C.I.P.S.

MATHEMATICAL MODEL OF THE
POLLUTION IN THE NORTH SEA.

1973/BIOL.-SYNTHESE 03

This paper not to be cited without prior reference to the author.

RESULTS OF THE QUALITATIVE AND QUANTITATIVE ANALYSES OF THE EPIBENTHIC AND BENTHIC FAUNA IN THE CATCHES OF THE EXPERIMENTAL SHRIMP-FISHERY.

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1. Introduction and Objective.

Since April 1973 qualitative and quantitative analyses of the epibenthic and benthic fauna in the catches of the experimental shrimp-fishery are performed. These investigations are mainly part of a population-dynamic study of Crangon crangon. Up to now the possible predative and competitive interactions between the populations of these benthic and epibenthic species on the one side, and the populations of commercially exploited species, like Crangon crangon, on the other side, were only studied occasionally.

The first objective of this study is collecting rough data with which a quantitative notion of the population-dynamic of the most important by-catch-species can be formed. In a later stage the interspecific interactions between the populations of the epibenthic and benthic organisms will be examined, on the understanding that the population of Crangon crangon will take a central place in it.

These populations however don't form a separate ecological unit but they are integrated in a community. For their food they depend on the benthic infauna or on detritus and, ultimately, also on the primary production of the environment. The examined populations, in their turn, are in a prey-predator-relation to the nektonic carnivores.

This investigation doesn't want to take an isolated place, but should be seen in a much larger research programme about the energy-balance of the marine environment.

2. Sampling-method.

The sampling-method already has been described extensively in an earlier report (REDANT, 1973), so that a short summary may suffice.

Each month 14 permanent sampling-stations, situated on the Westdiep (5), the Vlakte van de Raan (5) and the Thornton-bank (4) are sampled. In the whole of the half-yearly surveys of the commercial fish- and shrimp-stocks, 19 supplementary stations are fished, with intervals of about 6 months. The positions of the stations are represented in figure 1.

The sampling normally takes place by day. Except during the half-yearly stock-surveys, for which the beam-trawl is used, the sampling is always done with the ottertrawl. The mesh-width of the net is 18 mm and each haul takes 15 minutes.

On every station observations about the temperature, pH and salinity of the surface-water, the direction of the tide-current, the wind-force and direction and the degree of cloudiness are performed.

As soon as the catch has been brought upon deck, the commercial and great non-commercial fish species are graded. The study of this fish-fraction, mainly consisting of representatives of the Rajidae, Clupeidae, Anguillidae, Gadidae, Carangidae, Scombridae, Triglidae, Bothidae, Pleuronectidae, and Soleidae is executed by the Working-group 'Biology' (I.W.O.N.L.) of the Fisheries Research Station, in Ostend.

The remaining part of the catch is cleared and divided into two fractions with a crab-sieve. The fraction that remains on the sieve contains the great by-catch-species ; the fraction that falls through the sieve consists of shrimps (Crangon crangon) and small by-catch-species. The volumes of both fractions are measured apart from each other. After that a sample of each fraction, also with known volume, is held back for analysis in the laboratory. Normally the volumetric relation between sample and fraction varies, according to the size and the hetero- or homogeneity of the complete fraction, from 1/1 to 1/20 for the shrimp-samples and from 1/1 to 1/30 for the by-catch-samples. The minimum extent of these samples is, respectively, 1000 cc and 3000 cc.

The ultimate analysis of the samples involves countings of the number of individuals and determinations of the total wet-weight of these individuals, per species, with the exception of the planktonic Scyphozoa and Ctenophora.

The complete sampling-procedure is represented schematically on figure 2.

3. Results and Discussion.

After a few orientating test-hauls in March 1973, in order to adjust the sampling aboard the vessel, the definite investigations were started in the course of April 1973. Up to now two half-yearly (April and October 1973) and five monthly surveys (May, June, August, September and November 1973) have been undertaken.

The results mentioned in this report are based upon the already assimilated data of the period April-August 1973. During this period 75 samplings were carried out. The catches of 15 minutes trawling contained meanly 19,500 individuals. In this value the colonial Hydrozoa and Bryozoa are not taken into account. The average weight of the catches was 23.6 kg. The mean percentual numerical contributions (N) and the mean percentual weight-contributions (W) of the different species are listed in table 1 and 2 (resp. Invertebrates and Vertebrates). The already mentioned commercial and non-commercial Teleostomi were left out of consideration in the compilation of the catch-data and in the calculation of the percents.

From the results concerning the relative numerousness of the different species appears that only six species occured in high to very high concentrations (N $\geqslant$ 1) in the catches, namely Laomedea species, Crangon crangon (N=26.95), Macropipus holsatus (N=6.46), Asterias rubens (N=1.24), Ophiura texturata (N=60.47) and Pomatoschistus minutus (N=1.56).

Besides, reference can be made to a large number of organisms that were frequently observed in the samples (1 > N $\geqslant$ .025) but that took a much less important part in the composition of the catches, namely Hydractinia echinata, Abietinaria abietina, Hydrallmania falcata, Actinia equina (N=.580), Aphrodite aculeata (N=.060), Lanice conchilega (N=.385), Pectinaria koreni (N=.320), Spirorbis spirillum (N=.230), Mytilus edulis (N=.095), Abra alba (N=.083), Angulus tenuis (N=.037), A. fabula (N=.037), Sepiola atlantica (N=.025), Alloteuthis subulata (N=.034), Alcyonidium gelatinosum, Pontophilus trispinosus (N=.025), Pagurus bernhardus (N=.285), Macropodia rostrata (N=.058), Echinocardium cordatum (N=.050), Aphia minuta (N=.026), Callionymus lyra (N=.094) and Agonus cataphractus (N=.095).

In the light of the problematic round the food-chain and -pyramid of the marine environment, not only the numerical densities but also the biomasses of the different species play a part. Seen from this new standpoint, only a few dominant species remain (W $\geqslant$ 5), namely, Sepia officinalis (W=7.29), Crangon crangon (W=14.67), Macropipus holsatus (W=26.76), Asterias rubens (W=16.28) and Ophiura texturata (W=23.77).

Different species also provide a considerable, but clearly less notable weight-contribution to the composition of the catches (5 > W $\geqslant$ .1) namely, Laomedea species, Actinia equina (W=.49), Aphrodite aculeata (W=1.43), Lanice conchilega (W=.27), Pectinaria koreni (W=.25), Alcyonidium gelatinosum (W=.16), Pagurus bernhardus (W=2.58/shells included), Echinocardium cordatum (W=.27), Pomatoschistus minutus (W=1.07), Callionymus lyra (W=1.75) and Agonus cataphractus (W=.12).

