PRELIMINARY PLANKTON INVESTIGATIONS IN THE JAVA SEA.

By

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Introduction.

One of the first questions which the marine biologist is confronted with in the tropics is whether the tropical seas are as productive as the tropical soil when compared with what we find in higher latitudes. Already the wealth of shapes and colours, e.g. of the inhabitants of the coral reefs, and the great number of species found in the tropics awakens great expectations in this respect. In "Die Fische der Nord- und Ostsee" [1]) we find enumerated for the North and the Baltic Seas together about 250 true sea-fishes. For the seas of the Malayan Archipelago the number roughly estimated will be at least six times as large. On the other hand it can hardly be doubted that these fishes do not nearly occur in such enormous shoals as may be the case in the north. A visit to a sea-fish market on the Java coast is a disappointment to anyone who remembers the often enormous supply in the big European fishing ports. This may be partly ascribed to the more primitive methods of fishing with small vessels, without motor power, and with only primitive ways of conservation. But even experiments with modern methods, e.g. with steam trawling, did not yield very satisfactory results.

The dutch experiments by the exploration vessel "Gier" with trawling in the years 1907 - 1911 may be mentioned here [2]), and those with the steam trawler "Tongkol" from Singapore in 1926 - 1928. The latter, after a few years of exploration, was finally for some time worked on purely economical lines. It proved to be impossible to cover more than half of the expenses, even without any deductions [3]).

In this period the catches in 20 days amounted to:

29275 lbs = 12700 kg in water of 20 fathoms or more,

78506 lbs = 34000 kg in water of 10 fathoms (the former, however, fetching a prize of 18½ cents per lb against the latter 8 cents).

This corresponds with a daily catch of 635 and 1700 kg resp.

Now in the North Sea the daily catch of a steam trawler amounts to fully 1000 kg per day and the Singapore figures seem not to compare unfavourably with those for the North Sea which, it is true, are made for the greater part

[1]) 1929, in „Die Tierwelt der Nord- und Ostsee".
[2]) Mededeelingen van het Visscherijstation te Batavia.
[3]) Report on the Working of the S.T. "Tongkol" for the year 1927, Part II, p. 12.

in water deeper than 10 fathoms. However, we may not lose sight of the fact that the North Sea is an intensively fished area whereas the Java Sea and the South China Sea so far as regards bottom fishery, may be called absolutely virginal. Thus it would be more just to compare the Singapore catches with those made in the North Sea just after the end of the great war, when the trawl fishery had for some years practically lain idle and the fishing grounds had had opportunity to recover. In these years we find the following yields for the IJmuiden trawlers in the North Sea:

1919	2216 kg
1920	1854 kg
1921	1238 kg
1922	968 kg

so that in a virginal North Sea the daily catch may be easily taken to be more than 2000 kg; at any rate considerably higher than the Singapore catches.

The fact also that the sea fisheries in the Malayan Archipelago cannot satisfy the demand for fish, and that considerable quantities of dried and conserved fish must be imported every year from Siam and elsewhere (in 1932 e.g. to an amount of 11 million guilders) does not give us an impression of overwhelming wealth of the Malayan Seas. Very often, while cruising on the Java Sea, we have spoken to native fishing boats which had been rolling on the deep blue [1]) waves for days without catching anything with their payang net but a few small fishes.

A direct comparison, however, of the fish content and the yield of the fisheries e.g. of the Java Sea with that of the North Sea is very difficult, as not only the species are quite different but also the ways in which they are caught. Moreover, statistics are available for the Java Sea for the few last years only. An indirect indication could be furnished by a comparison of the quantities of plankton which are the final food source for everything living in the seas.

That the tropical seas are indeed poorer in general than those of higher latitudes has been suggested first by the results of HENSEN's plankton expedition which brought to light that the quantity of plankton in the tropical and subtropical ocean is considerably less than in the northern and, as has been shown by later expeditions, also in the Antarctic regions. The explanation of this phenomenon is given by the theories of BRANDT [2]) and of NATHANSOHN [1]). The former emphasized that it is the quantity of certain nutrient salts dissolved in the water on which the plankton production depends. The latter taught us that it is the vertical mixing of the sea water by which the deeper, fertile, layers are brought to the well-illuminated surface where photosynthesis can take place.

[1]) The desert colour of the sea, according to SCHÜTT. This does not mean to say that the Java Sea shows always and everywhere this deep blue colour, nor that the catches are always so scanty.

[2]) BRANDT, K., 1899, 1902, Über den Stoffwechsel im Meere. Wiss. Meeresunters., Kiel. N. F. Bd. 4 and 6.

[3]) NATHANSOHN, A., 1908, Über die allgemeinen Produktionsbedingungen im Meere. Intern. Revue d. ges. Hydrobiologie und Hydrographie, Bd. I.

Only where the surface water, depleted by plankton growth, is duly replaced by fertile water from the depth plankton growth is possible in the long run. In the tropics, however, as a consequence of the constant heating of the surface layers, no considerable vertical mixing takes place and the deeper layers, fertilized by decomposition and animal metabolism, are not brought to the surface unless under special circumstances. This accounts for the relative poverty of tropical seas as compared with those of higher latitudes where the succession of warm and cold seasons causes considerable vertical mixing. And where no rich plankton can develop, no rich macrofauna, no abundant fish population can either be expected.

Only under special conditions, as mentioned above, is a richer fauna found in tropical seas as well. This may be the case e.g. along coasts where constant off-land winds cause an upwelling of fertile water from the depth, or at places where a strong current passes over a sub-marine ridge. It would be worth while also with regard to fishery problems and possibilities, to find out what conditions are found in this respect in the different parts of the Indian Archipelago. How e.g. are things in the Java Sea? Is the plankton here rich or poor; is it better developed near the coast or at some distance away from it, and also what is the influence of the monsoons on the development of the plankton?

These questions induced me to make an attempt to obtain some insight into the nature of the plankton. The results are given below. After my return to Holland I had to leave it to my successors to continue these investigations and to elaborate upon my preliminary results.

During the years 1932 and '33, with the aid of Dr. J. D. F. HARDENBERG, I gathered a number of plankton samples from the Java Sea and from Sunda Strait. In studying these samples during the following years it was not so much my intention to make a complete inventory of the numerous species of copepods, diatoms etc. etc. occurring in the Java Sea plankton, (which, as emphasized already by Dr. SUNIER [2]), would require the coöperation of quite a number of specialists) as to get some insight into the local and seasonal distribution of its main constituents, which might prove to be of value also as a diagnostic in questions relating to fishery. In the course of the year 1932 I made two cruises across the Java Sea, from Java to Borneo and vise versa, as indicated on the maps illustrating this paper, visiting a number of stations which in general were taken closer to each other near the coast and further apart in the middle of the sea, where slighter differences might be expected. The first of these cruises was made in April, at the end of the, wet, west monsoon, the second in October, at the end of the, dry, east monsoon, so that the state of things at the end of these two seasons might be compared. Vertical hauls were made from near the bottom to the surface with an egg-net, width of the mouth 1⅓ m^2, length 4 m, Swiss planktongauze nr 3 (23 threads per 10 mm).

The Java Sea is shallow, the average depth in the centre, at least in the

[2]) A. L. J. SUNIER, 1921, Java Sea Plankton available for distribution to specialists. Treubia Vol. II.

western half, hardly exceeding 50 meters. Together with the South China Sea it forms part of the continental shelf on which Sumatra, Borneo and Java rest, and many big and smaller rivers of the three islands flow into this shallow sea. One might expect, therefore, to find that the plankton of the Java Sea would show certain peculiarities by which it differs from that of the surrounding, deeper, seas, e.g. of the Indian Ocean. To find out these differences and at the same time to study, if possible, the transition of the one plankton into the other, I made, in the year 1933, two similar cruises in Sunda Strait, beginning in the Java Sea and ending in the Indian Ocean. These voyages, too, were made one in April and the other in October. The results will be given in a later paper.

Besides my one-time assistant Dr. HARDENBERG, Ir. B. MARKUS, chemical engineer, also accompanied me on all these cruises. He made observations on the salinity and also on the phosphate-content of the sea-water at the different stations. The latter has proved in later years to be of great value for estimating the grade of fertility and the relative wealth also of nitrates and other nutrient salts of the water in different areas.

In examining the plankton samples attention was paid in the first place to the total amount of the sedimented plankton, and further to the relative quantity of phyto- and zooplankton, and finally to the numbers of a few prominent components of the plankton, which components were counted.

Salinity and phosphate content.

The shallow Java Sea has an almost rectangular shape; it is bordered on the north by Borneo and on the south by Java. SUNIER [1]) has calculated that it covers about the same area as the Red Sea, but the latter, being much deeper, has a contents of 10 × that of the Java Sea. The relatively shallow North Sea contains about double the quantity of water to that of the Java Sea.

SUNIER further gives the following short description of the bottom profile of the Java Sea, and of the temperature and salinity of its water as observed by captain K. M. VAN WEEL [2]) during the years 1917 - 1918:

"The bottom of the Java Sea shows everywhere a gradual slope from the coasts to the centre, the slope from the Java coast being slightly steeper than that from the Borneo shore. Besides, a very slight but gradual slope from W. to E. is also present, so that in general the western part of the Java Sea shows the lowest and the eastern part the highest depths. Thus the depth west of the meridian of Pekalongan, with the exception of a single channel, is everywhere less than 30 fathoms.

As regards the water of the Java Sea west of the meridian of 115° E, the extensive observations on the temperature and salinity gatheerd by the captain of our investigation vessel, K. M. VAN WEEL, show that, apart from

[1]) A. L. J. SUNIER, 1917, Voordracht over het Pelagiaal van de Javazee. 6e Bijeenkomst van Proefstationpersoneel, te Soerabaja op 29 Augustus 1917.

[2]) K. M. VAN WEEL, 1923, Meteorological and Hydrographical Observations made in the Western Part of the Netherlands East Indian Archipelago. Treubia Vol. IV.

the brackish water which may be present along the coast near the mouth of big rivers, the salinity during the whole year and over the whole area, in horizontal as well as in vertical sense, varies between fully 30.5 ‰ and fully 34.5 ‰.

The temperature in general varies only between slightly less than 27° C. The average temperature of the Java Sea water west of 115° E is during the monsoons hardly less than about 27.5° C; during both the change periods little less than about 29.0° C.

The salinity in the East monsoon and the subsequent change amounts to little more than 33.5 ‰; in the West monsoon and the subsequent transition period it is little more than 32.5 ‰.

BERLAGE [1]) has worked out more fully the data gathered by captain VAN WEEL in order to get an idea of the currents caused by the monsoons in the Java Sea. He concludes:

"Twice every year the Java Sea is completely swept clean. The yearly variation of salinity reaches 2 or 3 ‰. This variation would be much lower if the westerly and easterly stream were equally salt. The current coming from the shallow Southern China Sea, however, is less salt than that from the Flores Sea and Makassar Strait. To this asymmetry is due the fact that only one maximum and minimum salinity of the Java Sea exists. The former, as we have seen, is observed in the east monsoon about September, when the big westerly current comes to rest; the latter for the western part of the sea in the west-monsoon about February; for the eastern part at the monsoon change, in May".

Thus during the west-monsoon a west-east current prevails adducing water from the South China Sea; during the east-monsoon the current goes in inverse sense, adducing water from the Flores Sea. In the transition periods, when my observations were made, we find the end-stage of each of these movements. At the end of the east monsoon the highest salinities are found in the eastern part of the Java Sea, the highest temperatures in the western part. At the end of the west-monsoon the reverse state of things prevails, though less pronounced.

The salinity observations (by areometer [2])) made during our two plankton-cruises Java-Borneo and vice-versa in general agree with these conclusions, but at the same time show one peculiarity which is worth attention. A look at the curve diagram 1, which represents the surface salinities in April and October resp., reveals that in the middle of the Java Sea there is a place where in April, at the end of the west monsoon, the salinity is about the same as (in fact even slightly higher than) in October, viz. about 33.2 ‰. In the direction of the Java coast the two curves diverge, the surface salinity in April

[1]) H. P. BERLAGE, 1927, Monsoon-currents in the Java Sea and its Entrances. Verhand. Kon. Magn. en Meteor. Observatorium, Batavia.

[2]) as VAN WEEL (p. 320) and BERLAGE (p. 18) observe, VAN WEEL's areometer observations gave values about 0,5 - 1,0 % higher than those obtained by titration. It seems not improbable that we have used the same areometer.

being increasingly lower than in October the nearer we approach the coasts. But at the stations 11 - 13 of the western route and at the stations 30 - 31 of the eastern route we find no difference, the salinity being here about 33.2 ‰ and 33.5 ‰ resp. in April as well as in October. The same phenomenon is observed if we compare the salinities close above the sea bottom, although here the curves sink less and diverge less when approaching the coasts. At the same stations we find here too about the same values for the salinity in April and October, viz. about 33.8 ‰ for stations 11 - 12 and about 34 ‰ for station 30.

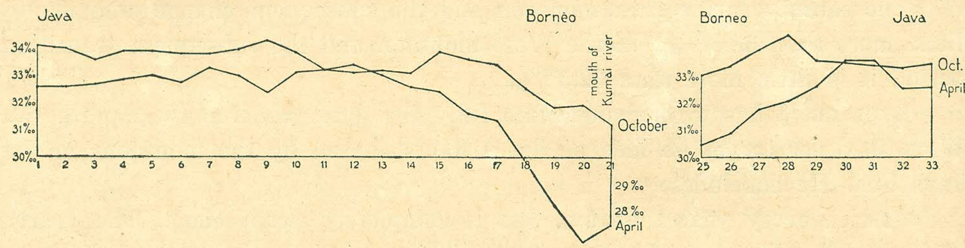

Diagram 1. Salinity at the surface in April and October 1932. The numbers at the horizontal axis in this and all other diagrams represent the different stations as given on the chart.

Evidently, then, the influence of the seasonal changes in the inflow of fresh water from the coasts of Java and Borneo seems not to reach to the middle of the Java Sea; at least this was the case in 1932. There remains a central band here where the salinity has remained constant, although being lower than in the surrounding oceans, viz. under 34 ‰. The direction of this band is indicated by a line uniting the stations 30 - 31 with 11 - 13, being west-northwest — east south-east. It runs over the central deepest channel of the Java Sea (as shown by the bathygraphicmap) where probably the great monsoon currents are also strongest, as many be derived from the course of the isobaths. Nearer the coasts we see the salinity decrease, especially at the surface and especially at the end of the west monsoon (April); and under the Borneo coast, with its many big rivers, still more so than under the Java Coast. From these coasts a belt of brackish water spreads over the more salt-laden water in the middle and in the depth of the Java Sea, gradually mixing up with the latter, so that the difference between surface and bottom salinity gradually decreases when approaching the central part of the Java Sea, without, however, quite disappearing even here. Only the seasonal variations in the coast water do not reach up to this central band, as we have seen above. We may not loose sight of the fact, however, that the water found in October, e.g. at the stations 11 - 13, cannot be the same as that found in April at the same place and that a great displacement has occurred as a consequence of the monsoon currents. Whether the salinity at these stations remains constant also during the monsoons cannot be derived from our data.

