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Shellfish Committee
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SETTLEMENT AND GROWTH OF BROWN SHRIMP (CRANGON CRANGON) IN A COASTAL AREA.

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Summary

The nursery function for Crangon crangon of shallow, silty estuarine areas is well known, but up till now little or no attention has been paid to the possible nursery function of marine, sandy coastal regions. However, permanent or temporarily improvement of the possibilities for settlement of postlarvae, and/or a decrease of predation on juvenile shrimps in such areas, can result also in recruitment to the adult stock.

These aspects were studied during four years along the Dutch west coast, where large but highly fluctuating recruitment to the adult stock occurs annually in September - November. This recruitment is the result of mass settlement of postlarvae in this area in the second half of May - July, while in estuarine shallow areas large scale settlement starts in April. A link between settlement of postlarval shrimps and the development of copepods is likely, because pelagic copepods proved (by stomach research) to be the major food item for postlarval shrimps of 10-20 mm and a bloom of pelagic copepods occurs annually in this area in May-July.

By the sharply defined start of the settlement in this coastal area and its simple hydrographical structure, growth from postlarvae (10 mm) to adult female shrimp (54 mm) could be followed, as well as changes in the pattern of distribution of the shrimp stock during summer and early autumn. Dispersion over deeper areas with increasing size proceeds faster in this coastal area than in inshore nurseries.

The impact of predators, in particular Pomatoschistus minutus, on this shrimp population is discussed on basis of survey data and extensive stomach research.

The results of this study, demonstrating that a coastal area can become an important nursery area for Crangon crangon by the presence of large numbers of pelagic copepods, throws new light on the traditional nursery concept.

Introduction

The word nursery: "a place where something is fostered or has its growth or development promoted" (Webster 1948), has been introduced(as far as we could trace it back)in marine biology by Cole and Johstone (1901). These authors applied the term nursery in particular to shallow estuaries of west English rivers the Blackpool closed ground and Morecambe Bay. In these localities vast quantities of young and immature plaice are found". They add further "The young plaice form part of an exceedingly abundant vertebrate and invertebrate fauna. They are associated with other Pleuronectid and Gadoid fishes... and great numbers of shrimps (Crangon)".
This first description shows already the ambivalent character of such nurseries for Crangon crangon. In these areas juvenile brown shrimps feed (like small plaice) on the abundant evertebrate fauna (Plagmann 1939). They are however also prey for many fish species of which juveniles and sometimes adults occur here. (Tiews 1984). On their turn they are predators on very small plaice (van der Veer, Bergman and Zijlstra 1984). What qualifies these inshore areas as nursery grounds for Crangon crangon is a mostly positive balance between settlement of postlarval and predation on juvenile shrimps. This results in a net migration of adult and semi-adult shrimps from these shallows to adjacent deeper areas. (Boddeke 1975). Little or no attention has been paid up till now to the possible nursery function for Crangon crangon of coastal regions, although there is no obvious reason why permanent or temporarily improvement of the possibilities for settlement of postlarvae and/or a decrease of predation on juvenile shrimps in a coastal area, should not lead also to recruitment to the adult stock.
Especially along the west coast of Holland, off Scheveningen and IJmuiden, very substantial off shore settlement of postlarval Crangon crangon has been likely for a long time. In this area, relatively far from inshore areas, large scale shrimpfishing by migrant boats starts every year in September. Catches are sometimes extremely large. In September and October 1982, more than two million kg of "consumption shrimps" (sexually mature females > 54 mm) were landed from the coastal zone south of Den Helder, while the average annual landings in the entire Netherlands in 1976-1981 were only 4.4 million kg. (Boddeke 1983).
Results of the International Young Flatfish and Brown Shrimp Survey carried out since 1969 in April and October in the coastal zone of Belgium, Netherlands, GFR and Denmark show relatively large numbers of small brown shrimps occurring outside the traditional nurseries.
In the period 1969-1973 brown shrimps < 54 mm were distributed over the Netherlands coastal region as follows:
April: Waddensea 51.3%, Zealand estuaries 5.2%, coastal zone (twelve miles) 43.4%. Autumn: Waddensea 48.8%, Zealand estuaries 9.7%, coastal zone 41.4% (Becker and Postuma 1974).
These percentages are largely defined by the size of these areas, 1437, 520 and 6866 km^2 respectively. The highest densities are found in the Waddensea, but by the large size of the coastal zone, the total numbers here are impressive.
The biannual survey on which these figures are based, is carried out with shrimp beamtrawls of which the minimum meshsize in the cod end is 20 mm. The average selection factor of Crangon crangon is 2.41 (Bohl and Koura 1962). For this reason, catches of shrimps smaller than 40 mm in this survey are not representative. To investigate the settlement of postlarval shrimps in the coastal zone between Scheveningen and

Den Helder, surveys were carried out during 1982-1985 directed at brown shrimps of 5-40 mm, with adapted trawls.
In 1982, this work concentrated on time and place of the settlement, during 1983 the food of these small shrimps got special attention, while in 1984 and 1985 the dynamics of the shrimpstock (predation, growth and dispersion) were the main subjects.
In this paper the results of this research programme will be summarized.

Methods and materials.

For the 1982 and 1983 beach surveys, a fine meshed (1.5 x 1.5 mm) pushnet with a width of 1.5 m, or a triangle dipnet with the same meshsize but 75 cm wide, were used till a depth of 1 m. Till depths of 5 m, a 3 m shrimp beamtrawl with a fine meshed inner cod end (1.5 x 1.5mm) was fished from a rubberboat with outboard engine.
The 1984 and 1985 coastal surveys (till depths of 15 m) were carried out with the research vessel Isis and a 6 m. shrimp beamtrawl with a fine meshed inner cod end (1.5 x 1.5 mm) of 4 m, on a total net length of 7 m.
Larval surveys were carried out with a high speed plankton sampler, 2.3 m long, mouth opening 0.2 m, fished at a speed of 5 miles/h.
This sampler moves up and down through the entire water layer on a regular speed (3 minutes per 10 m water depth).
For stomach research on juvenile brown shrimps, 25 specimens 10-20 mm long with full stomachs were selected from each sample and fixated in formaldehyde 4 %. Stomachs were removed, cut open and emptied in a petridisc filled with water. The food mass was separated in different categories under a binocular microscope.
Stomach research on sand gobies was done with a similar technique but of these fishes all length classes were investigated and stomachs were treated individually.
Sex determination was done by the size and shape of the endopodite of the first pleopode and the presence or absence of an appendix masculina on the endopodite of the second pleopode.
To obtain numbers of ripe eggs/fishing day, 4 samples of 125 g each are taken monthly from different fishing areas and the numbers of ripe eggs defined to obtain an average number/kg. The outcome is multiplied afterwards with the average catch/fishing day from fisheries statistics.
For washing out bottom samples, the method of Uhlig et al (1973) was followed.

Results

1. Settlement and dispersion

During the spring of 1982, extensive research has carried out in the beach zone between Scheveningen and Egmond at depths till 7 m., to follow the process of settlement of postlarval shrimps in this area. The results, expressed in numbers caught/1000 m^2, are summarized in figures 1 - 4.
In March and April practically no juvenile shrimps could be found. In May and June distribution of juvenile shrimps was patchy. This is well illustrated by the catches near Wassenaar at different depths on 25 June 25 June 1982 (figure 3). In July, numbers of juvenile shrimps < 25 mm increase in the entire zone investigated (till depths of 5 m) but the smallest length categories, 6-10 and 11-15 mm still were scarcely present in the catches. Dense concentrations of shrimps 10-15 mm however, were observed in puddles at the IJmuiden beach on 30 June 1982. Here, densities of 22, 76 and 82 shrimps caught per m^2, were recorded.

On basis of these results, four research vessel surveys were made in this area during 1984 and 1985, at depths of 4½ till 15 m.
The results are shown in figures 5-8.
The survey of 23 - 26 July 1984 showed, in accordance with July 1982, the presence of very large numbers of shrimps of 11-20 mm at depths of 4 to 10 m. A much smaller peak in the length distribution was formed by shrimps of 41-50 mm.
It is likely that the shrimps of 11-20 mm present here on 23 - 26 July 1983 stem mainly from settlement in June and to a lesser extent in May. After July however, settlement in this area comes to an abrupt halt as demonstrated by the very low numbers of shrimps smaller than 21 mm in early September (figure 5) and the lack of shrimps smaller than 30 mm in the beginning of October. The dispersion of the brown shrimp with increasing size over deeper areas, is demonstrated by the presence of large numbers of shrimps of 30-50 mm on 5 - 6 September 1984 at a depth of 15 m (figure 6), while two months earlier the shrimp population at that depth was extremely small. This fast dispersion over deeper areas with increased size is even better demonstrated by the results of September 27 - October 4, 1984 when densities at both 4½ and 15 m were considerably reduced.
During the survey on 25 - 26 March 1985 very low numbers were left in this coastal zone in comparison with the previous autumn.
The International Young Flatfish and Brown Shrimp survey shows an identical pattern (Boddeke 1982, table I). This survey covers such a wide zone (40 miles) that dispersion/migration can be excluded as an explanation for this decrease, leaving mortality as the main cause.

