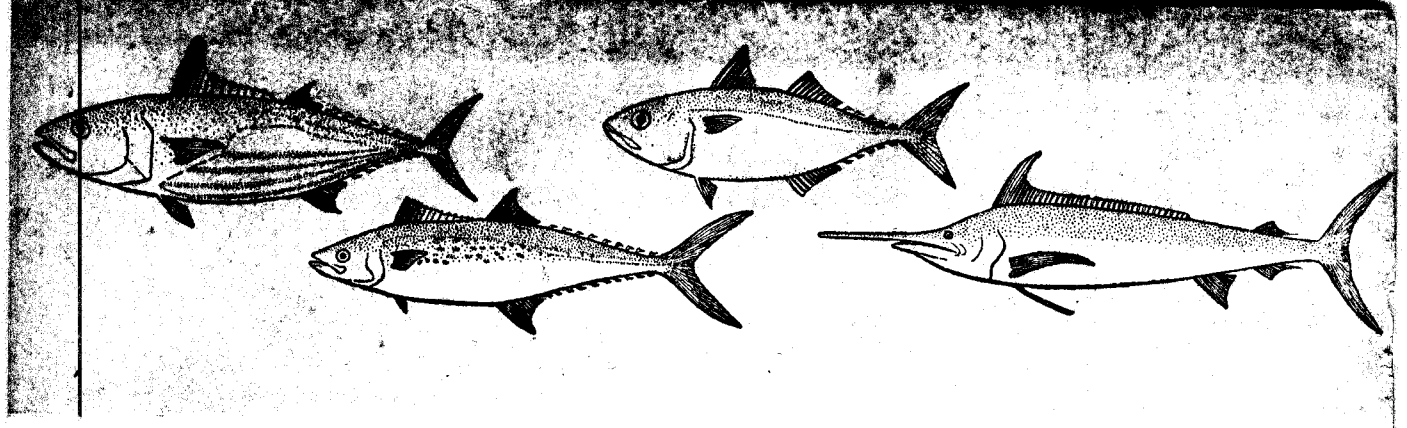
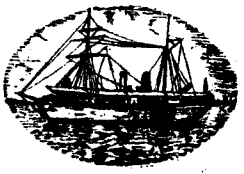


SYMPOSIUM ON

SCOMBROID FISHES

PART III



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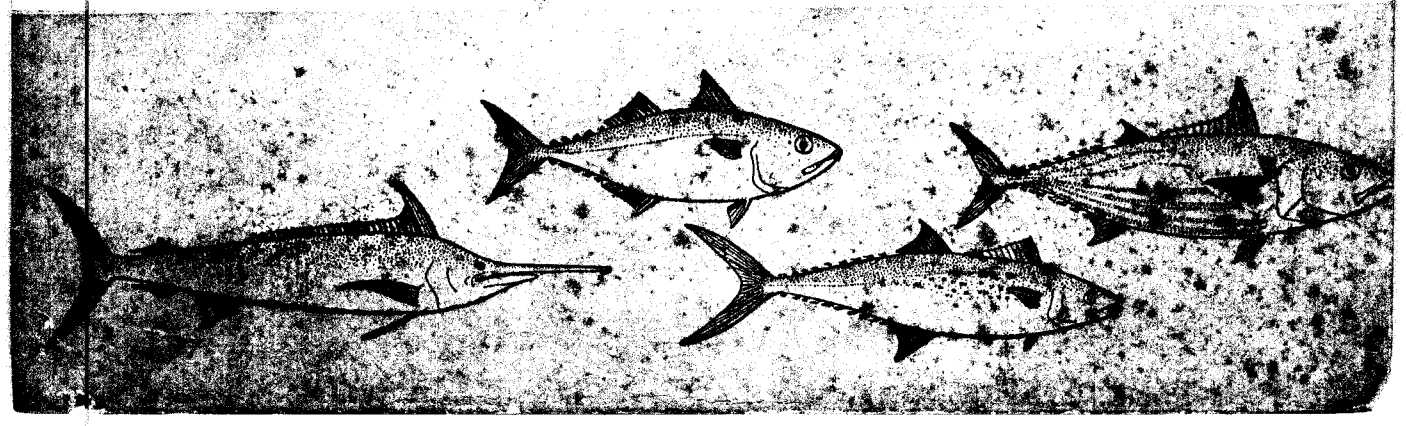
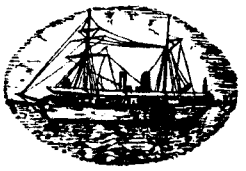