Yet it is necessary to add some important remarks to these ascertainments.

The numerous presence of Hydrozoa (with the exception of Hydractinia echinata) and Bryozoa can probably be explained by the period of stormy weather that preceeded the half-yearly survey in April 1973. In the course of this month large quantities of Hydrozoa and Bryozoa were fished, especially at the stations nearer to the coast (figures 3 and 4). Since May however, always less of these organisms were noticed. It is possible that the observed material had been brought down by the dominant SW-NE-coast-current (LELOUP and GILIS, 1963) from more western areas. This also explains the presence of Spirorbis spirillum because this species always was found in association with Abietinaria abietina.

The important weight-contribution of Sepia officinalis is due to the yearly spawning-migration of this species, which is closely connected to the water-temperature. During the months May and June the adult animals stay in shallow waters near the coast to spawn. After this the spent males and females die while the animals that didn't take part in a copulation leave the coastal waters (RICHARD, 1971). As a matter of fact, in August only 0-year cuttle-fishes were perceived. The short appearance of adult Sepia officinalis in the catches is so enormous that taking up this species into the final list of the most important by-catch-species is justified.

Remarkable in the results of this investigation are the rather small quantities of Polychaeta (N=1.33 and W=2.19), Gastropoda (N=.01 and W=.03) and Pelecypoda (N=.29 and W=.21). Probably the reason for this can be found in the sampling-method. The aim of the construction and the rigging of the fishing-gear, used for the commercial and the experimental shrimp-fishery, is to make the net glide over the bottom, as smoothly as possible. The penetration of the net into the bottom is reduced to a minimum by wooden or rubber rolls at the under-rope. A consequence of this might be that the net would only take up the benthic and epibenthic organisms that live on or immediately under the bottom surface. Moreover, small organisms, like most Polychaeta, Gastropoda and Pelecypoda have a considerable chance to be swept out of the net by the water-current, during the hauling or the drawing in of the net. This can explain the mostly small amounts and weights, noted for species like Nereis species, Arenicola marina, Spisula solida, S. subtruncata, Abra alba, Angulus tenuis, A. fabula, Donax vittatus, and others.

The use of a shrimp-net with a mesh-width of 18 mm, as a benthos-sampler, consequently doesn't give enough guarantees for justified quantitative investigations of the population-dynamic or -densities of smaller species.

Yet the sampling-method is appropriate for qualitative population analyses of Anthozoa, some Polychaeta (f.e. Aphrodite aculeata), Cephalopoda, Crustacea Decapoda, Asteroidea, Ophiuroidea, Echinoidea, Elasmobranchii and Teleostomi.

4. Conclusions.

From the autochtonous species that can be studied in a representative way with the applied sampling-method, Crangon crangon, Macropipus holsatus, Asterias rubens, Ophiura texturata, Actinia equina, Aphrodite aculeata, Sepia officinalis, Pagurus bernhardus, Echinocardium cordatum, Pomatoschistus minutus, Callionymus lyra and Agonus cataphractus take an important part in the composition of the catches of the experimental shrimp-fishery. To illustrate this, the densities of the four, first mentioned species, which are also the most important, have been mapped out on the figures 5, 6, 7 and 8.

Ophiura texturata, Aphrodite aculeata, Pagurus bernhardus and Echinocardium cordatum are clearly detritophages (BARNES, 1968 ; TAIT, 1968 and NEWELL, 1970). Crangon crangon and Macropipus holsatus are omnivores that play a part as detritophages and as carnivores of inferior order (BARNES, 1968 and PLAGMANN, 1939). The part taken by detritus in the food of Crangon crangon is rather small (PLAGMANN, 1939). Actinia equina, Sepia officinalis, Pomatoschistus minutus, Callionymus lyra and Agonus cataphractus are predators of an inferior or a medium order (BARNES, 1968 ; KUHL, 1961 and WHEELER, 1969).

Several of these species form a considerable part of the food of predatory fishes like Gadus callarias, G. luscus, Merlangius merlangus, Limanda limanda and Pleuronectes platessa (GILIS, 1952 ; JONES, 1954 ; KUHL, 1963 ; TIEWS, 1965 ; WHEELER, 1969 and BODDEKE, 1971) of which some are economically important.

In the food-chain and -pyramid of the marine environment, the species which the investigations have proved to be important, form a link between the benthic epi- and infauna and the demersal zooplankton on the one side, and the demersal predatory fishes on the other side.

Long-term and large-scale analyses of the numerical densities and the biomasses of these species may help to draw up turn-over-models for some important populations in the biocoenosis of the coastal waters.

5. Bibliography.

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Table 1.

Relative numerical and weight-contributions of the Invertebrates to the experimental shrimp catches.

Species	N %	W %
Phylum PORIFERA		
Unidentified species	.002	.008
Phylum COELENTERATA		
(except Scyphozoa)		
Class HYDROZOA		
Tubularia species	-	1.030
Hydractinia echinata (Fleming)	-	
Laomedea species	-	
Abietinaria abietina (L.)	-	
Hydrallmania falcata (L.)	-	
Sertularia species	-	
Class ANTHOZOA		
Actinia equina L.	.580	.490
Tealia felina (L.)	.002	.003
Metridium senile (L.)	.004	.053
Other Anthozoa	.001	ld .001
Phylum ANNELIDA		
Class POLYCHAETA		
Phyllodoce species	.002	ld .001
Aphrodite aculeata (L.)	.060	1.430
Lepidonotus squamatus (L.)	.003	.001
Gattyana cirrosa Pallas	.001	ld .001
Nereis species	.005	.002
Arenicola marina (L.)	ld .001	.004
Lanice conchilega (Pallas)	.385	.270
Pectinaria koreni (Malmgren)	.320	.250
Pomatoceros triqueter (L.)	ld .001	ld .001
Spirorbis spirillum (L.)	.230	ld .001
Other Annelida	.325	.230
Phylum ECHIURIDA		
Echiurus pallasi Guérin	ld .001	.003
Phylum MOLLUSCA		
Class GASTROPODA		
Natica catena (Da Costa)	ld .001	.002
Natica alderi (Forbes)	.007	.002
Crepidula fornicata (L.)	.003	.003
Buccinum undatum L.	ld .001	.027
Dendronotus frondosus (Ascanius)	ld .001	ld .001
Class PELECYPODA		
Mytilus edulis L.	.095	.012
Venerupis pullastra (Montagu)	.006	.002
Spisula solida (L.)	.003	.003
Spisula subtruncata (Da Costa)	.002	.007
Spisula elliptica (Brown)	ld .001	.001
Mactra corallina cinerea Montagu	.006	.054