2. Egg production/recruitment

Number of ripe eggs/fishing day in the Dutch coastal zone Hook of Holland - IJmuiden are presented in figure 9.
On average, ripe eggs are present in December - April in substantial numbers while in August - September the same high levels are reached as in May - June. The low level of settlement before the half of May and the nearly absence of settlement in July - September cannot be explained by scarcity of ripe eggs in these periods.
During 1978 - 1984, the ratio between P: the number of ripe eggs/ fishing day in May - July (month x) and R: the number of consumption shrimps in month x + 4, varied from 204.4 (June 1981) till 640.6 (June 1983). Values for P/R between 201 and 400 occurred 17 times, between 401 and 600 1 time and > 600 3 times.
Because of this asymmetric distribution, the line indicating the average ratio was based on the geometric mean (318.8) instead of the arithmetic mean (337.6) in figure 10.
This remarkable constant value for P/R is confirmed by earlier work (Boddeke and Becker 1982).
Although figure suggest that the yield of the egg production decreases above a level of 3×10^8 ripe eggs/fishing day, catches of the commercial fleet in this area in September - November depend largely on egg numbers four months earlier.

3. Larvae

The length of brown shrimp larvae hatching from winter eggs is 2.44 mm, from summer eggs 2.14 mm. (Boddeke 1982).
During their pelagic stage, these larvae grow till a length of 5-7 mm before settling at the bottom. Benthic shrimps below a length of 5 mm

are rare, the largest "larvae" observed were between 7 and 8 mm long. Power (1973) investigated the size of brown shrimp larvae in limited areas along the Dutch coast till a distance of 20 miles off shore, caught in March 1973, June 1973 and October 1969. The aim of this work was to demonstrate trends in size (south-north,west-east) in the pattern of distribution.

In March and October, the larvae caught between Scheveningen and Egmond were clearly smaller than those caught off Texel - Terschelling in March, and direct south of Texel in October.

In October the larvae off the Zealand estuary were also considerably larger than those caught between Scheveningen and Egmond. No data were available from this area in March. (figures 11 and 13).

In June however, there is no clear difference in size between the larvae caught off the Zealand estuary, the zone between Scheveningen and Egmond and off Texel - Terschelling (figure 12). Very remarkable is the presence of substantial numbers of larvae of "settling size" (5.5 - 6.5 mm) between Scheveningen and Egmond in June, which observation suggests that, in contrast to October and March, the larvae in this month stay in this area till the moment of settlement.

4. Growth

The sharply defined start of the settlement of large numbers of postlarval shrimps between Hook of Holland and Den Helder in May - July, provided an excellent opportunity to follow the growth of *Crangon crangon* under natural conditions.

Because of the patchy distribution of shrimps smaller than 16 mm, growth of the vanguard of the spring settlement could be followed only from a length of 21 - 25 mm. This size category was present at depths of 4-10 m during the survey of July 23-26 1984. In estimating the growth of this size group, the fast dispersion over deeper areas with increasing size has to be taken into account. For this reason, the surveys of September 5-6 and September 27 - October 4 1984 are represented by length distributions of the shrimp populations at 15 m depth. (figure 14).

The shift to the right of the graphs in this figure suggests a minimal growth from 21-25 mm at July 25-26 to 53 - 57 mm (September 27 - October 4), being 32 mm in 62-69 days. This estimate is supported by the sharp rise in catches per fishing day of consumption shrimps (> 54 mm) in this area by commercial vessels from the week 10 - 15 September 1984 (figure 15).

On basis of the results of the September 5 - 6 survey the vanguard of the spring settlers can be expected to pass the minimum size of consumption shrimps in this week. The assumed growth rate fits well with the calculated development of brown shrimps from ripe eggs to consumption shrimps in four months. (Boddeke and Becker 1979). At a length of 54 mm growth slows down considerably. Females in the IJmuiden beach zone grew from 53 - 54 mm to 67 - 68 mm, from July 24 till September 25 1964, being 14 mm in 63 days (Boddeke 1975).

5. Predation

From the data base of the International Young Flatfish and Brown Shrimp Survey, eight species has been selected considered important predators of the brown shrimp (Redant 1978 and Tiews 1984).

Densities of these species in a 12 mile zone between Hook of Holland and IJmuiden in the period 1978 - 1984 are given in Table I.

In April - May, just before the start of the brown shrimp settlement, densities of these species are very low.
In September - October numbers of whiting, bib, dab and sand goby have increased, mainly by the appearance of 0-group individuals. Other species are not relevant here during this period for various reasons. Whiting spawns from February to June in the southern North Sea. It starts living near the bottom at a length of 8-10 cm, usually in August - September and becomes then a predator of brown shrimps. The bib has a similar spawning season than whiting but appears in this area usually in smaller numbers. Dab spawns from February to June. 0-group dabs are in general 5-8 cm long at the end of September. Dab < 11 cm do not feed on brown shrimps, and predation mortality of brown shrimps caused by Pleuronectiform fishes in general is negligable off the Belgian coast (Nierynck and Redant 1983).
During the International Young Flatfish and Brown Shrimp survey sand gobies < 50 mm escape largely through the 20 mm cod.ends. (Table I). Table II gives a more complete picture of the densities of this species in 1984-1985. Numbers caught are split up at a length of 25 mm, being the minimum size on which sand gobies start eating <u>Crangon crangon</u>. On July 25-26 1984 practically no 0-group gobies > 25 mm were present. The main food of sand gobies of all sizes are copepods. In July only 1% of the food of sand gobies consists of <u>Crangon crangon</u>.
At September 5-6 1984 roughly 2/3 of the population was > 25 mm and the share of <u>Crangon crangon</u> in the food of <u>P. minutus</u> increased to 12%. Clearly is also that sand gobies, like brown shrimps move to deeper water with increasing size. Because sand gobies eat mainly shrimps of 6-18 mm, with an observed maximum of 28 mm, this dispersion over deeper water with size, anologue to <u>Crangon crangon</u>, reduces their role as a predator of this species. <u>P. minutus</u> suffers also a very high mortality during winter as demonstrated by the reduced numbers in spring. Predation in March-July on <u>Crangon crangon</u> will be mainly caused in this area by I-group gobies of which the numbers did not fluctuate greatly during 1978-1984. No relation between predator presence and the yield of ripe eggs in May-July could be demonstrated (see 2). Predation by 0-group sand gobies, whiting and bib will slowly increase during August, but settlement comes practically to a standstill. This makes predation an unlikely explanation for the observed annual pattern of settlement of <u>Crangon crangon</u> in this coastal area.

6. Food of juvenile shrimps.

During June - August 1983, extensive stomach research was carried out on shrimps of 10-20 mm body length, collected at depths from .5 to 5 m between Scheveningen and Egmond. In addition, 7 stations in the Easterscheldt all at .5 m were sampled on 6-8 June and 7 stations in the western Waddensea, also at a depth of .5 m, on 2 - 5 August. Between Scheveningen and Egmond the work was sometimes handicapped by absence of small shrimps, or each of sufficient individuals with a full stomach. In partially filled stomachs, practically no recognizable organisms were present. Complete series are available for Wijk aan Zee at 1 June and IJmuiden 6 July 1983 (figure 16 and 17).
At July 1-8 the majority of recognizable prey consisted of calanoid copepods along the coast, as well as in the Easterscheldt (figure 6). From the second half of July foraminifers became gradually the main food item till the end of the sampling period (August 15), with the exception of Noordwijk where polychaets were the most important food at the end of July.

This shift from (pelagic) copepods to benthic organisms like foraminifers and polychaets corresponds well with data on the annual density of copepods in the coastal region of the southern part of the North Sea, (Fransz and Gieskes 1984) (figure 18).

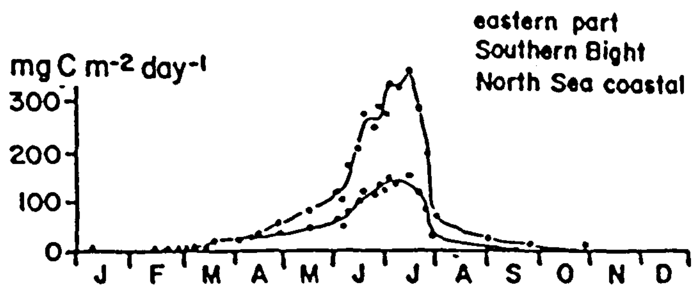

Figure 18 - Estimate of copepod production
Top line potential production, lower line lowest estimate. after Fransz and Gieskes.