PROCEEDINGS OF THE

SYMPOSIUM
ON
SCOMBROID FISHES

HELD AT MANDAPAM CAMP FROM JAN. 12-15, 1962

PART III



SYMPOSIUM SERIES I

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BIOLUMINESCENCE AND MACKEREL FISHERY*

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INTRODUCTION

BIOLUMINESCENCE or 'phosphorescence' is primarily associated with the marine environment, and this phenomenon has sporadically appeared in several marine organisms often involving even complex light organs and glandular structures as seen in certain species of euphausiids, copepods, ostracods, etc. Quite often spectacular luminescence on the surface of the sea is noticed and this may be caused by a profusion of dinoflagellates such as *Noctiluca*, *Gonyaulax*, and *Peridinium*. For a fuller discussion on the subject of bioluminescence reference is invited to Harvey (1940, 1952).

While all the practical applications to which this phenomenon of bioluminescence in the sea can be made use of to serve man are not yet fully apparent, at least from the fisheries point of view one useful purpose it serves is to aid in scouting movements of surface shoals of fish. Technological progress in the form of sonar devices and other fish finders which aid in scouting for shoaling fish both during daytime as well as at night have not altogether replaced visual scouting of fish such as sardines and mackerel at night. On the Pacific coast of North America, the dinoflagellate *Gonyaulax* which is both photosynthetic and luminescent is known when present to help by their luminescence, purse seine fishermen locate sardine shoals (Scofield, 1926 ; Fry, 1930 ; and Linder, 1930). Sweeny and Hastings (1957) have estimated the duration of the light flash given out by *Gonyaulax* upon stimulation to be 0.1 sec. When large numbers of these are stimulated in the ocean by the passage of a shoal of fish or by wave action, the disturbed water glows as a result of the flashing of myriads of these animals. To use fishermen's parlance—'the water fires' !

Bioluminescence has played and still plays no mean part in aiding purse seine fishery for mackerel along certain parts of the North Atlantic coast of North America. Sette (1950) speaking of the North Atlantic mackerel *Scomber scombrus* remarks that luminescent patches caused by moving schools, especially on moonless nights should be visible from some distance, and this should be so even when they are flashing at depths down to 10 fathoms on such nights. He cites one instance of exceptional clarity when a school was judged to be 'firing' at a depth of 25 fathoms as it was missed by a purse seine 22 fathoms deep.

Writing on Malayan purse seine fishery, Gopinath (1950) comments that the purse seine fishing operations for mackerel off the island of Pangkor on the Malayan Coast are conducted only on dark nights to enable the fishermen to detect the shoals at a distance, as a result of the luminescence thrown up by their movement. At Pangkor a fishing season is of 19 to 20 days duration each month as it starts about six days after the full moon and extends to about 10 or 11 days after the new moon. 'During the waning phase the fishing is done in the dark period preceding moonrise, and in the waxing phase in the hours following the setting of the moon. In the early part of the season, therefore, the fishermen start from their base at about 5 p.m. and return by about 1 a.m The starting time is gradually delayed as the season advances, and by the day of the new moon the men are fishing all through the night. Towards the close of the season they start at 11 p.m.

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or midnight, when the moon is well down in the sky, and fish until the morning, getting back to their base at 7 a.m. or even later. Slack tide is considered to be the best time for the operation of the net, since there is then no chance of it being carried away by strong currents.' Obviously luminescent planktonic organisms occur in the Malayan waters in some profusion all through the year as the data given by Gopinath on the landings of mackerel for all the months of the year by purse seine gear would indirectly indicate. Unfortunately, a qualitative and quantitative assessment of the plankton of those waters is not available to give us an idea of the various species responsible for this phenomenon of bioluminescence and their precentage composition and fluctuations from season to season. Kow's (1950) data on the plankton of the adjacent waters off the Singapore Straits, nor the results of his examination of the stomach contents of a few mackerel from that area throw no light on the organisms responsible for this phenomenon. Of the 12 specimens of *Rastrelliger kanagurta* examined, Kow found the stomachs of 10 to be packed with green digested material in which remains of *Coscinodiscus* and crustaceans including copepods, *Squilla* larvae and brachyuran zoea could be recognised. Of these food items, *Coscinodiscus* is a most conspicuous feature of the phytoplankton of the Singapore Straits for all the months of the year, while copepods and brachyuran larvae similarly occur in the zooplankton. *Squilla* larvae are very rare and are present in the months of March-April and December. Obviously none of these items of zooplankton may be responsible for the production of bioluminescence on such a large scale as mentioned above.

