. The present study has also revealed moderately high plankton production in this area. It may be generally stated that the plankton production at Port Blair is high during the colder months and low during the period of high temperature and high salinity.

ACKNOWLEDGEMENT

The authors are grateful to Dr. S. Z. Qasim, Director, Central Marine Fisheries Research Institute, for the encouragement. The facilities offered by the various departments of the Andaman Administration for conducting this study are gratefully acknowledged.

REFERENCES

- BIGELOW, H. B. AND M. SEARS. 1939. Studies of the waters of the continental shelf, Cape Cod to Chesapeake Bay. III. A volumetric study of the zooplankters. *Mem. Mus. Comp. Zool., Harvard*, 54:181-378.
- CHACKO, P. I., A. P. VALSAN AND C. MALU PILLAI. 1954. Meteorology and hydrography of the Kundugal Gut in the Gulf of Mannar. *Contributions from the Marine Fisheries Biological Station, Krusaddi Island, Gulf of Mannar*, No. 1:1-20.

- CHIDAMBARAM, K. AND M. D. MENON. 1945. The correlation of the West coast (Malabar and South Kanara) fisheries with plankton and certain oceanographical factors. *Proc. Indian Acad. Sci.*, **22B**: 355-367.
- GANAPATI, P. N. AND V. S. R. MURTHY. 1955. Preliminary observations on the hydrography and inshore plankton in the Bay of Bengal off Visakhapatnam coast. *Indian J. Fish.*, **2**:84-95.
- JAYARAMAN, R. 1951. Observations on the chemistry of the waters of the Bay of Bengal off Madras city during 1948-49. *Proc. Indian Acad. Sci.*, **33B**:92-99.
- LA FOND, E. C. 1957. Oceanographic studies in the Bay of Bengal. *Proc. Indian Acad. Sci.*, **46B**:1-46.
- LA FOND, E. C. 1958. Seasonal cycle of the sea surface temperature and salinities along the east coast of India. *Andhra Univ. Mem. Oceanogr.*, **2**:12-21.
- PRASAD, R. R. 1952. Preliminary observations on the temperature gradients and light penetration in the upper 200 feet waters of the Bay of Bengal. *Proc. Indian Acad. Sci.*, **36A**: 61-69.
- PRASAD, R. R. 1956. Further studies on the plankton of the inshore waters off Mandapam. *Indian J. Fish.*, **3**:1-42.
- PRASAD, R. R. 1957. Seasonal variation in the surface temperature of sea at Mandapam from January 1950 to December 1954. *Indian J. Fish.*, **4**:20-31.
- PRASAD, R. R. 1966. Recent advances in the study of production in the Indian Ocean. *Second Int. Oceanogr. Cong. Moscow, 1966, Abs. pap.*, 89-90.
- RAMAMURTHY, S. 1953. Hydrobiological studies in the Madras coastal waters. *J. Madras Univ.*, **23B**: 148-163.
- SEWELL, R. B. S. 1928. Geographic and oceanographic research in Indian waters. IV. The temperature and salinity of the coastal waters of the Andaman Sea. *Mem. Asiat. Soc. Beng.*, **9**:133-205.
- SEWELL, R. B. S. 1929. Geographic and oceanographic research in Indian waters. V. The temperature and salinity of the surface waters of the Bay of Bengal and Andaman Sea with reference to the Laccadive Sea. *Mem. Asiat. Soc. Beng.*, **9**:207-355.
- VARMA, T. P. U. AND C. V. G. REDDY. 1959. Seasonal variations of the hydrological factors of the Madras coastal waters. *Indian J. Fish.*, **6**:298-305.
- ZERNOVA, V. V. 1962. Quantitative distribution of the phytoplankton in the northern Indian Ocean. *Trudy. Inst. Okeanol.*, **58**:45-53.
- ZERNOVA, V. V. AND J. V. IVANOV. 1964. The dependance of distribution of phytoplankton upon the hydrological conditions in the northern part of the Indian Ocean. *Trudy. Inst. Okeanol.*, **64**:257-264.