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Trends in het voorkomen van vissen en epibenthische evertebraten in de Noordzee: een vergelijking van data sets

Beleidsgericht
ecologisch onderzoek
van de
Noordzee/Waddenzee

BEON

NIOO-CEMO
NIOZ
RIVO-DLO

Trends in het voorkomen van vissen en epibenthische evertibraten in de Noordzee: een vergelijking van data sets

644

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april 1995

BEON Rapport nr. 1995-3

BEON project 93 A 04

ISSN 0924-6576

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Netherlands Institute for Sea Research (NIOZ)
P.O. Box 59, 1790 AB Den Burg Texel
The Netherlands
ISSN 0923-3210

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1. SAMENVATTING

Dit rapport behandelt de lange termijn trends in het voorkomen van vissen en epibenthische evertibraten in de Noordzee.

De eerste bijdrage richt zich op de bruikbaarheid van fuikvangsten in de analyse van lange termijn trends in het voorkomen van vissen en evertibraten. Wil een fuik bruikbaar zijn voor een dergelijk doel, dan dient een konstante fractie van de daar aanwezige populatie gevangen te worden door een fuik. Deze voorwaarde is getest door het vergelijken van de trends in vangsten van vissen en evertibraten in een aantal gelijktijdig geplaatste fuiken. Voor een aantal soorten werden identieke patronen gevonden. Sommige soorten vertoonden echter volledig tegengestelde patronen in de verschillende fuiken. Fuiken blijken bruikbaar bij de analyse van lange termijn trends in het voorkomen van vissen en evertibraten, echter dit geldt slechts voor een gedeelte van de gevangen soorten.

In de tweede bijdrage worden de trends in voorkomen van een aantal evertibraten soorten in een drietal lange termijn series met elkaar vergeleken: namelijk het NIOZ-archief, bestaande uit meldingen van vangsten uit de visserij over de periode 1930-1990; de bijvangstgegevens van de RIVO-DLO surveys in de Noordzee 1970-1991; en de NIOZ fuikgegevens over de periode 1960-1991. Een zevental soorten bleek in meerdere series voor te komen: de wulk, de zeemuis, de zeeëgel, de Noordzeekrab, de helmkrab, de fluwelen zwemkrab en de zwemkrab. Op grond van de vergelijking van de verschillende series konden er geen definitieve conclusies getrokken worden. De vergelijking was slechts mogelijk over een relatief korte tijdsperiode van 20 jaar (1970-1991). Bovendien bleken de meeste soorten relatief weinig voor te komen en bovendien nogal onregelmatig verspreid te zijn. Voor de wulk en de zeeëgel leken de patronen redelijk overeen te stemmen. Bij de verschillende soorten krabben werden er geen overeenkomsten in patronen gevonden. Het NIOZ-archief lijkt zeker niet toepasbaar voor alle soorten. Een uitgebreidere analyse, waarbij ook andere groepen, zoals vissen, betrokken worden is noodzakelijk. Tevens lijkt het zinvol om de individuele soortenbenadering te verlaten ten gunste van meer algemenere technieken zoals principale componenten analyse.

2. CONCLUSIES EN BELEIDSAANBEVELING

De verschillen in patronen, zowel tussen soorten als binnen één soort tussen de verschillende lange termijn, series toont duidelijk aan dat de individuele soortenbenadering verlaten dient te worden ten gunste van meer algemenere technieken zoals principale componenten analyse.

De grote variabiliteit in voorkomen en verspreiding van de diverse soorten dwingt ertoe om de Noordzee op te splitsen in diverse deelgebieden.

Deze opsplitsing compliceert de analyse van trends in voorkomen van vissen en epibenthische evertibraten aanzienlijk.

Het lijkt gewenst om rekening houdend met deze problemen een monitoring programma voor niet-commerciële vissen en epibenthische evertibraten op te zetten in de Noordzee.

3. SUMMARY

This report deals with the study of long-term trends in abundance of fish invertebrate species in the North Sea.

The first contribution deals with the suitability of the NIOZ-fyke catches for the assessment of long-term trends in fish and epibenthic invertebrate populations. This implies that it is expected that a fyke catches a constant sampling fraction from the study population(s). This assumption was examined by comparing trends over years for a number of different traps within the study area. In a number of species, all traps showed more or less parallel fluctuations in catches. In some other species distinct different trends were found between traps. Fyke nets appeared to be suitable for the assessment of long-term trends, however only for a restricted group of species.

In the second contribution three data sets of trends in invertebrates of the North Sea were analysed: the NIOZ-archive, consisting of records of catches of landings over the period 1930-1990; the RIVO-DLO by-catches of beam trawl surveys over the period 1970-1991 and the NIOZ fyke catches over the period 1960-1991. The trends of the occurrence in invertebrates in the RIVO-DLO by-catch and the NIOZ fyke was compared with the records in the NIOZ-archive to evaluate the importance of these records as indicator of fishing intensity or abundance in the North Sea. In total 7 species could be compared: the whelk, the sea-mouse, the sea-urchin, the fiddler crab, the edible crab, the masked crab and the swimming crab. No definitive conclusion could be drawn. The time period over which the data sets could be compared (1970-1991) was too short, besides, the distribution and occurrence of most invertebrates was too patchy. The trends in occurrence of some species (whelk and sea-urchin) corresponded rather well with the trends in records in the NIOZ-archive. For other species (crabs) completely different patterns were found. It was concluded that the NIOZ-archive cannot be used for all species. It is suggested to extend the intercomparison by including fish species and by using techniques such as principal component analysis to reveal overall patterns in long-term occurrence of species.

THE SUITABILITY OF A SINGLE INTERTIDAL FISH TRAP FOR THE ASSESSMENT OF LONG-TERM TRENDS IN FISH AND EPIBENTHIC INVERTEBRATE POPULATIONS

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ABSTRACT

The suitability of a single intertidal fish trap for the assessment of long term trends in fish and epibenthic invertebrate populations relies upon the assumption of an on average constant sampling fraction from the study population. This assumption was examined by comparing trends over years in five different traps within the study area. For some species, like cod, the traps showed more or less parallel fluctuations. This is in agreement with the assumption. However, for other species, like mackerel, the assumption was invalidated by distinct trends over years.

1. INTRODUCTION

Monitoring programmes of marine organisms often suffer from two major methodological shortcomings. Firstly, sampling is restricted to a single or a few non-randomly selected stations thought to be representative for a much larger area of interest. Other sampling designs might be too demanding in effort. The term representative is often used (MCINTYRE *et al.*, 1984; LUNDÄLV *et al.*, 1986; CADÉE & HEGEMAN, 1993), but rarely defined. Obviously it requires the assumption that at each sampling occasion on average a constant fraction of the study population is caught. This fraction is often supposed to be equal to the sampled area divided by the area of interest. In repeated sampling, however, estimates of changes in relative density may be adequate, and the assumption of a constant but unknown fraction suffices. A single station approach is followed in long-term studies of, for example, sediment communities (BUCHANAN & MOORE, 1986), rocky communities (LUNDÄLV *et al.*, 1986), plankton communities (CADÉE & HEGEMAN, 1993), and fish communities. The second shortcoming is that population density is measured in units other than area or volume. For example, in studies of fish populations densities are often expressed in units of trapping effort. This is easier, as no costly studies on the efficiency of fishing gear are needed. In cases, estimates on the efficiency can only be obtained by draining ponds (BUCK & THOITS, 1965) or by enclosure experiments (KUIPERS, 1975). Such relative estimates, however, are particularly useful in detecting changes in population density with time (SEBER, 1973). Yet it should be recognised that the assumption is made that in each catch on average a constant (although unknown) fraction of the study population is caught. Hence the two shortcomings discussed require the same assumption to be made.

In the early sixties the Netherlands Institute for Sea Research started a long term sampling program of the fish and epibenthic fauna in the western Wadden Sea. A single kom-fyke trap has been used at the same location near the southern point of Texel from then until the present day. Presumably the series is unrivalled in its sort, because estimates of long-term trends in population size of non-commercial fish and epibenthic invertebrate species are extremely rare. The same is true for commercial species in non-exploited areas. Nevertheless, the sampling programme suffers from the two methodological shortcomings mentioned above. Only a single trap has been used. Furthermore, population density is measured in units of trapping effort. These two shortcomings require the assumption of a constant sampling fraction of the population of interest.

Additionally, between 1966 and 1973 two more kom-fykes, a fyke, and a kom have been used at other locations near Texel. Ideally, the assumption of a constant sampling fraction from the same population should be true for these four devices as well. This implies that the pattern of catches over the years of the five nets should parallel each other. If, on the contrary, the relative time trends for the different devices are not similar, the assumption of a constant sampling fraction from the same population for each trap separately might be seriously doubted.

By studying the similarity in the trends over years of the five traps the present article examines the assumption of a constant sampling fraction of the population of interest. A preliminary study, with more or less the same objective but which only focused on four flatfish species, has been published by VAN DER VEER *et al.* (1992).

2. MATERIAL AND METHODS

2.1. FISHING TRAPS

All nets were set up at the southern point of Texel, one of the Frisian Islands in the Dutch Wadden Sea. Three different types of fish traps were used: kom-fyke, kom and fyke (Fig.1). We refer to Van der Veer *et al.* (1992) for a detailed description of the three different kinds of fish traps and of the precise locations. For the three kom-fykes (1 Stuidijk; 2 Ferry Harbour; 3 Schanserwaard) fishing normally started in March or April and lasted at least until October. The fyke (4 Hoek van de Staak) and the kom (5 Schanserwaard) were only set up in September and October, and contrary to the kom fykes have not been set up in 1972 and 1973. The nets were emptied every morning from Monday to Friday, except when bad weather conditions prevented this. In that case the nets were emptied the following morning or later. However, catches of a duration longer than two days have been left out of the analysis. All catches were sorted out immediately and all specimens identified to species level. Of each species numbers were counted. When numbers were large only mass was determined, and before data analysis masses were transformed into counts, using a fixed ratio, i.e. a fixed mean individual mass.

The kom-fyke 1 (Stuidijk) is still in use at the present day.

2.2. STATISTICAL MODEL

For each species separately a log-linear model has been assumed, which relates the number of specimens in a single catch to the effects of year, trap, month, and duration of the catch. Species with less than 100 non-zero observations were not considered. Only main effects and first-order interactions were included. Our main interest focused on the size of year main effect compared to the year-trap first order interaction effect. The latter effect takes into account that differences among years might not be equal for different traps. Higher-order interactions, whose inclusion would have resulted in a large number of empty cells, were left out. The model therefore looked like:

$$(\log)E_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + \alpha\beta_{ij} + \alpha\gamma_{ik} + \alpha\delta_{il} + \beta\gamma_{jk} + \beta\delta_{jl} + \gamma\delta_{kl}$$

where E_{ijkl} is the expected number of specimens in year i , month j , trap k and duration l ; α_i , β_j , γ_k , and δ_l are main effects of year i , month j , trap k and duration l , respectively; and $\alpha\beta_{ij}$, etc. are first order interaction effects. For the random variation the assumption of a Poisson-like distribution (where the dispersion of the data is equal to some unknown constant, the so-called dispersion factor, times the dispersion predicted by the Poisson model) seems reasonable.

Two different data subsets were used. The first subset only contained the three kom fykes (traps 1, 2 and 3), over the months April to October, and the years 1966 until 1973. So the factors year, month and trap had eight, seven and three levels, respectively. The number of observations or catches that were used in this analysis was equal to 3017. The second subset contained all five fish traps, but was restricted to the months September and October, between 1966 and 1971. So the factors year, month and trap had six, two and five levels, respectively. Altogether 928 catches were involved. For both subsets the factor duration had two levels: one or two days fishing duration. By splitting the data into these two subsets the problem of missing cells was reduced and first-order interaction terms could be estimated almost completely.