Besides Pangkor, purse seine fishing for mackerel is carried on, on a much smaller scale on other parts of the Malayan coast, namely, on the Mersing coast; Kedah; and off Singapore (Gopinath, 1950; Burdon, 1954).

Bioluminescence and Sighting of Mackerel Shoals off the Ratnagiri Coast (India)

On the night of 17 November 1960, through the courtesy of the Department of Fisheries, Bombay State, I was able to go out for drift net fishing on one of their mechanised fishing vessels, *SURUMAI*, to the 16 fathom line about 16 km. (10 miles) off Ratnagiri on the west coast. We left Mirya Bay, Ratnagiri at 17.30 hours, and being one day prior to new moon, it was sufficiently dark by the time we reached the fishing grounds at 18.45 hours to make out the abundance of luminescent planktonic organisms at the surface, made evident by the disturbance caused by the vessel. This profusion of planktonic life was more conspicuous later in the night when within 30 minutes of hanging a gas-light about half a metre above water on the starboard side of the vessel, a thick scum of luminescent zooplanktonic organisms, predominantly ostracods, amphipods, and coelenterates (siphonophores) started continuously gathering at the surface and gradually drifting in a broad brown band. Hauls with a suspended one metre plankton net were made every 15 or 20 minutes from 19.30 hours to about 02.00 hours on the 18th. An analysis of the plankton collected (graphically shown in text-figure 1) indicate percentage-wise: Ostracods (*Pyrocypris* sp.) 38%, amphipods (*Hyperia* spp.) 31.5%, siphonophores 8%, copepods (*Acrocalanus longicornis*, *Oncaea cleui*, *Corycaeus* (*Corycella*) *gibbula*, *Acartia erythraea*, *Eucalanus* sp.-copepodi tes; *Temora turbinata*) 20%, and other crustacea (e.g. *Lucifer*, Megalopa of crab, etc.) 2.5%. The light as well as the accumulation of the planktonic matter beneath it attracted several smaller fish.

At 20.30 hours a large mackerel shoal was sighted about one mile to the south of *SURUMAI* by the luminescent patch at the surface and with the help of field glasses it was possible to keep track of the shoal for about 7 minutes while it was moving in a slightly north-easterly direction. This was a ' silent shoal ' as the fish were moving just below the surface, and the luminescent patch which had the appearance of a broad crescentic band had one of the arms longer, the distance between the ends of the two arms being about two hundred metres or slightly less. At 21.15 hours a second shoal was sighted about one mile to the south of *SURUMAI* and in about five minutes it approached to within about 400 metres of the vessel, but kept on moving in a northerly direction. Unlike the first shoal, this shoal could be ' heard ' from the time it was sighted by the considerable surface agitation caused by the fish, making the crescentic luminescent patch very

conspicuous and appear to bubble. At 22.00 hours, a third 'silent shoal' was sighted south of the vessel, but heading towards it, which it reached in about four minutes, passing under it at a depth of about a fathom. The luminescence thrown up by the movement of the shoal which had an anteriorly dented crescent shaped pattern was such that when it passed under the vessel individual fishes could be seen very clearly and even the markings on their body were easily discernible. As far as could be seen there was no evidence of any predatory fish or any other species mixing or remaining with this shoal, which was smaller than the first two, being hardly a hundred metres wide.