We see that the water of the Java Sea has a lower salinity at the surface than in the depth. At the same time the surface water is warmer than the water at the bottom. It needs not be emphasized that these circumstances are

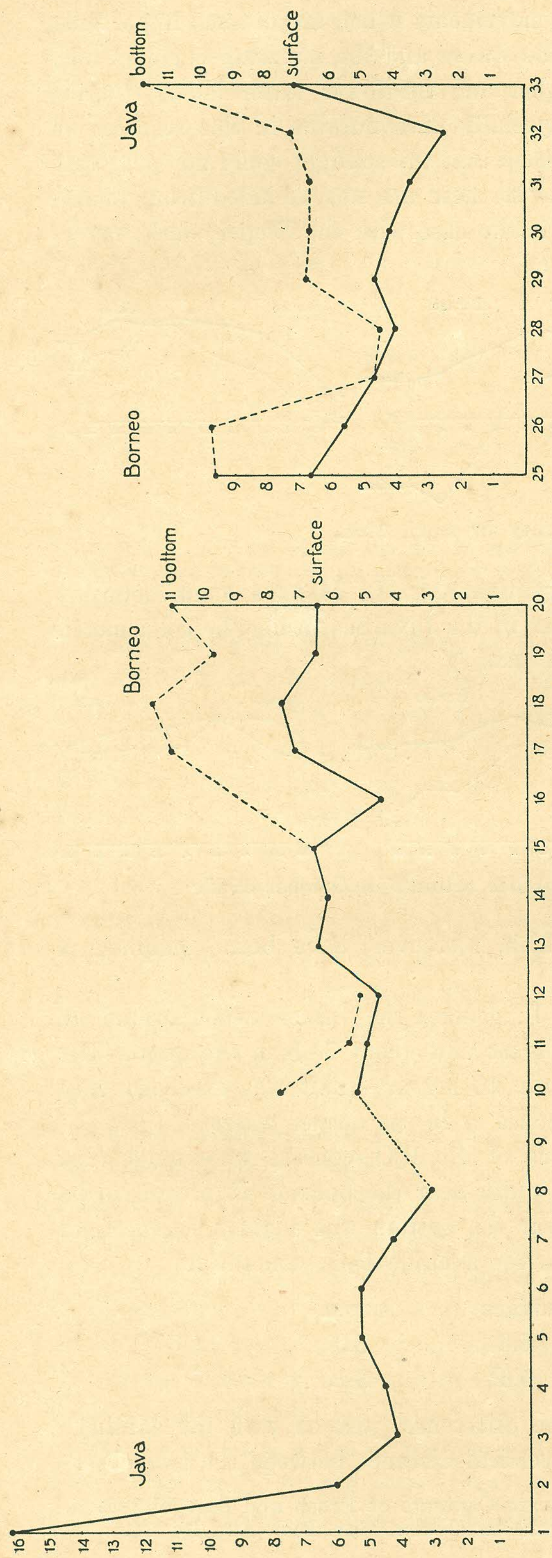

Diagram 4. P_2O_5 in mg pro m^3. April 1932.

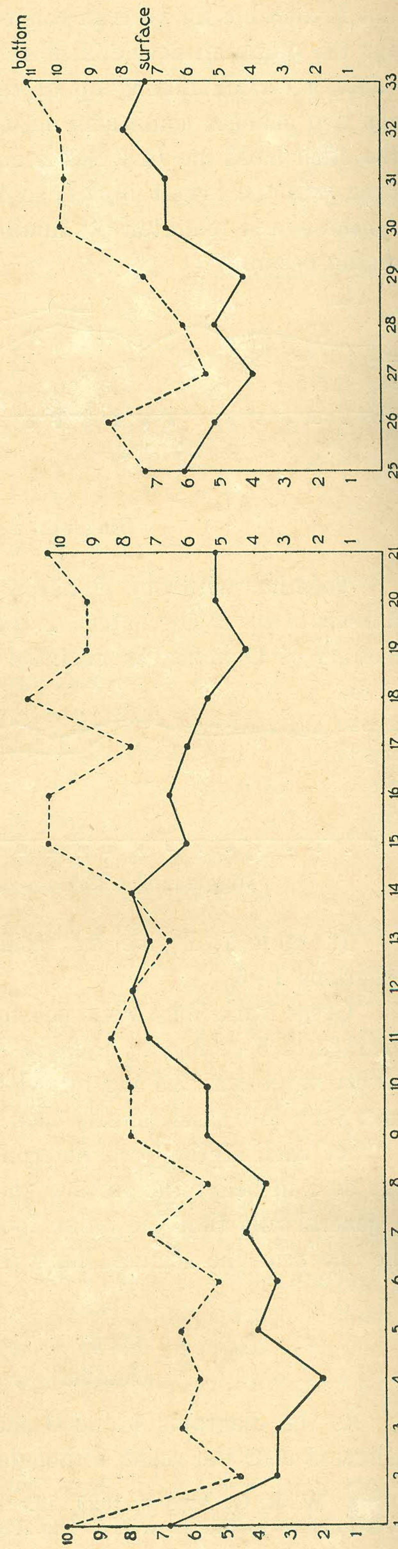

Diagram 5. P_2O_5 in mg pro m^3. October 1932.

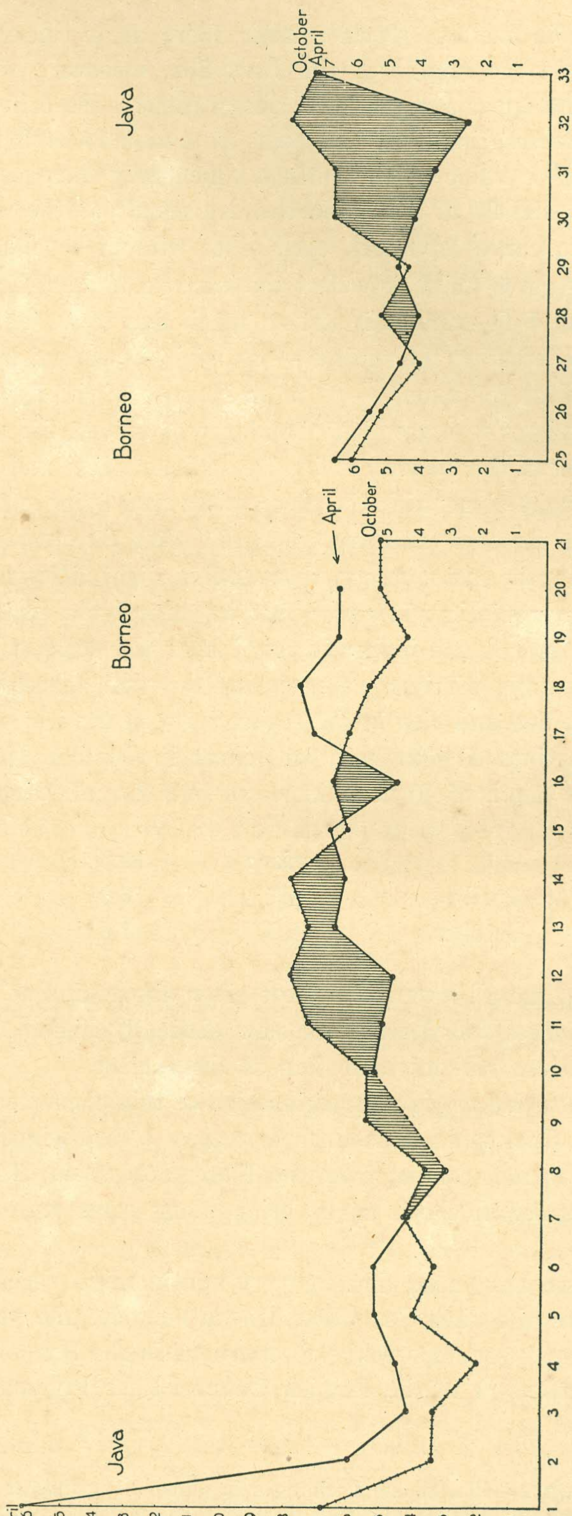

Diagram 6. P_2O_5 in mgr pro m³ at the surface April and October 1932.

vations, expressed in meters, grows smaller there as a consequence of the decreasing depth. In the middle of the Java Sea, however, (with increasing distance between the upper and the lower observations!) the difference between the two values decreases, finally to disappear. At station 13 we found in October even a slightly higher value at the surface which may have been accidental. At the stations 15 and 27 of April the two are equal; at the stations 27 - 28 of October the two curves approach each other without touching each other.

A look at diagram 4 and 5 show that the increase of the difference between surface and bottom P_2O_5-content is not so much due to a decrease near the coast of the P_2O_5-content at the surface — as might be caused by the presence of more phytoplankton (cf. anon) — as to an increase of the P_2O_5-content near the bottom, due perhaps to a greather abundance of animal life near the coast, especially near and on the bottom, or by the sedimentation and decomposition of animal life brought along with the river water and dying off in the sea.

If we compare the state of things in April, after the west monsoon, with that in October, after the east monsoon, then we find slight differences only which yet show a certain regularity. It seems that in general the surface as well as the bottom P_2O_5-contents are higher in April near the coast, which might be attributed to the supply of river water during the west monsoon. But in the middle of the Java Sea and also in the region between the isle of Bawean and the Java coast (stations 30 - 32) both are higher in October. If we take only the stations with a depth of 40 m or more we find the following averages:

	surface	depth
April	4.7	6.2
October	5.5	7.6.

These averages are all lower than those given above, and at the same time we see that the figures for October are now distinctly higher than those for April, near the bottom still more so than at the surface.

I refrain from trying to give an explanation of this phenomenon until more date are available. One would be inclined to suggest a fertilizing influence from the east monsoon current coming from the Flores Sea which, flowing over the border of the continental shelf, might bring along some water from deeper regions.

At any rate we have seen that no very considerable variations occur in the P_2O_5-content of the Java Sea water. If we compare the values found in the Java Sea during a year of weekly observations in the Bay of Batavia with those found by ATKINS [1]) in the English Channel near Plymouth and in the North Sea:

[1]) W. R. G. ATKINS, 1925, Seasonal changes in phosphate contents of sea water in relation to the growth of algal plantation during 1923 and 1924. Journal Mar. Biol. Ass. Vol. XIII. (Cited in: HARVEY, Biological Chemistry and Physics of Sea Water).

	surface	depth		stations of 40 m or more depth surface	depth
Java Sea, April	5.6	8.0		4.7	6.2
„ October	5.6[5]	8.1		5.5	7.6
Bay of Batavia, average	5.2[5]	6.5	(18 m)		
English Channel	15 - 16	21 - 22	(70 m)		
North Sea, May [1])	11 - 25	15 - 19	(60 m)		

then our impression is confirmed that the Java Sea cannot be counted among the richest seas although we must be cautious in making comparisons: it cannot be denied that the much more rapid metabolism in tropical seas checks such accumulations of nutrient substances as occur in more northern waters during the winter.

On the other hand the P_2O_5-content in northern waters too may get very low and, indeed, may even approach zero at the surface during an outburst of phytoplankton development. No such thing, however, can be observed in the Java Sea. Diatom plankton, as we will see, is found well developed only near the coasts, where, however, the P_2O_5-content is even slightly higher than in the centre of the Java Sea. At by far the majority of the stations the phytoplankton development is quite insignificant. If, nevertheless, no high P_2O_5-values are found, this cannot be taken as an indication of a high fertility of the Java Sea.

One might have expected to find an important addition of phosphate from the influx of fresh water from the many rivers of Borneo and Java. Recent researches, however, tend to show that such water contains only traces of phosphate and that its fertilizing influence on the sea has been greatly overestimated.

Indeed, diagram 6 proves that at the end of the rainy season, in April, the phosphate content of the coast water is only slightly higher than after the dry season, in October.

If, finally, we consider the conditions prevailing in the tropical oceans then we see that the P_2O_5-content here is very low at the surface. During the Meteor-expedition (1925-'27) [2]) the layer 0 - 50 m of the tropical and southern Atlantic proved to contain less than 2 mg/m^3 P = 4⅔ mg/m^3 P_2O_5. In deeper layers a gradual increase is observed in all the oceans until below 200 meters a uniform content of 100 mg/m^3 is attained which remains constant down to a depth of 3000 meters. At the surface the P_2O_5-content increases when approaching the coasts (especially those with constant off-land winds like the

[1]) W. R. G. ATKINS, 1923, The Phosphate Content of Fresh and Salt Waters in its Relationship to the Growth of the Algal Plankton. Journ. Mar. Biol. Ass. Vol. XIII. cf. also: HELGE THOMSON, 1933, The Distribution of Phosphate and Nitrate in the North Sea in May 1932. Rapp. et Proc. Verb. Vol. 85, 3-ième partie.

[2]) E. HENTSCHEL and H. WATTENBERG, 1930, Plankton und Phosphat in der Oberflächenschicht des Südatlantischen Ozeans. Ann. d. Hydrogr. und Maritimen Meteorologie, VIII.

west coast of Africa) and in the polar and sub-polar regions, where vertical convection, as a consequence of the periodical cooling of the surface water in winter, plays a much greater role than in the tropics. Between 40° and 50° S, e.g., the content amounts to 9 - 22 P = 21 - 51 mg/m³ P_2O_5 and between 50° and 60° S even to 22 - 25 P = 51 - 81 P_2O_5 and higher.

Reverting to the tropics, we see that ORR [1]) in the Barrier Reef lagoon found an average of about 4 mg/m³ P = fully 9 P_2O_5 throughout the year and at all depths, due to the constant mixing of higher and deeper layers as a consequence of the disturbance of the sea by the wind. His figures, then, are slightly higher than ours for the Java Sea. The Barrier Reef lagoon differs in several respects from the Java Sea (average temperature 25.6° C, annual range 8.6°, average salinity 34.7 ‰, depth 30 - 40 m). The constitution of the plankton, however, seems to show a great likeness to that of the latter.

The volume of the plankton.

A simple, be it a rough, method for estimating the wealth or poverty of a given area of the sea is to determine the volume of the plankton after it has settled at the bottom of the conserving fluid. The reliability of the result is diminished by the fact that some organisms have a relatively much larger volume than others. When a great number of salps, siphonophores, or similar gelatinous organisms is present, very high values will be found. A high volume may be caused also by the presence of large crowds of echinoderm-, or balanid-, or other planktonic larvae of nonplanktonic organisms. This was the case at several stations in Sunda Strait where either echinopluteus or balanid larvae abounded to such an extent that they constituted the greater part of the plankton volume. At other stations, there was a manifest deficiency of plankton and the few planktonorganisms present were in a bad condition, evidently due to some unknown disturbing influence (e.g. in April 1932, nrs. 26 and 27).

The influence of such aberrant cases may be eliminated to a certain degree by comparing and combining a great number of the samples from different localities or collected at different times, or by leaving aside those samples which evidently represent abnormal conditions.

In table I and chart 2 the volumes per m³ are represented for the successive stations, for the April cruise at the left and for the October cruise at the right side of the route line. We see at once that the highest volumes are found near the coast. This is evident especially on the western route which has its beginning and its end near a river mouth, viz. that of the Tjimanuk of Java and that of the Kumai river of Borneo. It is especially the diatom flora which thrives here. No doubt if a finer meshed net had been used, the volumes near the coast would have been considerably higher still.

Further from the coast the diatoms become scarce or disappear altogether and the zooplankton soon begins to dominate. The volume of the plankton is

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[1]) A. P. ORR, 1933, Physical and chemical conditions in the sea in the neighbourhood of the Great Barrier Reef. Great Barrier Reef Exp. 1928-'29, Vol. II nr. 3.

as a rule considerably less here. If e.g. we take out the stations where the depth is 40 m or more, then we find the following averages:

stations 4 - 15	April 0.7^5	October 0.8^5 [1])	cm^3 per m^3.
stations 27 - 32	April 0.6^5	October 1.1^5	cm^3 per m^3.
General average for	April 0.7^1,	October 0.9^5	cm^3 per m^3.

General average for both cruises 0.8^3 cm^3 per m^3.