Genstat 5.0 (PAYNE *et al.*, 1987) was used for obtaining maximum likelihood estimates of the model parameters. For the first subset three parameters were not estimable, since their accompanying cells were missing. For the second subset one parameter could not be estimated. The trend over years for each trap was summarised by the predicted value for each year-trap combination, averaged over months and durations. In order to obtain predictions the few unestimable parameters were arbitrarily set to zero. The contribution of each main effect, i.e. the regression deviance, was calculated by subtracting the residual deviance of the model with only the other main effects from the residual deviance of the model with all main effects included. The interaction effects were obtained in a similar way. If an effect is non-significant the difference in residual deviance between the model that has or has not included the effect (divided by the dispersion factor) has approximately a χ_t^2 distribution, where t is the difference in degrees of freedom of both models. The dispersion factor was estimated by the mean deviance of the most complicated model. All tests were performed at the 0.05 level. The data consisted of a time series, which might have caused a dependency among the errors. This means that particularly the results in terms of p-values must be interpreted with caution. However, because the number of observations is in the order of thousands, even small effects will yield significant p-values. The analysis therefore emphasised effect size instead of significance. Log-linear models belong to the class of generalized linear models, and are discussed in detail by McCullagh and Nelder (McCULLAGH & NELDER, 1989).

3. RESULTS

Table 1 gives a list of the 35 species with at least 100 non-zero observations out of 3017 catches. For all species the analysis of deviance revealed that the major part of the total explained deviance was accounted for by the main effects. The relative proportion of the different main effects varied considerably among species. Some species, like the scad, showed a relatively large month effect, while others, like the sole, showed a small month effect.

Our interest focused on the size of the year main effect relative to the year-trap interaction effect. For all species the year main effect was significant for both subsets. In most cases the year-trap interaction effect was significant, except for a few rare species: twaite shad, saithe, stickleback, and hooknose (where the year-trap interaction was not significant in the second subset), and tub gurnard, turbot, and common hermit crab (no significance in both subsets). The trap main effect, which reflects differences in the average catch between traps, revealed non-significant results only for saithe and common hermit crab in the first subset. The results of the analyses of deviance (concerning the year main effect, the trap main effect, and the year-trap interaction effect) are also presented in the form of ternary diagrams (Figs. 2 and 3). For a few species the trend over years for each trap is shown. The ternary diagrams visualise the proportion of the regression deviances for each of these three factors relative to their sum. Hence the diagram indicates which species will show more or less parallel or even similar fluctuations among years and which species will not. For example, cod showed a large year effect relative to the trap effect and the year-trap interaction effect. This implies that different traps revealed almost similar fluctuations among years,

particularly for subset 1. On the contrary, mackerel is a species with a relatively small year/year-trap ratio. Hence this species showed more distinct trends over years among traps. Sole is an example of a large group of species with more or less parallel trends. It should be noted that the second subset was only concerned with the months September and October. The first subset concerned data from April to October. Hence the trend lines for the second subset (Fig. 3) do not necessarily have to parallel the lines for the first subset (Fig. 2), because a large year-month interaction effect was found for all species.

4. DISCUSSION

One of the aims of the long term sampling programme was to examine changes in the fish and epibenthic fauna of the western Wadden Sea. A single kom-fyke (Stuifdijk) was set up from the early sixties until the present day. Implicitly the assumption was made that over the entire period for all species a constant sampling fraction from the western Wadden Sea population would be caught. However, non-parallel fluctuations between the five (three) different traps that were set up from 1966 to 1971 (1973) imply that these traps do not catch a constant sampling fraction from the same population. This means that either sampling fractions vary, or different (subgroup) populations are sampled. Or both. Long-term data of the single kom-fyke (Stuifdijk) therefore are of severely limited scope for those species that showed non-parallel fluctuations. Clearly, this was true for species like mackerel, for which the three different kom-fykes did show non-parallel fluctuations over years. For other species, like the thick-lipped grey mullet, the three different kom-fykes showed more or less parallel fluctuations over years. Yet, no obvious relation emerged between the ecology of the species (e.g. in terms of demersal or pelagic occurrence) and whether or not the traps showed parallel fluctuations over years. Generally, parallel fluctuations were less manifest when the fyke and the kom were also considered (second subset). Even for the cod, for example, the fyke showed a slightly different trend over years than the other four traps. For most species, e.g. sole, it is rather arbitrary whether the trends over years for the different traps can be considered as more or less similar or not. Statistical significance of the year-trap interaction seems no appropriate criterion. Small effects, for example for cod in the first subset, already appeared statistically significant. Apparently, the power of the test is quite large, with more than 3000 observations.

In short, for those species that showed more or less parallel fluctuations the assumption that a constant fraction of the western Wadden Sea population is sampled could not be invalidated. Admittedly, this does not imply that the assumption is valid. For example, the five traps of the present study were all located near the southern point of Texel, within a radius of three kilometres. Hence it remains unclear whether the sampled population is equivalent to the western Wadden Sea population or is restricted to a local population around southern Texel. Furthermore, it should be noted that similar trends over the years are also no guarantee for constant sampling fractions, because the possibility of a similar systematic change in the sampling fractions of the five traps cannot be ruled out. Yet, the assumption of a constant sampling fraction often is explicitly or implicitly made, without any attempts to indicate the reliability of this assumption. Although consistency in the conditions under which the sampling takes place might reduce the risk of a systematic change in the sampling fraction, SEBER'S (1973) warning that blind application of a relative estimate could give a completely false picture, should be taken seriously. The present article has tried to do so.

Acknowledgement - We thank H.A. Beumkes, P. Boer, T. Eilander and W.P. Jongejan for collecting the data. We are also grateful to the late J. Verwey and the late J.J. Zijlstra for initiating and continuation of the sampling programme, respectively. R. Dapper assisted with the analysis of the data. This publication is a contribution of the cooperative research project between the Netherlands Institute for Sea Research and Nederlandse Aardolie Maatschappij B.V. on 'Long-term changes in Wadden Sea and North Sea due to anthropogenic activities'.

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TABLE 1

The number of catches n for all species with at least 100 non-zero observations out of 3017 catches. Common species (more than 1000 non-zero observations) are coded by a capital; rare species (less than 1000 non-zero observations) are coded by lower case.

code	English name	scientific name	n
A	shore crab	<i>Carcinus maenas</i>	3007
B	flounder	<i>Platichthys flesus</i>	2909
C	plaice	<i>Pleuronectes platessa</i>	2698
D	eel	<i>Anguilla anguilla</i>	2503
E	viviparous blenny	<i>Zoarces viviparus</i>	2394
F	bull-rout	<i>Myoxocephalus scorpius</i>	2115
G	garfish	<i>Belone belone</i>	2046
H	thick-lipped grey mullet	<i>Chelon labrosus</i>	1820
I	five-bearded rockling	<i>Ciliata mustela</i>	1791
J	scad	<i>Trachurus trachurus</i>	1790
K	twaité shad	<i>Alosa fallax</i>	1627
L	dab	<i>Limanda limanda</i>	1435
M	herring	<i>Clupea harengus</i>	1349
N	sea trout	<i>Salmo trutta</i>	1185
O	sole	<i>Solea solea</i>	1169
P	cod	<i>Gadus morhua</i>	1139
Q	pollack	<i>Pollachius pollachius</i>	1074
a	swimming crab	<i>Macropipus holsatus</i>	866
b	giant jellyfish	<i>Rhizostoma pulmo</i>	758
c	whiting	<i>Melangius merlangus</i>	634
d	sand-smelt	<i>Atherina presbyter</i>	585
e	mackerel	<i>Scomber scombrus</i>	563
f	brill	<i>Scophthalmus rhombus</i>	473
g	saithe	<i>Pollachius virens</i>	375
h	sprat	<i>Sprattus sprattus</i>	369
i	bass	<i>Dicentrarchus labrax</i>	369
j	smelt	<i>Osmerus eperlanus</i>	351
k	bib	<i>Trisopterus luscus</i>	293
l	lumpsucker	<i>Cyclopterus lumpus</i>	237
m	tub gurnard	<i>Trigla lucerna</i>	189
n	turbot	<i>Scophthalmus maximus</i>	176
o	stickleback	<i>Gasterosteus aculeatus</i>	147
p	common hermit crab	<i>Pagurus bernhardus</i>	147
q	butterfish	<i>Pholis gunnellus</i>	114
r	hooknose	<i>Agonus cataphractus</i>	104

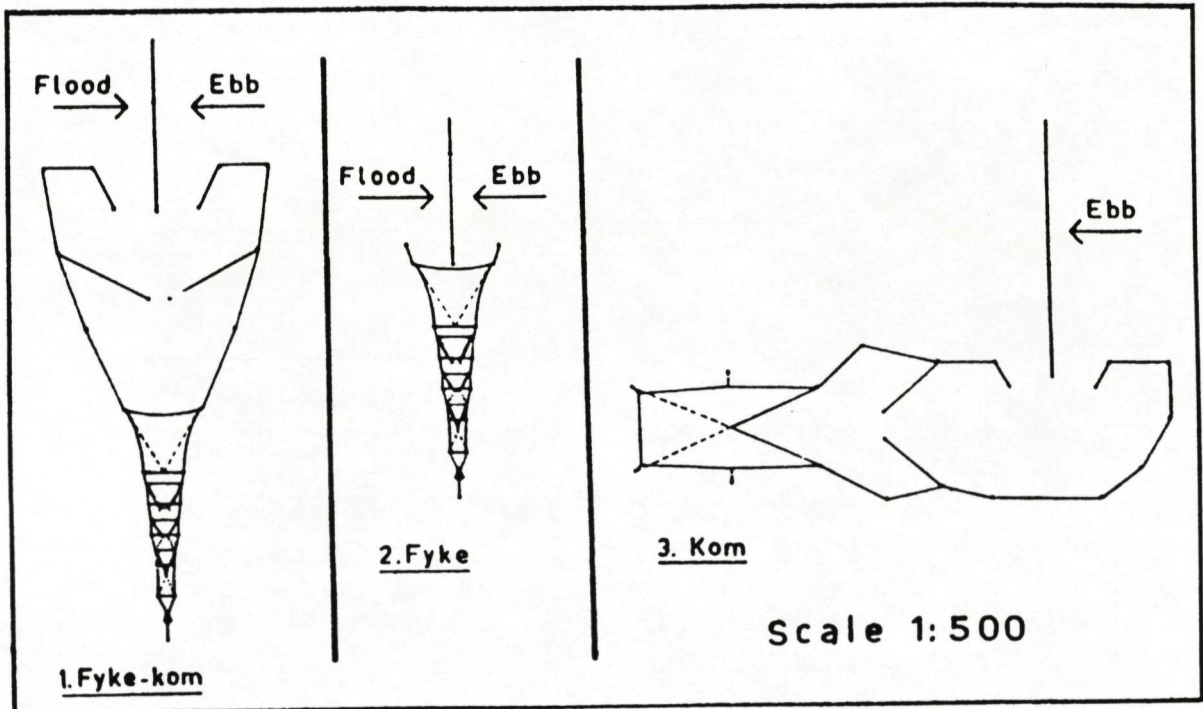


Fig. 1. The three types of fish traps.