Sandy beaches with a strong wind influence like the Dutch west coast have a low benthic biomass, with crustaceans as the dominating group. Silty, estuarine inshore areas like the Waddensea have a more varied benthic fauna with a much higher biomass and lamellibranchs and polychaets as quantitatively dominating groups (de Lange and Hummel 1978). This general picture was confirmed by the results of our bottom sampling program in the area Wassenaar-Egmond, Easterscheldt and western Waddensea (Table III).
Plagmann (1939) found that shrimps < 26 mm fed on <u>Corophium volutator</u> (not occurring along the Dutch west coast), copepods, foraminifers, polychaets, nematodes, cypris larvae, mussel larvae, silt and detritus. In the Dutch Waddensea shrimps of 10-20 mm proved to have a widely varying stomach contents during August 1983. (figure 19).
On August 5 1983, at Inschot 9, 30% of the stomach contents consisted of copepods and 2% of foraminifers, while close by, at Inschot 7-9, 15% were copepods and 31% foraminifers.
The observed decrease of pelagic copepods in the coastal zone after July, will not form a comparable obstacle for settlement in silty, estuarine inshore areas, due to the wide variety of benthic food organisms in these areas and the low food preference of juvenile shrimps.

Discussion

From the data assembled in III 1-6, we may conclude that the main factor defining the suitability of an area as a nursery ground of Crangon crangon is the presence of sufficient small evertebrates serving as food for juvenile shrimps. A coastal area with a sandy bottom, poor on suitable benthic food organisms, can function as an important nursery area during periods of bloom of pelagic copepods, which is relevant along the Dutch west coast in May-July. Here, copepods form the main food for shrimps of 10-20 mm long till mid July, after which settlement of postlarval shrimps becomes quantitatively unimportant.
Supplies of benthic evertebrates are defined by surface, those of pelagic copepods by volume, which means a practically unlimited supply for bottom dwelling juvenile shrimps. This can explain why the yield of ripe eggs in May-July stays constant till densities at least 5 times the observed minimum level.
For the observed highly constant P/R over the years two other conditions must be fulfilled:

1. Commercial landings from which these data are derived, must mainly consist of newly recruited shrimps. Outside December-March when adult shrimps are concentrated, older shrimps as a rule occur in lower densities than younger ones, by dispersion over deeper areas with increasing size and mortality. These lower densities are normally not compensated by larger size (due to the reduced growth rate over 55 mm) or higher price.

2. The influence of factors defining the survival from ripe egg till recruit of Crangon crangon in May-July must be rather constant, which is the case for predation on postlarval shrimps.
   Dispersion over deeper areas, resulting normally in densities of hundreds of brown shrimps/1000 m^2 $\pm$ 25 km off the coast as early as the beginning of October, proceeds faster between Hook of Holland and IJmuiden than from inshore nursery grounds (Boddeke 1975). The relative scarcity of benthic food organisms in the coastal zone in comparison with inshore areas seems a good explanation for this difference. (Table III).
   The sharp decrease of pelagic copepods after July will not form a comparable obstacle for settlement in silty inshore areas with a rich benthic micro-fauna. The likely influx of postlarvae from the coastal zone to inshore nurseries will give a certain compensation in these areas for the increasing level of predation in August-October.

The great difference in productivity between the coastal zones Hook of Holland - IJmuiden and Vlieland - Terschelling (see 1), can be related to the eutrophication of the coastal zone north of Hook of Holland by water from the river Rhine of which a major part is sluiced there. (Boddeke, 1978).
In the period 1945-1975, N (NO_3^- and NH_4^+) contents in this area has increased five fold. (During spring nutrient levels drop sharply as the result of primary production. (RIVO, annual report 1984).

Relations between phytoplankton production and copepod densities seem to be complex, due to a preference of copepods for flagellates as food which flagellates feed on other phytoplankton. (Klein Breteler and Gonzalez) (in press).
These findings offer an explanation for the discrepancy between the general production of phytoplankton and copepod densities in the southern North Sea (Fransz and Gieskes 1984).

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References

Becker, H.B. and K.H. Postuma, 1974 - Enige voorlopige resultaten van 5 jaar Waddenzee-project.
Visserij, 27 (2) : 69 - 79.

Boddeke, R. 1975 - Autumn migration and vertical distribution of the brown shrimp Crangon crangon L. in relation to environmental conditions.
Proc. 9th Europ. mar. biol. Symp. pp. 483 - 494 Harold Barnes, Editor, Aberdeen University Press.

Boddeke, R. 1976 - The seasonal migration of the brown shrimp Crangon crangon.
Neth. J. Sea. Res., 10 (1) : 103-130.

Boddeke, R., 1978 - Changes in the stock of brown shrimp (Crangon crangon L.) in the coastal zone of the Netherlands.
Rapp. P. -v. Réun. Cons. int. Explor. Mer. 172 : 239-249.

Boddeke, R., 1982 - The occurrence of "winter" and "summer" eggs in the brown shrimp (Crangon crangon) and the pattern of recruitment.
Neth. J. Sea. Res. 16 : 151-162.

Boddeke, R., 1983 - The coastal zone of Holland, a new Waddensea.
ICES C.M. 1983/K:21 (mimeo).

Boddeke, R., & H.B. Becker, 1979 - A quantitative study of the fluctuations of the stock of brown shrimp (Crangon crangon) along the coast of the Netherlands. Rapp. P. -v. Réun. Cons. int. Explor. Mer. 175 253-258.

Boddeke, R., & H.B. Becker, 1979 - A quantitative study of the fluctuations of the stock of brown shrimp (Crangon crangon) along the coast of the Netherlands.
Rapp. P. -v. Réun.Cons. int. Explor. Mer. 175 253-258.

Boddeke, R., N. Daan, K.H. Postuma, J.F. de Veen & J.J. Zijlstra, 1969 - Young fish survey.
Annls. Biol. 26: 269-275.

Bohl, H. and Koura, R. 1962 - Selektionsversuche mit Garnelenkurren vor der nord.friesischen Küste.
Protok. z. Fischereitech. (8) 1-33.

Cole, F.J. and Johnstone, J. 1901.
L.M.B.C. Memoirs VIII Pleuronectes, Williams and Noyate, London.

Franz, W.G. and Gieskes, W.W.C. 1984 - The umbalance of phytoplankton and copepods in the North Sea.
Rapp. P. -v. Réun. Cons. int. Explor. Mer. 183: 218-225.

Klein Breteler, W.C.M., and S.R. Gonzalez, - Culture and development of Temora longicornis (Copepoda, Calanoida) at different conditions of temperature and food. Syllogeus, 58 (in press).

Lange, G.J. de and H. Hummel 1978 - Beschrijving van het abiotisch milieu van het Nederlands continentaal plat.
NIOZ Int. rapp. 1978-3.

Plagmann, J., 1939 - Ernährungsbiologie der Garnele (Grangon vulgaris L.)
Helg. wiss. Meeresunters. 2, 1, 113-162.

Redant, F., 1978 - Consumptie en Produktie van Post- larvale Crangon crangon (L.) (Crustacea, Decapoda) in de Belgische kustwateren. 2 delen Proefschrift. Vrije Universiteit Brussel.

Redant, F. and E. Nierynck, 1983 - Caridean shrimps in the food of demersal fish off the Belgian coast 3. Pleuronectiformes. ICES C.M. 1983/K: 20. (mimeo).

Tienes, K., 1983 - Über die Veränderungen im Auftreten von Fischen und Krebsen im Beifang der deutschen Garnelenfischerei während der Jahre 1954-1981.
Arch. Fisch. Wiss. 34, 1, 1-156.

Uhlig, G., H. Thiel & J.S. Gray, 1973 - The quantitative separation of meiofauna. A comparison of methods.
Helgol. wiss. Meeresunters. 25: 173-195.

Veer, H.W. van der, M.J.N. Bergman and J.J. Zijlstra, 1984 - Predation of newly settled 0-group plaice (Pleuronectes platessa L.) by crustacea in a continental tidal nursery area, the Waddensea.
ICES C.M. 1984/G: 76 (mimeo)

TABLE I - International Young Flatfish and Brown Shrimp Survey cod end : 20 mm.

