

## SWARMING OF *NOCTILUCA* IN THE PALK BAY AND ITS EFFECT ON THE 'CHOODAI' FISHERY, WITH A NOTE ON THE POSSIBLE USE OF *NOCTILUCA* AS AN INDICATOR SPECIES<sup>1</sup>

BY R. RAGHU PRASAD

(Central Marine Fisheries Research Station, Mandapam Camp)

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AN unusual occurrence of *Noctiluca miliaris* Suriray in great numbers in the inshore waters of the Palk Bay off Mandapam was noticed in April 1952. Their first appearance was on the 14th when in one c.c. of the standardized sample of plankton<sup>2</sup> there were only 25 *Noctiluca*. Soon they showed signs of rapid increase and by April 18 their number in one c.c. reached the order of 3,300. From then on they continued to be present in this area in swarms until July except on three days—May 5, 30 and June 2 when there was an appreciable decline in their numbers being 52, 40 and 60 respectively per c.c. When these occur in enormous numbers a discolouration of the water is clearly visible from the shores showing generally shades of red. Locally the *Noctiluca* which swarmed did not have a pink or red colour as observed along the west coast of India or off Madras, but had a bright green tint because of the presence of numerous actively moving green flagellates in them and they produced a green colouration of the surface water. Delsman (1939) noted that: "A peculiarity of the tropical *Noctiluca* is the presence of a large number of small green flagellates in the spaceous vacuoles, as first stated by the Weber's who, however, did not observe living material. If we do so, we find that these small green organisms of which hundreds, perhaps even thousands, are present in each *Noctiluca*-cell do not be still there but are swimming vigorously about in the fluid which fills the spaceous vacuoles."

Aiyar (1935) was probably the first to record the widespread mortality among fishes in Indian waters caused by the swarming of *Noctiluca*. In

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<sup>2</sup> The entire plankton sample collected during a fifteen-minute horizontal haul was made up to 250 c.c. and after thoroughly mixing it a sub-sample of 1 c.c. taken from this was used for counting the number of *Noctiluca* and other organisms.

the opinion of Devanesan (1942) *Noctiluca* is a competitor for the food of oil-sardines as both feed on diatoms such as *Coscinodiscus*, *Nitzschia* and *Fragillaria* and the abundance of the inedible *Noctiluca* may have a bearing on the scarcity of oil-sardines along the west coast of India at certain seasons. He further adds that the spawning mackerels probably select areas where the *Noctiluca* abound for laying eggs as fish feeding on fish-eggs would loathe to enter such areas. Panikkar (1949) remarked: "It is known that 'red water' phenomena are inimical to fisheries because shoaling fish do not frequent such patches, and on the Indian coasts the fishermen have learnt to avoid such patches." More recently abrupt set-backs in the fisheries of the Malabar and South Kanara coasts have been reported by Bhimachar and George (1950). They remark: "The immediate effect of the occurrence of the 'red water' or slimy water phenomena was a steep fall in the fish catches over a long stretch of the coastal waters. It is clear from our observations and enquiries that the bulk of commercial fishes—particularly the shoaling species, the chief among them being the mackerels and allied forms, sardines and anchovies—did not appear in such waters. There was however no severe mortality among fishes. It would appear that the physico-chemical conditions of the water thus affected were in some way unfavourable for fish to live that they completely avoided such areas." Further, they add: "It appears clear from the foregoing observations that the severe set-back in the fishery over a long stretch of coastal waters in the Malabar and South Kanara Districts during October 1948 was mainly due to the putrefaction of the superabundant *Noctiluca* population, giving rise to thick masses of slimy substance occurring in a state of suspension in the coastal waters. The most characteristic feature of the phenomenon was the extensive slimy masses of dead and decaying *Noctiluca* mixed partly with the fine clay of the mud banks characteristic of the area."

As for the causes responsible for these sudden outbursts it is not possible now to give satisfactory explanations and as Galtsoff (1948) has pointed out: "A thorough knowledge of the ecological conditions preceding the outbreak of red tide, as well as those existing during and after its maximum development are necessary for the understanding of the problem." However, it may be mentioned that although there were no violent fluctuations in the concentration of phosphates, nitrates and pH from January to July 1952, the monthly average values for nitrates were clearly of a lower order during May, June and July compared to the preceding months and also in relation to the values obtained for June-July of the previous year (Table I). Also, there were indications of an increase in the silicate contents of the sea water (although within the normal range of silicate in sea water, Ref. Robinson and

Thompson, 1948) at the time when there were swarms of these dinoflagellates. Ketchum and Keen (1948) observed unusually high phosphorus concentration in the Florida 'Red tide' sea-water; the total phosphorus content varied from 4.9 to 20.4 microgram atoms per litre which was approximately two and a half to ten times the normal expected concentration. The total phosphorus content estimated during the swarming of *Noctiluca* ranged between 0.80 to 1.29 microgram atoms per litre and at other times the samples taken at the same place contained 0.77 to 1.03 microgram atoms per litre, consequently the values were within the normal range to be expected in sea water. The salinity showed a steady rise from January to July 1952 and compared to the previous year, it was higher in May-June and lower in July (Table I).