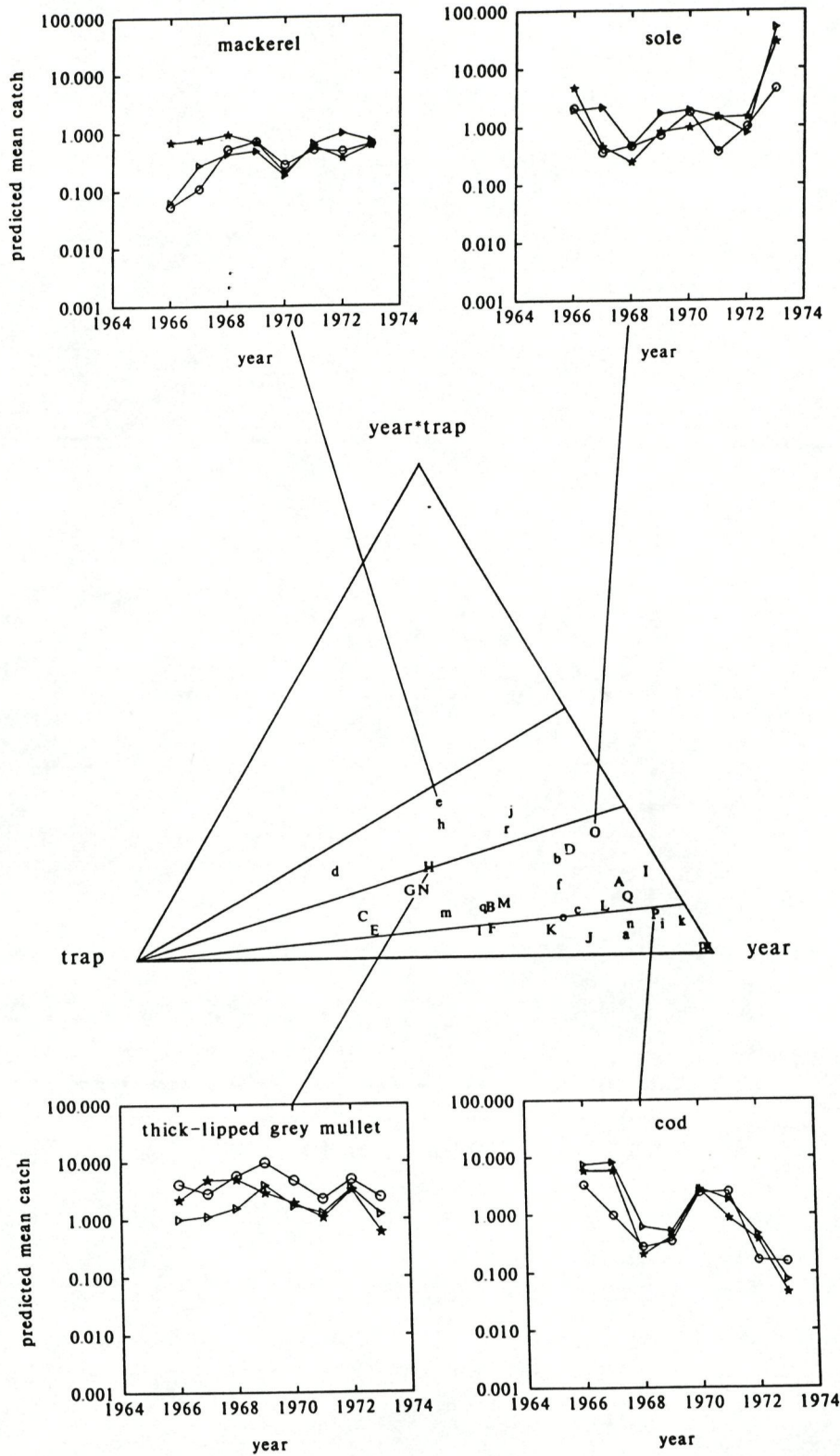


Fig 2. Ternary diagrams, showing the relative size of the year main effect, trap main effect, and year-trap interaction effect. Subset 1. Lines of equal year/year-trap ratio (0.5, 0.7, and 0.9 respectively) are also shown. See Table 1 for codes. For a few species the trend in the predicted catch, averaged over months and fishing duration, is shown for each trap. ○ Stuifdijk, kom-fyke; ▷ Ferry Harbour, kom-fyke; ☆ Schanserwaard, kom-fyke.

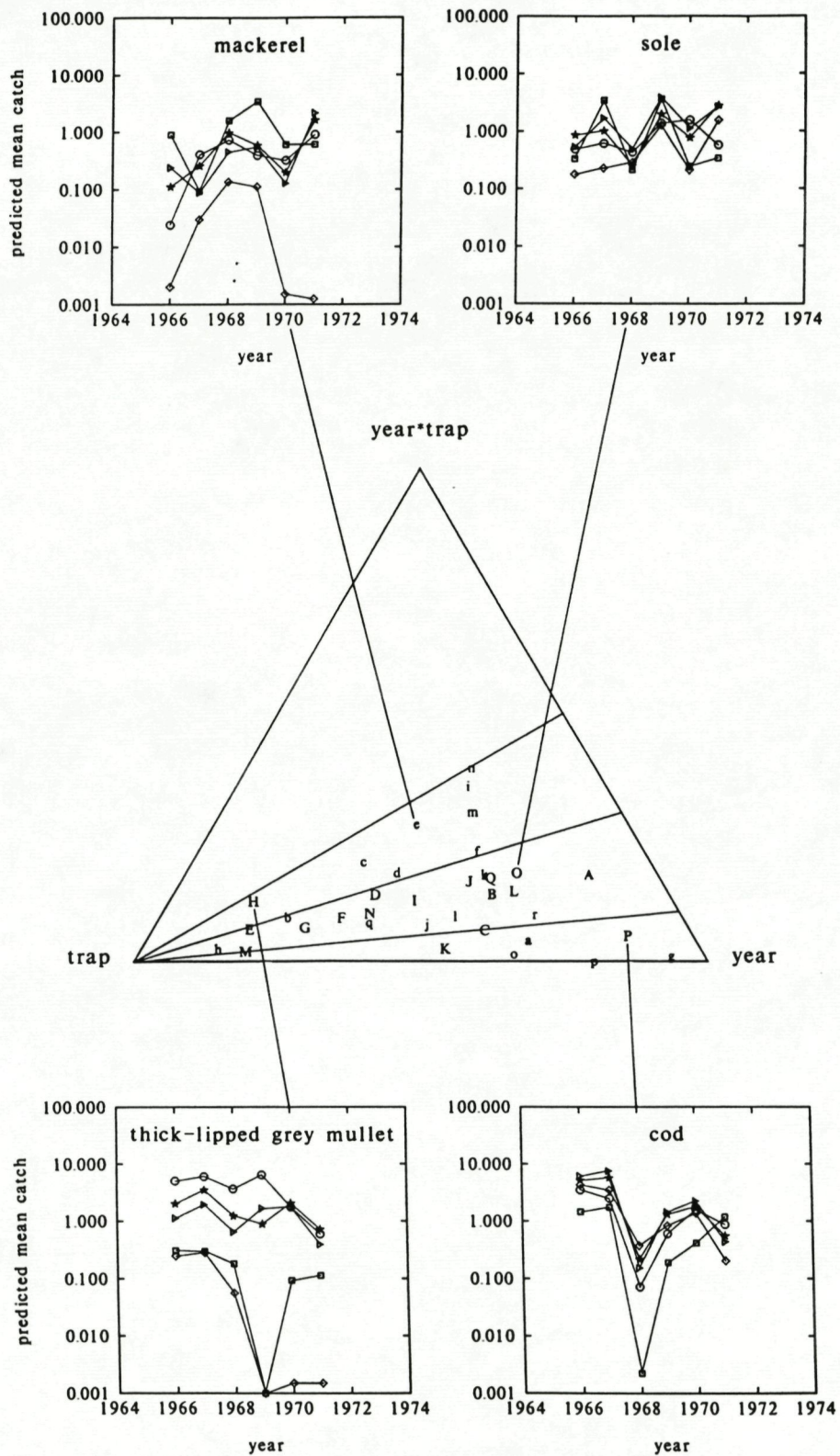


Fig. 3. Ternary diagrams, showing the relative size of the year main effect, trap main effect, and year-trap interaction effect. Subset 2. Lines of equal year/year-trap ratio (0.5, 0.7, and 0.9 respectively) are also shown. See Table 1 for codes. For a few species the trend in the predicted catch, averaged over months and fishing duration, is shown for each trap. ○ Stuidijk, kom-fyke; ▷ Ferry Harbour, kom-fyke; ☆ Schanserwaard, kom-fyke; □ Hoek van de Staak, fyke; ◇ Schanserwaard, kom.

TRENDS IN INVERTEBRATES IN THE NORTH SEA: A PRELIMINARY COMPARISON OF DATA SETS

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ABSTRACT

Three data sets of trends in invertebrates of the North Sea were analysed: the NIOZ-archive, consisting of records of catches of landings over the period 1930-1990; the RIVO-DLO by-catches of beam trawl surveys over the period 1970-1991 and the NIOZ fyke catches over the period 1960-1991. The trends of the occurrence in invertebrates in the RIVO-DLO by-catch and the NIOZ fyke was compared with the records in the NIOZ-archive to evaluate the importance of these records as indicator of fishing intensity or abundance in the North Sea. In total 7 species could be compared, the whelk, the sea mouse, the sea urchin, the fiddler crab, the edible crab, the masked crab and the swimming crab. No definitive conclusion could be drawn. The time period over which the data sets could be compared (1970-1991) was too short, besides the distribution and occurrence of most invertebrates was too patchy. The trends in occurrence of some species (whelk and sea urchin) corresponded rather well with the trends in records in the NIOZ-archive. For other species (crabs) completely different patterns were found. It was concluded that the NIOZ-archive cannot be used for all species. It is suggested to extend the intercomparison by including fish species and by using techniques such as principal component analysis to reveal overall patterns in long-term occurrence of species.

1. INTRODUCTION

Until present the study of long-term changes in the Wadden Sea and North Sea ecosystem was restricted to a rather qualitative description of the changes over the last decades. Quantitative data sets are required to gain insight into the long-term changes in the ecosystem. Based on such data sets, null hypotheses can be formulated and tested to evaluate the relative importance of the various factors.

There are different sources available that can generate the necessary long-term data sets. One of them concerns the by-catches of the fish survey programme carried out RIVO-DLO. This survey started in 1948 and is still being continued. Another data set is formed by the fyke catches of NIOZ near the entrance of the Wadden Sea. This programme started in 1960 and is also still being continued. Finally both NIOZ and RIVO-DLO have records of rare fish species from about 1930 onwards until present. DE VOOYS *et al.* (1991; 1993) present a preliminary analysis of the NIOZ data base of respectively some fish species and some invertebrates. At present RIVO-DLO data are not worked out. These data show rather large trends in the frequency of registration, however, so far no information is available to what extent these data represent an indication of fishery intensity or in real occurrence in the North Sea. In case these data represent an estimate of the abundance in the North Sea, it would mean that long-term trends can be studied from 1930 onwards.

This paper focusses on the invertebrates. The RIVO-DLO by-catch programme and the NIOZ-fyke catches represent abundance estimates of the different species over time. The trends in

abundance of the various species found in the RIVO-DLO by-catch programme and the NIOZ-fyke catch will be compared to evaluate the importance of the NIOZ-archive in studying long-term trends in abundance of invertebrates in the North Sea. First objective will be the analysis and selection of species present in all three data sets. Subsequently, for each species the long-term trends in the various data sets will be compared with the records of the NIOZ-archive.

2. MATERIAL AND METHODS

2.1. THE NIOZ-ARCHIVE

The NIOZ-archive was set-up in 1930 with the aim to register information on the distribution and abundance of North Sea species, collected as catch and/or by-catch by commercial fishermen from especially the harbour of Den Helder. Specimen were delivered by fishermen on request and in case of the catch of a rare and/or unknown species. In all cases the individuals were bought by the institute for an amount more or less equal to the market price. Rare species were kept and added to the institute's collection. A number of species were bought in larger quantities to be re-sold to universities. Each record consists of species, date of catch, latitude, longitude, total length and sometimes weight and sex. For more details see DE VOOYS *et al.* (1991; 1993).

So far a group of fish species and a group of invertebrates were analysed (DE VOOYS *et al.*, 1991; 1993). Almost all records were from the Dutch continental area of the North Sea. In total 15 invertebrate species were analysed. Of each species, the total mean number of individuals recorded was determined, The pattern of this mean monthly number was for all species rather irregular. To exclude the influence of seasonal fluctuations, the time series was smoothened. Each month was valued **1** in case during that month one or more individuals were recorded, or **0** in case during that month no records of the species were registered. Subsequently, running average means over 60 months periods (= 5 years) were calculated for each species to filter out the long-term trend in record. For more information see DE VOOYS *et al.* (1991; 1993).