Area : Hook of Holland-IJmuiden, 12 miles zone, densities/1000 m^2

Species	1		2		3		4		5		6		7		8		Number of stations	
Year	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
1978	1	169	1	8	0	1	2	12	0^+	2	3	38	0	1	0^+	0^+	15	15
1979	1	49	0^+	38	0^+	1	0^+	9	0	0	23	30	0	0	0	0	7	14
1980	5	195	1	13	0^+	0	1	0	0^+	0	15	136	0	3	0	0	15	7
1981	2	0^+	0^+	32	0^+	0^+	0^+	8	0^+	0	15	717	0	0^+	0^+	0^+	13	9
1982	12	14	2	3	0	0	2	22	0	0	10	11	0	0	1	0	14	8
1983	4	44	0^+	26	0^+	0^+	1	4	0^+	0	22	55	0	0^+	0^+	0	13	13
1984	5	31	6	2	0^+	0^+	1	3	0^+	0^+	5	6	0	0^+	0^+	0	13	12
Average	4			17				8			17							

Species: 1: Dab (Limanda limanda)
2: Whiting (Merlangius merlangius)
3: Cod (Gadus morhua)
4: Bib (Trisopterus luscus)
5: Hooknose (Agonus cataphractus)
6: Sandgoby (Pomatoschistus minutus) >50 mm
7: Sea-snail (Liparis liparis)
8: Gurnards (Triglidae)

A = April - May

S = September - October

TABLE II - Pomatoschistus minutus, numbers/1000 m^2. Fine meshed trawl surveys codend: 3 mm. Coastal area Wassenaar-Egmond.

date	25/26-7-84		4/5-9-84		25/26-3-85	
size	< 25 mm	>	< 25 mm	≥	> 25 mm	≥
depth						
4.5	7355	142	103	791	0	135
6	6238	24	1190	2473	0	142
10	1820	104	679	1609	1	31
15	548	9	316	1067	1	20

TABLE III - Numbers/m^2 of potential food organisms for juvenile C. crangon at .5 m depth. 7 stations per area and period.

	30 May - 1 June 1983		6 July - 10 August 1983	
	Dutch west coast	Easterscheldt	Dutch west coast	w. Waddensea
Nematodes	86285	379612	176370	597626
Polychaets (larval)	8088	3006	5812	17237
Diatoms	14030	34674	8618	39304
Foraminifers	5612	16435	26256	17638
Copepods	2105	18840	1203	14030
Nauplii	351	10222	2405	5011
Bivalve spat	351	3407	1002	5011
Snails	-	601	-	3608

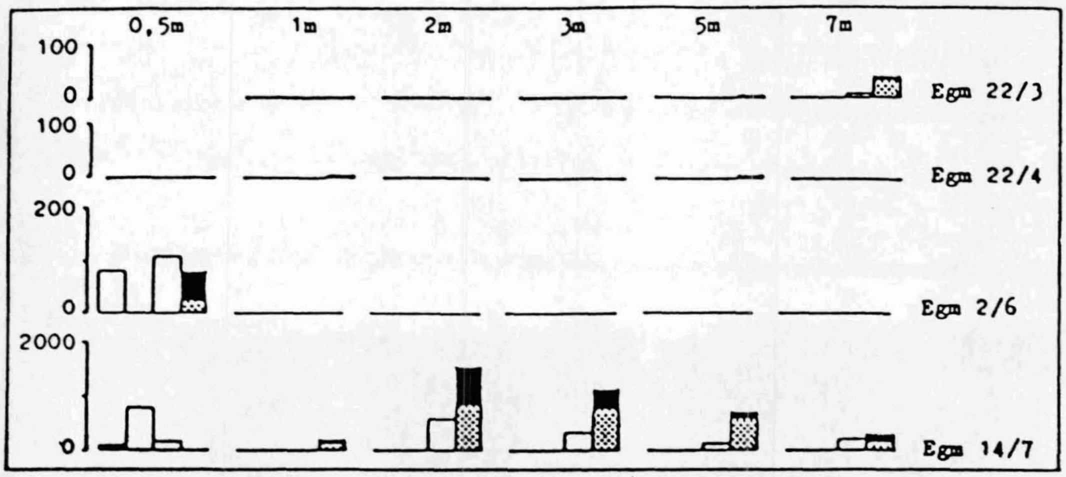

Figure 1. Beach survey. Station: Egmond. March - July 1983

Numbers/1000 m2 of brown shrimps smaller than 26 mm at different depths (m) divided in four length categories: 6-10, 11-15, 16-20 and 21-25 mm. The category 21-25 mm is divided in males (black) and females (dotted).