Table 1 (continued)

Species	N %	W %
Class PELECYPODA (continued)		
Petricola pholadiformis Lamarck	ld .001	ld .001
Abra alba (W.Wood)	.083	.022
Macoma balthica (L.)	.004	.007
Angulus tenuis (Da Costa)	.037	.021
Angulus fabula (Forbes)	.037	.015
Donax vittatus (Da Costa)	.014	.037
Ensis ensis (L.)	ld .001	ld .001
Ensis arcuatus (Jeffreys)	.005	.001
Mya truncata L.	.001	.028
Class CEPHALOPODA		
Sepia officinalis L.	.012	7.290
Sepiola atlantica d'Orbigny	.025	.034
Loligo vulgaris Lamarck	ld .001	.023
Alloteuthis subulata (L.)	.034	.074
Phylum BRYOZOA		
Class ECTOPROCTA		
Alcyonidium gelatinosum (L.)	-	.160
Alcyonidium polyoum (Hassall)	-	ld .001
Flustra foliacea (L.)	-	.024
Other Bryozoa	-	.115
Phylum ARTHROPODA		
Class CRUSTACEA		
Order CUMACEA		
Diastylis species	.008	ld .001
Order ISOPODA		
Idotea linearis (L.)	.007	ld .001
Order AMPHIPODA		
Hyperia galba (Montagu)	ld .001	ld .001
Caprella linearis (L.)	ld .001	ld .001
Other Amphipoda	.074	.003
Order DECAPODA		
Pandalus montagui Leach	.019	.013
Pandalina brevirostris (Rathke)	.002	ld .001
Hippolyte varians Leach	ld .001	ld .001
Processa canaliculata Leach	.004	.007
Crangon crangon (L.)	26.950	14.670
Pontophilus trispinosus (Hailstone)	.025	.003
Pagurus bernhardus (L.)	.285	2.580
Porcellana longicornis (L.)	.014	ld .001
Macropipus puber (L.)	ld .001	.010
Macropipus holsatus (Fabricius)	6.460	26.760
Carcinus maenas (L.)	ld .001	.011
Hyas araneus (L.)	ld .001	.002
Macropodia rostrata (L.)	.058	.026

Table 1 (continued)

Species	N %	W %
Phylum ECHINODERMATA		
Class ASTEROIDEA		
Asterias rubens (L.)	1.240	16.280
Class OPHIUROIDEA		
Ophiotrix fragilis (Abildgaard)	.001	ld .001
Ophiura texturata Lamarck	60.470	23.770
Class ECHINOIDEA		
Psammechinus miliaris (Gmelin)	.008	.070
Echinocardium cordatum (Pennant)	.050	.270

The values larger than .100 were rounded off to the nearest .005 ; the values larger than 1.000 were rounded off to the nearest .01 .

ld .001 = less than .001 % .

Table 2.

Relative numerical and weight-contributions of the Vertebrates to the experimental shrimp catches.

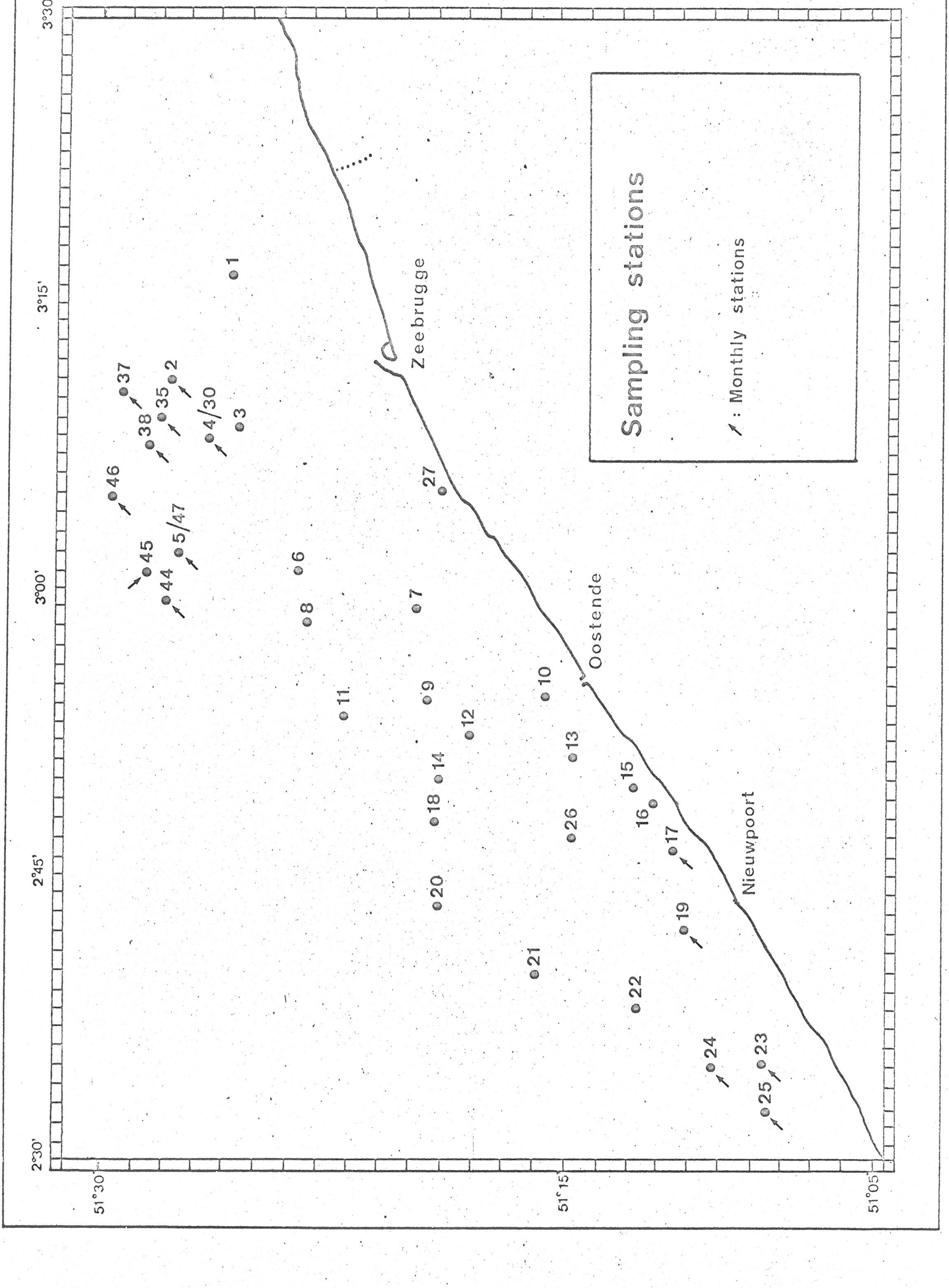
Species	N %	W %
Phylum CHORDATA		
Class ELASMOBRANCHII		
Scylliorhinus canicula (L.)	x	x
Galeorhinus galeus (L.)	x	x
Mustelus mustelus (L.)	x	x
Raja clavata L.	x	x
Class TELEOSTOMI		
Clupea harengus L.	x	x
Clupea sprattus L.	x	x
Engraulis encrasicolus L.	ld .001	.006
Anguilla anguilla (L.)	x	x
Belone belone (L.)	ld .001	ld .001
Syngnathus acus L.	.006	.001
Merluccius merluccius (L.)	x	x
Gadus callarias L.	x	x
Gadus luscus L.	x	x
Merlangius merlangus (L.)	x	x
Ciliata mustela (L.)	.002	.026
Trachurus trachurus (L.)	x	x
Ammodytes lanceolatus Lesauvage	ld .001	.001
Scomber scombrus L.	x	x
Pomatoschistus minutus (Pallas)	1.560	1.070
Aphia minuta (Risso)	.026	.021
Callionymus lyra L.	.094	1.750
Trigla corax Bonaparte	x	x
Agonus cataphractus (L.)	.095	.120
Cyclopterus lumpus L.	ld .001	ld .001
Liparis liparis L.	.005	.005
Gasterosteus aculeatus L.	ld .001	ld .001
Scophthalmus maximus (L.)	x	x
Limanda limanda (L.)	x	x
Pleuronectes platessa L.	x	x
Platichtys flesus (L.)	x	x
Solea solea (L.)	x	x