2.2. THE RIVO-DLO BY-CATCH PROGRAMME

In 1969 a standard survey programme for flatfish was initiated by RIVO-DLO in spring and autumn. During all cruises also the by-catches were analysed and registered. The survey was based on 14 transects, each consisting of 4-10 hauls along the European coast of the North Sea (Fig. 1). Fishing took place with a 5.8 standard beam-trawl with 4 tickler chains in front of the net and a mesh size of 4.5 x 4.5 cm. Fishing speed amounted 4 miles per hour, and fishing duration was 15 minutes. Of each haul, the total catch or a subsample was analysed on board and all invertebrates were registered and their number counted. In this report data of the autumn survey are presented. All information is based on the analysis carried out by BUIJS *et al.* (1993). Since the number of individuals of a species showed a rather irregular pattern, the by-catch data were transformed in a similar way as the NIOZ-archive records. In case of the presence of a species in a haul, the catch record was **1**, in case of absence of a species in a haul, the catch record was **0**. Per survey, the mean record was estimated as a relative scale of abundance. This scale could vary between 0 and 1.

2.3. THE NIOZ-FYKE PROGRAMME

The NIOZ fyke-net programme was initiated in 1960 and has been continued until present. The net is a combination of a pound net and a fyke and it is called a 'fyke-kom' or 'kom-fyke'. A kom-fyke has a leader of 200 m and a 2 chambers. The mesh-size of the nets in the chambers and the fyke itself is 1x1 cm. The net was set up near the southern point of Texel at the entrance of the western Wadden Sea (Fig. 2). Fishing normally started in March-April and lasted until October. In winter the

trap had to be removed, because of possible damage by ice floes. In summer large amounts of jellyfish or ulva would sometimes clog the nets, making fishing impossible. The kom-fyke was emptied every morning from Monday to Friday, except when bad weather conditions prevented this. All catches were sorted out immediately and identified to species. Of each species numbers were counted and weights sometimes determined.

Some species were caught frequently enough to analyse their long-term patterns. For each species the mean catch per day fishing per year was determined and plotted on a relative scale.

3. RESULTS

Table 1 presents the list of invertebrate species occurring in at least two of the data sets in sufficient numbers to permit a comparison between series. Also it is indicated in which of the data sets the various species occurred.

3.1. THE NIOZ-ARCHIVE

The frequency of the trends in records in the NIOZ archive were not similar in all species. The whelk showed two distinct peaks in the past, disappeared in the mid 1970s and was recorded again from the mid 1980s onwards (Fig. 3). The sea-mouse showed a more or less similar pattern, although its peaks were more pronounced (Fig. 4). Also the period of nearly absence differed and was shorter. The sea-urchin showed a completely different pattern (Fig. 5). Maximum records occurred around the 1970s followed by a steady decrease until an absence for the mid 1980s onwards. Three crab species were recorded. They all showed a different pattern. The edible crab had maximum records in the 1950s (Fig. 6). Hereafter, records decreased, only interrupted by a second smaller peak in the late 1960s, to an absence from the mid 1970 onwards. The fiddler crab showed a peak-wise increase in course of time with a maximum frequency of records in the mid 1970s (Fig. 7). Hereafter, they almost completely disappeared. The masked crab was present in more or less constant frequency until the mid 1970s (Fig. 8). Hereafter, the frequency of records dropped quickly to zero from the beginning of 1980s onwards.

3.2. THE RIVO-DLO BY-CATCH PROGRAMME

The whelk showed a rather constant pattern of abundance over the period of observation from 1972 onwards (Fig. 9). However, the maximum index did not exceed 0.1, indicating that this species was rare in the catches. The sea-mouse was more common in the catches (Fig. 10). The index varied considerably over the years and no clear trend could be observed. Data on the sea-urchin is presented in Fig. 11. Despite the rather high variability, there appeared to be a weak decrease in index until 1990. The sea-urchin was rather common in catches over the years. The edible crab was the most commonly found crab species (Fig. 12). The index varied without clear trend. The fiddler crab was less oft found (Fig. 13). Over the whole time period it was a rare species, only found in a number of years in some hauls. The masked crab was present in the survey almost each year (Fig. 14). No clear trend was observed. The suggestion of a slight decrease was present. Figure 15 shows the swimming crab. No clear pattern could be observed. The swimming crab was present in all years in almost all catches of the survey.

3.3. THE NIOZ-FYKE PROGRAMME

Only two crustacean species were found in the kom-fyke, the edible crab and the swimming crab. The edible crab showed a very variable pattern of occurrence (Fig. 16). During the 1960s it was hardly found in the fyke. Numbers increased in the beginning of the 1970s but remained variable. In the late 1980 the species almost disappeared again and in the 1990s low numbers were found.

The swimming crab was present more oft in the fyke, however numbers were also very variable (Fig. 17). Maximum numbers were observed in the 1970s. Low numbers were found in the 1980s and catches increased again in the beginning of the 1990.

3.4. INTERCOMPARISON OF TRENDS IN INVERTEBRATES

In total 7 species could be compared. For each species the various data sets were plot in one graph (sometimes after standarization of the data), and a smoothed curve with fitted to facilitate a comparison of the different trends. The interpretation is hampered by the relatively short time period over which data of more than one data set is available.

Figure 18 shows the trend in occurrence of the whelk in the RIVO-DLO by-catch and in the NIOZ-archive. The general trend of both sets corresponded rather well, except for the last year of observation. However, this might be due to normal variability. In the sea-mouse, no correspondence in patterns could be observed (Fig. 19). The NIOZ-archive suggested low occurrence in the mid 1980s, whereas the RIVO-DLO by-catch showed no such pattern at al. The trend for the sea-urchin corresponded rather well (Fig. 20). All series showed a decreasing trend in the 1980s. In recent years, the NIOZ-archive suggested an increase, while in the RIVO-DLO by-catch a constant low fraction was found. For the edible crab, a comparison between the three data sets was possible (Fig. 21). Although due to the scaling of the data, the trends seemed to correspond, the three curves showed a different pattern. In the NIOZ-archive, the edible crab was absent in recent years, whereas the RIVO-DLO by-catch showed a constant occurrence. The NIOZ-fyke showed a completely different irregular pattern. Also in the fiddler crab, the patterns between the different series did not correspond (Fig. 22), however in both series the fiddler crab was a rather rare species. The patterns in the masked crab also did not correspond (Fig. 23). The suggestion of a decrease in occurrence in the NIOZ-archive was not supported by the index of the RIVO-DLO by- catches. The swimming crab was a rather common species, both in the NIOZ-fyke and in the RIVO-DLO by-catch (Fig. 24). However, the variability in occurrence was much larger in the NIOZ-fyke than in the RIVO-DLO by-catch.

4. DISCUSSION

The assessment of long-term trends of fishes and invertebrates of the North Sea ecosystem forces a reconstruction based on data sets that were not collected with the aim to monitor the environment. The three data sets discussed in this paper are the longest records of non-commercial fish species of the Dutch point of the North Sea. The NIOZ-archive has the longest record from 1930 onwards, however at present the value of these records in reflecting trends on abundance in the North Sea is unclear. Therefore, the main aim of the this study was to compare the records of the NIOZ-archive with other time series that do reflect such trends.

In this respect, the NIOZ fyle-catches can be considered as the most restrictive time series of abundance of fish and invertebrates. Although lasting for already 30 years, the data are collected at one sampling station only. This might partly explain the large variability observed in the data. Furthermore, a kom-fyke is a passive fishing gear, which means that only actively swimming and/or moving animals can and will be caught. This immediately implies that sessile invertebrates will never be collected in such a fyke. The most accurate series is formed by the RIVO-DLO by-catch data. However, even this time series has its restrictions. First of all, the survey started in the beginning of the 1970s which means that data are available over a rather short time period only. Furthermore, each survey did not consist of exactly a similar amount of hauls and also the precise location varied sometimes. All by-catch data are recorded as numbers only. No other information on sex, age, weight etc. is present. A restriction of the by-catch data is formed by the fact that the data show that some invertebrates are distributed rather irregular and patchy. This complicates the

reconstruction of trends in occurrence, and makes it difficult to compare these trends with other information on the same species.

The comparison of the data sets of invertebrates of the NIOZ-archive was restricted to 6 species only, of which 3 crustacean species. The patterns of the whelk and of the sea-urchin were not clearly different. In case of the sea-mouse no correspondence in pattern could be observed. This would mean that based on these observations, it can not be excluded that for the whelk and the sea-mouse the records of the NIOZ-archive can be used for reconstruction of the occurrence in the past, back to 1930. On the other hand, in all three crustacean species, the patterns did not show any correspondence at all. At least this means that the NIOZ-archive can not be applied for all species. The absence of any correspondence in pattern in these crustacean species might result from their patchy distribution and their relatively low occurrence in the catches and the records. It simply illustrates that rare species are not suitable for monitoring purposes.

In an analysis of the NIOZ-archive for some non-commercial fish species DE VOOYS *et al.* (1991) argued that the trends in records might reflect either the fishery intensity or the abundance of some species. Also in their analysis, they concluded that for a number of species the NIOZ-archive could not be used. At least this would mean a selective applicability of the data set. The main argument by DE VOOYS *et al.* (1991) in support of their data arose from the correspondence between the records of the NIOZ-archive at the commercial landings of the greater weever, a species that became more or less extinct in the 1960/1970. Even if this argument holds true, their other data and this study illustrates that the NIOZ-archive for sure cannot be used in general for all species.

What to conclude and how to proceed is the remaining question. This preliminary analysis still does not provide a clear answer, mainly because of lack of sufficient data. One may doubt whether it is really possible to split up the NIOZ-archive into species that reflect a trend over the past and species that do not. Maybe the analysis should not be based on the comparison of patterns in individual species. An analysis of common patterns by means of principal component analysis as done by DE VOOYS *et al.* (1991; 1993) or other applied statistical techniques might overcome this problem. However, such an analysis should be restricted to relatively abundant species only. Furthermore, also other groups besides invertebrates should be included and some groups maybe should be excluded. This analysis suggests that crustaceans are not suitable for such an analysis of the NIOZ-archive.

Even if such an analysis can be performed, it remains unclear whether the conclusions arising from such a study will be clear enough to permit the construction of hypotheses. It cannot be excluded that these data sets can only be used the other way round in the process of falsification of hypotheses. Maybe the data sets are too variable to even allow the rejection of any hypothesis at all.

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TABLE 1

List of invertebrate species occurring in at least two of the long-term data sets.
Indicated are in which sets the various species occur (X).

Scientific name	Common name	NIOZ- archive	RIVO-DLO by-catch	NIOZ-fyke
<i>Buccinum undatum</i>	Whelk	X	X	
	Sea-urchin	X	X	
<i>Aphrodite aculeata</i>	Sea-mouse	X	X	
<i>Macropipes puber</i>	Fiddler crab	X	X	
<i>Corystes</i>	Masked crab	X	X	
<i>cassivelaunus</i>				
<i>Cancer pagurus</i>	Edible crab	X	X	X
<i>Macropipus</i>	Swimming crab		X	X
<i>holsatus</i>				