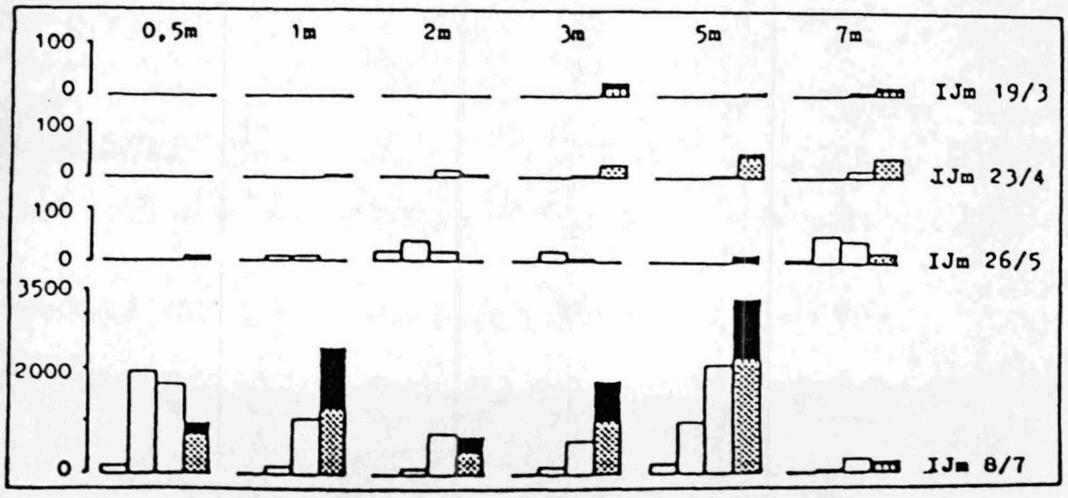

Figure 2. As figure 1, but station: IJmuiden

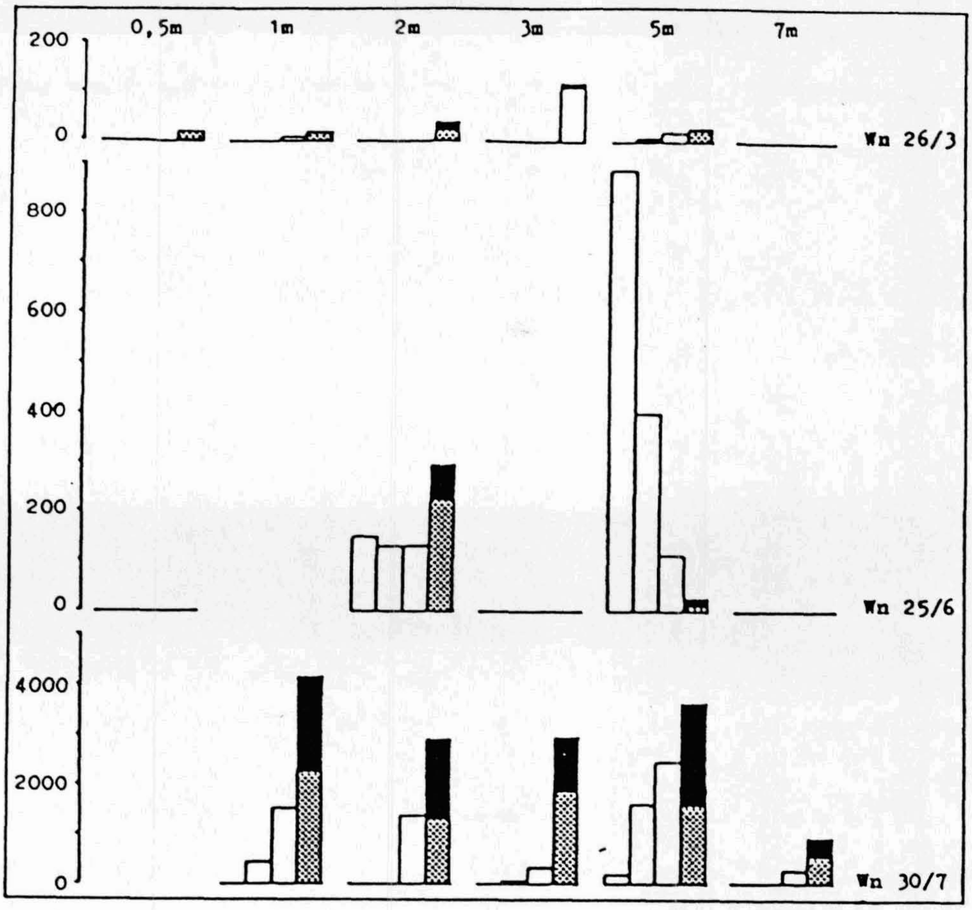

Figure 3 - As figure 1 but station: Wassenaar

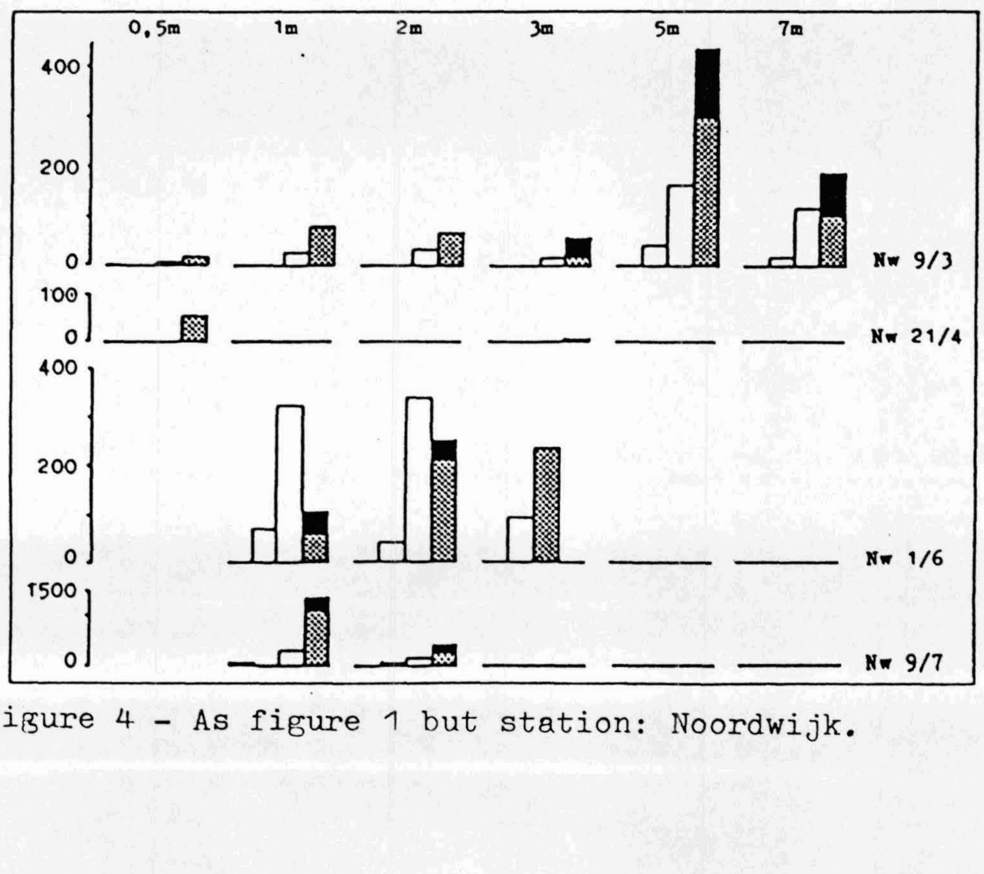

Figure 4 - As figure 1 but station: Noordwijk.

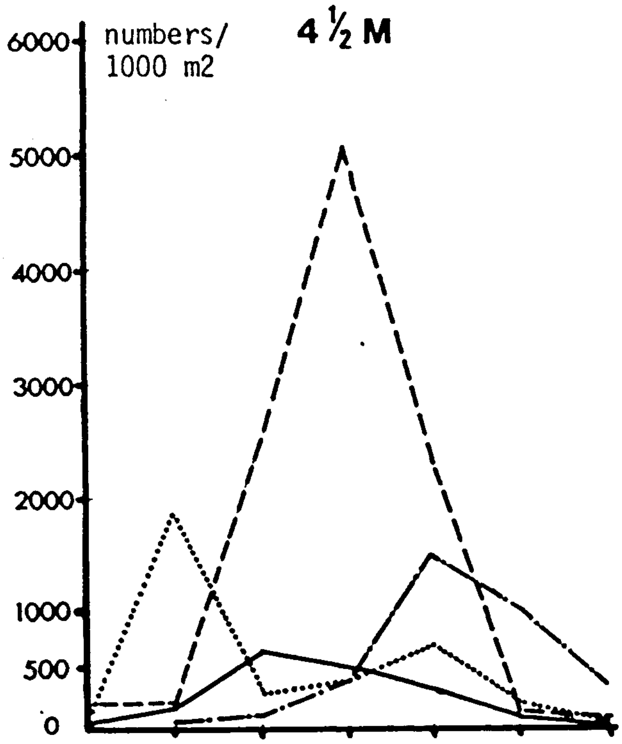

Figure 5

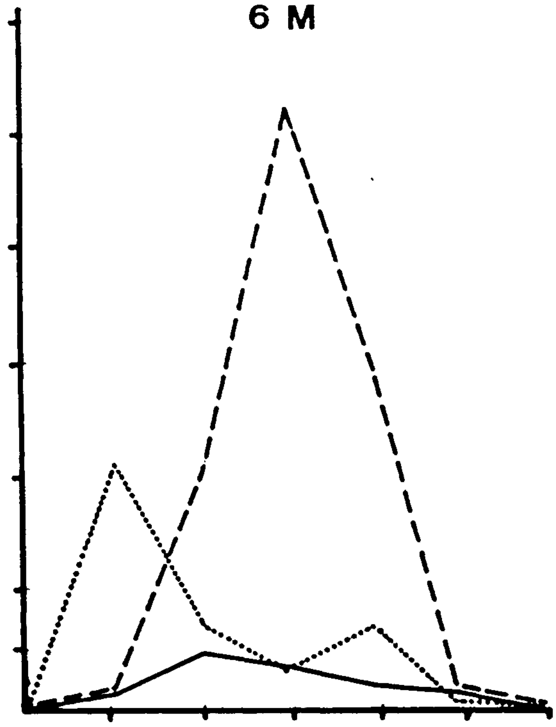

Figure 6

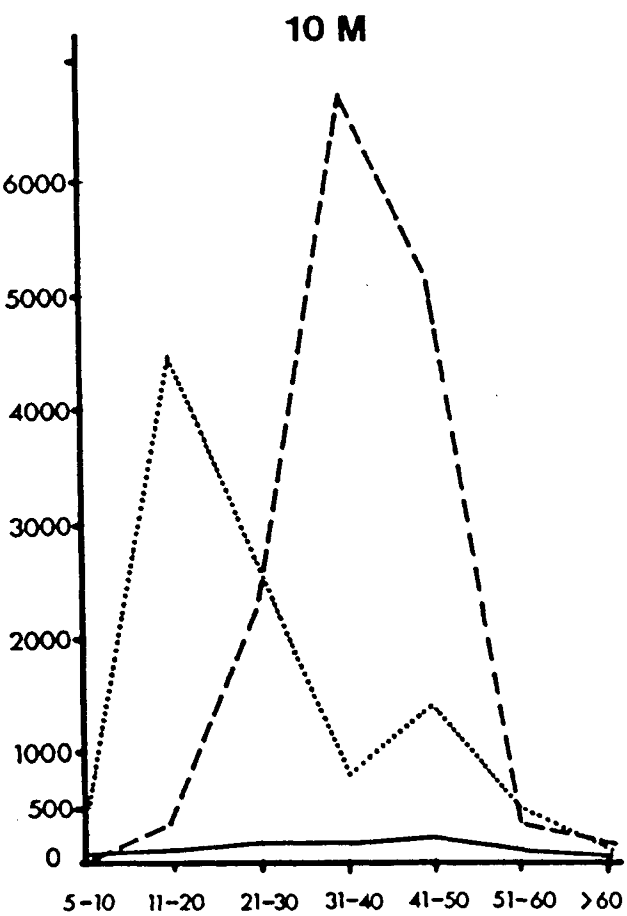

Figure 7

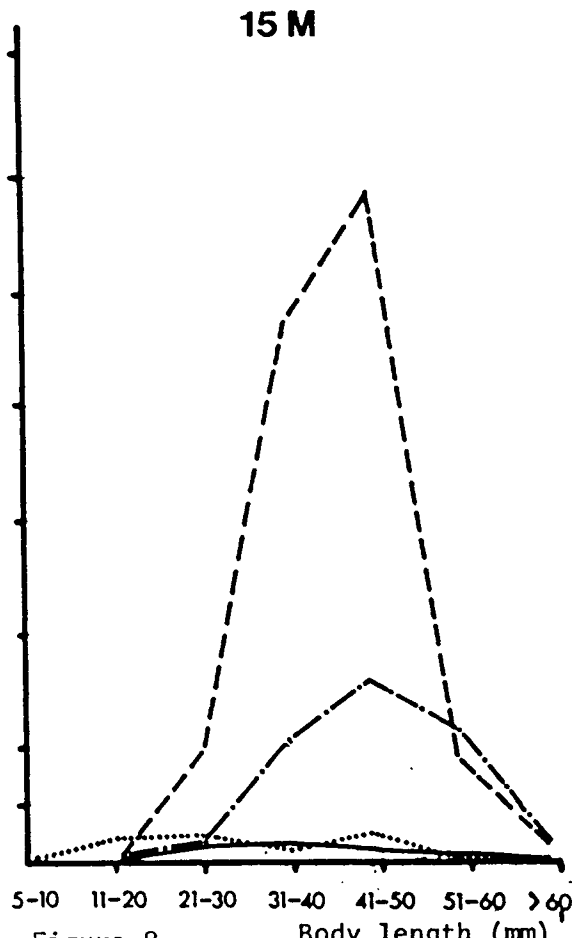

Figure 8

Crangon crangon. Surveys with fine meshed trawls in the area Wassenaar - Egmond.