Considerably more would have been caught, no doubt, if a net of finer plankton gauze, e.g. nr. 20, as in the medium Apstein net, had been used. Sunier e.g. found for the average of 15 plankton hauls with such a fine-meshed net in the Java Sea, all made at a distance of no less than 45 miles from the coast, 2.6 cm^3 per m^3, i.e. fully 3 times as much.

After my return to Holland, Dr. Hardenberg has, at my request, made a number of double hauls, with the Hensen's egg net (gauze nr. 3) and the medium Apstein net (gauze nr. 20) resp., in order to find out with which factor the catches of the former ought to be multiplied to be comparable with those of the latter. This factor, however, proved to be variable and, as might be expected, to depend upon the composition of the plankton. The fine coast plankton of course, passes in much greater quantity through the meshes of the coarser net than plankton consisting of bigger organisms as found in the middle of the Java Sea. In the former case the multiplication factor will prove to be higher than in the latter. This it seems practically impossible, by applying a uniform correction to my catches, to make them comparable to those made with the gauze nr. 20 or 25 e.g. in European waters, or elsewhere, e.g. during Hensen's plankton-expedition in 1889.

This is very much to be regretted and I hope that my successors in Batavia will have the opportunity of completing my observations by making a number of hauls with the medium Apstein net, gauze nr. 20, which arrived at the Batavia Laboratory only after my return to Holland. The few catches made for me by Dr. Hardenberg with this net seem to point even rather to a higher than to a lower average volume than found by Sunier.

During the years 1910 - 1911 I made weekly plankton observations from the light ship "Haaks" in the North Sea near Den Helder. This light ship lies at a distance of 28 km from the coast, the depth of the sea being 27 m there. The average volume of the plankton fished with the medium Apstein net was for the year 8.V.1910 - 8.V.1911 [2]) 200 cm^3 under 1 m^2, i.e. about 8 cm^3 per m^3 or slightly less. This average in considerably higher than that found by Sunier for the Java Sea but, as observed above, I have found higher values too, so that it seems better to delay drawing conclusions until more data relating to the Java Sea are available.

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[1]) The values for stations 11 - 13 evidently being abnormally high, due to the presence of many salps, siphonophores etc., I have corrected these by reducing them to 1 cm^3 per m^3 which still is higher than the average quantity found above.

[2]) For the year V.1911 - V.1912 it was considerably higher which, however, was due to the exceptionally warm summer of 1911 making this year abnormal.

SUNIER himself compares his result with those obtained by Mielck in February and May 1906 in the North Sea and which were considerably lower than my yearly average for the "Haaks", being 1.3 and 3.2 cm^3 resp., so that this does not compare at all unfavourably with the Java Sea, especially if we take into account that the Mediterranean near Naples and the Sargasso Sea yielded average catches of 16 and 30 - 33 cm^3 resp. under 1 m^2. The former figure refers to vertical hauls of 100 (as a matter of fact made mostly in winter!), the latter to vertical hauls of 200 - 0 m. These figures would be lower still — though, probably, not proportionately — if hauls of 50 m had been made. Indeed SCHÜTT [1]) gives in his tables 13 a few hauls of 50 - 0 m in the Bay of Naples which yielded an average catch of 13 cm^3 under 1 m^2 = 0.26 cm^3 per m^3. KRÄMER [2]) who centrifuged the contents of the HENSEN's plankton net found in the Pacific, going from Samoa via the equator to the Marshall Islands, from 0.4 - 0.9^5 cm^3 per m^3 (hauls mostly of 100 - 0 m). On the other hand the same author found with the same method near Kiel in the Baltic 1.9 - 11 cm^3 per m^3. And during the Plankton Expedition catches were made in northern waters (Irminger Sea) of more than 1600 cm^3 under 1 m^3 in hauls of 200 - 0 m, which, if we assume that most of this plankton is present in the uppers, would answer perhaps to 800 cm^3 in a haul of 50 m or 16 cm^3 in 1 m^3.

SUNIER's average of 2.6 cm^3 per m^3 seems to keep the due medium between these extremes and we might conclude that the Java Sea, though not so rich as northern seas, yet contains more plankton than the tropical oceans generally. But comparisons are difficult, in one case the hauls have been made mostly in winter, i.e. the poor season of the northern hemisphere (Naples!), in the other case they have been made in summer only (Irminger Sea); in one case the plankton has been left to subside whereas in the other case it has been centrifuged. For a comparison of a northern sea with a tropical sea (e.g. North Sea with Java Sea) we would require in the former case an annual average based on a series of observations distributed regularly over the whole year (to eliminate the influence of the seasons) and, preferably over a number of stations; further absolutely similar fishing methods und measurement in both cases. These conditions not yet being fulfilled, it seems advisable to be careful in drawing conclusions regarding the relative plankton wealth of e.g. the North and the Java Sea.

If we compare the catches of October, at the end of the east monsoon with those of April, at the end of the west monsoon, then we find the volume of the former higher. The average volume of the 30 October catches is 2.2^5 cm^3 per m^3, that of the April catches 1.3 cm^3. Even taking into consideration that the October catches nrs. 11 - 13 had a relatively high volume due to the presence of a good deal of salps, siphonophores etc. and, on this account, applying a correction to the October average, then still we find the latter to be fully 1½ times as large as the April average.

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[1]) F. SCHÜTT, 1892, Analytische Planktonstudien.
[2]) A. KRÄMER, 1906, Ergebnisse meiner Korallenriff- und Plankton-studien.

For the stations deeper than 40 m the difference is slightly less (averages 0.71 and 0.95 resp. cf. above) which is caused especially by the stations of the western route. For the coast stations, therefore, the difference must be greater. However, the differences are too small to warrant far reaching conclusions. Other years may yield other results again and it is advisable to await further observations. Provisionally we can state only that the differences seem not very considerable.

Phytoplankton.

According to its general composition we might divide the plankton of the Java Sea into the following types:

1° diatom plankton
2° animal plankton
3° mixed phyto- and zooplankton
4° *Trichodesmium*-plankton.

The diatom plankton was generally found along the coasts, whereas the zooplankton predominated in the middle of the Java Sea, where often diatoms are practically absent but where *Trichodesmium* may appear. The coast plankton in general is of a finer composition, containing, besides diatoms, only smaller copepods, such as those belonging to the first group on p. ???.

I sent, in 1929, a number of phytoplankton samples from the coasts of Java, Borneo and Sumatra to Mr. W. E. ALLEN and Miss E. E. CUPPS, of the Scripps Institution at La Jolla, Cal. U.S.A. They kindly undertook to examine these samples and to write a treatise on the diatoms contained in them. Unfortunately the publication of this essay was delayed in consequence of the great economical depression from 1929 onwards, but in the year 1935 the paper was printed [1]. This valuable and richly illustrated treatise will be of great help to every student of the marine diatoms of the Indian seas, as it has been to me.

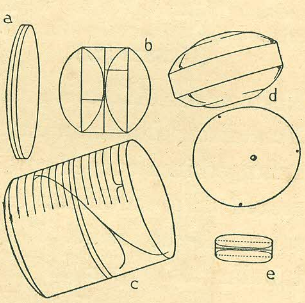

Fig. 1. a. *Coscinodiscus gigas* var. *praetexta*; b. *C. jonesianus*; c. *C. nobilis*; d. *C. jonesianus* var. *tenuis* MEISTER?; e. *C. janischii*?

Although the number of species is great — and would, no doubt, be increased still by further researches — yet a restricted number only may be said to play a more or less predominant role in the plankton catches or in part of them. And on the whole the same species found by ALLEN and CUPP to dominate in the relatively few catches I sent to them were found by me, too, to be most common in my samples. I give here two tables [2] of their occurrence, one for the April cruise, the other for the October cruise, and containing only the commoner species. The indications c (common), + (present) and r (rare) rest on personal estimates, not on countings. Countings, in using catches made by such a coarse-meshed net, would

[1]) W. E. ALLEN and E. E. CUPP, 1935, Plankton Diatoms of the Java Sea Ann. Jardin Botan. de Buitenzorg, Vol. XLIV.
[2]) See page 176 - 177 and 178 - 179.

not have been sufficiently reliable to repay the considerable trouble connected with them.

True diatom plankton, in which the diatoms dominate, is found only in a very few of my samples and, indeed, is almost confined to stations 1 and 2 in April and station 2 in October, an to station 33 (c.q. also 34) in both months. Further away from the Java coast the diatoms rapidly diminish in number, finally to practically disappear.

Also under the Borneo coast an increase of the number of diatoms may be observed but the belt seems to be less narrow here and less confined to the close neighbourhood of the coast. As a matter of fact, the shallow water and the lower salinities reach here much further than under the Java coast.

As a rule species of *Rhizosolenia, Chaetoceras* and *Coscinodiscus* dominate in the coast plankton. Not only the number of individuals but also the number of species belonging to these genera increase in the neighbourhood of the coast.

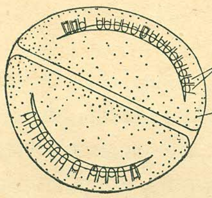

Fig. 2. *Hemidiscus hardmanianus* (GREV.) Mann. with ciliates (*Amphorella borealis*) (HENSEN (?)).

As SUNIER has observed already, the common *Chaetoceras coarctatum* is hardly ever found without a more or less considerable number of an epiplanktonic *Vorticella* on it, whereas the bigger *Rhizosolenia's* nearly always contain in their cells a number of short threads of the Nostocacea *Richelia intracellularis*. A curious symbiosis exists also between *Hemidiscus hardmanianus* and a small Ciliate. A number of the latter is found arranged in a curved row on the scale of the former, seated in a semilunar silt on each of the two flat sides of the scale. Each ciliate has a hyaline, tubular test, open at the upper end and in which it can retract itself. The *Hemidiscus*, however, may be found also without these occupants and in this case no trace of the semilunar slits can either be observed, so that one gets the impression that they are formed only under the influence of the presence of the Ciliates. Truly, if we study a sample with profits in state of division, we see that on the new valves the semilunar slits are present before the ciliates have occupied them. It would be worth while, no doubt, to make a closer study of this symbiosis.

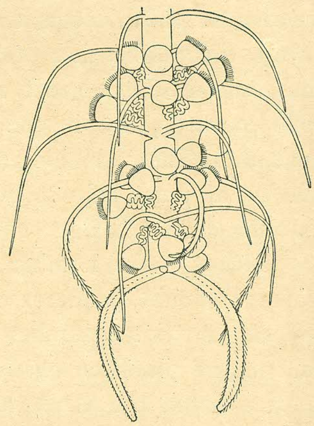

Fig. 3. *Chaetoceras coarctatum* LANDER, with *Vorticella's*.

Mr. ALLEN draws my attention to the fact that it has been observed first by OSTENFELD [1]) who gives a figure and says: "Curious is a curved fissure on the valves; in most specimens which I have seen this

[1]) JOHS. SCHMIDT, Flora of Koh Chang, Part VII, Marine Plankton Diatoms, by C. H. OSTENFELD, Botanisk Tidsskrift, Bd. 25, 1902.

fissure was a place of refuge for a little protist, probably an *Amphorella borealis* (HENSEN) Dad., var. nov.; the small, more or less numerous, organisms were fixed to the inner side of the fissure".

One species of diatom was never wholly absent from the catches. It was the flat, disc-shaped *Coscinodiscus gigas* which really also had its maximum near the coast, together with the other species of diatoms. But whereas the latter were often practically absent in the middle of the Java Sea, *Coscinodiscus gigas* might be rare but never was wholly absent.

Comparing the table for April with that of October, we get the impression that in April, at the end of the west monsoon, diatoms are more numerous on the western route than on the eastern, whereas in October, at the end of the east monsoon, the difference seems less evident.

I have made few observations on Peridinians which rarely were abundant and which, moreover, were caught only very incompletely by the wide meshes of my net. *Ceratium tripos, fusus, macroceros* and other species known from northern waters may be found now and then. *Ceratium fusus* was once found in great quantity in the mouth of the Kumai-river, together with *Noctiluca.* The salinity here was only 17.4 ‰.

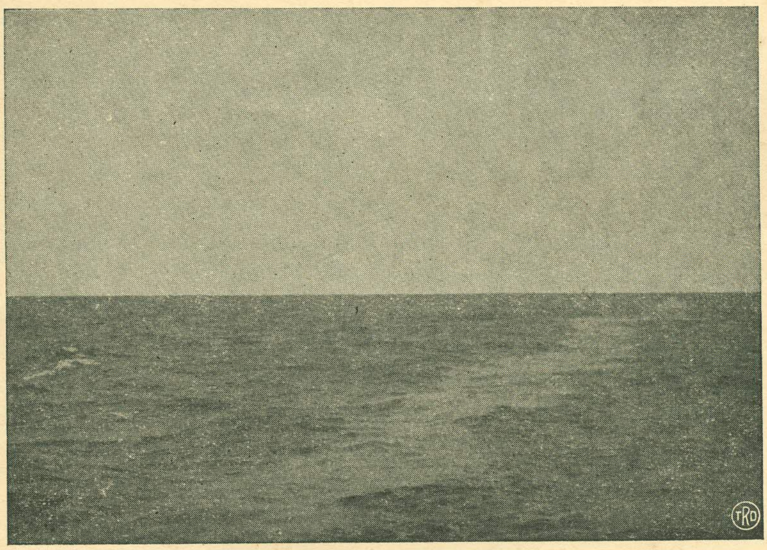

Fig. 4. Yellow strip of *Trichodesmium.*

Trichodesmium spp. and related Schizophyceans (a.o. *Katagymene* which, however, as SUNIER observes, is not common) are found nearly always at a certain distance from the coast. They seem to avoid the more or less brackish coast water and only where this is not present, as e.g. in the narrowest part of Sunda Strait with its strong tidal currents, did I see *Trichodesmium* close to the shore. At certain places it may become very abundant and the small bundles, gathering at the surface, may occur in such quantities that they remind one of sawdust, colouring the sea a brownish-yellow. More or less broad bands of the sea surface may seem coloured in this way and these bands, as a rule, appear to run at a good distance from the coast (often several tens of miles)