The values larger than .100 were rounded off to the nearest .005 ; the values larger than 1.000 were rounded off to the nearest .01 .

ld .001 = less than .001 % .

The species indicated with 'x' were observed during the period under review, but are beyond the scope of this research.

Figure 1.-


Sampling stations
↗ : Monthly stations
Zeebrugge
Oostende
Nieuwpoort
3°30'
3°15'
3°00'
2°45'
2°30'
51°30
51°15
51°05
1
2
3
4/30
5/47
6
7
8
9
10
11
12
13
14
15
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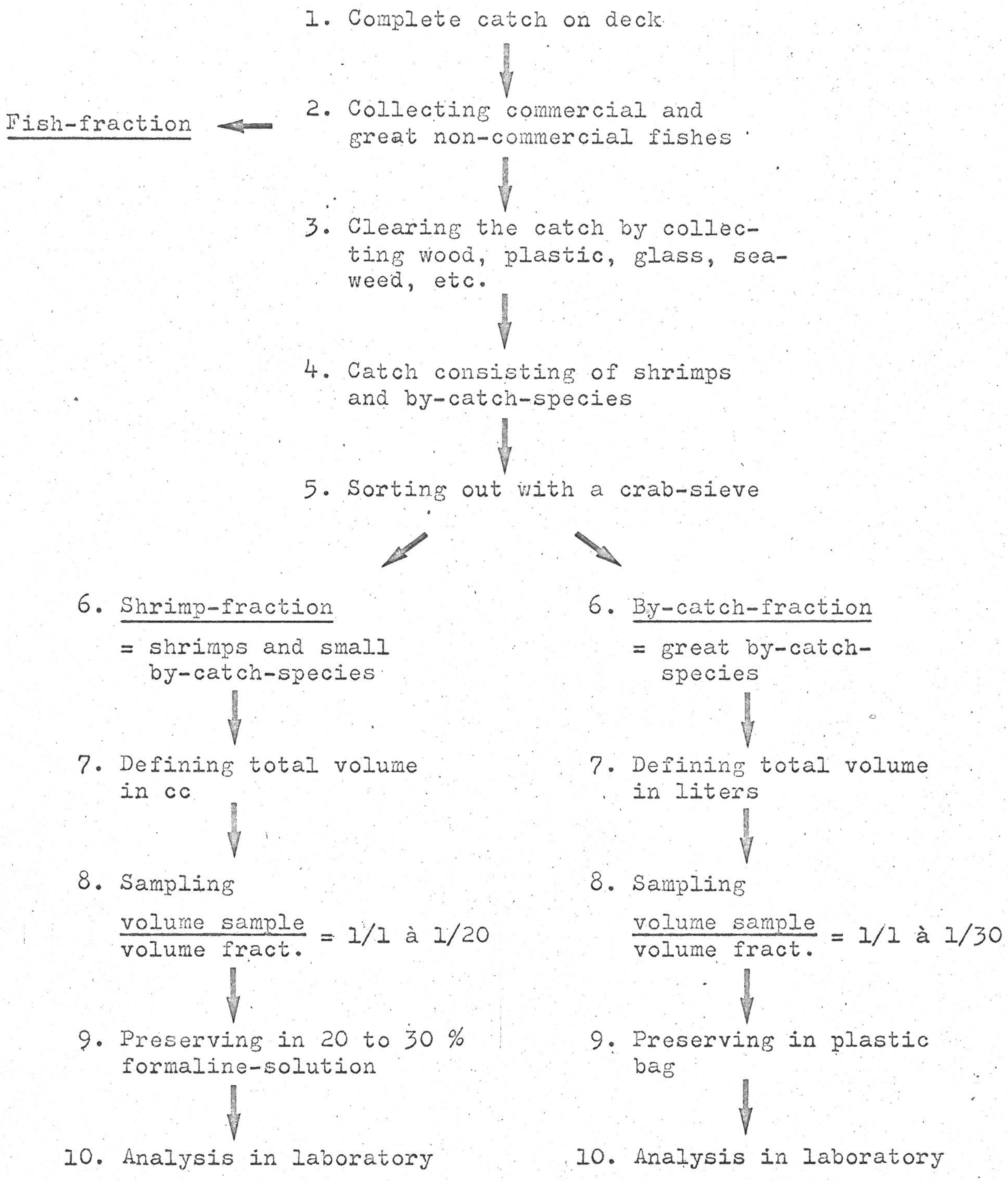
38
44
45
46