.... = 23-26 July 1984 ---- = 5-6 September 1984

-.-. = 27 September - 4 October 1984 ____ = 25-26 March 1985

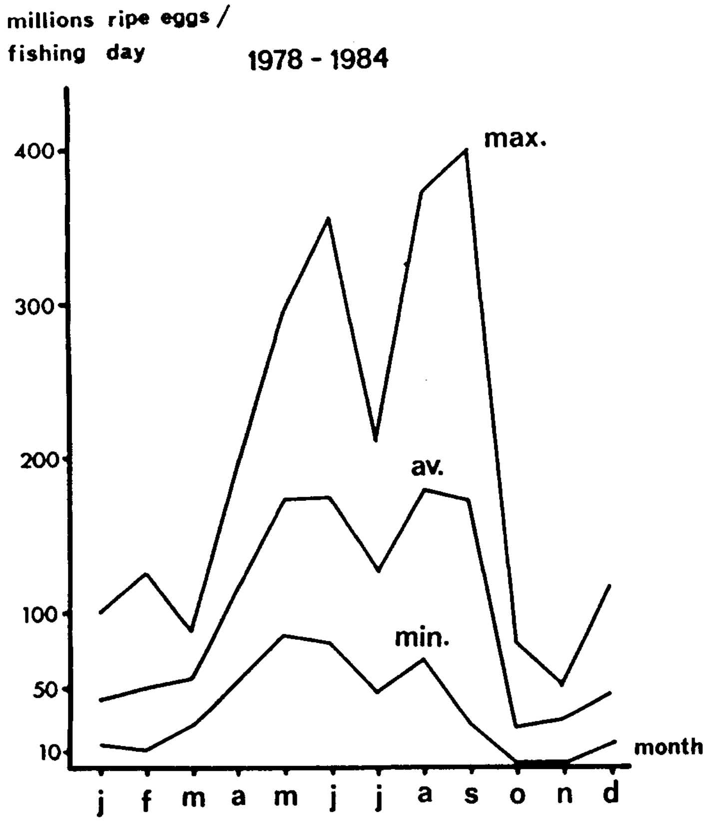

Figure 9

Numbers of ripe eggs/fishing day in the area Hook of Holland - IJmuiden. Monthly averages; maximum, average and minimum values.

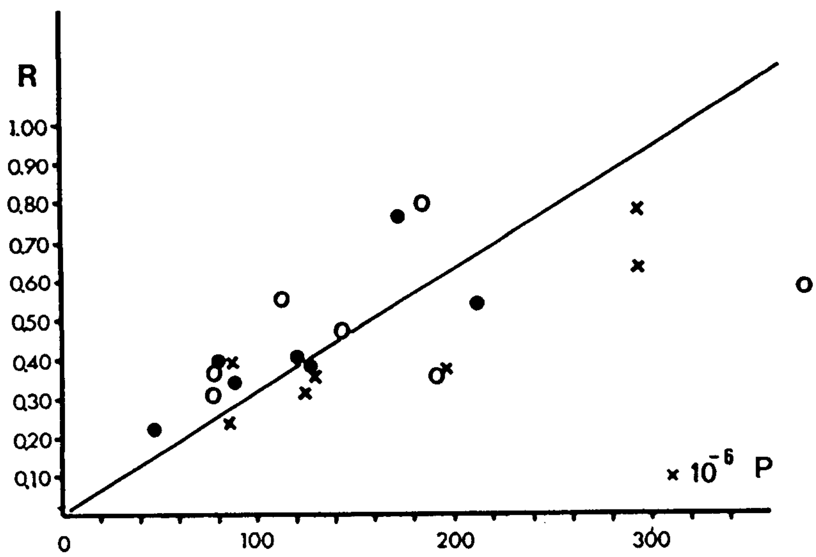

Figure 10

Relation between number of ripe eggs/fishing day (P) in May-July and catch of consumption shrimps/fishing day (R) four months later. Dutch coastal area south of Scheveningen.

x = May - September
o = June - October
• = July - November

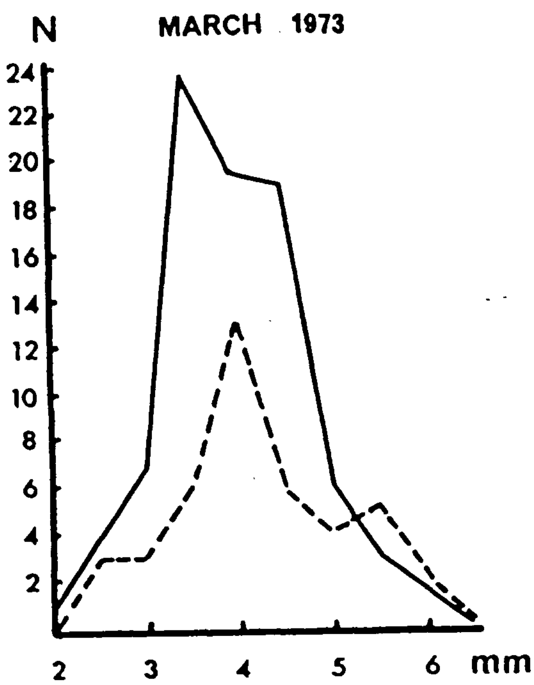

Figure 11

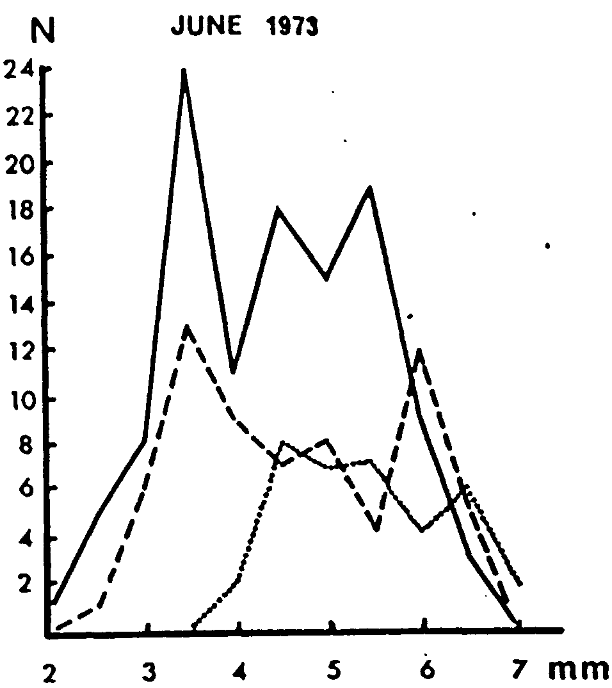

Figure 12

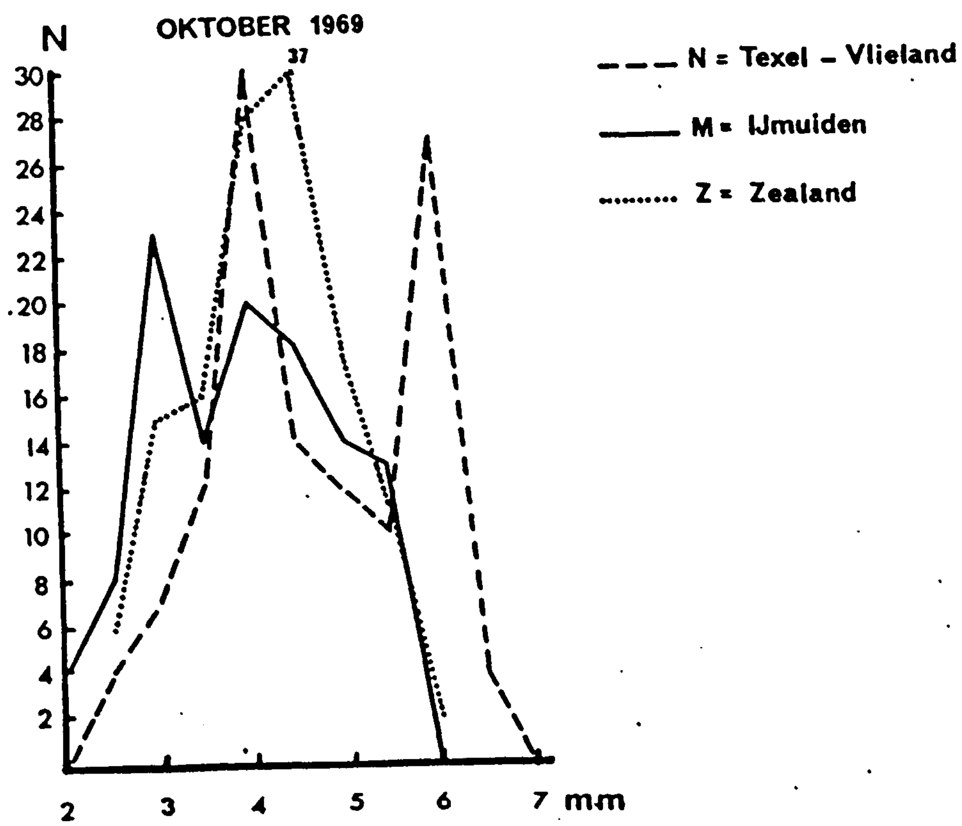

Figure 13

Size of larval C. crangon from different Dutch coastal areas.
N = numbers caught per area in a comparable number of hauls.