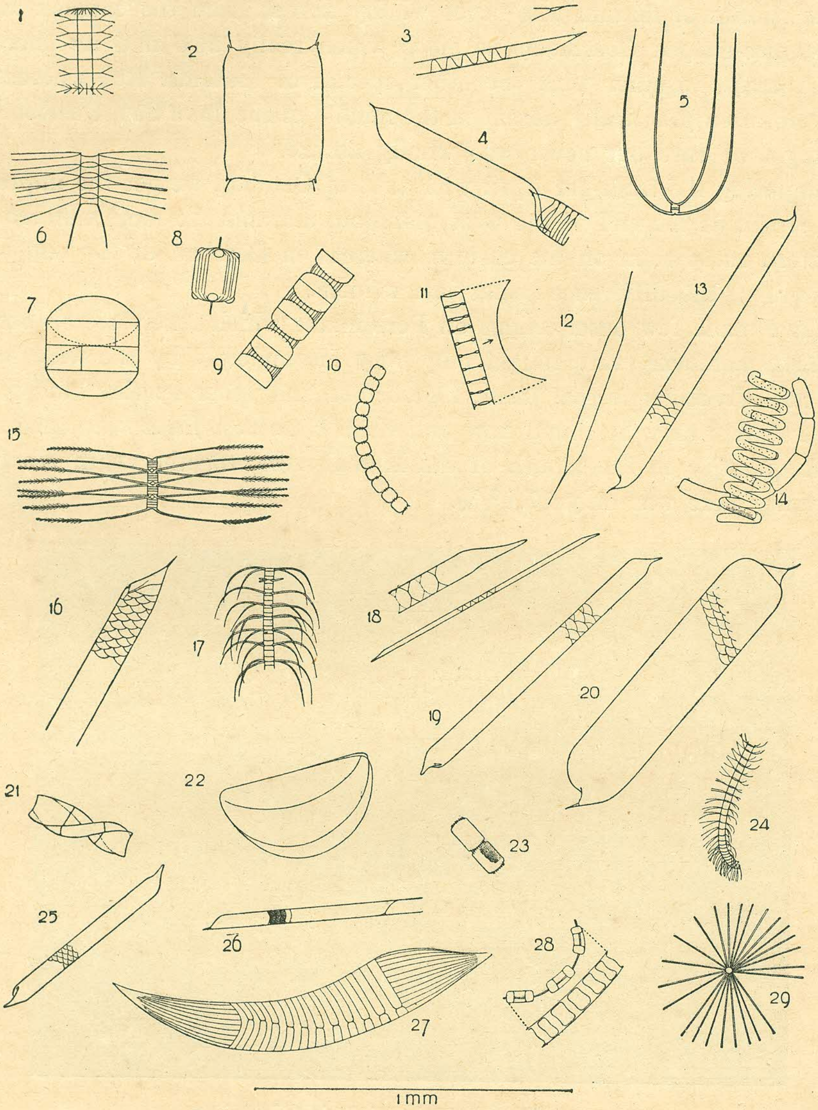

Fig. 5. Planktondiatoms from the Java Sea.
1. *Bacteriastrum hyalinum*; 2. *Biddulphia sinensis*; 3. *Rhizosolenia styliformis*; 4. *Rhizosolenia styliformis* var. *latissima*; 5. *Chaetoceras peruvianum*; 6. *Chaetoceras lorenzianum*; 7. *Coscinodiscus jonesianus*; 8. *Ditylum sol*; 9. *Stephanopyxis palmerina*; 10. *Cerataulina bergonii*; 11. *Bellerochia malleus*; 12. *Rhizosolenia setigera*; 13. *Rhizosolenia calcar avis*; 14. *Rhizosolenia stolterfothii*; 15. *Chaetoceras denticulatum*; 18. *Rhizosolenia alata* forma *genuina*; 19. *Rhizosolenia alata* forma *indica*; 20. *Rhizosolenia clevei*; 21. *Streptotheca indica?*; 22. *Hemidiscus hardmanianus*; 23. *Lauderia annulata*; 24. *Chaetoceras pseudocurvisetum*; 25. *Rhizosolenia arafurensis*; 26. *Rhizosolenia imbricata (shrubsolei)*; 27. *Rhizosolenia robusta*; 28. *Hemiaulus sinensis*; 29. *Thalassiothrix frauenfeldii*.

and parallel to the latter. They may have a length of many miles and once, indeed, we have followed such a *Trichodesmium* band with our investigation-vessel for half a day, steaming east-west parallel to the north coast of Java until night drawing near forced us to give it up. From some distance away such a *Trichodesmium* zone may be signalized by the calmer water there and by a rather strong smell of chlorine.

Quite near the coast, in more or less brackish water, *Noctiluca miliaris* may be present in great quantity. A peculiarity of the tropical *Noctiluca* is the presence of a large number of small green flagellates in the specious vacuoles, as first stated by the WEBER'S [1]) 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 up the spacious vacuoles. As observed by the WEBERS [1]), the green colour caused by the presence of the flagellates is quite evident where accumulations of *Noctiluca* at the surface of the water occur.

The occurrence of *Noctiluca* is restricted to coastal and even to slightly brackish water, so that it is never found at some distance from the coast.

Copepods.

For the sake of convenience we might subdivide the copepods into three groups, according to the length, viz.

1° those reaching a length of more than 2 mm
2° the medium-sized, between 1 and 2 mm
3° those smaller than 1 mm.

The numbers of these three groups are by no means evenly spread over the area investigated, as will be shown.

To those smaller than 1 mm belong such forms as: *Oncaea conifera* GIESBRECHT a.o. *Corycaeus venustus* DANA and other small *Corycaeus* species, *Euterpina acutifrons* (DANA), *Oithona rigida* GIESBRECHT, *Clytemnestra scutellata* DANA, *Microsetella* spp.

Of the species between 1 and 2 mm mention *Temora discaudata* GIESBRECHT and *stylifera* DANA, *Centropages furcatus*, *Oithona plumifera* BAIRD, *Tortanus gracilis* (BRADY), *Calanopia elliptica*, *Pontellina plumata* (DANA), *Pontellopsis krameri* (GIESBRECHT), *Paracalanus aculeatus* GIESBRECHT, *Canthocalanus pau-*

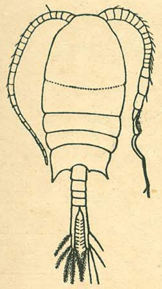

Fig. 6. *Temora stylifera* ♂.

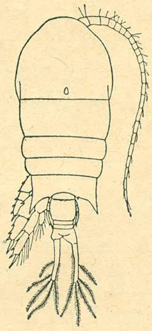

Fig. 7. *Temora discaudata* ♀.

[1]) M. WEBER and A. WEBER-VAN BOSSE, 1890, Quelques nouveaux cas de Symbiose.
Zoöl. Ergebn. einer Reise in Niederl. Ost Indien, I.

per (GIESBRECHT), *Acrocalanus gibber* GIESBRECHT, *Candacia* spp. *Acartia pietschmanni, pacifica* a.o.

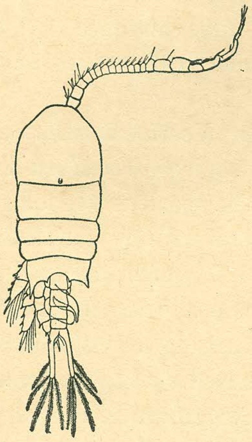

Fig. 8. *Temora discaudata* ♂.

The third group, containing the copepods of more than 2 mm, comprises in the Java Sea a restricted number of species only, viz. *Undinula vulgaris* (DANA), *Eucalanus subcrassus* GIESBRECHT, *Euchaeta concinna* DANA, *Candacia bradyi* A. SCOTT, *Labidocera acuta* (DANA) and *Pontella securifer* BRADY. The latter, though fairly widely distributed, was never found in any considerable number, and in the same way a few other species reaching a length of 2 mm or more can only be observed now and then. Only five species, however, may be present more or less plentifully, as far as my observations reach. Many species and genera occurring in the surrounding oceans, and e.g. in Sunda Strait, were not met with in the Java Sea. Thus the genera *Pleuromamma, Euchirella, Undeuchaeta,* each represented by several fairly big species in the Sunda Strait plankton, were absent in the Java Sea which, of course, doesnot exclude the possibility that they will ever be found there.

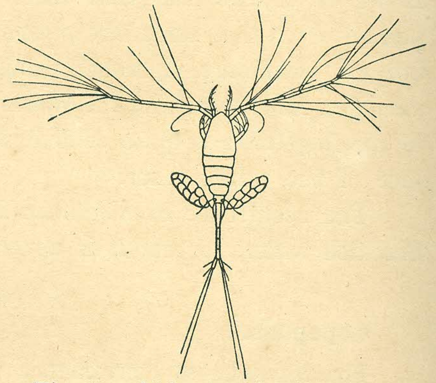

Fig. 9. *Oithonia plumifera.*

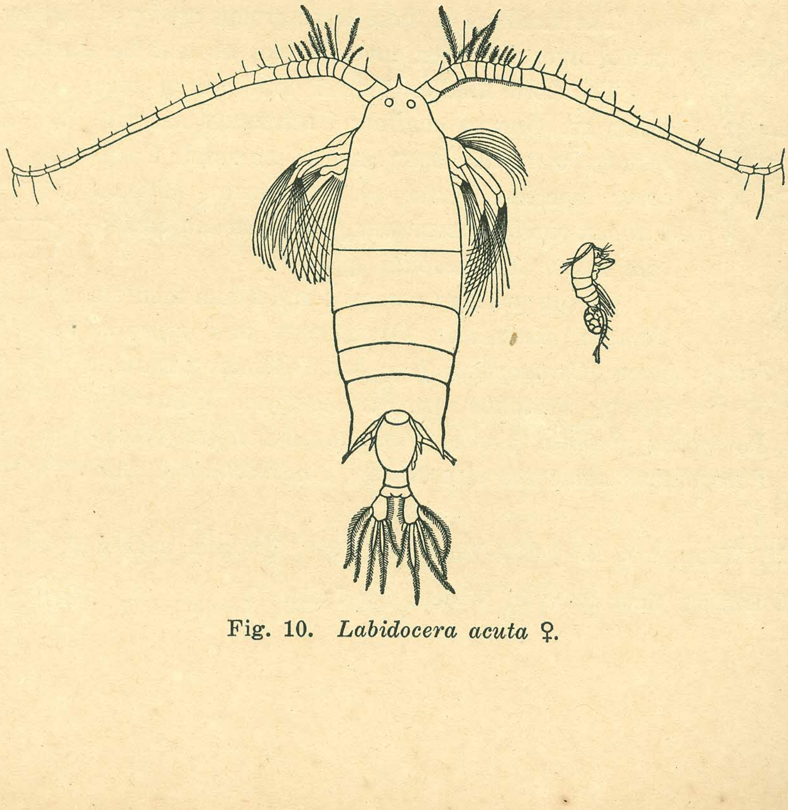

Fig. 10. *Labidocera acuta* ♀.

My egg-net catches are especially suitable for studying the distribution of the bigger species, as the mouth of the net is sufficiently wide to catch a good number of individuals, whereas the width of the meshes does not allow any to escape as is the case with smaller forms and with young stages.

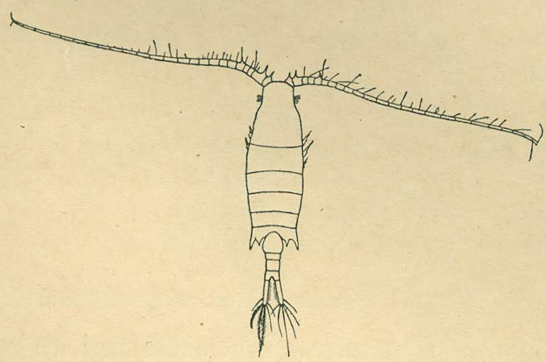

Fig. 11. *Centropages furcatus* (DANA).

The biggest of the five Java Sea species are *Undinula* (formerly *Calanus*) *vulgaris* and the blue *Labidocera acuta,* both reaching a length of 3 mm. The former, however, was much more widely distributed and occurred in greater numbers than the latter. Especially the female *Undinula vulgaris* is the biggest common copepod in the Java Sea and must be highly appreciated as food by the plankton-feeding pelagic fishes whose stomachs are often filled with them. Perhaps its role might even be compared with that of *Calanus finmarchicus* in northern seas, although the latter is still a good deal bigger (length ♀ 3 - 5 mm). But the same can be said of many northern fishes: the northern herrings, mackerel, anchovies, tunnies and flatfishes are on an average all bigger than their tropical, and certainly bigger than their Java Sea and South China Sea relatives.

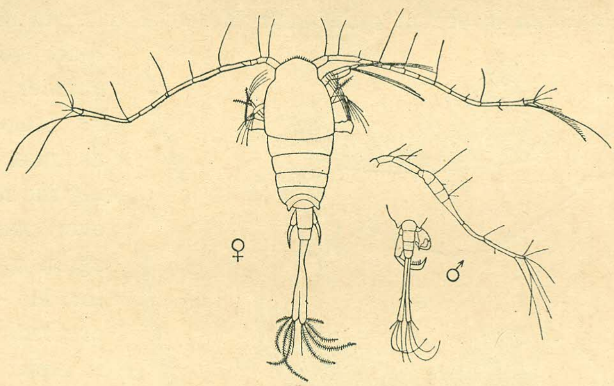

Fig. 12. *Tortanus gracilis* ♀ and ♂.

The male of *Undinula vulgaris* is slightly smaller and easily distinguished from the female by the caudal setae being directed perpendicular to the longitudinal axis of the animal, and by the absence of the paired spines into which the last thoracic segment of the female is produced. The former

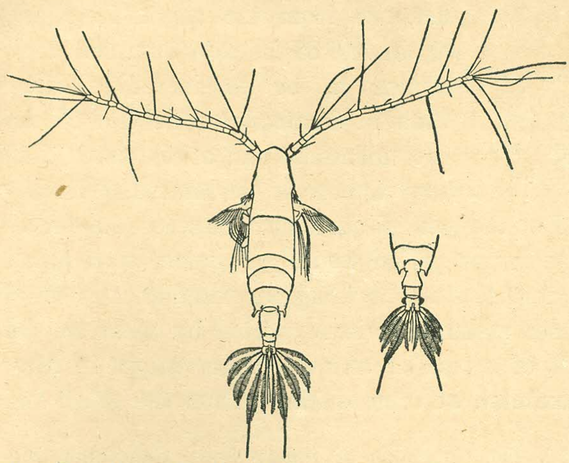

Fig. 13. *Acartia pietschmanni* PESTA ♀ and ♂.

characteristic is not quite so not quite so reliable as the latter, as sometimes males are found with the caudal setae directed backwards in the same way as with the female. But in this case the enormous prehensile leg of the male renders it easy to recognize the species.

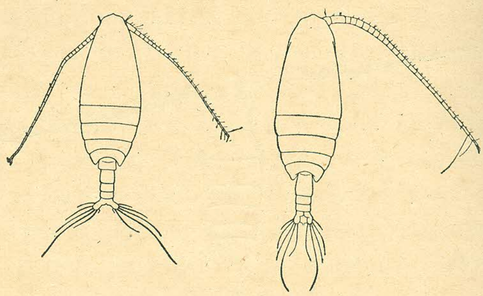

Fig. 14. *Canthocalanus pauper* ♂ and ♀.

SEYMOUR SEWELL [1]) has elaborately described and measured the successive copepodid stages of *Undinula vulgaris*. His observations indicate that already the copepodid stage V may reach (♂) and surpass (♀) the 2 mm-limit. We will, however, mainly confine ourselves to the adult stage when studying the distribution of this species in the Java Sea.

In charts 3 and 4 the distribution of the adult *Undinula vulgaris* in the Java Sea in April and in October resp. are represented. Both charts show that *Undinula* is absent quite near the coast (e.g. stations 1, 2, 3, and 20, 21) and that, going seaward, we see the number increase. This phenomenon is observed as well under the Java as under the Borneo coast. Approaching the middle of the Java Sea, however, we see the number decrease again so that e.g. at the stations 10 (or 11) - 14 *Undinula* is practically or absolutely absent, and this as well in April as in October. Most evident is this phenomenon on the western route passage, stations 1 - 21. The maxima are found at a certain distance from the coast. In April, at the end of the west monsoon, they appear to be considerably higher than in October, at the end of the east monsoon, and at the same time they appear to be somewhat further from the coast in the latter case. But the general agreement between the curves is evident. Observations covering a longer period would, of course, be required to make out whether this is the normal state of things or whether it is valid only for the year 1932. The former assumption is supported by what we see in chart 8 which shows the result of a smaller series of observations in May 1934. Here we find again the maximum at some distance from the coast and

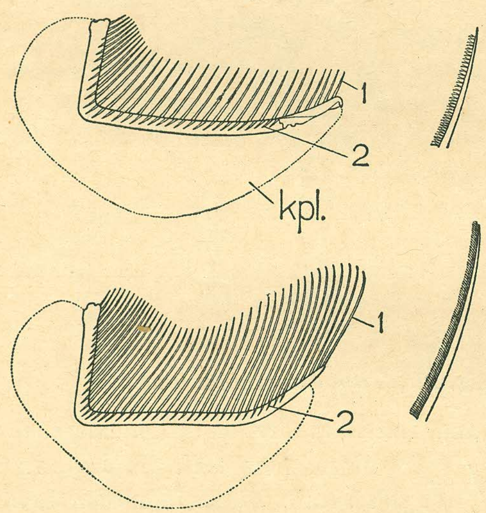

Fig. 15. Above: gill sieve of *Scomber kanagurta*; below: gill sieve of *Scomber neglectus*, × 1. 1. Gillrakers of first gill split. 2. Gillrakers of second gill split. kpl: red gill lamellae. To the right: One gillraker.