Figure 2.-



1. Complete catch on deck

2. Collecting commercial and great non-commercial fishes

Fish-fraction

3. Clearing the catch by collecting wood, plastic, glass, seaweed, etc.

4. Catch consisting of shrimps and by-catch-species

5. Sorting out with a crab-sieve

6. Shrimp-fraction = shrimps and small by-catch-species

7. Defining total volume in cc

8. Sampling $\frac{\text{volume sample}}{\text{volume fract.}} = 1/1$ à $1/20$

9. Preserving in 20 to 30 % formaline-solution

10. Analysis in laboratory

6. By-catch-fraction = great by-catch-species

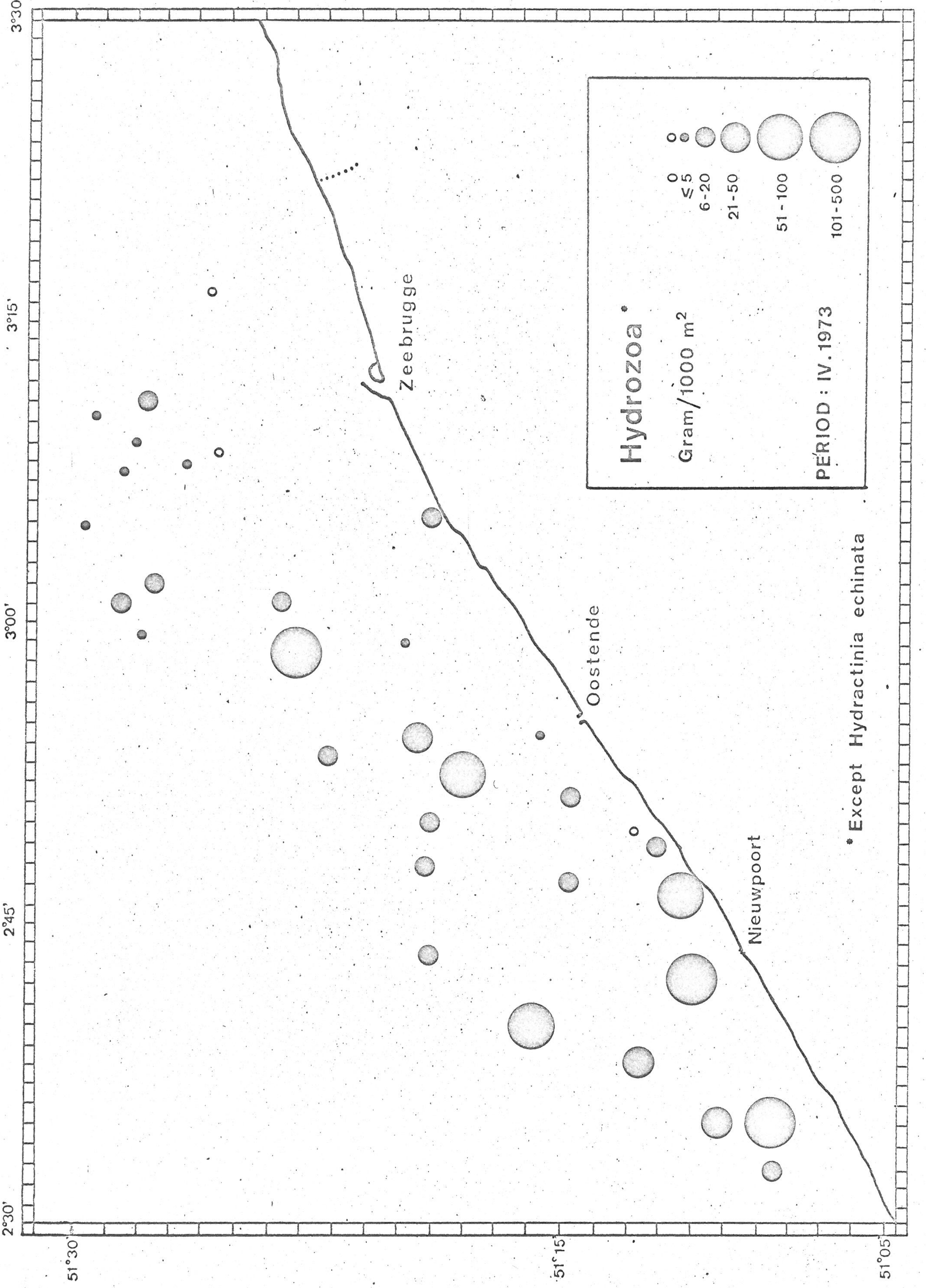
7. Defining total volume in liters

8. Sampling $\frac{\text{volume sample}}{\text{volume fract.}} = 1/1$ à $1/30$

9. Preserving in plastic bag

10. Analysis in laboratory

Figure 3.-



* Except Hydractinia echinata

Figure 4.-

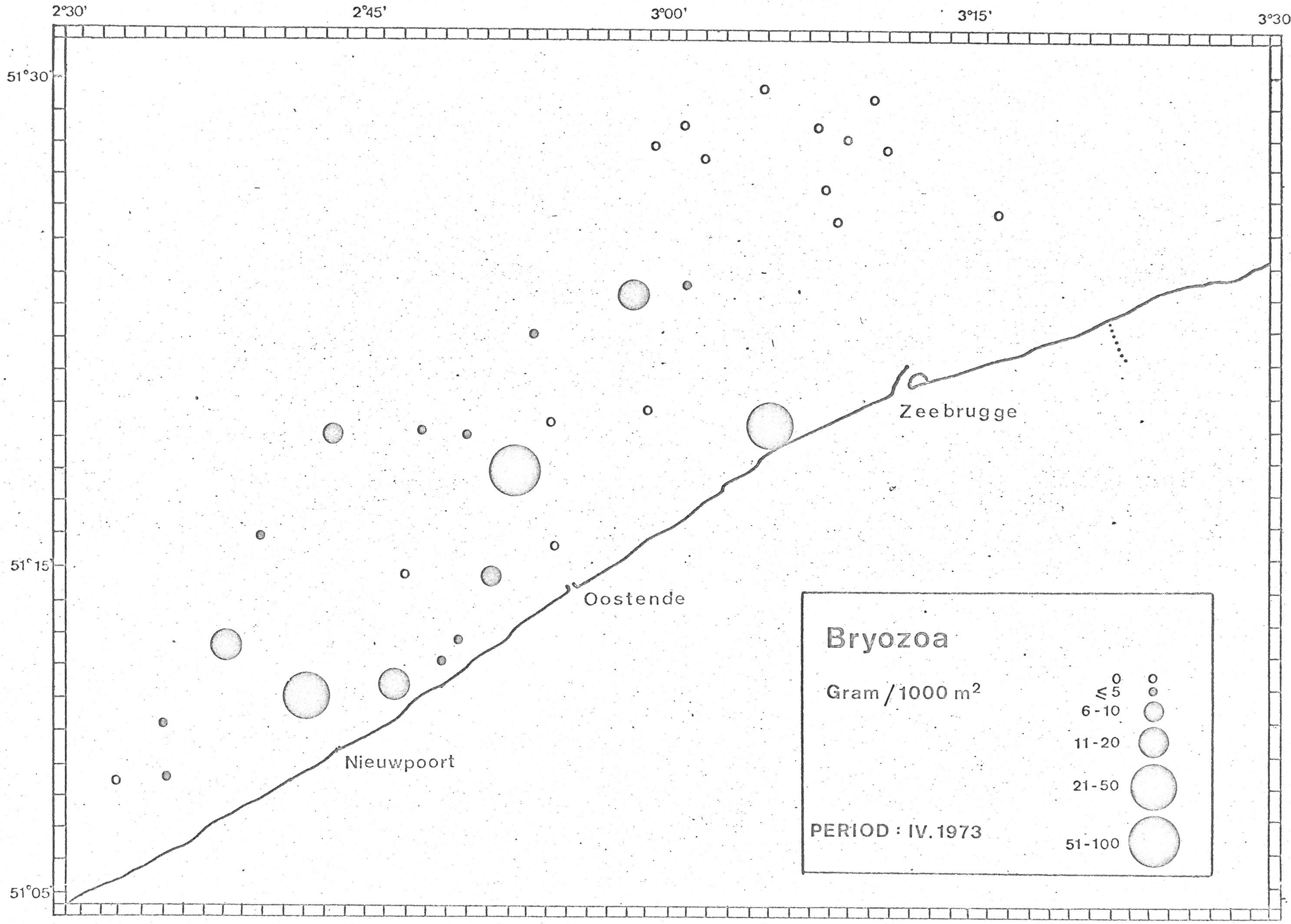
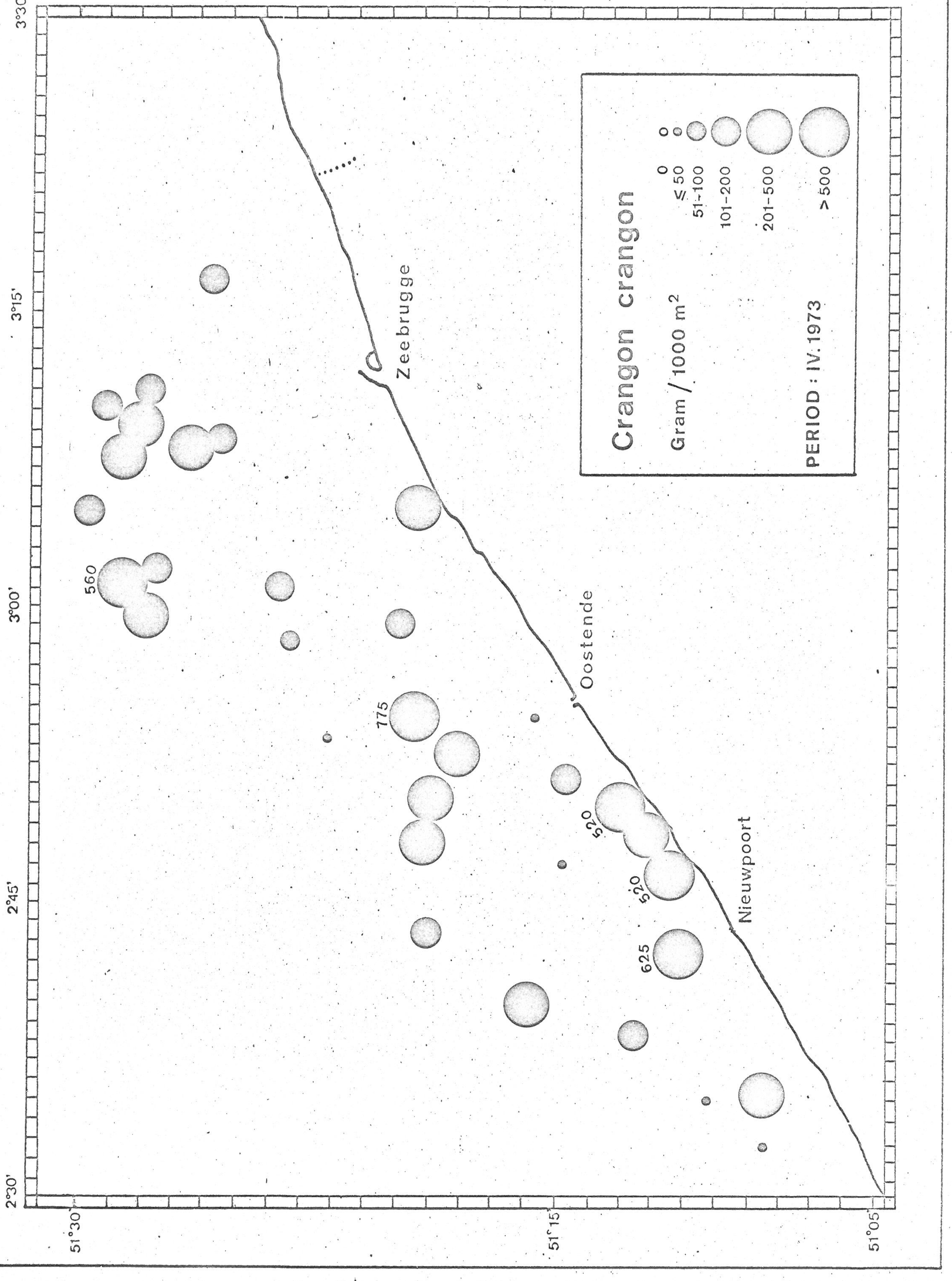

2°30'
2°45'
3°00'
3°15'
3°30'
51°30'
51°15'
51°05'
Zeebrugge
Oostende
Nieuwpoort
Bryozoa
Gram / 1000 m²
0
≤5
6-10
11-20
21-50
51-100
PERIOD : IV.1973