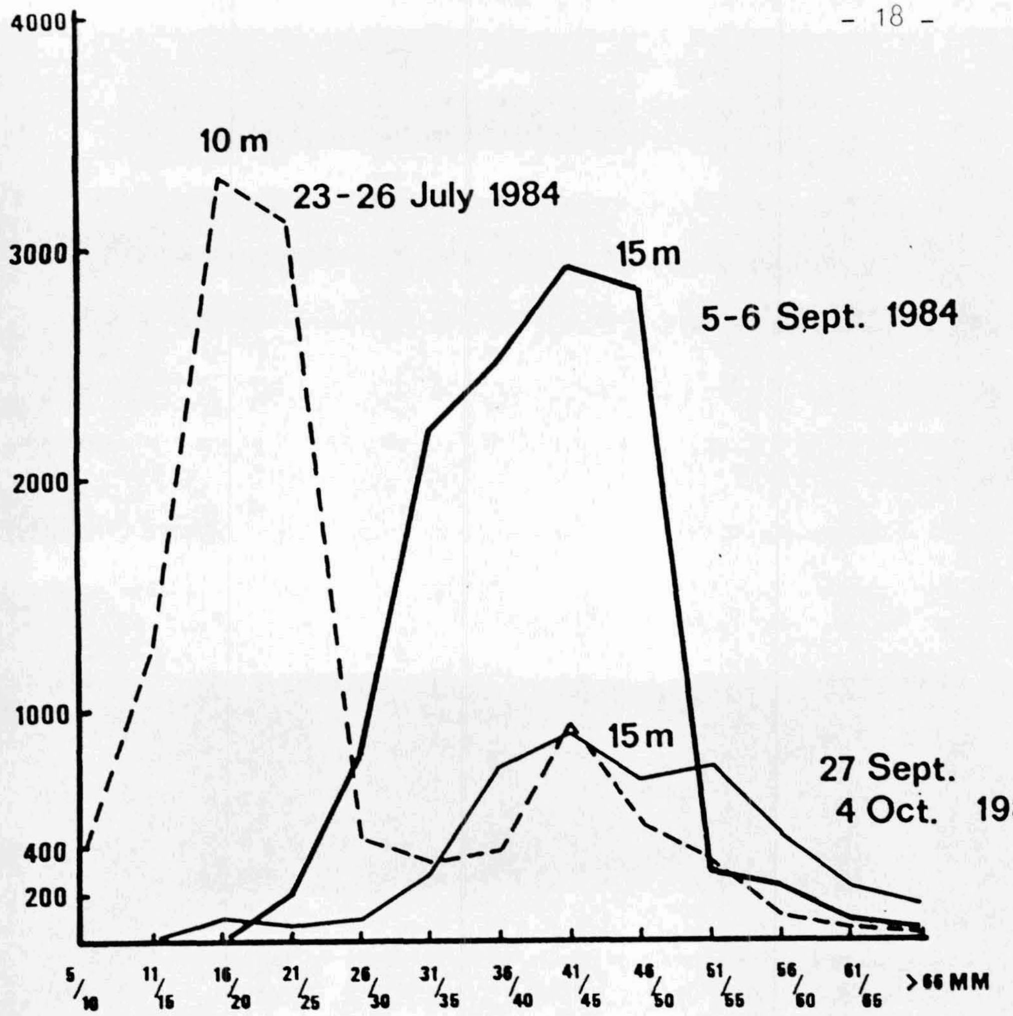

Figure 14

Increasing size and dispersion over deeper areas of C. crangon between Scheveningen and Egmond.

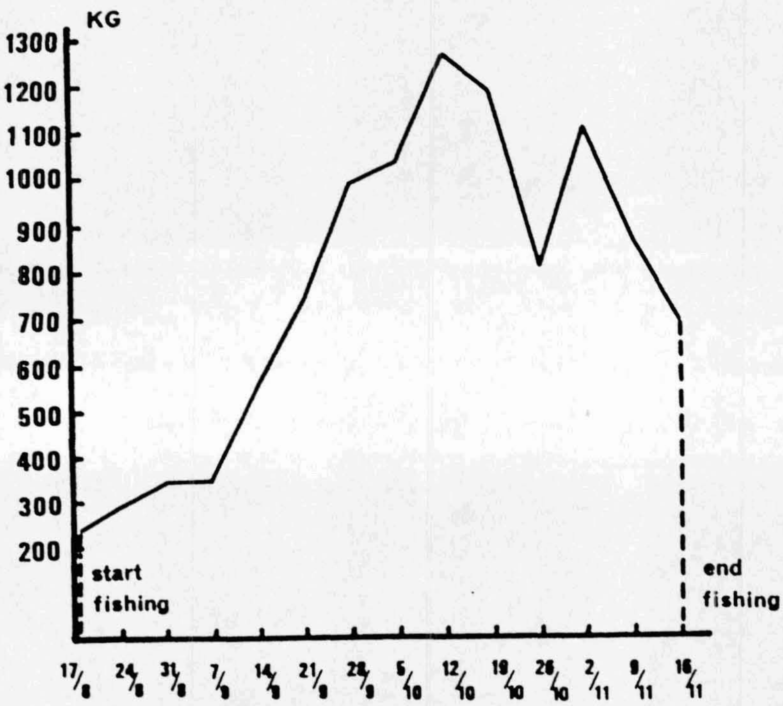

Figure 15

Average weekly catch/fishing day of commercial sized C. crangon (>54 mm long) in the area Hook of Holland - IJmuiden from 12 August to 16 November 1984.

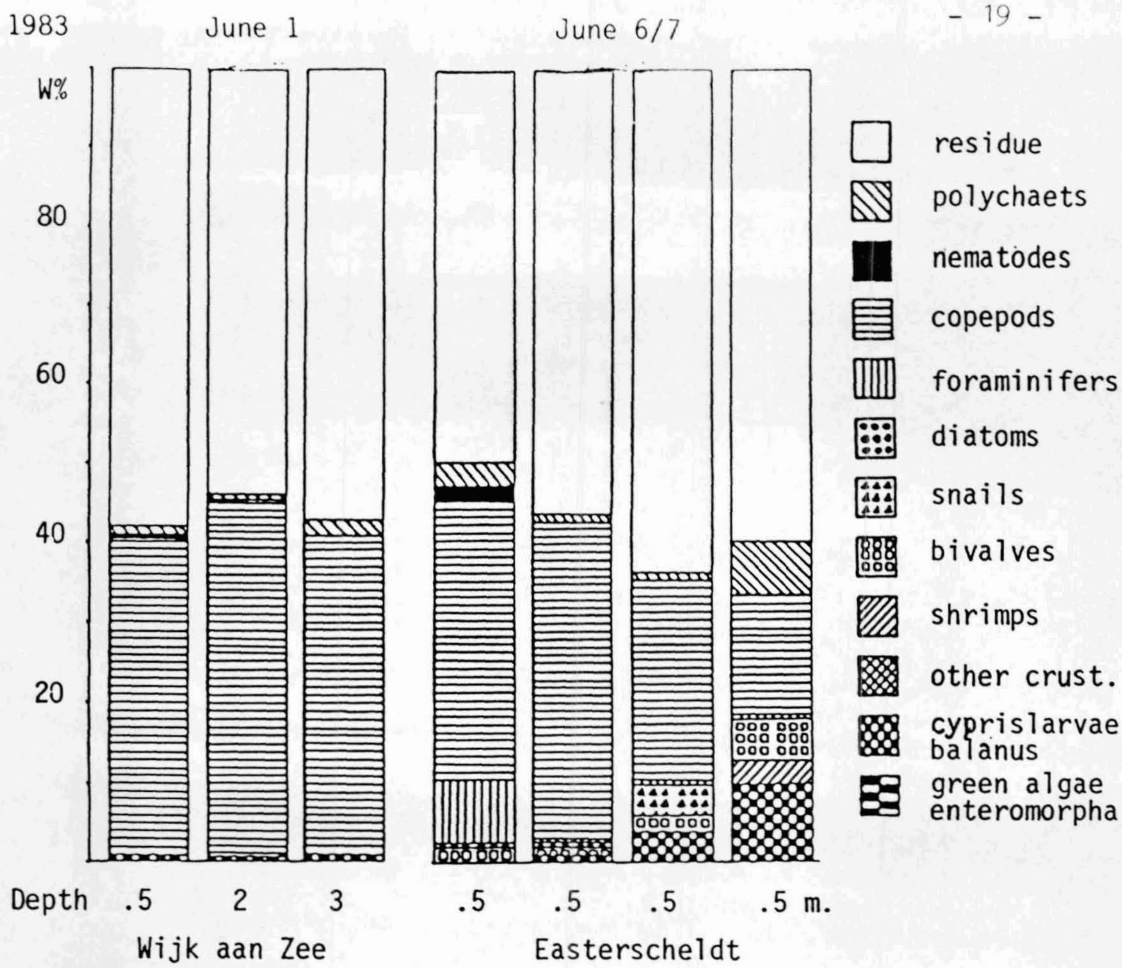

Figure 16. Stomach contents of C. crangon 10-20 mm long.