[1]) R. B. SEYMOUR SEWELL, 1929. The Copepoda of Indian Seas, Calanoida. Memoirs of the Indian Museum, Vol. X, 1st part.

the same gradual decrease and final disappearance of *Undinula* if we proceed to the middle of the Java Sea. Whether also the left fig. on this chart is the expression of the same rule is not so easy to decide as this series consists of three observations only which, moreover, have not been made at the same time.

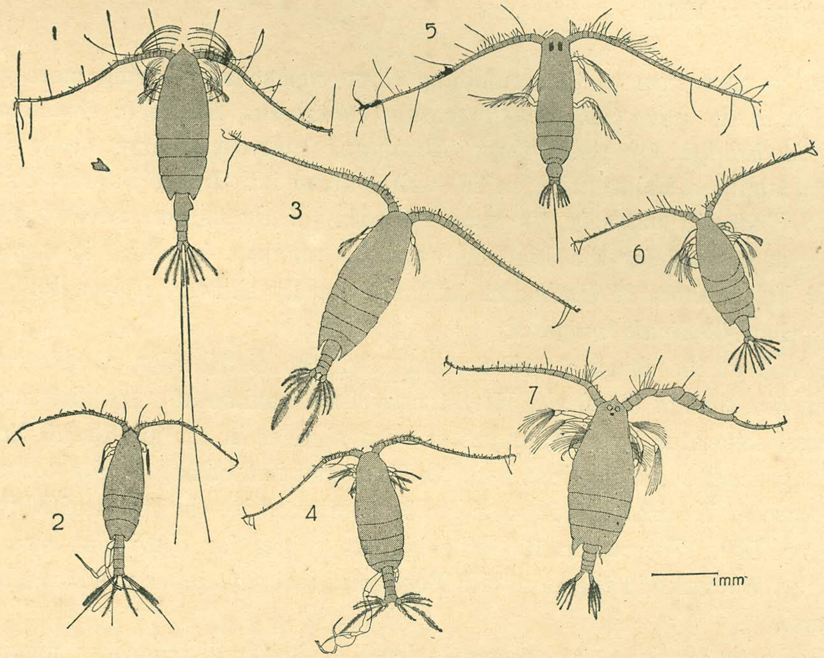

Fig. 16. Five big Copepods from the Java Sea.
1. *Euchaeta concinna* DANA ♀ (often with eggs); 2. *Euchaeta concinna* DANA ♂; 3. *Undinula* (*Calanus*) *vulgaris* (DANA) forma minor ♀; 4. *Undinula* (*Calanus*) *vulgaris* (DANA) forma minor ♂; 5. *Eucalanus subcrassus* GIESBRECHT; 6. *Candacia bradyi* A. SCOTT; 7. *Labidocera acuta* (DANA), often coloured beautifully blue.

For the eastern half of the Java Sea things are not so easily brought under this rule. Here, too, we find a minimum or absence of *Undinula* near the coast and an increase of its numbers when going seawards. But a decrease and final disappearance in the middle of the Java Sea can be observed only in the curve for October, whereas in April it was quite absent, the maxima lying here in the middle of the Java Sea. It looks as if the two maxima present in the other curves have fused here so that the minimum in the centre has disappeared. Here, too, the maxima in April are higher again than those in October.

In the October curve the maximum under the Java coast seems practically not developed. On the other hand this is the only occasion where *Labidocera acuta* appears in any considerable numbers. This beautiful blue copepod seems to me to be not so characteristic for the shallow Java Sea as *Undinula* but more so for oceanic water which during the East monsoon may have penetrated into the Java Sea along the deep channel (60 - 70 m) in the middle of which

[1]) FARRAN l.c., p. 75.

the isle of Bawean is situated. One gets the impression that *Undinula* is replaced here more or less by *Labidocera acuta.* FARRAN [1]) really counts *Labidocera acuta* among the coastal species, to which practically all the Java Sea species belong. As shown by table IV it was present also at several stations of the series of May 1934.

Let us now turn to the remaining three copepods occurring more or less regularly in the Java Sea, viz. *Eucalanus subcrassus, Euchaeta concinna,* and *Candacia bradyi.* Of these three *Eucalanus subcrassus* may occur in the greatest numbers. FARRAN (l.c., p. 78) writes about it: "Inside the reef this was, next to *Undinula vulgaris,* the most plentiful of the larger species" and the same may be said for the Java Sea, but the numbers in which it may occur are not below those of *Undinula.* Although hardly shorter, it is a less robust species than *Undinula vulgaris.*

A look at the charts 5 and 6 shows that the distribution of this copepod is much like that of *Undinula.* Here too we find maxima at some distance from the coast, separated by a minimum or total absence in the middle of the Java Sea. In general these maxima seem to lie somewhat nearer to the coast than in the case of *Undinula.* This seems to be confirmed by the series of May 1934 (table nr. IV). Whereas in 1932 the highest values for *Undinula* were found in April, the reverse in the case with *Eucalanus* where October yields the highest numbers.

Euchaeta concinna, too, seems to have a similar distribution: maxima at some distance from the coast, as is evident especially on the western route and somewhat better developed in April than in October.

Candacia bradyi differs from the other bigger copepods in that it is present also in the middle of the Java Sea, indeed, is only absent in a few catches, although not always being represented by individuals of 2 mm or more, a size reached only by fullgrown specimens.

As regards the distribution of the middle sized and the smaller species of copepods our results with the wide meshed net are, of course, less reliable, as part of them, and especially of the latter, may escape through the meshes. Diagram 7 and 8 and chart 2 show us the total number of copepods found in 1 m^3. We see the number increase in the neighbourhood of the coasts. In reality the gradient of this increase must be steeper still than indicated in chart 2 and 8 as 1° the coast stations lie nearer to each other than those in the middle of the Java Sea, whereas in diagrams 7 and 8 the distances are all alike, and 2° the coast plankton contains the highest number of small species, part of which will get lost by the wideness of the meshes.

Of course the number of copepods is no measure for the quantity of copepod material present in a catch as e.g. one *Undinula vulgaris* or *Labidocera acuta* may perhaps have the same weight as 100 *Euterpina acutifrons* from near the coast.

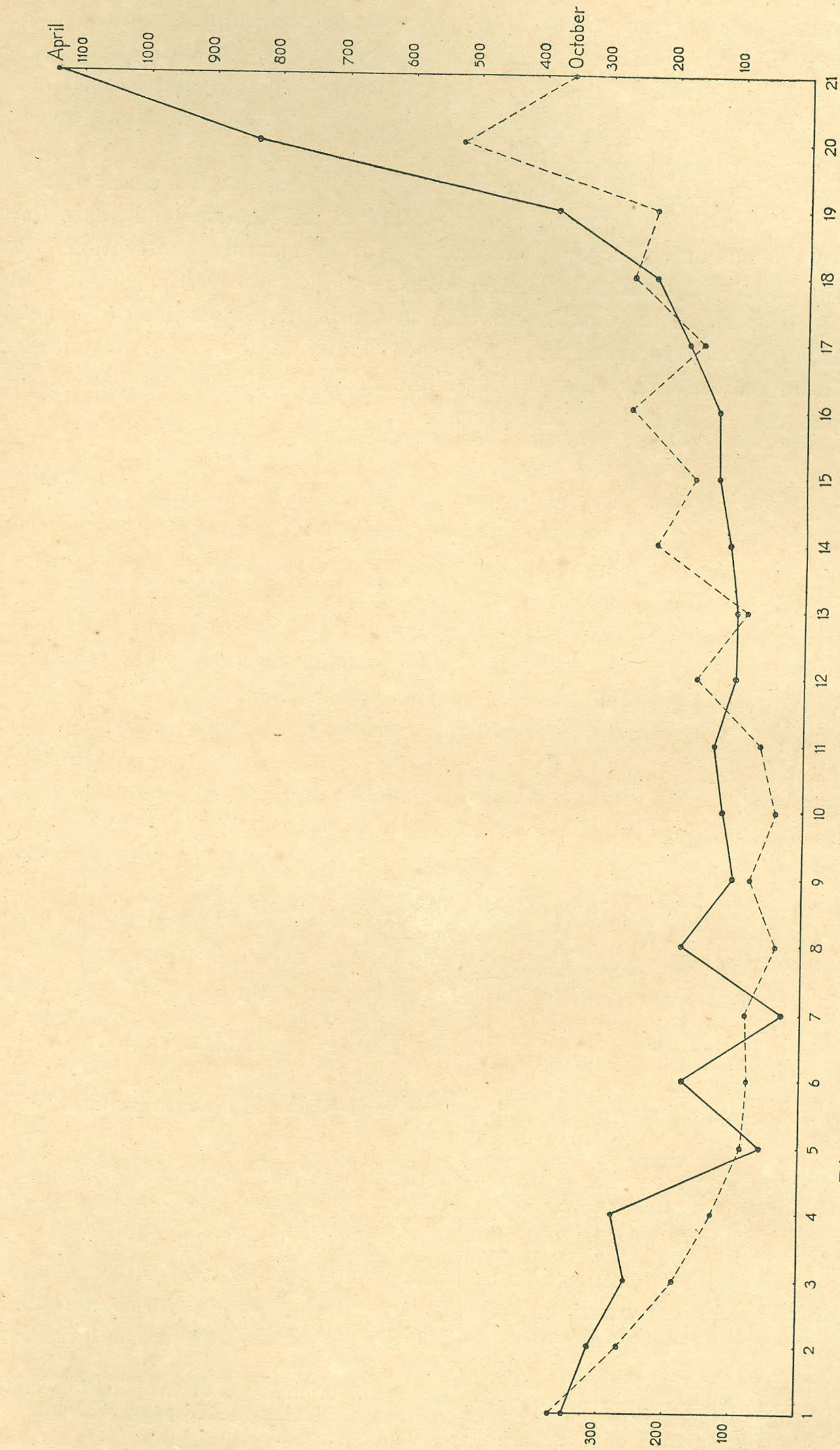

Diagram **7.** Total number of Copepods in 1 m^3 April - October. Javasea. Stations 1 - 21.

From neither of the curves 7 and 8 do we get the impression that there is a great difference between April and October. In both cases the number of copepods in the middle of the Java Sea (as caught by the wide meshed net) between 50 and 200 per m^3, whereas near the coasts it may amount to several hundreds and even to above 1000.

This tallies fairly well with what RUSSELL [1]) finds for the Great Barrier Reef lagoon. From the figures given on p. 177 of his treatise I calculate that the average number of copepods during a year of monthly observations was 4000 per catch = 20.000 under 1 m^2 = 625 per m^3. These vertical hauls were made with a net of silk nr. 3 and thus are directly comparable with mine. Similar numbers were found by me in the vicinity of the coast, but further away from the coast they soon decrease and in by far the greater part of the Java Sea they remain below 200 per m^3.

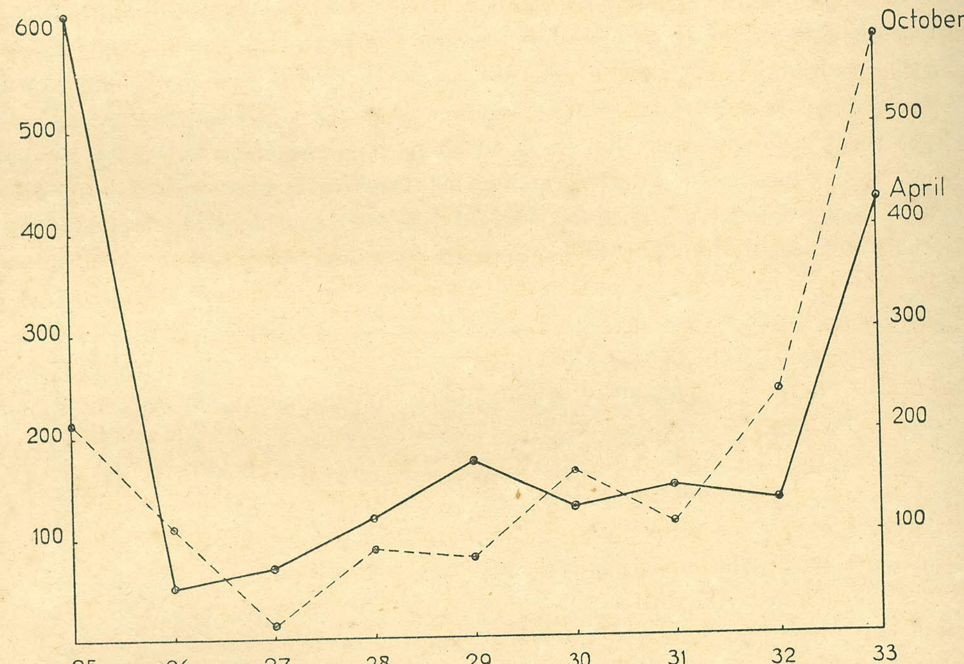

Diagram 8. Total number of Copepods in 1 m^3 April - October. Java sea Stations 25 - 33.

RUSSELL compares his figures with those obtained at several lightships in the North Sea and the English Channel which, however, are mutually so very divergent that one hesitates to draw any general conclusion from them. In general one gets the impression that the comparison is very favourable for the Barrier Reef Lagoon as only the Borkumriff lightship yields similar numbers, the others remaining far behind. For the greater part of the Java Sea,

[1]) F. S. RUSSELL, 1934, A Comparison of the Abundance of Zooplankton in the Barrier Reef Lagoon with that of some Regions in Northern European Waters. Great Barier Reef Exp. Scient. Rep., Vol. II, nr. 6.

however, the average is 4 - 5 times lower and the comparison for this sea would not be so bad when compared with most of the lightships mentioned by RUSSELL.

Much higher numbers are found if we look at similar observations made in the North Sea with fine meshes nets (silk nr. 20 or 25). From the weekly observations on the Dutch lightship "Haaks" near Den Helder, made during the years 1910 - 1911, I found [1]) an annual average of nearly 150.000 copepods (nauplii excluded) under 1 m^2 = about 5500 per m^3. From the figures given by APSTEIN [2]) for four cruises over the North Sea in 1906, we may calculate similar average for the number of copepods and young copepods (nauplii excluded). In all these catches, however, the small *Oithona nana* and the young stages of bigger copepods play a great rôle. A considerable part of them, no doubt, passes through the meshes of the coarse net.

The peculiar distribution of the bigger copepods in the Java Sea, which serve as food for the pelagic fishes, may prove to have a certain influence on the distribution of these fishes too which are of so much importance for the fisheries of Java (e.g. *Decapterus* spec. and *Caranx* spp., *Scomber kanagurta, Clupea leiogaster* o.a., *Caesio* spp.). The mayang-fishers indeed, in trying to attract the Carangids and Clupeids with their rumpons and to envelop them with their payang-net, do so at a certain distance from the coast, some 25 - 40 miles, and one is naturally inclined to ask, if this is the zone where the bigger copepods are most abundant and where, as a consequence, these fishes are most numerous? This is a question which merits the attention of future investigation.