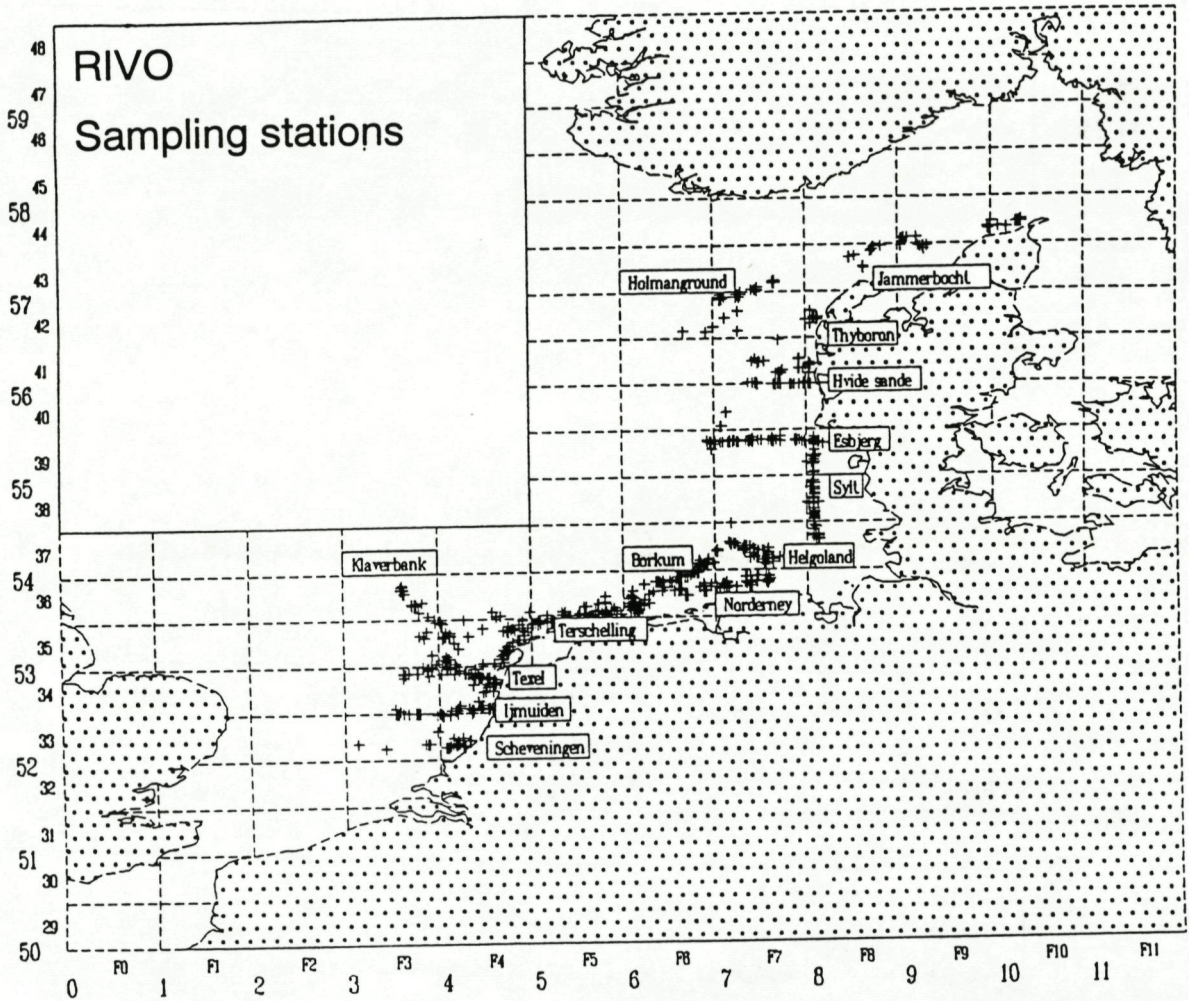


Fig. 1. Position of the individual hauls of the RIVO-DLO by-catch data 1972-1991 (after Buus *et al.*, 1993).

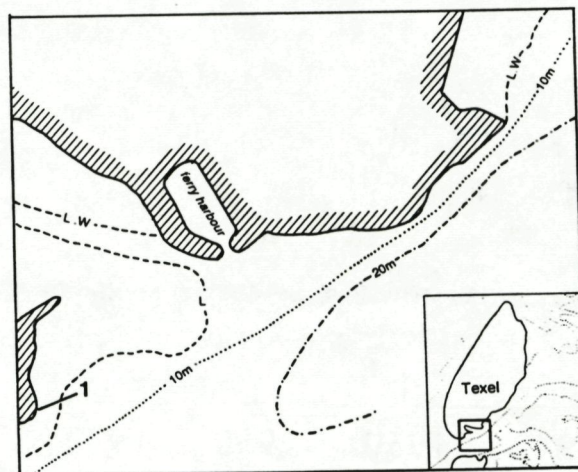


Fig. 2. Location of the NIOZ kom-fyke near the Isle of Texel (after VAN DER VEER *et al.*, 1992).

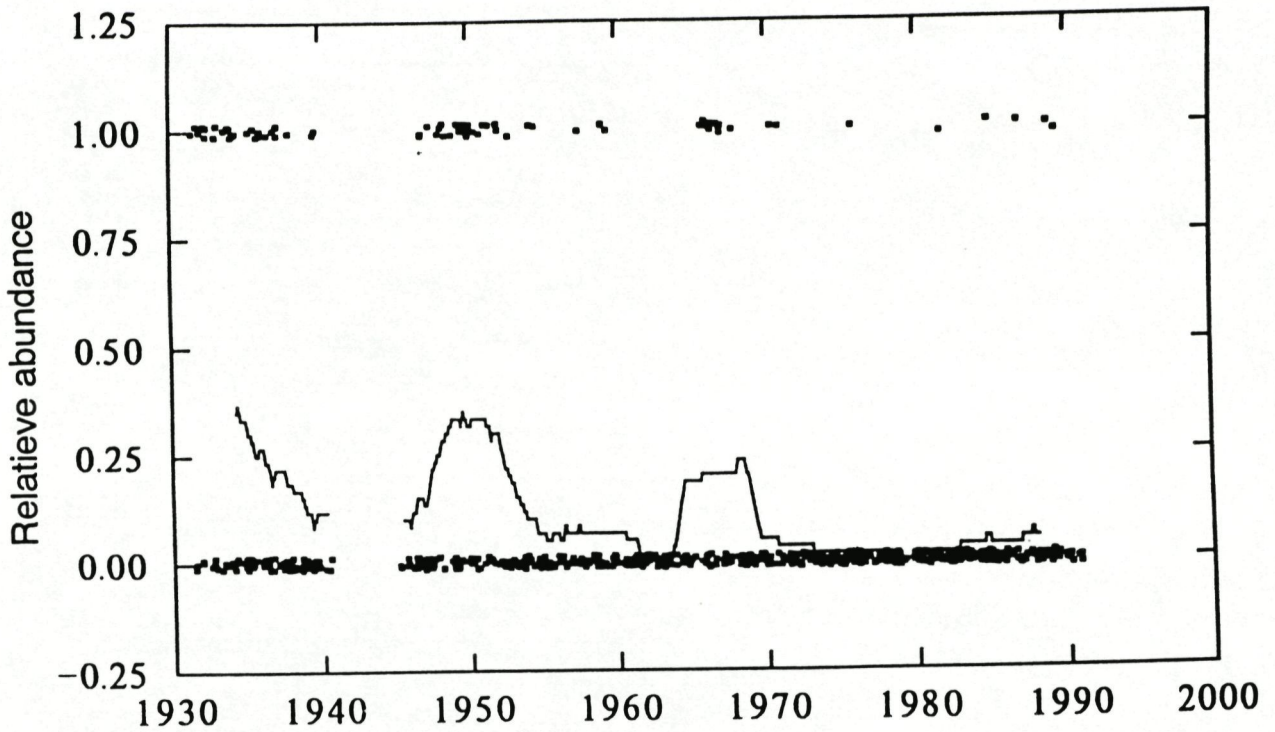


Fig. 3. Frequency of records of the whelk *Buccinum undatum* in the NIOZ-archive during the period 1930-1990. For more information see text.

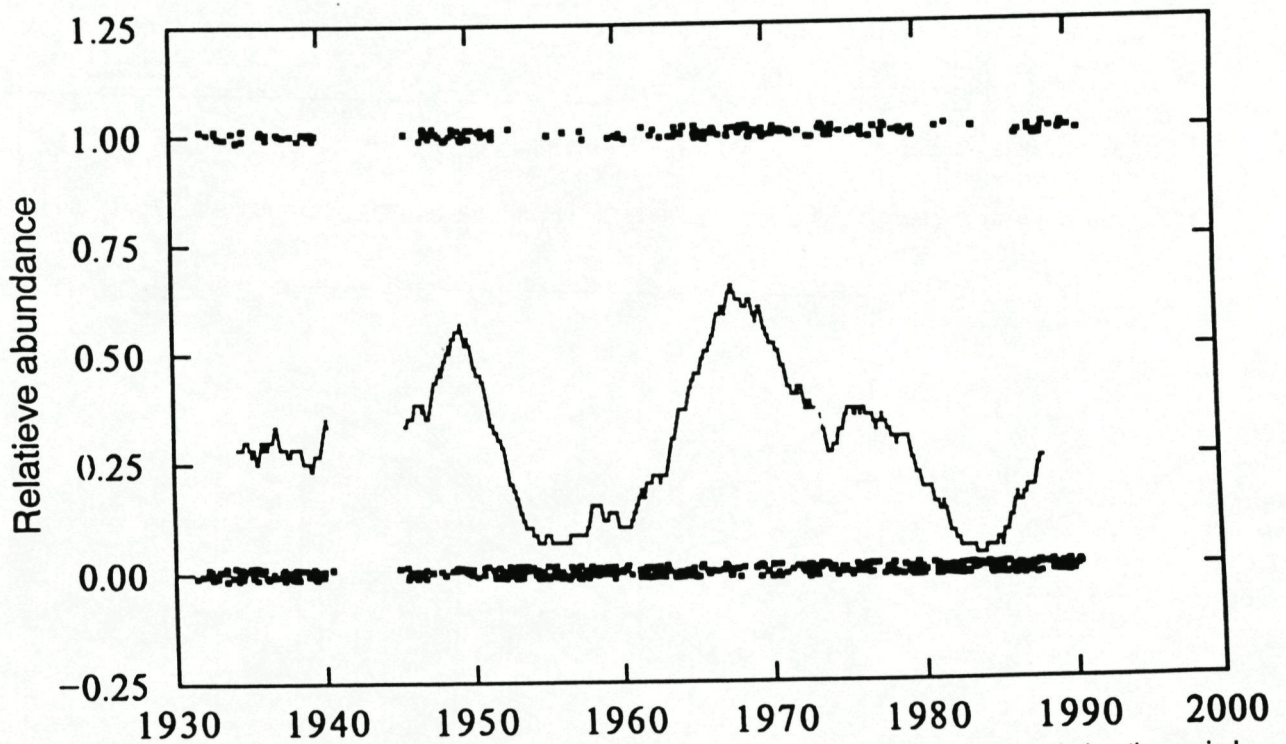


Fig. 4. Frequency of records of the sea mouse *Aphrodite aculeata* in the NIOZ-archive during the period 1930-1990. For more information see text.

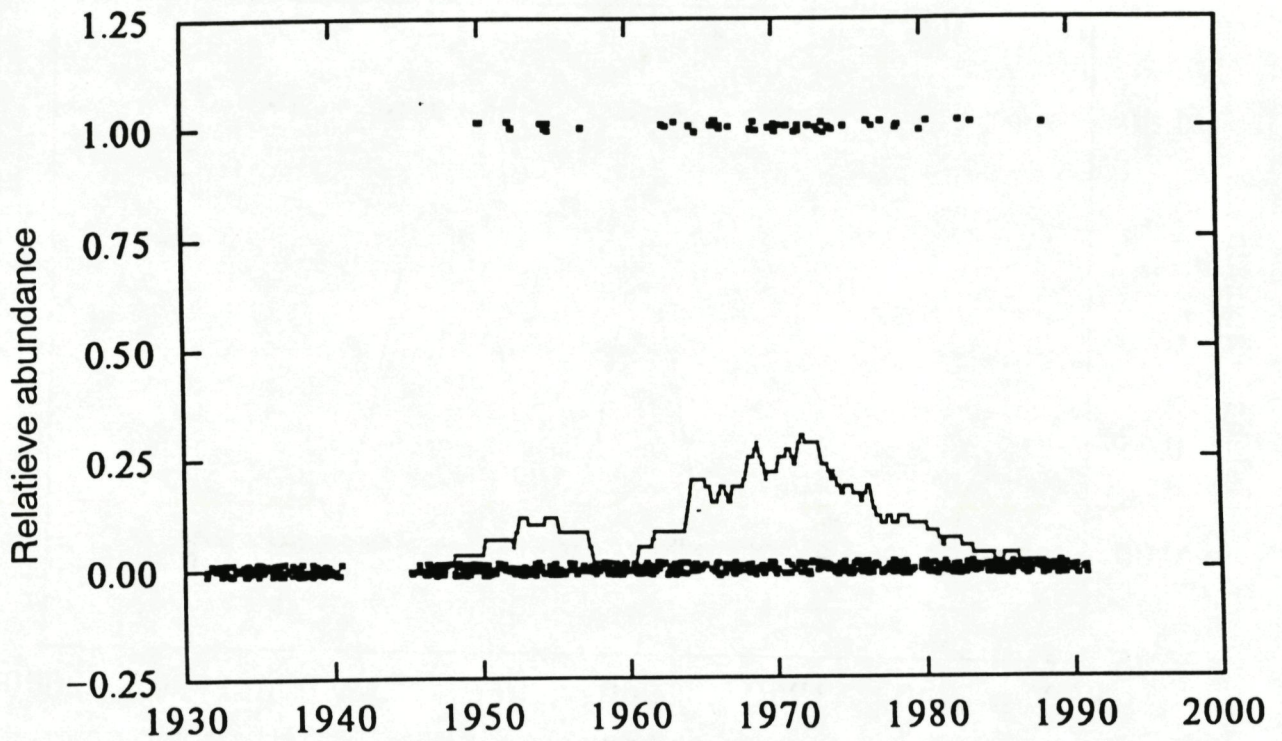


Fig. 5. Frequency of records of the group of sea urchin in the NIOZ-archive during the period 1930-1990. For more information see text.