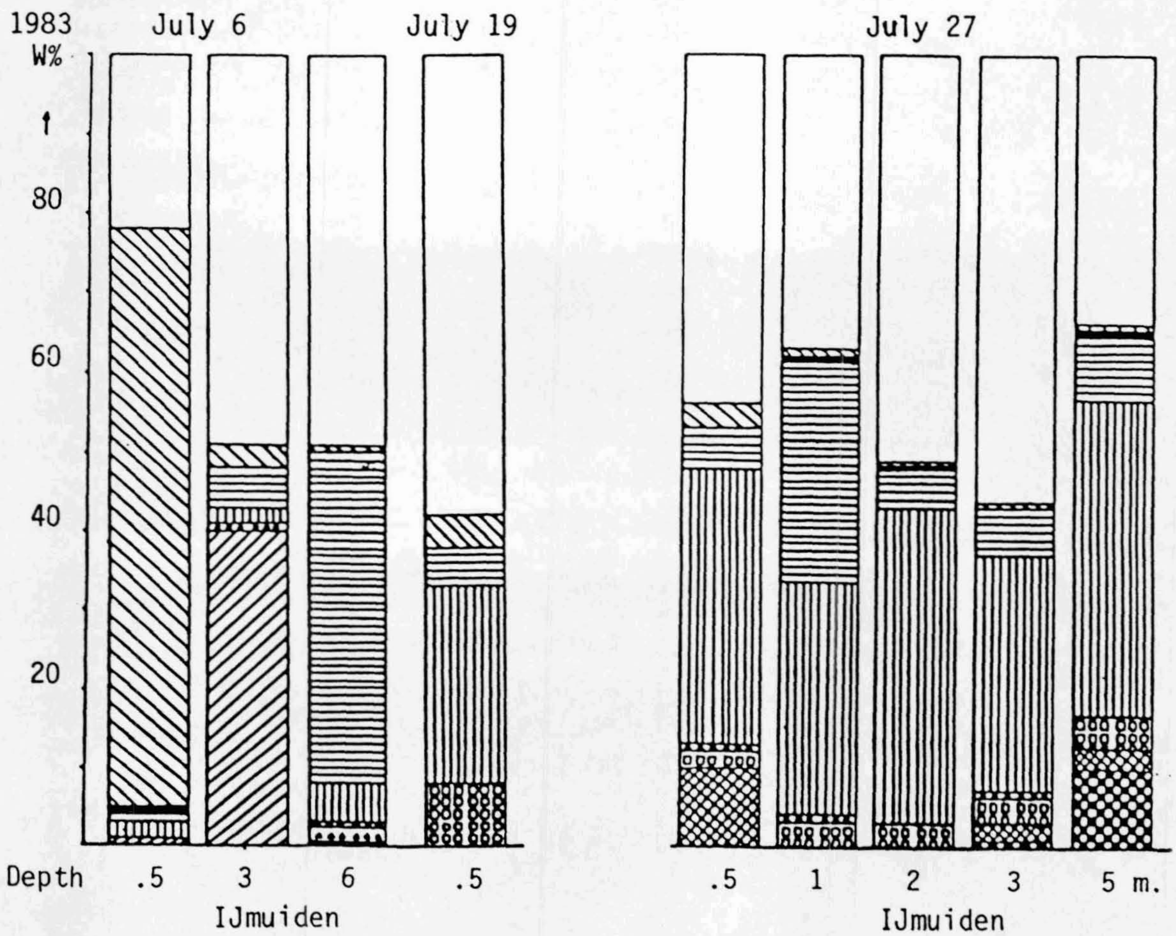

Figure 17. Stomach contents of C. crangon 10-20 mm long.

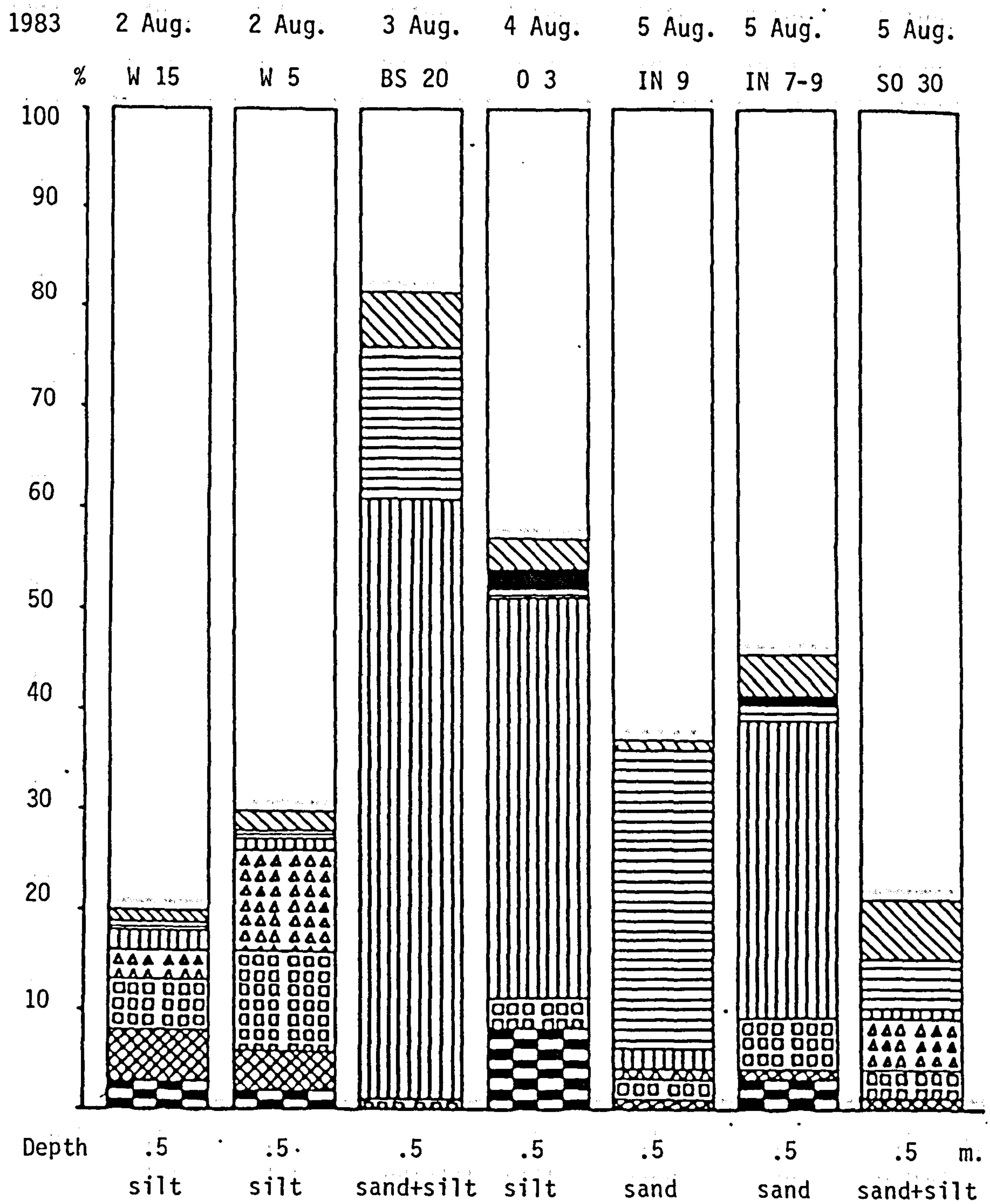

Figure 19

Stomach contents of C. crangon 10-20 mm long from various stations in the Waddensea.