It seems fairly evident that there is a certain relation between the structure of the gill-rakers and the nature of the plankton. It we compare two related species of fishes of which the one lives near the coast and the other further away, then we find that the gill-rakers of the former are finer and more numerous and at the same time longer than those of the latter. This is illustrated by fig. 16 showing the gill-rakers of the more pelagic *Scomber kanagurta* and of the more neritic *Scomber neglectus*. Even the fine hairs of each gill-raker are more slender in the latter than in the former. Evidently all this is an adaptation to the fine nature of the coast plankton in which diatoms and small copepods dominate, whereas the plankton at a certain distance from the coast is much coarser. Here the plankton is probably also swallowed less indiscriminately; the fishes look for the big copepods and dart at them; they are swiffer and dexterous, their body is more slender and their eyes bigger. Thus if we compare the number of gill-rakers in three *Clupea*-species of which the first is a true neritic species, the second an intermediate and the last one a more pelagic species, then we find for

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[1]) H. C. DELSMAN, 1911, De warme zomer van 1911 en het plankton bij de „Haaks".
Jaarboek Rijksinstituut v/h Onderzoek der Zee; cf. also Bulletin Planktonique 1908 - 1911.

[2]) C. APSTEIN, 1906, Plankton in Nord und Ostsee auf den deutschen Terminfahrten. Wiss. Meeresunters. Kiel, Bd. 9.

	nr. of gill-rakers on lower half of first gill arch.	length of gill-rakers.
Clupea kanagurta (m a t a b ĕ l o)	88	$1^1/_3 \times$ diameter of eye.
Clupea fimbriata (t e m b a n g)	50	$^3/_5$ - $^3/_4 \times$,, ,, ,,
Clupea leiogaster (l e m u r u)	30	$^1/_2 \times$,, ,, ,,

The higher the number of gill-rakers, the greater their length and the smaller the diameter of the eyes, so that the ratio length of the gill-rakers: diameter of the eye is in this case especially suitable for distinguishing the species.

Other zoöplankton.

Of the further components of the zoöplankton I mention first the Crustaceans. The following species of Schizopods have kindly been identified by Prof. TATTERSALL, of Cardiff:

Euphausiacea: *Pseudeuphausia latifrons* (G. O. SARS), closely related to *Nyctiphanes*. In the Barrier Reef report TATTERSALL [1]) says about this species: ,,......is a shallow-water coastal form, quite widely distributed in the Pacific, but always near to land and never under oceanic conditions. This species is the dominant one ......of the shallow lagoon area inside the reef". In the Java Sea we see it appear only at a certain distance from the coast, in the same way as the big copepods. In the series of May 1934 e.g. it had its maximum at station 16, i.e. one or two stations further away from the coast than the big copepods.

Mysidacea: *Anchialina typica* KRÖYER, according to TATTENSALL "one of the most characteristic species of the Barrier Reef Lagoon". Another species

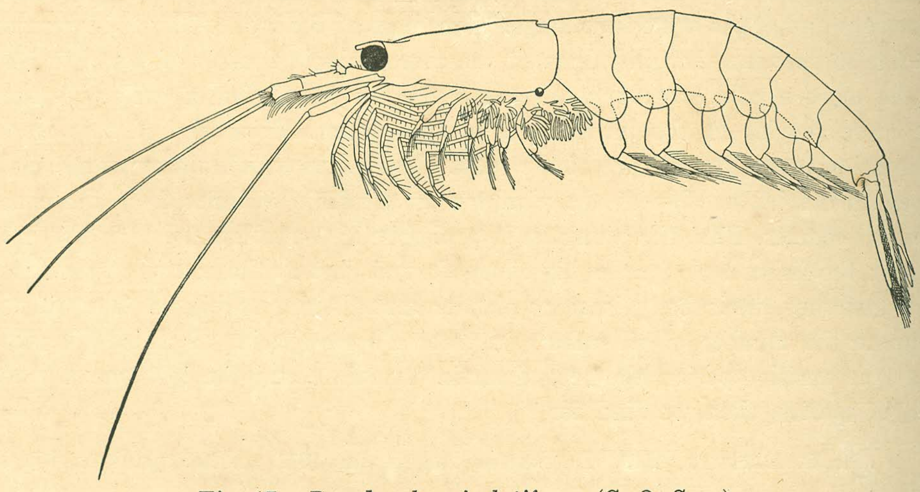

Fig. 17. *Pseudeuphausia latifrons* (G. O. SARS).

[1]) W. M. TATTERSALL, 1936, *Mysidacea* and *Euphausiacea*. Great Barrier Reef Exp., Scient. Rep. Vol. V, nr. 1.

of *Anchialina* could not be identified with any previously described species and will probably prove new.

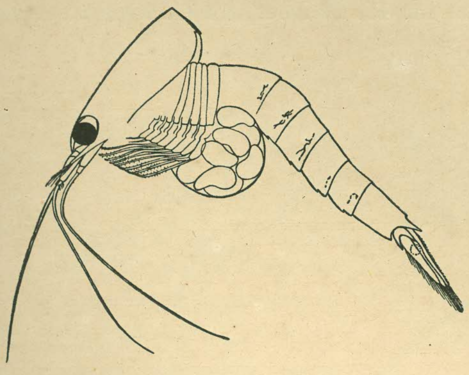

Fig. 18. *Anchialina typica* KRÖGER.

Hemisiriella parva H. S. JANSEN.

Gastrosaccus indicus H. J. JANSEN (?, immature specimens only).

Leptomysis xenops TATTERSALL.

These species were found at the stations 16 and 15 of the above series and had their maximum at station nr. 15, being still one station further from the coast than *Pseudeuphausia latifrons*.

A number of Amphipods too could be found now and then at the stations somewhat further from the coast. One of the biggest in the Oxycephalid *Tullbergella cuspidata* BOVALLIUS which e.g. in the series of May 1934 occurred at the stations 17 and 16. At these same stations *Synopia ultramarina* DANA and *Hyperia sibaginis* STEBBING (according to J. M. PIRLOT) [1]) perhaps a subspecies of *Hyperia schizogeneios* STEBBING) were present, together with *Simorhynchotus antennarius* (CLAUS), *Parascelus edwardsii* CLAUS (= *zebu* STEBBING) and *Hyperia dysschistus* STEBBING.

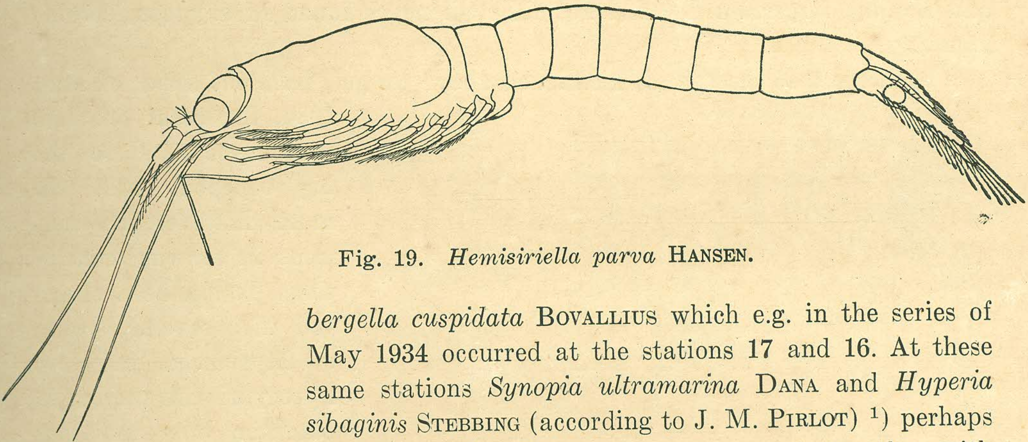

Fig. 19. *Hemisiriella parva* HANSEN.

Xiphocephalus whitei was found now and then only, single or in small numbers.

Very common in the plankton is often the slender Sergestid *Lucifer intermedius* HANSEN which in the series of May 1934

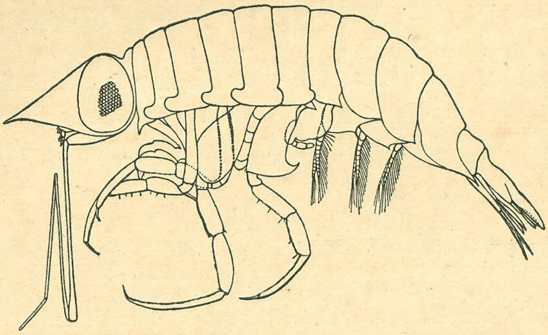

Fig. 20. *Tullbergella cuspidata* BOVALLIUS.

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[1]) J. M. PIRLOT, Siboga Exp.

had its maximum at station no. 15, the Ostracod *Pyrocypris natans* (BRADY [1]) which also has its maximum at station nr. 15. Neither are *Conchoesia* species

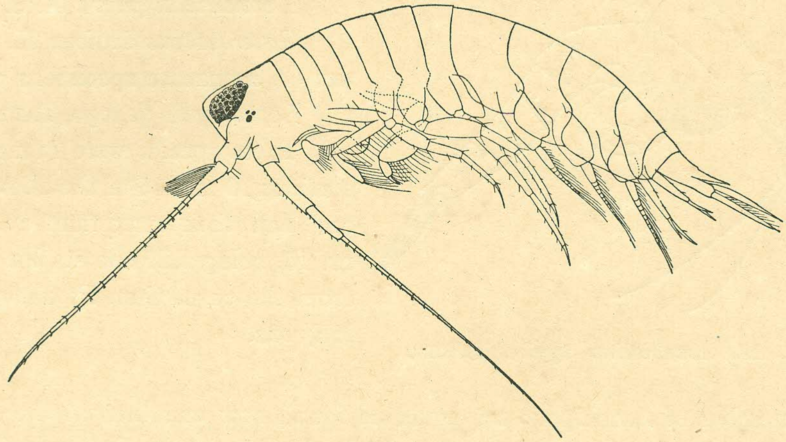

Fig. 21. *Synopia ultramarina* DANA.

and *Evadne tergestina* CLAUS rare, although never found in any considerable numbers.

With most of the species mentioned above we get, from the series of May 1934, the coast seaward, they appear where the big copepods end. We must, however, be cautious in drawing conclusions. It has been observed that several species of Mysidacea and also Pyrocypris are present in plankton only that has been fished during the night and disappear from the plankton at daylight. Evidently they retire to the bottom then. According to TATTERSALL from the above mentioned species only *Anchialina typica* is found in the daylight plankton, although it exhibits diurnal migrations too.

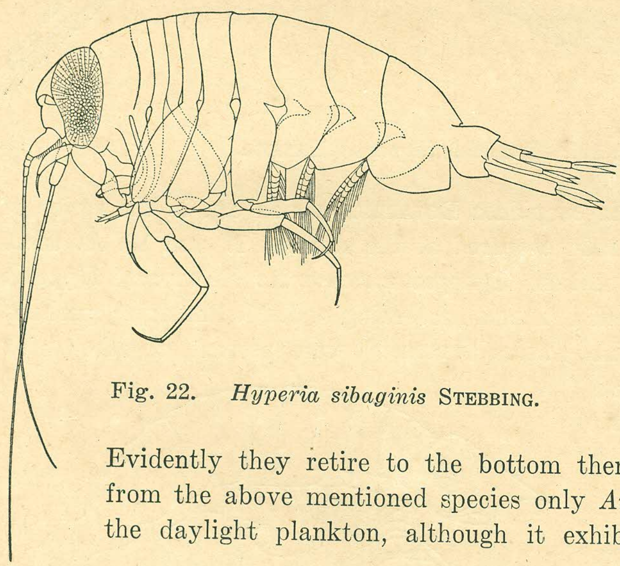

Fig. 22. *Hyperia sibaginis* STEBBING.

[1]) Kindly indentified by mr. J. P. HARDING, British Museum. MÜLLER, in "Die Ostracoden der Siboga Expedition" (1906) doesnot mention this species among the seven species distinguished by him. About his *P. acuminata,* however, he remarks: „Steht *P. natans* BRADY nahe, unterscheidet sich von ihr durch das an der vorderen Ecke stark abgerundete Rostrum." Mr. HARDING wrote me: "As you will see from my camera drawings or by looking at your own specimens some (like A) resemble *P. acuminata,* others (like B) are almost exactly the shape figured by BRADY as *P. natans* while others appear to be intermediate between the two. It looks as if the two species are identical but I am unwilling to make such a decision without seeing the types".

Hemisiriella parva is mentioned by him among the species that are found only very occasionnally and in single specimens by day. Now the station 15 was visited on May 21th 1934 in the evening at 9 o'clock and 16 on May 22th early in the morning at 2 o'clock.

A few words, finally, regarding some other constituents of the zooplankton which have been studied somewhat more in detail.

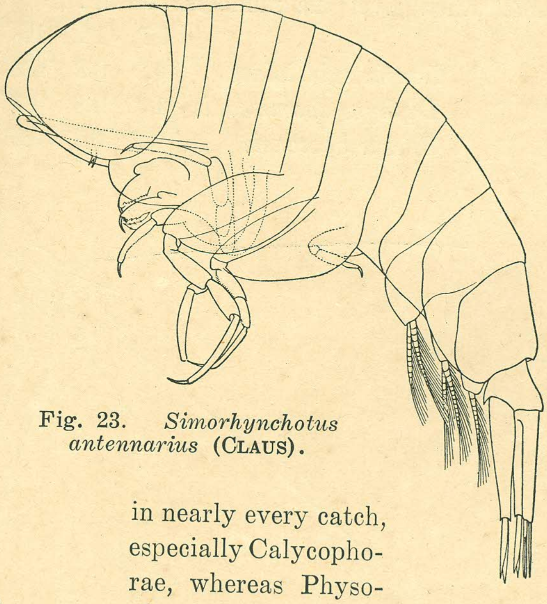

Fig. 23. *Simorhynchotus antennarius* (CLAUS).

Siphonophores were present in nearly every catch, especially Calycophorae, whereas Physophorae were much rarer. The commonest Calycophorae are *Diphyes chamissonis* HUXLEY, *Lensia subtiloides* LENS and VAN RIEMSDIJK (these two were commonest also in the Barries Reef Lagoon), and *Bassia bassensis* QUOY and GAIMARD [1]).

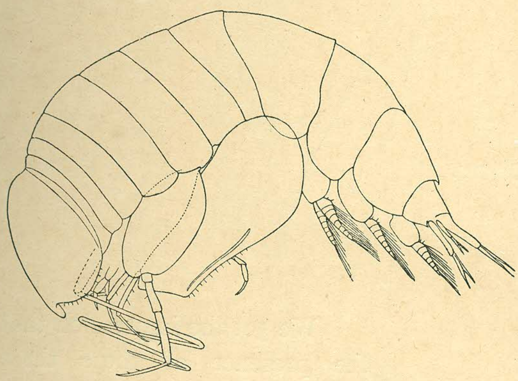

Fig. 24. *Parascelus edwardsii* CLAUS.

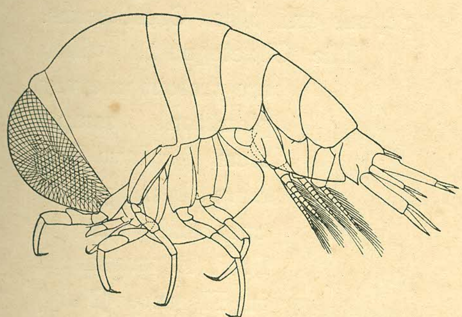

Fig. 25. *Hyperia dysschistus* STEBBING.