TABLE I

*Hydrological data on the surface waters of the Palk Bay. The values are averages for the months and blanks indicate the lack of data*

Month	1951					1952				
	Salinity ‰	pH	Phos- phate mg/m. <sup>3</sup>	Nitrate mg./m. <sup>3</sup>	Oxygen saturation %	Salinity ‰	pH	Phosphate mg./m. <sup>3</sup>	Nitrate mg./m. <sup>3</sup>	Oxygen saturation %
Jan.	..	..	..	..	..	28.52	8.45	5.20	61.75	74.60
Feb.	..	..	..	..	..	29.58	8.40	6.36	51.00	63.22
March	..	..	..	..	..	30.89	8.40	5.55	53.57	65.75
April	..	..	..	..	..	32.00	8.40	5.42	59.42	66.25
May	32.16	8.46	5.23	38.07	64.46	33.03	8.35	4.78	41.85	63.57
June	33.49	8.46	8.00	66.00	..	33.78	8.41	8.07	39.33	77.33
July	34.50	8.48	..	71.00	..	33.80	8.40	6.45	42.00	65.25

The occurrence in good numbers of *Creseis acicula* during April seems to be of interest in this connection. They first appeared on April 8 and in all subsequent plankton samples of April they were present. By about the second week of May they almost completely disappeared. Last year during May they were not present in any of the plankton samples and no data are available for April 1951. Whether the appearance of these and the higher salinity recorded this year for May and June indicate an influx of water from elsewhere into this area, during the period under consideration, is a possibility that cannot be overlooked. It may also be mentioned that *Evadne tergestina* occurred in very small numbers during last year only in July but

this year they were common during May and continued to be present up to the beginning of July although in fewer numbers. If these indicate an incursion of water masses from outside there is the possibility that the *Noctiluca* might have been brought into this area. However, no significant differences in the species composition of the diatoms which were present during 1951 and 1952 were noticed although the diatom population level was considerably lower in May, June and July 1952. The copepods on the other hand were higher during May-June and lower during July 1952 as compared to 1951 (Table II). But it must be noted that though the monthly average figures for copepods were higher during May-June there was an appreciable decimation of copepods on the days when the intensity of *Noctiluca* population was high.

TABLE II

*Average number of diatoms and copepods per c.c.*

Month	1951		1952	
	Diatoms	Copepods	Diatoms	Copepods
April ..	..	..	10216	171
May ..	85604	163	25174	323
June ..	69394	144	56879	311
July ..	56609	352	495	258

The swarming of *Noctiluca* was not accompanied by their death, decay and subsequent formation of a slimy substance as noticed by Bhimachar and George *op. cit.*, and there was no appreciable reduction in the oxygen saturation, it being of the usual order (Table I). During this period the range of saturation varied between 91% in June 2 and 44% in July 11.

Since there has been reports of the swarming of *Noctiluca* causing heavy mortality amongst marine fauna the present occurrence of these in great numbers was watched with interest for its possible effects on the local fauna especially fishes. Curiously enough contrary to the observations made along the coast of Madras, no cases of mass mortality caused by the phenomenon among marine fauna were noticed but there was a definite effect on the local fish and fisheries.

During the period from the middle of March to the middle of July there is a very lucrative fishery, known locally by the name 'choodai' fishery, along the coast of the Palk Bay extending from Dhanushkodi to Panakulam.

The commencement and the closing of the season might vary slightly from year to year. The fish landed during a season at Monakad near Mandapam alone usually exceeds 120,000 lb. which is equal to about 40,000 lb. of dried fish<sup>3</sup> fetching approximately Rs. 14,000.

The catches are composed mostly of juvenile clupeoids belonging to the *Sardinella*, *Hilsa* and *Anchoviella* groups. Of these *Sardinella* spp. form the major portion. The important species are *S. albella*, *S. gibbosa*, *Anchoviella* spp., *Hilsa kanagartha* and *S. fimbriata* in the order of abundance. Anchovies may not be present in all the samples and occasionally a few *Leiognathus* spp., may also be found along with the others in the catches. The fish caught during the early part of the season are on an average 30 mm. but individuals as small as 20 mm. in standard length are also fairly common and by the close of the season the average size of fish landed is 60 mm.

These young ones congregate probably for feeding on the abundant diatoms and copepods usually found in this area at this time of the year. Examination of the stomach contents shows that they feed chiefly on diatoms and copepods and occasionally on molluscan larvæ.