The patterns of the shoals and the direction of movements which may be of interest is shown in text-figure 2. The sighting of the three shoals first spotted 6 to 8 miles off the coast in the earlier part of the night and the general direction of movements northwards are points worth noting. Mr. A. V. Shivde, Gear Technician, Bombay State Fisheries, who on board the *SURUMAI* was conducting the drift net operations informed me that he had witnessed similar movements of mackerel shoals on previous occassions earlier in November while conducting drift net or gill net fishing operations in the 10 to 25 fathom lines off Ratnagiri. The present state of our knowledge does not permit us to even speculate as to whether these represent movements of shoals from the deeper waters towards inshore waters ; a general northward movement of the whole fishing population or stock ; or localised movements within a particular area.

Possibilities of Purse Seine Fishing for Mackerel at Night in Indian Waters

One of our principal aims is discovering possibilities of establishing suitable offshore fishery for pelagic fishes such as mackerel, the fishery of which, perforce is at present restricted to inshore waters not exceeding two to three kilometres from the shore and dependent primarily on beach seines operated mostly during day time. Considering the likelihood that most of the mackerel shoals may be moving outside these limits, apparently only a fraction of this potential wealth is being tapped at present. The luminescence thrown up by the mackerel shoals at night which probably would be more conspicuous 6 to 7 days prior to and 10 to 12 days after the new moon on the dark nights or dark phases of the nights when they could be sighted at a distance should undoubtedly aid in purse seine fishing for mackerel at night from mechanised boats in Indian waters as successfully carried out off the west coast of Malaya and Singapore (Gopinath, 1950 ; Burdon, 1954) and the same may also apply for sardines. On the south west coast of India off Mangalore and Calicut fishermen use a type of trawl net known locally as *Aila kolli vala* at night for the capture of mackerel shoals. The net is operated from two boats at depths generally less than 10 fathoms and usually within 10 kilometres from the coast. There is antipathy towards the use of this net locally on account of its operation relatively close to the shore and the consequent feeling that this depletes the legitimate catches of shore seiners. However, the picture could be different if such fishing could be carried out from mechanised craft which may enable such fishing to be carried out farther away from the coast.

It may not be proper while drawing attention to the desirability of exploring possibilities of purse seine fishing for these fishes at night, not to indicate some attendant problems. Some of these are :

1. It remains to be seen whether the observations recorded here for the Ratnagiri coast is an unusual event and that the profusion of planktonic organisms, mainly ostracods and amphipods represent local swarming of these organisms probably governed by the phase of the moon or vertical movements to the surface from the bottom layers attracted by the suspended light. However, the sighting of the mackerel shoals by the luminescence thrown up by their movements, is of interest. On 20th November night while travelling by ferry steamer from Ratnagiri to Malwan accompanied by Mr. K. Narasimham, Fishery Survey Assistant of this Institute, the luminescence caused by the slightest agitation of the water was found to be much greater, but unfortunately a sample of the plankton could not be collected. From these and Mr. Shivde's remarks of

sighting mackerel shoals by their luminescence already mentioned it would appear that this phenomenon of bioluminescence which could assist in scouting mackerel shoals is not unusual