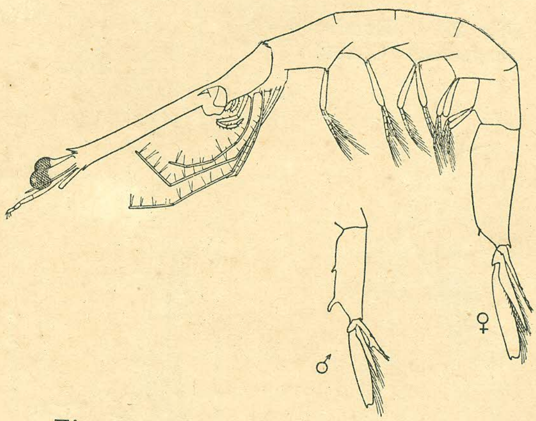

Fig. 26. *Lucifer intermedius* HANSEN.

[1]) All kindly identified by Mr. MONRO, British Museum. In LENS en VAN RIEMSDIJK's Siphonophora of the Siboga Expedition these three species are mentioned under the names *Diphyopsis weberi*, *Diphyes subtiloides* and *Abyla bassensis* resp.

Their distribution in the catches of May 1934 is shown by the following table which gives the numbers per m³.

	13	14	15	16	17	18	19	20
Lensia subtiloides	0.1	0.8	4.2	1.3	1.7	1.2	6.1	2.7
Diphyes chamissonis	1	0.8	0.7	0.3	—	1.7	1.6	5
Bassia bassensis	0.2	0.1	0.5	0.1	0.3	1.9	rr	—

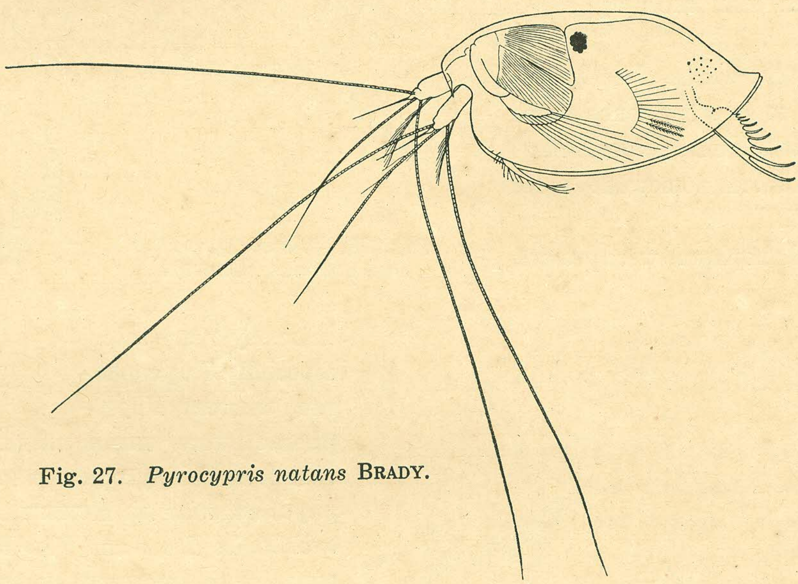

Fig. 27. *Pyrocypris natans* BRADY.

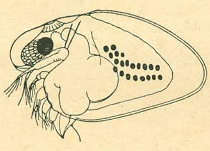

Fig. 28. *Evadne tergestina* CLAUS.

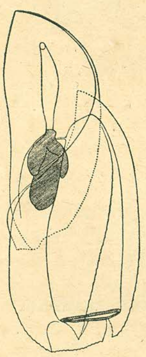

Fig 29. *Diphyes chamissonis* HUXLEY. *Eudoxid.*

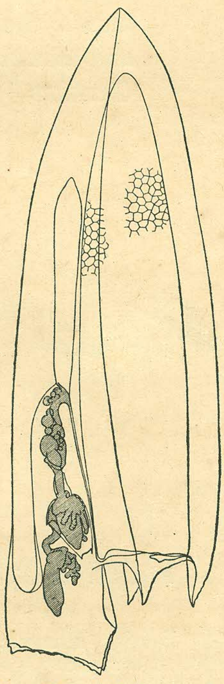

Fig. 30. *Diphyes chamissonis* HUXLEY.

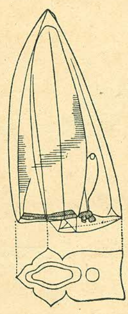

Fig. 31. *Lensia subtiloides* LENS and RIEMSDIJK.

We get the impression that the presence of these three Siphonophores is not so restricted to a definite zone as seems to be case with the bigger Copepods and other Crustaceans.

The Chaetognaths, which are present in every plankton sample from the Java Sea, have been picked out and sent to Prof. BALDASSERONE in Florence (Italy) but have not yet been received back. P. VAN OYE, in 1917, published a paper on the Chaetognatha of the Java

Sea [1]). The commonest species was the very transparent *Sagitta enflata* GRASS which in my catches too was often numerous. On the other hand *Sagitta planctonis* STEINHAUS, which was also not rare in my material, is easily to be recognized by its straight, stiff and opaque appearance. It is not mentioned by VAN OYE, who seems to have been unaware of STEINHAUS' paper, nor was it numerous in the Siboga material. Next to *Sagitta enflata* VAN OYE found *S. robusta* DONC. and *S. bedoti* BERANECK the commonest species, whereas *S. regularis* AIDA and *S. neglecta* AIDA were not rare either.

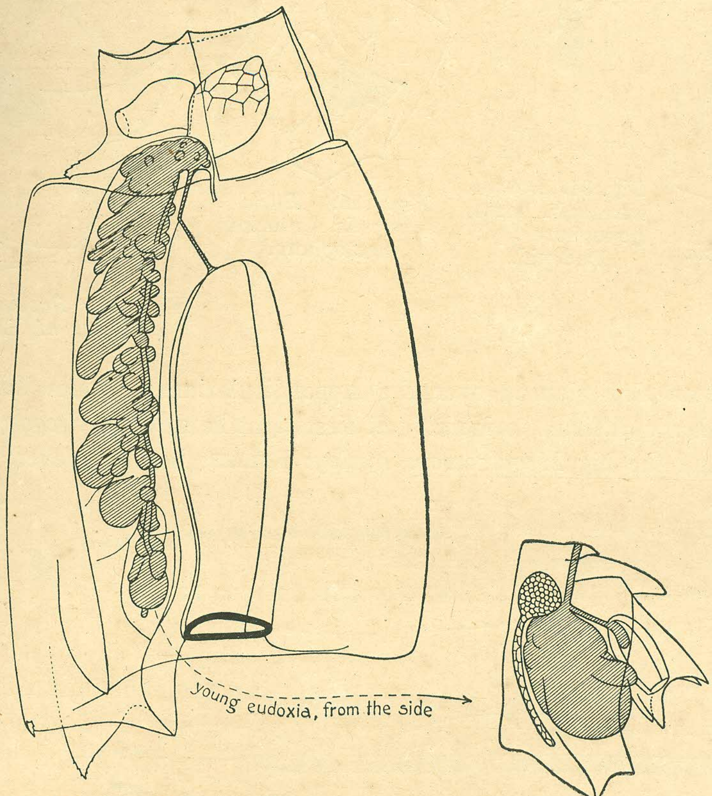

Fig. 32. *Bassia bassensis* QOUY and GAIMARD. Polygastric stage.

Regarding the Pteropoda SUNIER [2]) records the following species found by him in the Java Sea plankton: *Hyalocylix striata* (RANG), *Creseis acicula* RANG, *Cavolinia longirostris* LESUEUR, *Diacria quadridentata* LESUEUR and *Limacina* sp. In my samples *Hyalocylix striata* (RANG) was by far the commonest form, next came *Creseis acicula* (RANG).

The Salps have been studied by IHLE [3]). He found that *Thalia democratica* (FORSKÅL) was the commonest species. According to APSTEIN this is by far the

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1) P. VAN OYE, 1918, Untersuchungen über die Chaetognathen des Javameeres. Contributions à la Faune des Indes Neerlandaises, Fasc. IV.

2) A. L. SUNIER, 1917, Voordracht over het Pelagiaal van de Javazee.

3) J. E. W. IHLE and M. E. IHLE-LANDENBERG, 1935, Über eine kleine Salpen Sammlung aus der Javasee. Zoöl. Anz. Bd. 110.

commonest warm water salp, which was confirmed for the Malay Archipelago by the catches of the Siboga expedition. Next came *Cyclosalpa floridana* APSTEIN. Rarer were *Salpa cylindrica* CUVIER, S. *fusiformis* CUVIER and *Brooksia rostrata* (TRAUSTEDT).

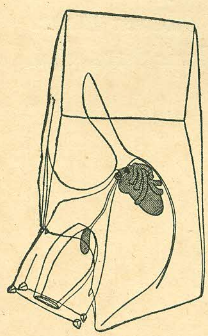

Fig. 33. *Bassia bassensis.* Eudoxid.

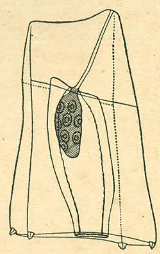

Fig. 34. *Bassia bassensis.* Loose gonophore of Eudoxid.

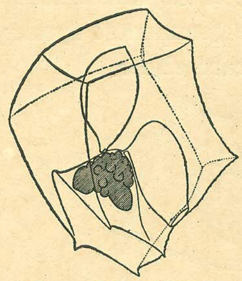

Fig. 35. *Bassia bassensis.* Anterior nectophore.

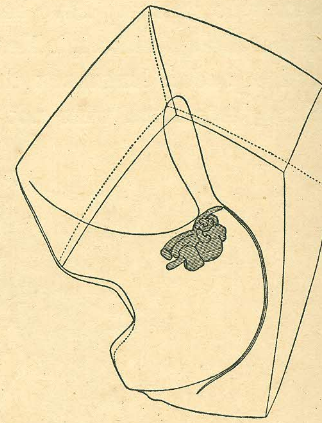

Fig. 36. *Bassia bassensis.* Bract of Eudoxid.

Prof. IHLE also glanced over the Appendicularians. Besides *Oikopleura*-species which are difficult to identify at first sight he saw a.o. *Stegosoma magnum* LGH. and the big *Megalocercus huxleyi* RITTER, both, however, in a few

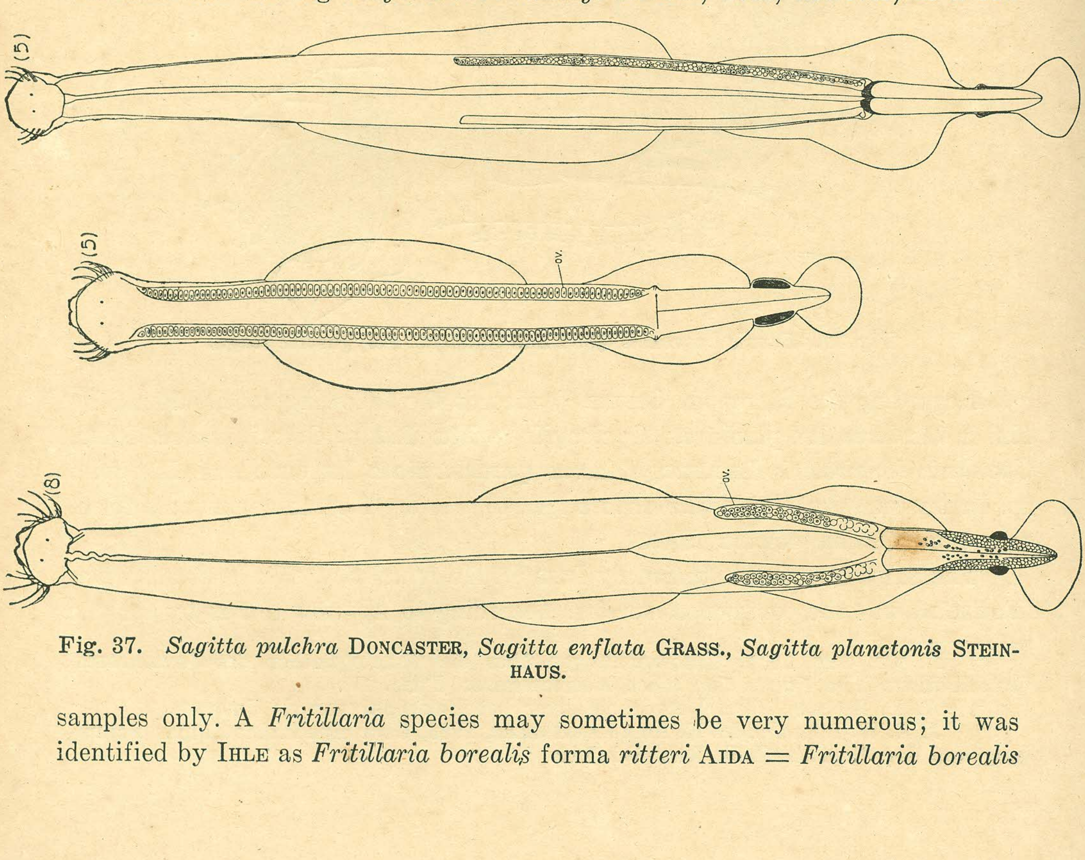

Fig. 37. *Sagitta pulchra* DONCASTER, *Sagitta enflata* GRASS., *Sagitta planctonis* STEINHAUS.

samples only. A *Fritillaria* species may sometimes be very numerous; it was identified by IHLE as *Fritillaria borealis* forma *ritteri* AIDA = *Fritillaria borealis* *truncata ritteri* LOMAN, one of the seven species found by IHLE among the Siboga material and probably not the only one occurring in the Java Sea. It was

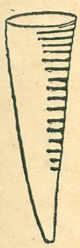

Fig. 38. *Hyalocyclix striata* (RANG).

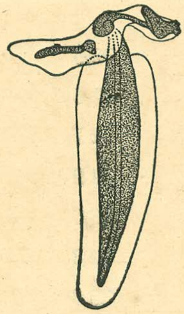

Fig. 39. *Fritillaria borealis* forma *ritteri* AIDA.

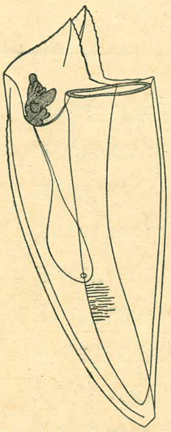

Fig. 40. *Chelophyes contorta* (LENS en VAN RIEMSDIJK).

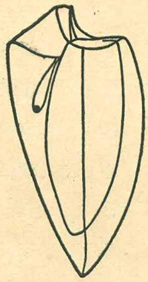

Fig. 41. *Muggiaea* spec. nov.

numerous at station nr. 18 of the series of May 1934, and absent at the other stations of his series, with the exception of a few specimens at stations nr. 17 and 20.