A sudden fall in the catch of 'choodai' was noticed in the 1952 season. The total landings of fresh fish were only 60,350 lb. as against 120,960 lb. landed during 1951. This year (1952) the fishing started around April 9 and as usual the catches were not very large during the first two or three days. About 4,000 lb. were landed up to April 14 and on the next day 14,000 lb. were landed, this being the highest single catch for the season. Following this there was a steady decline and the fishery came to a premature close by the middle of May because the catches were extremely poor or nil. It was earlier mentioned that *Noctiluca*, although appeared on April 14, assumed a swarming proportion only on the 18th. On that day the total catch of fish was 500 lb. As already pointed out the number of *Noctiluca* was very low during May 5, 30 and June 2. On May 2, when the *Noctiluca* population was high the <sup>quantity</sup> quality of fish caught was 525 lb. but on the 5th there was a marked increase in the fish catch (6,000 lb.) and a corresponding fall in the number of *Noctiluca* there being only 52 per c.c. Unfortunately no data are available for May 30 and June 2 as there was no fishing. From this it appears that the fish are avoiding the areas where there are dense patches of *Noctiluca*. This assumption is supported by the fact that those few fishermen who went out beyond the region of *Noctiluca* swarms located large schools of fish. Some of the local fishermen have reported that a similar phenomenon occurred many years ago in the same area but none

<sup>3</sup> The wet weight will be about three times dry weight as estimated in the laboratory.

of them could give the exact year in which it happened. Here is probably another instance of animal exclusion ascribable to the direct effects of external metabolites or *ectocrines*. It may be pointed out that several examples of dinoflagellate swarms accompanied by a decimation of zooplankton are found in the literature (Ref. Galtsoff, 1948 and Sproston, 1949). Fig. 1 shows the monthly average number of *Noctiluca* per c.c. and the total landings of 'choodai' for April and May 1952.

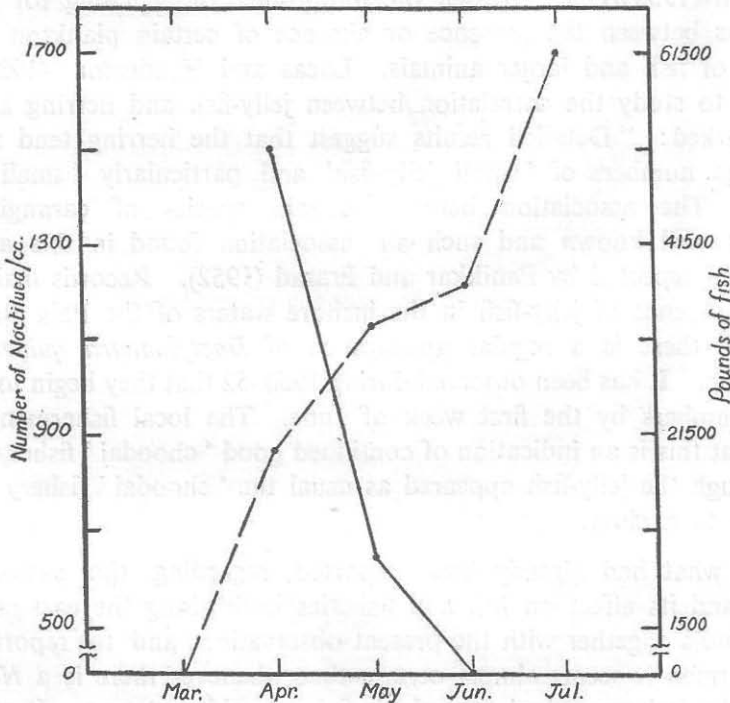


FIG. 1. Showing the average number of *Noctiluca* per c.c. (broken line) of the standardized sample and the total 'choodai' landed.

Plankton studies in relation to fisheries conducted in several places, particularly in the North Sea, have brought to light certain interesting correlations between the fisheries and the environment both animate and inanimate. As a result of these investigations on the ecological relationships there have been established what are called 'indicator species'. Some of the well-known examples of such relationships are the occurrence in certain areas of dense patches of certain species of diatoms such as *Rhizosolenia*, *Biddulphia* or sometimes both mixed together and the absence of herring from that region. These patches of diatoms when they occur near the main shoaling ground delay the arrival of herring or sometimes the fish are

deflected from these normal grounds. Similarly it is also well established that when in these areas there is an abundance of the copepod—*Calanus* instead of the diatoms, the herring catches are extremely good. Several other such examples of indicator species not only of fisheries but also of water movements in general are found in the literature (Ref. Bullen, 1908; Russell, 1935 *a* and *b*; Henderson, 1936; Henderson, Lucas and Fraser, 1936; Lucas and Henderson, 1936; and Corbin, 1947).