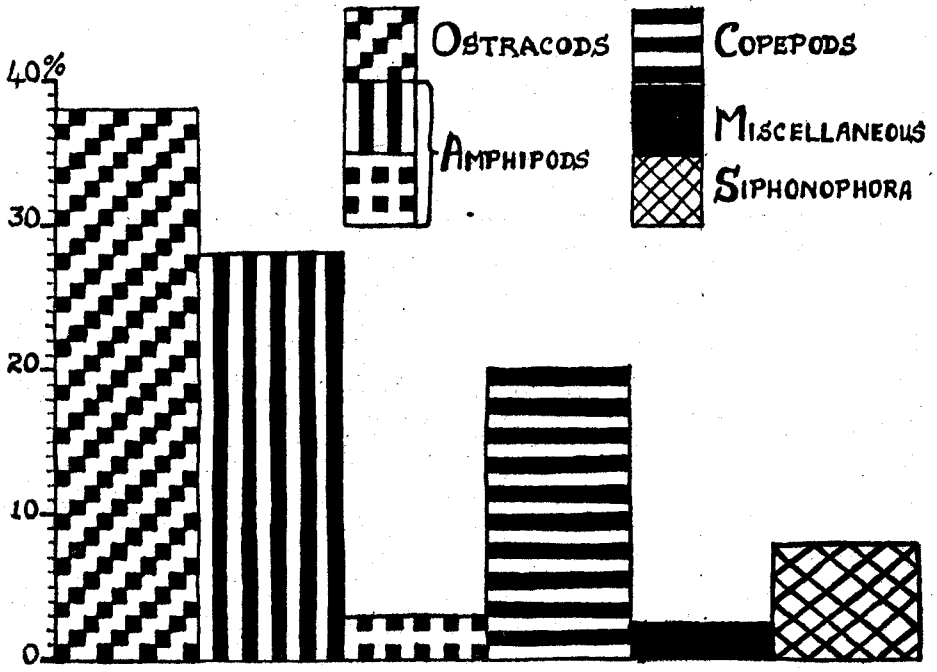

FIG. 1. Percentage composition of zooplankton collected 16 Km. off Ratnagiri on 17-11-1960 night.

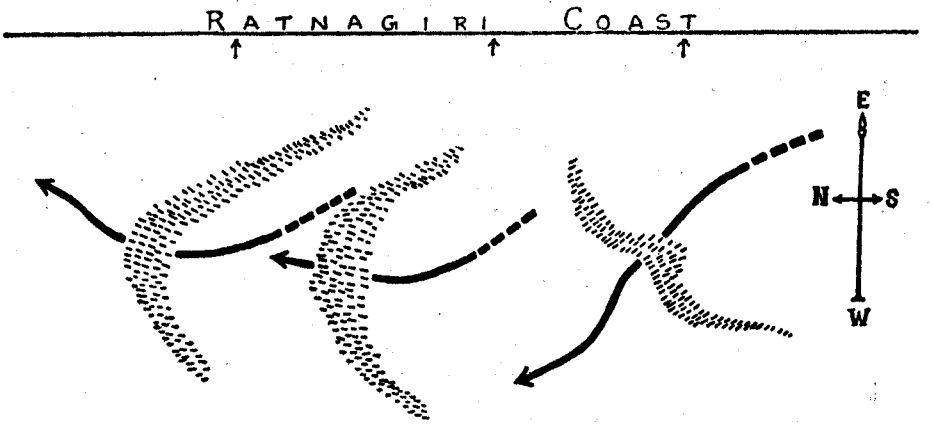

FIG. 2. Showing the pattern and direction of movement of the mackerel shoals sighted off Ratnagiri on the night of 17 November 1960. Shoal numbers 1, 2, and 3 are from left to right respectively.

along the Ratnagiri coast. Quite likely the components in the zooplankton may differ, from time to time, but luminescent organisms may be present in some profusion over an extended period.

2. This could be investigated by work carried out on more fundamental lines, the data of which could indirectly assist mackerel and sardine purse seiners in night fishing. I have in mind

the measurement of the intensity of luminescent flashing in the surface waters using a portable bathyphotometer and also correlating the data with actual analysis of plankton hauls from the area. Some information on measurement of surface luminescence and luminescence at depths in the sea and the methodology used in carrying out such work could be had from the works of Clark and Wertheius (1956), Boden and Kampa (1957), Clark and Hubbard (1959), and Clark and Breslau (1959, 1960). Such study could be carried out in different locations after preliminary scouting to see areas where regularly mackerel shoals could be spotted at night, the depth of water in which the shoals occur to enable use of purse seine gear etc. Comparative measurements of surface luminescence may help in eventually defining areas where such fishing could be carried out both for mackerel and sardines.

3. It will indeed be hasty to find an answer to the last said by an assessment of the previous studies on the food of the Indian mackerel, for as Bhimachar and George (1952) have shown, *R. kanagurta* may be selective in its food habits. They found that in spite of the common occurrence of forms such as *Sagitta*, stomatopoda, spionid larva, hydromedusae, ctenophores, and *Noctiluca* these items were rarely recorded from the stomach of the fish off Calicut on the west coast.