TABLE I **Java Sea**

Station	Position				Depth of the sea	Salinity			
						Surface		Depth	
						April	October	April	October
1	6° 18,4'	S	108° 25'	E	12,5 m	32,6	34,1		33,9
2	6° 16'	S	108° 24'	E	20 m	32,6	34,0		33,9
3	6° 13'	S	108° 28'	E	32,5 m	32,7	33,6		33,8
4	6° 9,4'	S	108° 29'	E	40 m	32,9	33,9		33,9
5	6° 4,6'	S	108° 31,5'	E	44,5 m	33,0	33,9		34,0
6	5° 59'	S	108° 34'	E	48 m	32,8	33,8		34,0
7	5° 38'	S	108° 37'	E	53 m	33,3	33,8		34,2
8	5° 38'	S	108° 52,5'	E	55 m	33,0	34,0		34,0
9	5° 28'	S	109° 8'	E	54 m	32,4	34,3		34,4
10	5° 10'	S	109° 27'	E	56 m	33,1	33,9		$34,2^5$
11	4° 54'	S	109° 41'	E	57 m	33,2	33,2	33,8	33,9
12	4° 41'	S	109° 55,2'	E	59 m	33,4	33,1	34,0	33,7
13	4° 26,6'	S	110° 12,8'	E	47 m	33,0	33,2		34,2
14	4° 12'	S	110° 25'	E	48 m	32,6	33,1		34,0
15	4° 0'	S	110° 37'	E	40 m	32,4	33,9	33,2	34,0
16	3° 49'	S	110° 52'	E	35 m	31,6	33,6		34,1
17	3° 40'	S	111° 15'	E	37 m	31,3	33,4	33,1	34,4
18	3° 28,5'	S	111° 24'	E	27 m	29,9	32,5	32,7	$34,2^5$
19	3° 21,5'	S	111° 29'	E	22 m	28,2	31,8	$32,2^5$	33,7
20	3° 18'	S	111° 38'	E	14,5 m	26,9	31,9	31,7	33,6
21	3° 8'	S	111° 40'	E	$13,2^5$m	27,5	31,2	31,5	33,5
25	3° 41,5'	S	112°	E	20,5 m	30,4	33,0	31,6	33,8
26	4°	S	112°	E	31 m	30,9	33,3	32,6	34,4
27	4° 30'	S	112°	E	45 m	31,8	34,0	33,2	34,5
28	5°	S	112°	E	60 m	32,1	34,5	33,5	34,5
29	5° 30'	S	112°	E	67 m	32,7	33,6	$33,6^5$	34,3
30	5° 48'	S	111° 37'	E	67 m	33,6	33,5	33,8	34,1
31	5° 58'	S	111° 22'	E	57 m	33,6	33,4	$33,6^5$	34,1
32	6° 11'	S	111° 5'	E	58 m	32,5	33,3	33,8	33,9
33	6 23'	S	110° 47'	E	23 m	32,6	33,4	33,3	33,6

[1]) High volumes caused by presence of many salps, siphonophores etc.

April — October 1932.

P_2O_5 mg/m³ Surface		bottom		Plankton volume cc per m³		Copepoda in 1 m³		Undinula vulg. in 1 m³	
April	October	April	October	April	October	April	October	April	October
16,2	6,8	—	10,0	3,6	6,1	355	373	—	—
6,0	3,4	—	4,6	2,2	6,7	319	273	$2,9^3$	—
4,1	3,4	—	6,4	$1,6^4$	1,8	261	191	$0,2^8$	—
4,5	2,0	—	5,8	$0,9^6$	0,4	287	135	$5,0^3$	$0,9^4$
5,2	4,0	—	6,4	$0,3^4$	0,2	59	90	1,4	3,1
5,2	3,4	—	5,2	0,8	0,2	179	86	$3,0^5$	3,1
4,2	4,3	—	7,3	$0,7^7$	2,0	29	89	$1,2^1$	$0,3^7$
3,0	3,7	—	5,5	1,4	0,7	186	44	16,2	$1,7^2$
—	5,5	—	7,9	$0,7^8$	1,0	106	83	$7,0^5$	$0,4^8$
5,3	5,5	7,7	7,9	0,7	1,1	126	46	$6,4^4$	—
5,0	7,3	5,5	8,5	$1,0^6$	2,4[1])	142	67	$0,1^2$	$0,3^9$
4,7	7,9	5,2	7,9	$0,5^8$	2,2[1])	106	161	—	—
6,5	7,3	—	6,7	$0,5^3$	3,6[1])	104	92	—	—
6,2	7,9	—	7,9	0,4	1,0	120	227	0,3	$0,0^8$
6,7	6,1	6,7	10,4	$0,5^9$	1,6	142	174	$1,0^6$	$0,4^3$
4,5	6,7	—	10,4	1,9	0,9	143	264	$0,0^7$	$0,3^5$
7,2	6,1	11,0	7,9	0,9	1,6	180	158	2,7	$0,3^6$
7,7	5,5	11,7	11,0	1,3	$1,8^5$	238	264	$3,1^5$	$1,6^5$
6,5	4,3	9,7	9,2	$2,2^5$	3,4	379	237	0,9	1,1
6,5	5,2	11,0	9,2	2,9	5,6	838	526	—	—
—	5,2	—	10,4	5	7,8	1142	357	—	—
6,7	6,1	9,7	7,3	1,1	2,3	617	210	$0,4^1$	$0,3^5$
5,6	5,2	9,8	8,5	$0,2^4$ [2])	2,2	50	107	—	$7,2^7$
4,7	4,0	4,7	5,5	0,3 [2])	1,5	67	22	3,7	$3,2^6$
4,0	5,2	4,5	6,1	1,6	1,5	118	92	8,0	0,4
4,7	4,3	6,8	7,3	0,9	1,3	175	82	8,1	0,6
4,2	6,7	6,7	10,0	0,4	0,9	129	162	$5,6^4$	$0,5^2$
3,5	6,7	6,7	9,0	$0,3^8$	0,8	149	108	$1,6^4$	$0,2^5$
2,5	8,0	7,2	10,0	0,3	0,9	135	243	—	$0,3^6$
7,2	7,3	11,8	11,0	1,6	2,1	423	590	—	—

[2]) Abnormally low volumes caused by bad condition of plankton.

TABLE II **Diatoms,**

Symbols: [1]) rr = very rare; r = rare; + = present, neither rare nor common; c = common;

April 1932	Java										
Station	1	2	3	4	5	6	7	8	9	10	11
Bacteriastrum hyalinum et *varians*	r										rr
Biddulphia sinensis	rr	rr				r					
Cerataulina bergonii et *compacta*		rr	rr	rr	rr	r					
Chaetoceras coarctatum	+	+						r		rr	r
„ *lorenzianum*	cc	c		r				r			
„ *peruvianum*	+	+									
„ *pseudocurvisetum*		+									
Coscinodiscus gigas	c	+	r	rr	rr	rr		rr		rr	r
„ *jonesianus*	r	rr		r							
„ „ var. *tenuis* MEISTER [1])	+	r		rr							
„ *nobilis*	r	r		rr		+					
Guinardia flaccida	rr	rr									
Hemiaulus sinensis	rr	rr									
Hemidiscus hardmanianus	rr	rr				r		rr		r	r
Rhizosolenia alata	c	+		rr				r	rr		
„ *arafurensis*											
„ *calcaravis*	c	+		rr							
„ *clevei* [2])	cc	c	r	rr	rr		rr	+		rr	
„ *clevei* [3])	rr							rr		rr	rr
„ *hebetata*	+	r								rr	c
„ *imbricata*	c	+									
„ *robusta*											
„ *styliformis* (atq. *latiss.*)	r	r								rr	
„ „ var. *longispina*	c	+							rr	rr	cc
Stephanopyxis palmeriana											
Streptotheca indica			rr					rr		r	r
Thalassiothrix frauenfeldi et *nitzschioides*	r	r									
Trichodesmium								rr		r	cc

[1]) According to ALLEN and CUPP. Plankton Diatoms of the Java Sea. Annales du Jardin Botanique de Buitenzorg, Vol. XLIV, 1935.
[2]) a variety of *Coscinodiscus jonesianus* which resembles the var. *tenuis* MEISTER (MEISTER, possibly a new variety; [3]) diameter 107^5 rr; [4]) ?, diameter 170 rr!

April 1932.

cc = very common; ccc = abundant.

	Borneo																		Java
1	12	13	14	15	16	17	18	19	20	21	25	26	27	28	29	30	31	32	33
r					r				rr	+									r
				r	c	c	c	+	+	c	c	rr					rr		r
																	r		
	c	r	c	+	r	c	+	r	+	c	r	rr	rr		rr			rr	r
			rr	+	r	+		rr	+	+	+								+
					rr	+													r
						+			rr	r									rr
	r	r	+	c	rr	rr	rr	rr		rr	rr	rr	rr	rr	rr	rr	rr	rr	r
					cc	cc	c	c	c	c	cc	r				r	r	+	c
											rr								+
					r	r	r		rr		r					rr			r
				rr			rr		r	r									
	+	r		+	r	+		rr	rr		rr								r
				r	r	+	r	rr	r										+
			r	r					r	r									
	rr			r		+				r									r
	+	+	+	+	r	rr			r			rr							+
				r		rr	r		rr	rr								rr	r
	r	r	r	rr	rr	rr												rr	+
			r	r	r	r			r		rr								+
				rr	rr	rr	rr												rr
					r	+	+	r	rr	rr							rr		
	+	+	+	+	r	rr									rr				c
									r										rr
	r					rr							r					rr	rr
									+	+	r								+
	+	+	r	rr	rr	rr							rr	+	r	r	rr	rr	rr

Kieselalgen aus Asien, 1932) but, as mr. ALLEN and miss CUPP write me, identification is not certain;

TABLE III **Diatoms,**

October 1932	Java										
Station	1	2	3	4	5	6	7	8	9	10	11
Bacteriastrum hyalinum et *varians*		rr								r	
Biddulphia sinensis		c	r					rr			
Cerataulina bergonii et *compacta*	rr	r	rr						r		
Chaetoceras coarctatum	+	+									
„ *lorenzianum*		+									
„ *peruvianum*											
„ *pseudocurvisetum*		cc								r	
Coscinodiscus gigas	+	c	+	r	rr	rr	rr	r	r	r	r
„ *jonesianus*		+									
„ „ var. *tenuis* MEISTER			rr								rr
„ *nobilis*		cc	rr								
Guinardia flaccida	rr	+	r								
Hemiaulus sinensis		+	r								
Hemidiscus hardmanianus	r	+	r					rr			r
Rhizosolenia alata			r					rr		r	rr
„ *arafurensis*											
„ *calcaravis*	rr		rr					rr			
„ *clevei*											
„ *clevei*								+			
„ *hebetata*			r								
„ *imbricata*	rr										
„ *robusta*											
„ *styliformis* (atq. *latiss.*)	rr	cc	+								
„ „ var. *longispina*										r	r
Stephanopyxis palmeriana		c	rr								
Streptotheca indica			r					rr	rr	+	c
Thalassiothrix frauenfeldi et *nitzschioides*	rr	r									
Trichodesmium			rr	r	+	r	r			+	+

October 1932.

										Borneo									Java
12	13	14	15	16	17	18	19	20	21	25	26	27	28	29	30	31	32	33	34
	rr			rr	rr					r									
				r	+	r				+	r						rr	+	r
																	rr	cc	cc
				r	r	r	rr	r	r	r					rr	rr	r	+	
										r							rr	c	+
																		+	+
										r								+	+
r	r	r	r	+	+	r	rr	r	+	c	+	r	rr	rr	rr	rr	rr	+	r
				rr	rr	rr	rr	rr	rr	r						rr	r	+	+
				r	rr													r	r
				rr	rr	rr	rr	rr	r	rr	rr								
				r														+	+
																	rr	r	
r		r	r	+	+	r		rr	r	c	r	rr				rr		rr	r
		rr		rr	r					r	rr				rr	rr			+
		rr		rr	rr				rr	r								+	+
					r					rr	r	r							r
			rr	rr	r				rr	r	rr	r			rr	rr		rr	
				rr														+	r
						rr				rr								rr	
										rr							r	c	c
r			r	r		r	r		rr	rr					rr		r	c	c
r																			r
+	+	r	r	r	r	r					r	r			rr	rr	rr	r	r
																		rr	
r	rr												rr	r	r	r	rr		

TABLE IV

Java Sea

Nr.	May 1934	Position	Depth. meters	Salinity, surface	Salinity, bottom	Volume under 1 m²	Volume in 1 m³	Undinula vulgaris under 1 m²	Undinula vulgaris in 1 m³	id. juvenes under 1 m²	Labidocera acuta under 1 m²	Eucalanus suberassus > 2 mm under 1 m²	Euchaeta concinna > 2 mm under 1 m²	Candacia bradyi > 2 mm under 1 m²	Copepods > 2 mm total under 1 m²	Copepods > 2 mm total in 1 m³	Temora discandata	Centropages furcatus	Acartia pietschnanni a.c.sp.
1	3	5° 16′ S 106° 57′E	19	32,1	32,7^5	33	1,7	—	—	2	2	135	—	—	140	7,3			
2	3	5° 6′ S 106° 57′E	20	32,2^5	32,8	95	4,2	—	—	—	—	—	—	—	—	—			
3	4	3° 8′ S 107° E¹)	36	32,3^5	32,8^5	30	0,8	43	1,2	43	45	90	2	—	223	6,2	no further		
4	5	2° 43′ S 106° 56′E¹)	26	32,3^5	32,9^5	28,5	1,1	42	1,6	132	18	372	—	—	564	21,7			
13	21	3° 40′ S 109° 10′E	32	33,3	33,3	18	0,6	—	—	—	4,5	13,5	—	—	20	0,6	1,8	7,7	39
14	21	4° 12′ S 109° 3′E	41	33,1^5	33,5	24	0,6	—	—	—	—	4,5	r	—	45	0,1	1,1	7,7	11
15	21	4° 41′ S 108° 57′E	45	32,3	33,4	30	0,7	144	3,2	135	—	9	r	—	288	6,4	0,7	10	27
16	22	5° 12′ S 108° 49′E	45	32,4	33,5	37	0,8	246	5,5	18	12	168	12	12	468	10,4	11	21,7	20
17	22	5° 42′ S 108° 44′E	49	32,4^5	33,5	37	0,8	700	14,1	144	18	333	189	36	1404	28,6	5	11	4,8
18	22	5° 57′ S 108° 23′E	45	32,7^5	31,6	42	0,9	37	0,8	2	37,5	2250	—	37,5	2362	52,5	80	15	10
19	22	6° 5′ S 108° 20′E	33	32,6	32,7^5	86	2,6	112	3,4	194	2	544	—	—	825	25	140	3,4	5,7
20	22	6° 13′ S 108° 18′E	10	33,3	33,6	19	1,9	22	2,2	—	4,5	18	—	—	63	6,3	25	2,2	27
21	23	5° 31′ S 107° E	48	32,2	31,9	30	0,6	292	6,1	27	45	90	—	—	454	9,5	no further		
22	23	5° 50′ S 107° 6′E	26	32,1	33,0	8,4	0,3	9	0,3^5	3	3	48	—	3	66	2,5			

¹) between Bangka en Billiton.

May, 1934.

Oithona	Calanopia minor	Calanopia elliptica	Calanus pauper	Tortanus gracilis	Tullbergella cuspidata	Synopia ultramarina	Hyperia sibaginis	Pseudeuphausia latifrons	Mysidacea	Lucifer intermedius	Pyrocypris natans	Remarks
in 1 m³												
analyzed												Diatoms fairly many.
												Mostly echinopluteus, causing high volume.
												Mixed zoo- and phytoplankton.
												Eggs of *Clupea leiogaster* not rare.
17	—	—	2,1	—	—	—	—	—	—	1,3	—	*Trichodesmium*, diatoms, salps, *Stolephorus* eggs common.
50	—	—	6,6	1,1	—	—	—	—	—	0,3	22	Diatoms common, *Stolephorus* eggs fairly common.
12	5,3	0,7	8	9,3	—	—	—	—	4	5	10	Many Radiolarians, less diatoms.
13,3	28,3	1,7	8,3	3,3	1,1	2	1,3	6,7	0,7	2,8	2	Rich zooplankton, sagitta's, salps, *Hyalocylix* common.
32	14,6	—	1,2	—	1,6	0,6	0,6	0,2	0,4	3,0	0,6	As nr. 16, many fish larvae Clupeids, (*Fistularia* a.o.)
35	10	—	—	—	—	—	—	0,1	—	2,7	—	Many *Fritillaria*, some *Stolephorus* a.o. fish eggs.
—	—	—	—	—	—	—	—	—	—	—	—	Few diatoms and *Noctiluca*.
6,7	—	—	—	—	—	—	—	—	—	—	—	Many *Noctiluca*, few diatoms.
analyzed												Some *Trichodesmium*.
												Mostly zooplankton, little *Trichodesmium* and diatoms.