Russell (1935 *b*) has stressed the importance of watching for possible correlations between the presence or absence of certain plankton animals with that of fish and larger animals. Lucas and Henderson (1936) have attempted to study the correlation between jelly-fish and herring and they have remarked: "Detailed results suggest that the herring tend most to avoid large numbers of 'small jelly-fish' and particularly 'small white' jelly-fish." The association between certain species of carangids and jelly-fish is well known and such an association found in this area has already been reported by Panikkar and Prasad (1952). Records maintained on the occurrence of jelly-fish in the inshore waters of the Palk Bay have shown that there is a regular appearance of *Dactylometra quinquecirrah* in early June. It has been observed during 1950-52 that they begin to appear in large numbers by the first week of June. The local fishermen are of opinion that this is an indication of continued good 'choodai' fishery. This year although the jelly-fish appeared as usual the 'choodai' fishery had by then come to a close.

From what had already been reported regarding the swarming of *Noctiluca* and its effect on fish and fisheries both along the east and west coasts of India together with the present observations and the report of the local fishermen it seems almost certain that whenever there is a *Noctiluca* swarm in the inshore waters the pelagic fishes avoid that area. It seems to be a parallel example to that of the *Rhizosolenia* or *Biddulphia* and herring relationship observed in the North Sea except that the organisms involved are different. Therefore, it is suggested that *Noctiluca* can be considered as an indicator species of a poor 'choodai' fishery locally and in view of the remarks made by Bhimachar and George *op. cit.*, it may even be said that they indicate a poor pelagic shoaling fish fishery.

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## REFERENCES

- Aiyar, R. G. .. "Mortality of fish of the Madras coast in June, 1935," *Curr. Sci.*, 1935, 4, 488-89.
- Bhimachar, B. S. and George, P. C. "Abrupt set-backs in the fisheries of the Malabar and Kanara coasts and "Red water" phenomenon as the probable cause," *Proc. Ind. Acad. Sci.*, 1950, 31B, 339-50.
- Bullen, G. E. .. "Plankton studies in relation to the western mackerel fishery," *Jour. Mar. Biol. Assoc.*, 1908, 8, 269-302.
- Corbin, P. G. .. "The spawning of mackerel, *Scomber scombrus* L., and Pilchard *Clupea pilchardus* Walbaum, in the Celtic Sea in 1937-39 with observations on the zooplankton indicator species, *Sagitta* and *Muggiea*," *Ibid.*, 1947, 27, 65-132.
- Delsman, H. C. .. "Preliminary plankton investigations in the Java Sea," *Treubia*, 1939, 17, 139-81.
- Devanesan, D. W. .. "Plankton studies in the fisheries branch of the Department of Industries and Commerce, Madras," *Curr. Sci.*, 1942, 11, 142-43.
- Galtsoff, P. S. .. "Red tide. Progress report on the investigations of the cause of the mortality of fish along the west coast of Florida conducted by the U. S. Fish and Wildlife Service and co-operating organizations," *U. S. Fish and Wildlife Service Special Scientific Rept.*, 1948, 46, 1-44.
- Henderson, G. T. D. .. "The zooplankton-herring correlations in the Scottish fisheries," *Jour. Mar. Biol. Assoc.*, 1936, 21, 243-76.
- , Lucas, C. E. and Fraser, J. H. "The relation between catches of herring and phytoplankton collected by the plankton indicator," *Ibid.*, 1936; 21, 277-91.
- Ketchum, B. H. and Jean Keen "Unusual phosphorus concentrations in the Florida 'Red tide' sea water," *J. Mar. Res.*, 1948, 7, 17-21.
- Lucas, C. E. and Henderson, G. T. D. "On the association of jelly-fish and other organisms with catches of herring," *Jour. Mar. Biol. Assoc.*, 1936, 21, 293-302.
- Panikkar, N. K. .. "A survey of the pelagic fisheries of the world. Pt. II.— The biology of pelagic fishes," *Proc. Indo-Pacific Fish. Council, 1st Meeting, Singapore*, 1949, 123-32.
- and Prasad, R. R. "On an interesting association of ophiuroids, fish and crab with the jelly-fish *Rhopilema hispidum*," *Jour. Bombay Nat. Hist. Soc.*, 1952, 51, 295-96.
- Robinson, R. J. and Thompson, T. G. "The determination of silicate in sea water," *J. Mar. Res.*, 1948, 7, 49-55.
- Russell, F. S. .. "On the value of certain plankton animals as indicators of water movements in the English Channel and North Sea," *Jour. Mar. Biol. Assoc.*, 1935 a, 20, 309-31.
- .. "A review of some aspects of zooplankton research," *Cons. Perm. Int. pour l'explor. de la Mer, Rapp. Proc. Verb.*, 1935 b, 95, 5-30.
- Sproston, Nora G. .. "A preliminary survey of the plankton of the Chu-San region, with a review of the relevant literature," *Sinensia*, 1949, 20, 58-161.