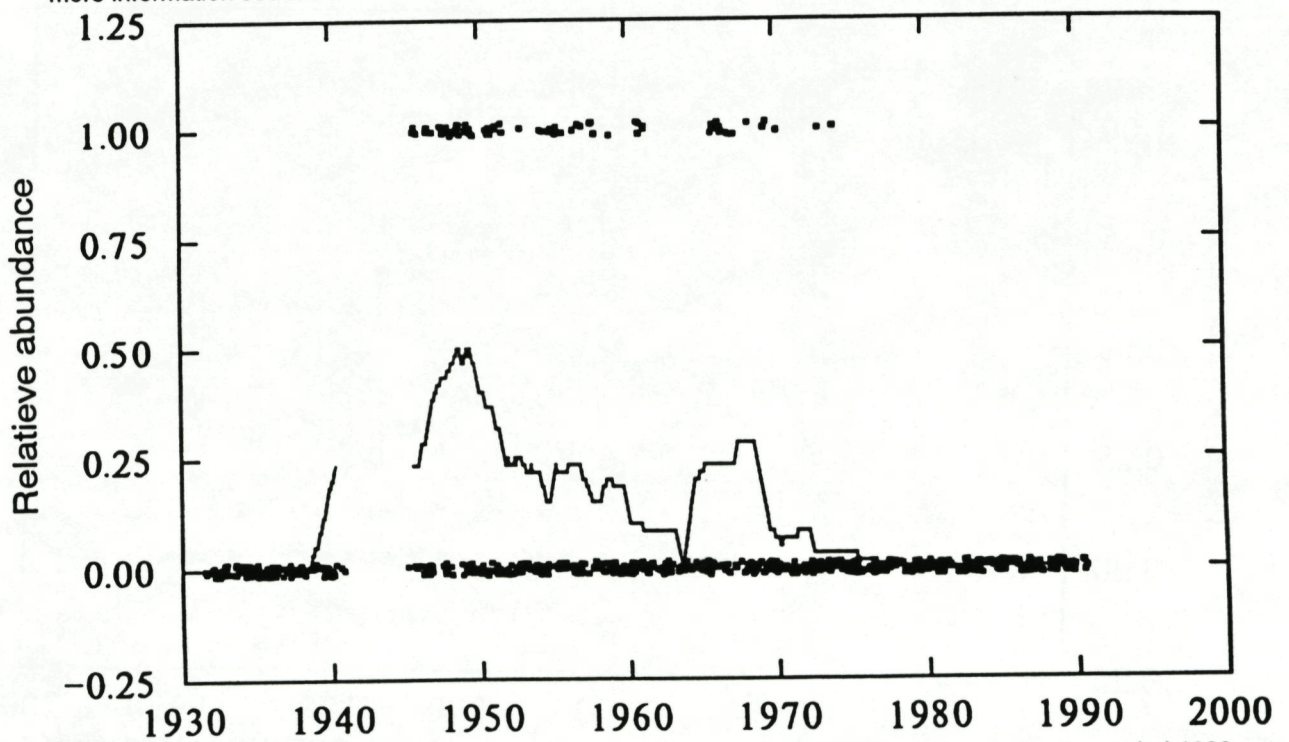


Fig. 6. Frequency of records of the edible crab *Cancer pagurus* in the NIOZ-archive during the period 1930-1990. For more information see text.

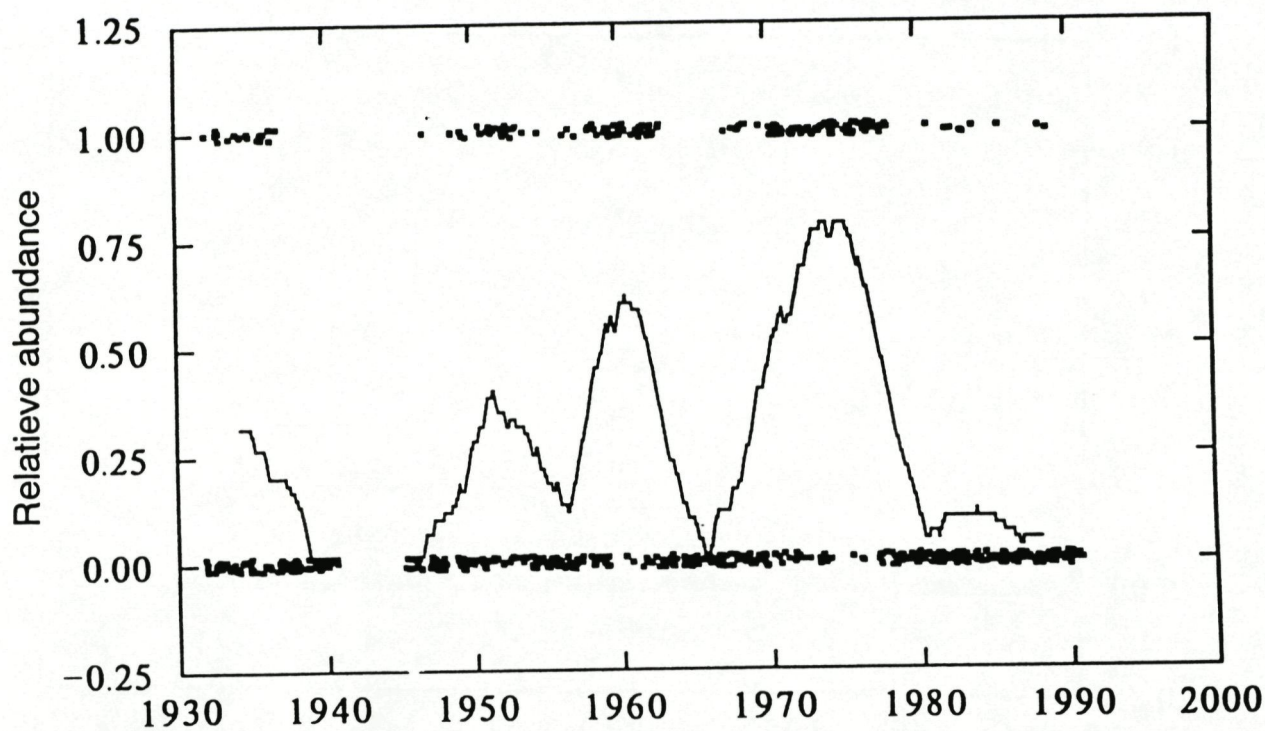


Fig. 7. Frequency of records of the fiddler crab *Macropipus puber* in the NIOZ-archive during the period 1930-1990. For more information see text.

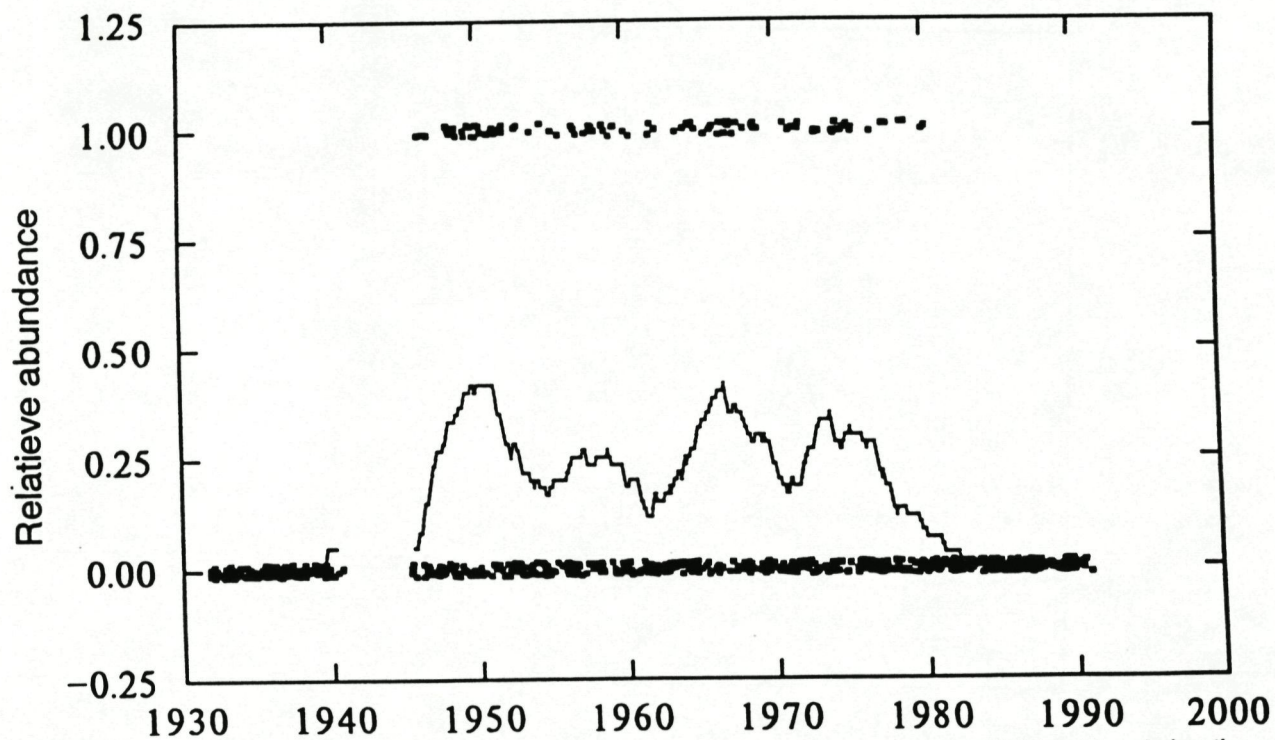


Fig. 8. Frequency of records of the masked crab *Corystes cassivelaunus* in the NIOZ-archive during the period 1930-1990. For more information see text.

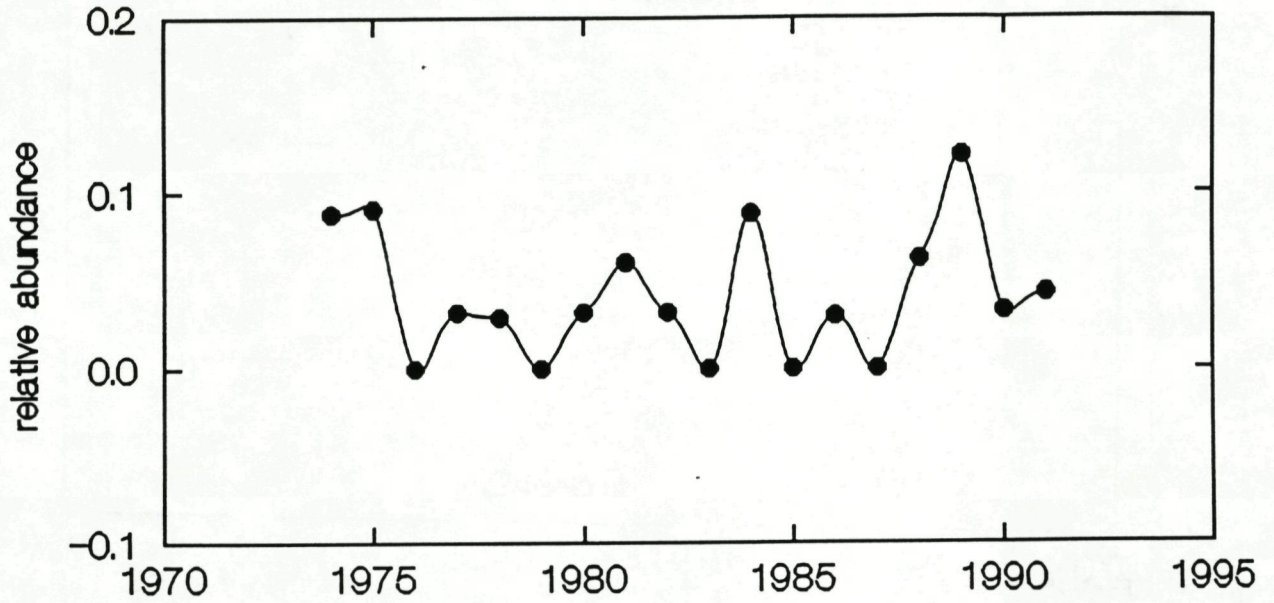


Fig. 9. Fraction of hauls of the RIVO-DLO survey in which the whelk *Buccinum undatum* was present over the period 1973-1991.