Figure 5.-


Crangon crangon
Gram / 1000 m²
0
≤ 50
51-100
101-200
201-500
>500
PERIOD : IV.1973
Zeebrugge
Oostende
Nieuwpoort
560
775
520
520
625
3°30'
3°15'
3°00'
2°45'
2°30'
51°30'
51°15'
51°05'

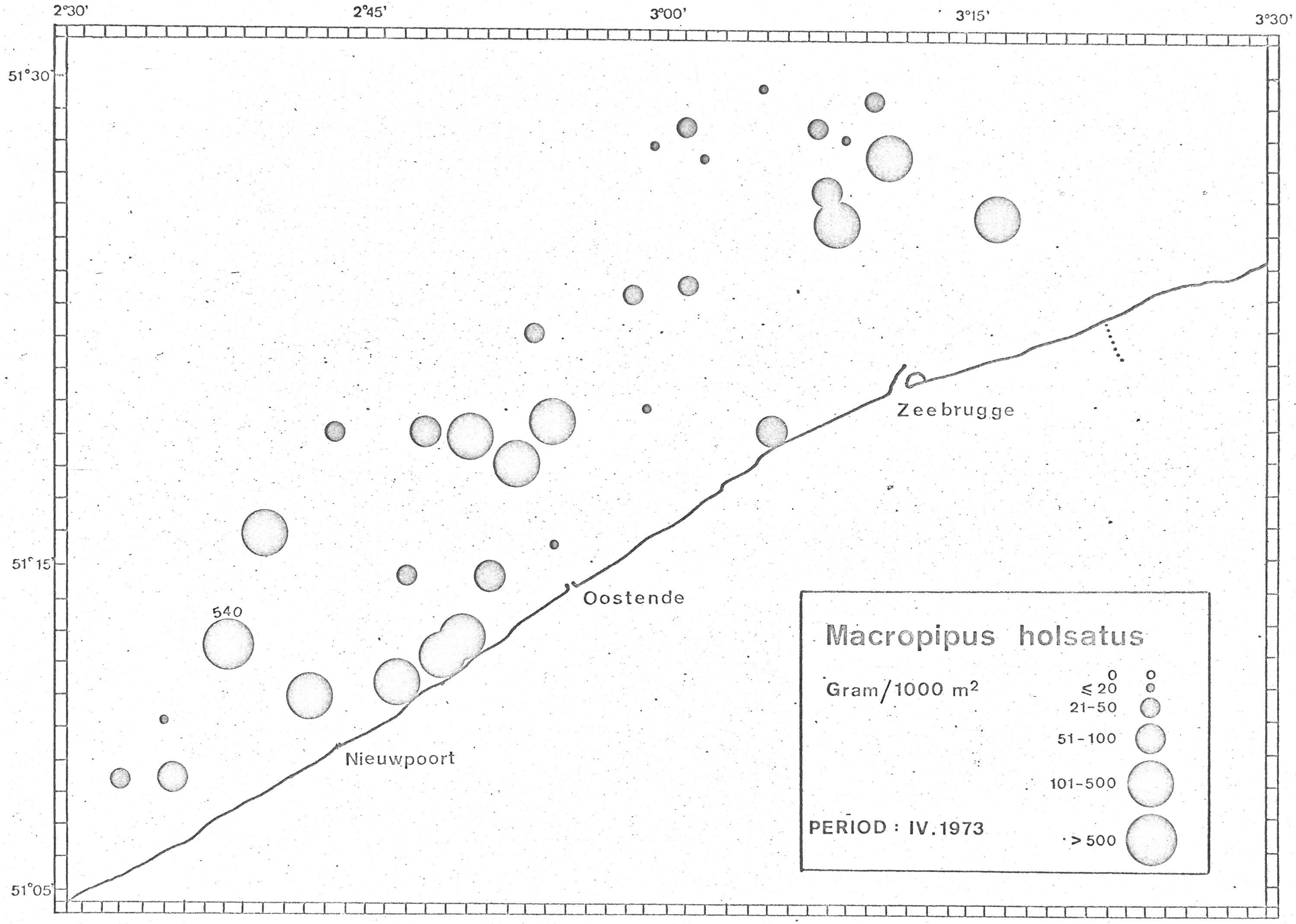

2°30'
2°45'
3°00'
3°15'
3°30'
51°30'
51°15'
51°05'
Zeebrugge
Oostende
Nieuwpoort
540
Macropipus holsatus
Gram/1000 m²
0
≤ 20
21-50
51-100
101-500
> 500
PERIOD : IV.1973