4. Bioluminescence also plays a role in the shoaling behaviour of mackerel and other pelagic fishes. That visual perception is the principal factor underlying the shoaling habit of fishes was postulated by Parr (1927) as a result of his studies of the habits of the scombroid *Pneumatophorus grex*. Elaborating on this theory Sette (1950) remarks that '. . . . if the aggregations into schools depend on vision, it would take place during the daytime and schools should be broken down during every sufficiently dark night. If this is true, the nightly reshuffling of individuals should tend to keep the population homogenously mixed. At certain seasons, however, the breakdown of schools does not take place at night, for purse seiners locate and catch schooled mackerel at night both in spring time and in autumn. At these seasons the schools are located by luminescence associated with them. This occurrence of schools at night need not be contrary to Parr's theory, for obviously the luminescence may be as effective as day light in permitting the visual perception necessary.' Other aspects of mackerel behaviour, such as, whether schools would tend to be 'wild' and scatter to reform into smaller schools when approached by a mechanised boat; the sizes of shoals; direction of movements; difference in size composition within the school; swimming speed, etc., could be studied by observations on mackerel schools at night aided by bioluminescence and from purse seine catches made at night under such circumstances.

5. The average yearly mackerel landings along the Indian coast for the years 1950 to 1959 has been estimated to be about 68,4791 metric tonnes, in other words 10% to 15% of the total yearly fish landings along our coast. That there is scope for improving the position by the introduction of gear such as purse seines cannot be denied. When this is done, it is likely that better fishing could result by using purse seines for mackerel and even sardines at night when scouting for shoals would be easier as successfully carried out from mechanised boats in other parts of the world.

REFERENCES

BHIMACHAR, B. S., and GEORGE, P. C. 1952. Observations on the food and feeding of the Indian mackerel *Rastrelliger kanagurta* (Cuvier). *Proc. Indian Acad. Sci.*, **36**(3) : 105-118.

BODEN, B. P., and KAMPA, E. M. 1957. Records of Bioluminescence in the ocean. *Pacific Sci.*, **2** : 229-235.

BURDON, T. W. 1954. The Fishing methods of Singapore. *J. Malay Br. Roy. Asiat. Soc.*, **27**(2) : 5-76

CLARK, G. L., and BRESLAU, L. R. 1959. Measurements of bioluminescence off Monaco and North Corsica. *Bull. Inst. Oceanogr. Monaco*, No. 1147.

————. 1960. Studies on luminescent flashing in Phosphorescent Bay, Puerto Rico, and in the Gulf of Naples using a portable bathyphotometer. *Ibid.*, No. 1171 : 1-32.

———, and HUBBARD, C. J. 1959. Quantitative records of luminescent flashing of oceanic animals at great depths. *Limnology and Oceanogr.*, **4** : 163-180.

———, and WERTHEIUS, G. K. 1956. Measurements of illumination at great depths and at night in the Atlantic Ocean by means of a new bathyphotometer. *Deep-Sea Res.*, **3** : 189-205.

FRY, D. H. JR. 1930. The Ring Net, Half Ring Net, or Purse Lampara in fishery of California. *Fish. Bull.*, **Calif. Fish & Game, 27** : 1-65.

GOPINATH, K. 1950. The Malayan Purse Seine (Pukat Jerut) Fishery. *J. Malay Br. Roy. Asiat. Soc.*, **23**(3) 75-96.

HARVEY, E. N. 1940. *Living Light.*

———. 1952. *Bioluminescence* (New York, Academic Press).

LINDER, M. J. 1930. Luminescent Fishing. *Calif. Fish. Game*, **16**(3) : 237-240.

PARR, A. E. 1927. A contribution to the theoretical analysis of the schooling behaviour of fishes. *Occ. Papers, Bingham Oceanogr. Coll.*, No. 1 : 1-32.

SCOFIELD, W. L. 1926. Purse seines for California Sardines. *Calif. Fish. Game*, **12**(1) : 16-17.

SETTE, O. E. 1950. Biology of the Atlantic Mackerel (*Scomber scombrus*) of North America. **Part II. Migration and Habits.** *Fishery Bull.*, 49, *U.S. Fish Wildl. Serv.*, 51 : 250-385.

SWEENY, M. B., and HASTINGS, J. W. 1957. Characteristics of the diurnal rhythm of luminescence in ***Gonyaulax polyedra.*** *J. Cell. Comp. Phy.*, **49**(1) : 115-128.