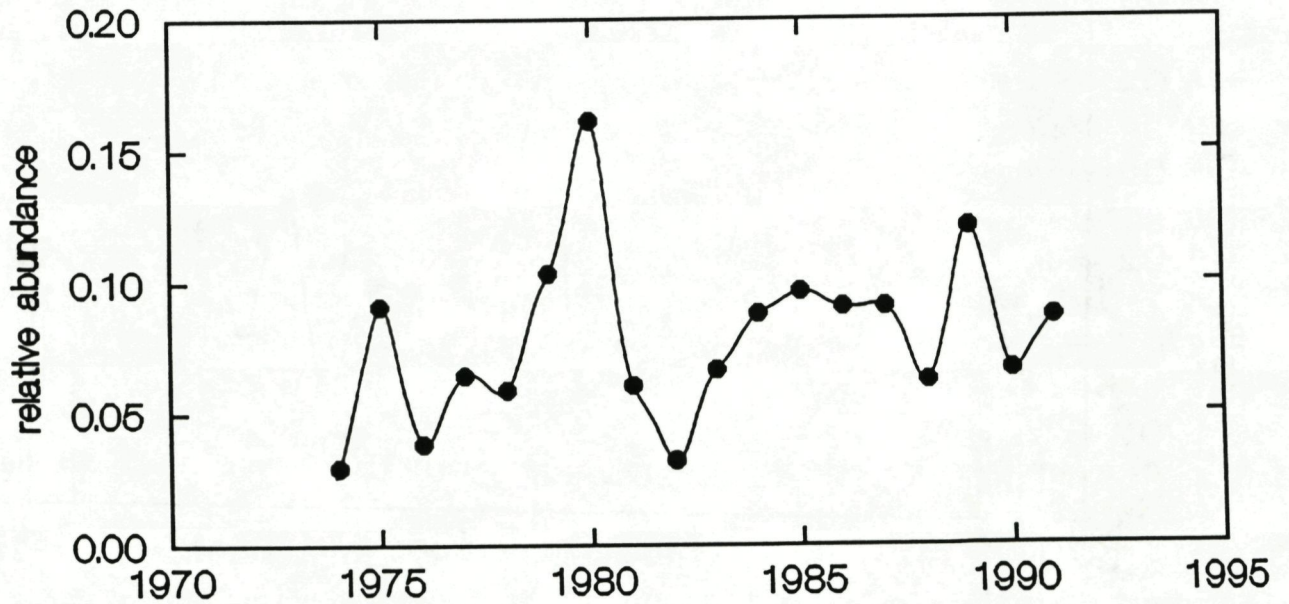


Fig. 10. Fraction of hauls of the RIVO-DLO survey in which the sea mouse *Aphrodite aculeata* was present over the period 1973-1991.

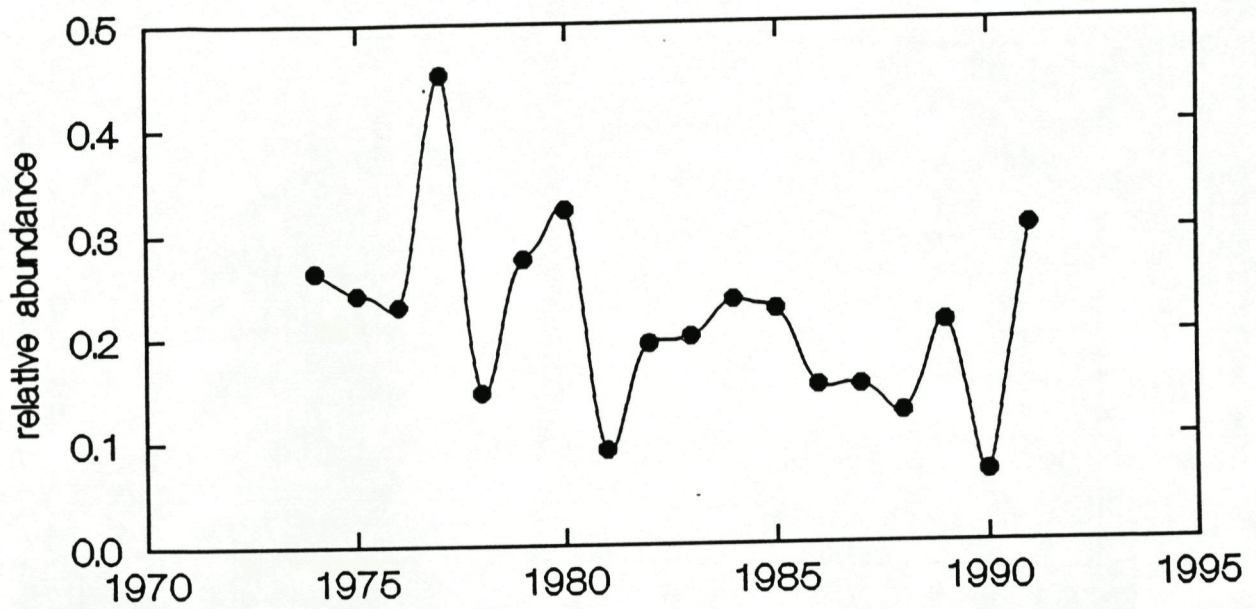


Fig. 11. Fraction of hauls of the RIVO-DLO survey in which the sea urchin was present over the period 1973-1991.

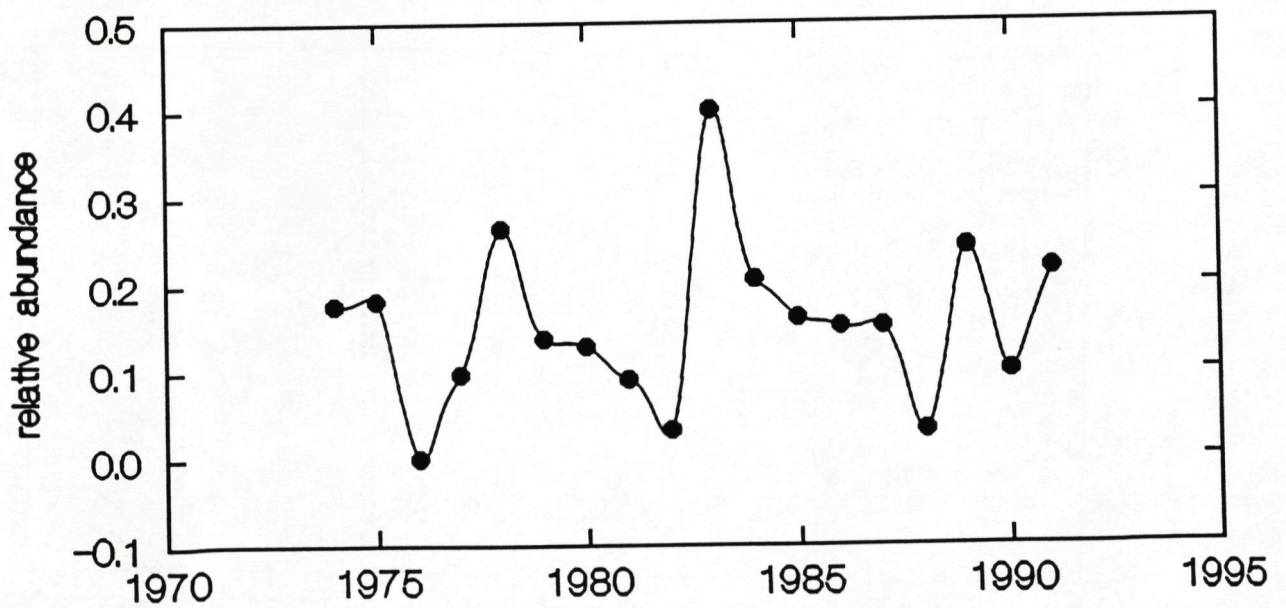


Fig. 12. Fraction of hauls of the RIVO-DLO survey in which the edible crab *Cancer pagurus* was present over the period 1973-1991.

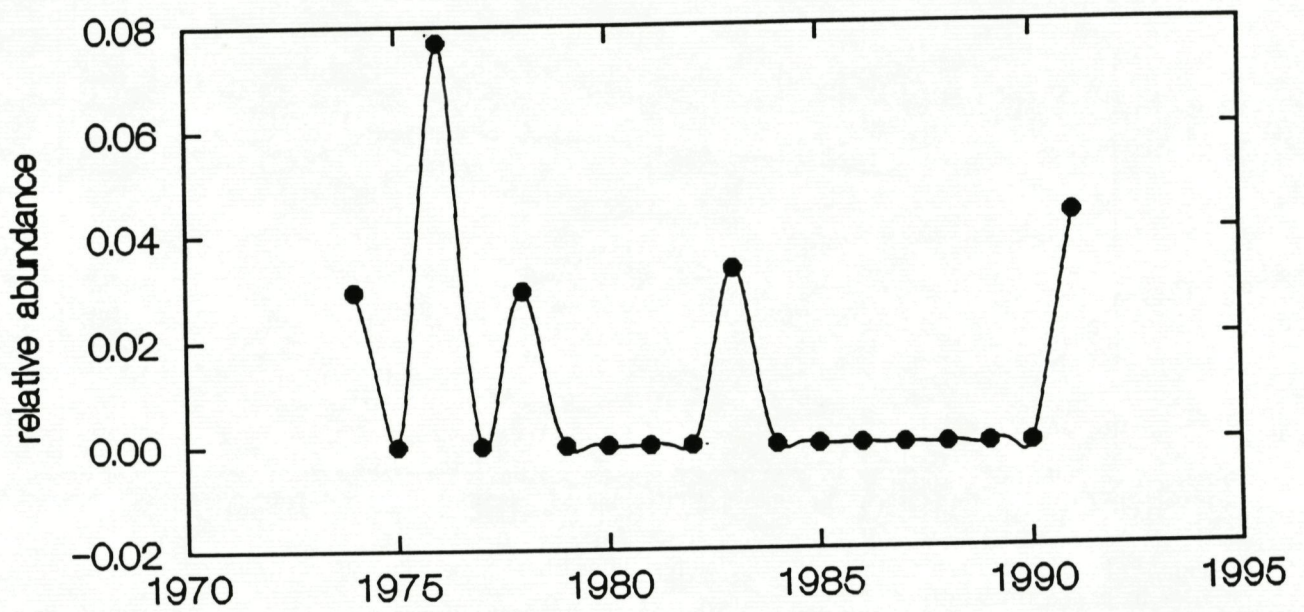


Fig. 13. Fraction of hauls of the RIVO-DLO survey in which the fiddler crab *Macropipus puber* was present over the period 1973-1991.