Figure 6.-

Figure 7.-

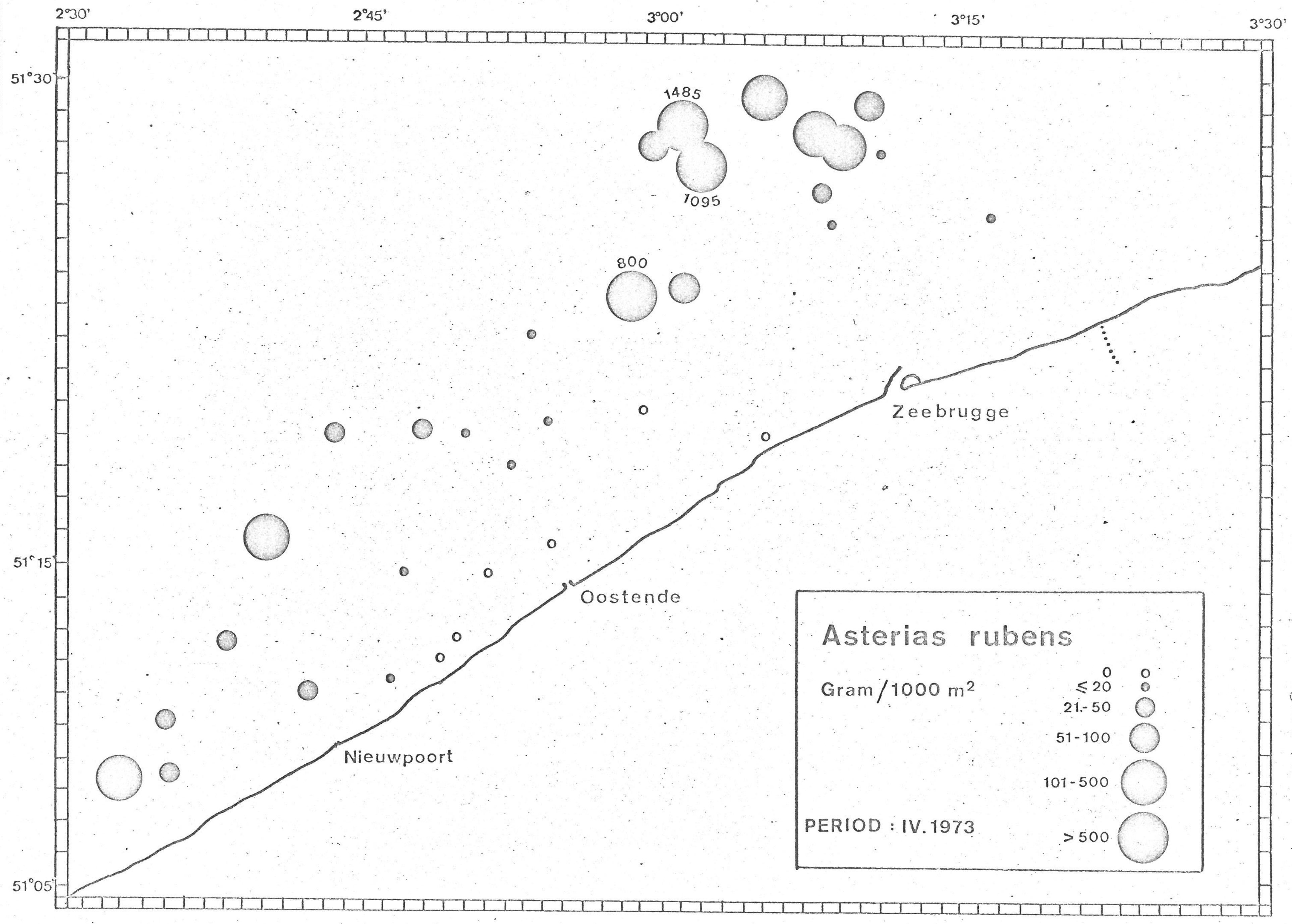
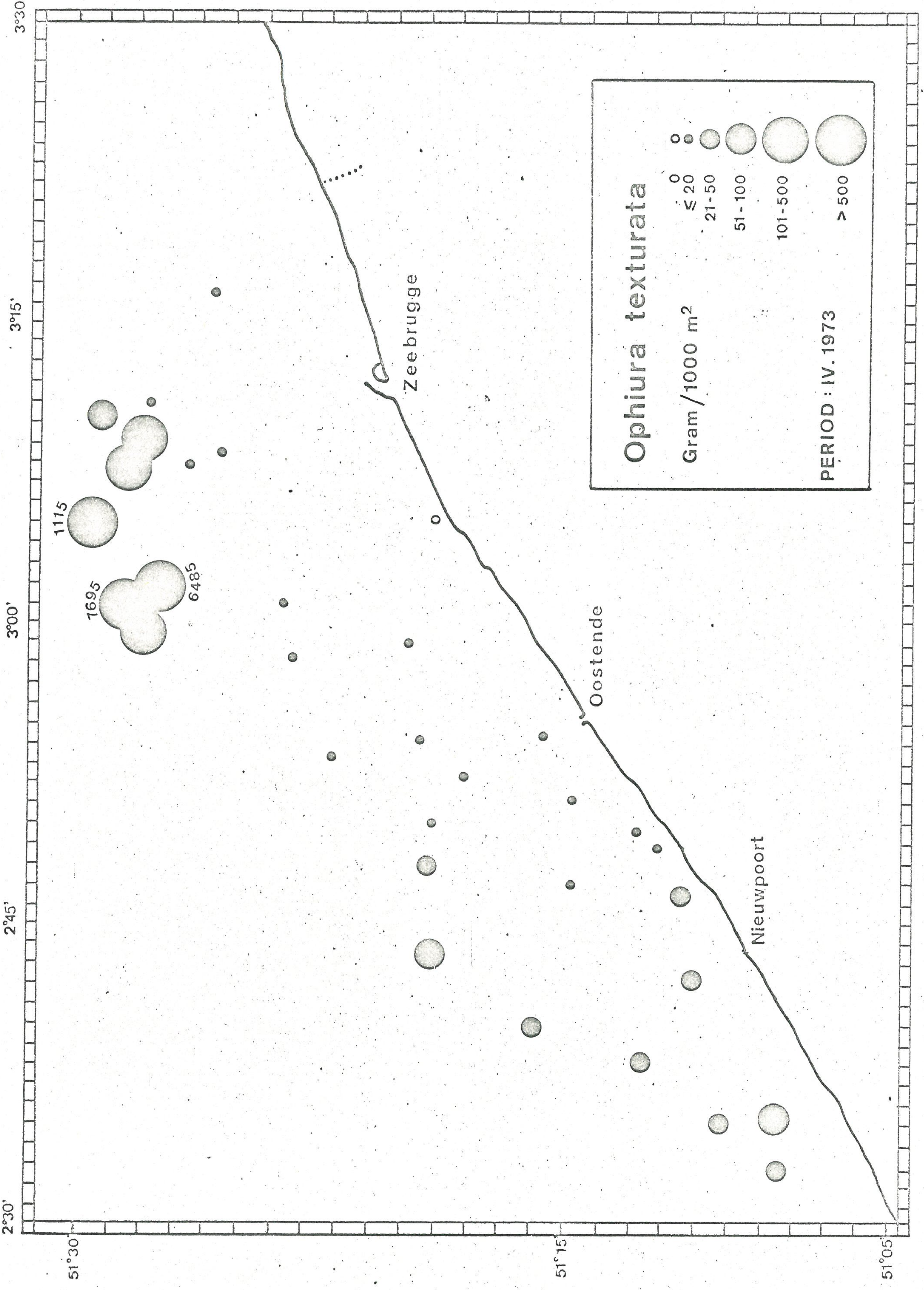

2°30'
2°45'
3°00'
3°15'
3°30'
51°30'
51°15'
51°05'
1485
1095
800
Zeebrugge
Oostende
Nieuwpoort
Asterias rubens
Gram/1000 m²
0
≤ 20
21.-50
51-100
101-500
> 500
PERIOD : IV.1973

Figure 8.-


Ophiura texturata
Gram/1000 m²
0
≤ 20
21-50
51-100
101-500
> 500
PERIOD : IV. 1973
Zeebrugge
Oostende
Nieuwpoort
1115
1695
6485
3°30'
3°15'
3°00'
2°45'
2°30'
51°30'
51°15'
51°05'