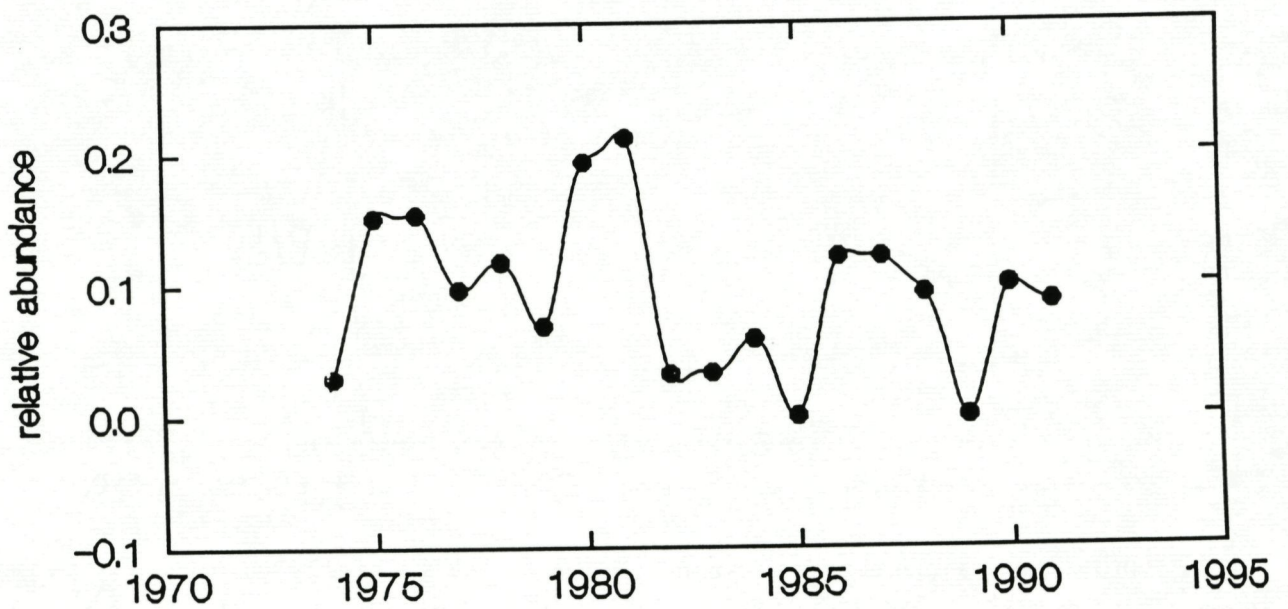


Fig. 14. Fraction of hauls of the RIVO-DLO survey in which the masked crab *Corystes cassivelaunus* was present over the period 1973-1991.

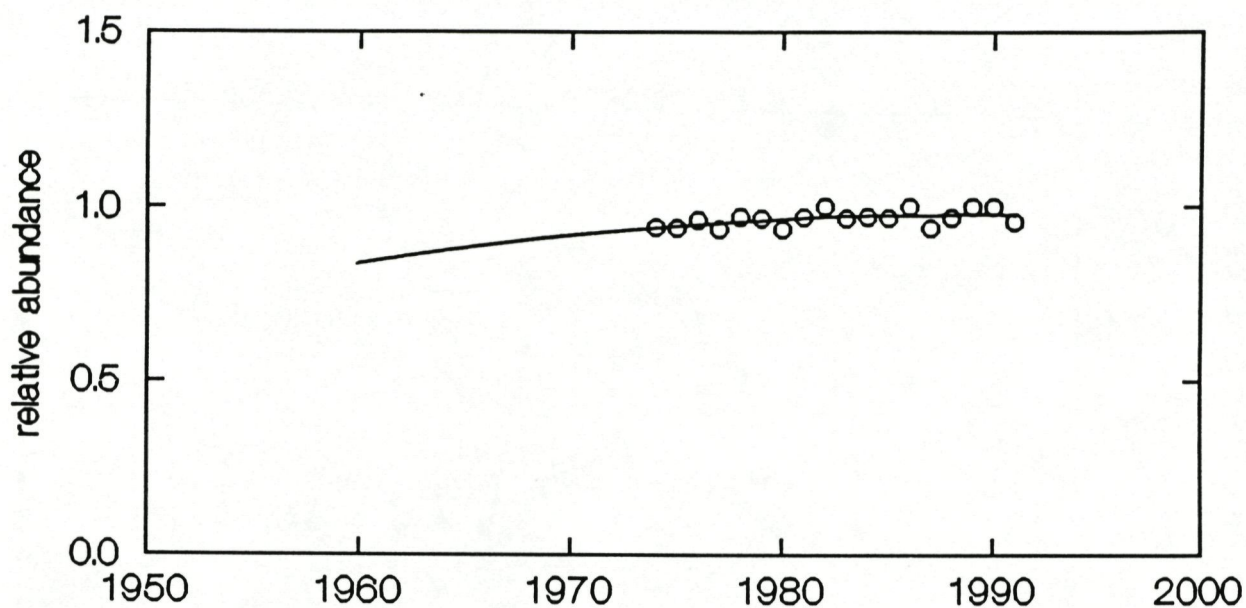


Fig. 15. Fraction of hauls of the RIVO-DLO survey in which swimming crab *Cancer pagurus* was present over the period 1973-1991.

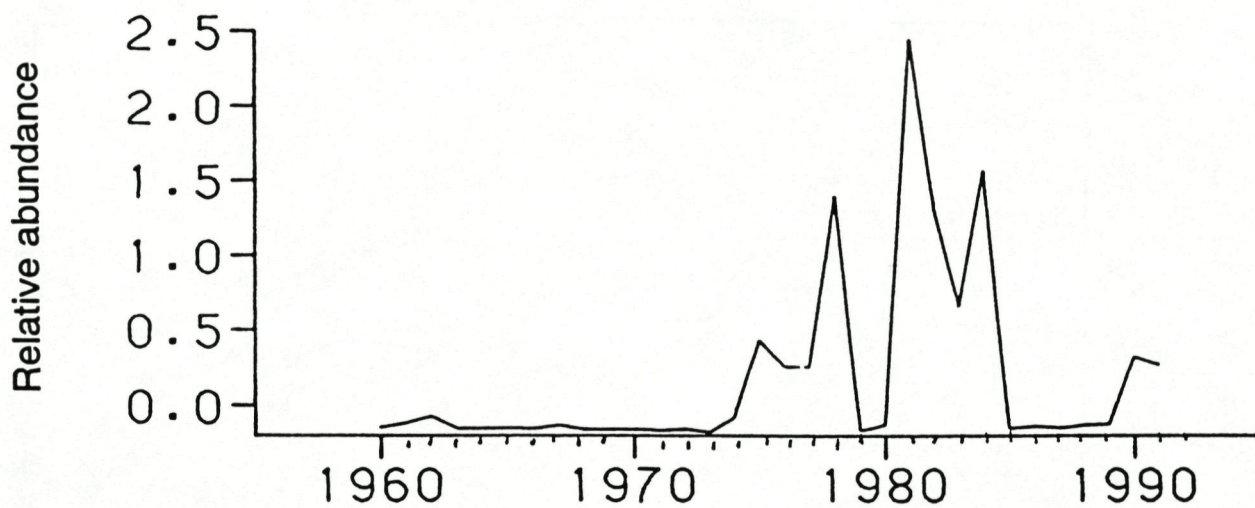


Fig. 16. Relative mean annual catch of the edible crab *Cancer pagurus* in the NIOZ kom-fyke over the period 1960-1991.

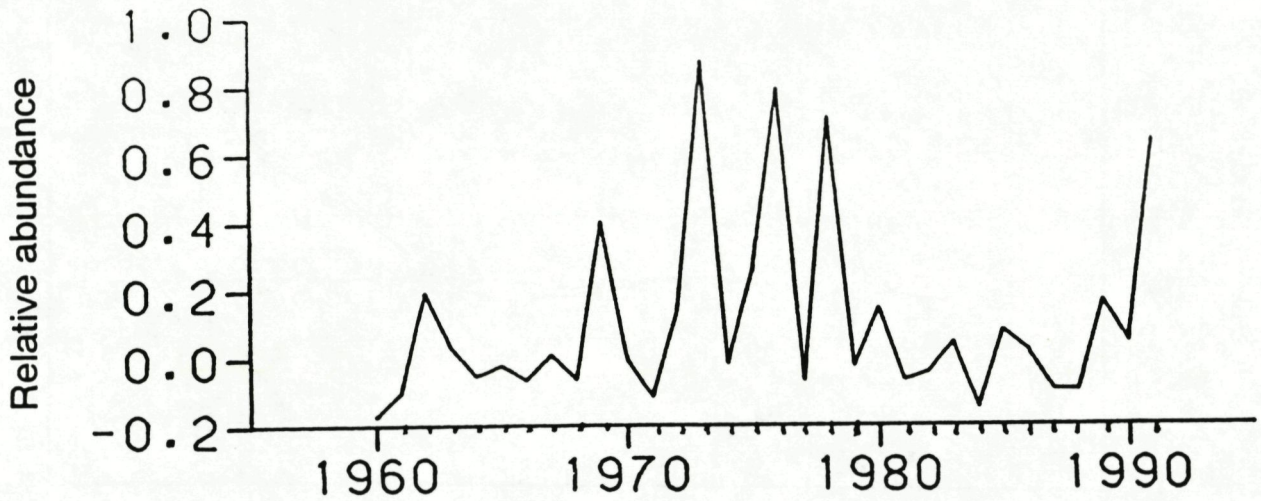


Fig. 17. Relative mean annual catch of the swimming crab *macropipus holsatus* in the NIOZ kom-fyke over the period 1960-1991.

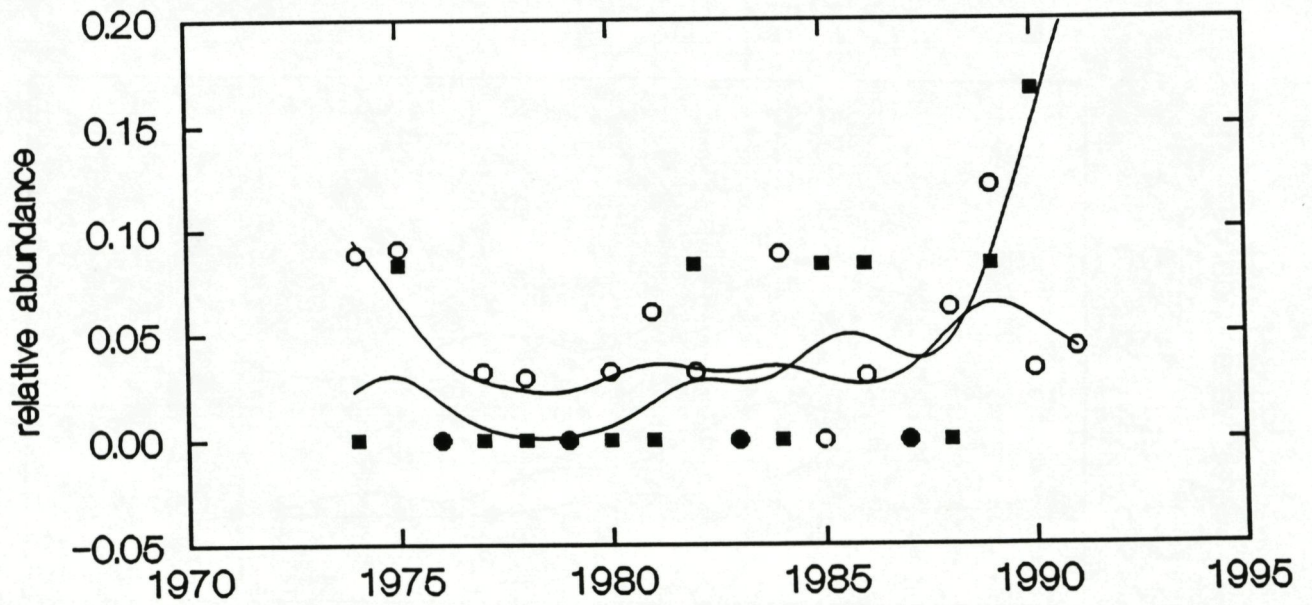


Fig. 18. Comparison of the smoothed trends in the whelk *Buccinum undatum* in the NIOZ-archive (open circles) and the RIVO-DLO by-catches (black squares).

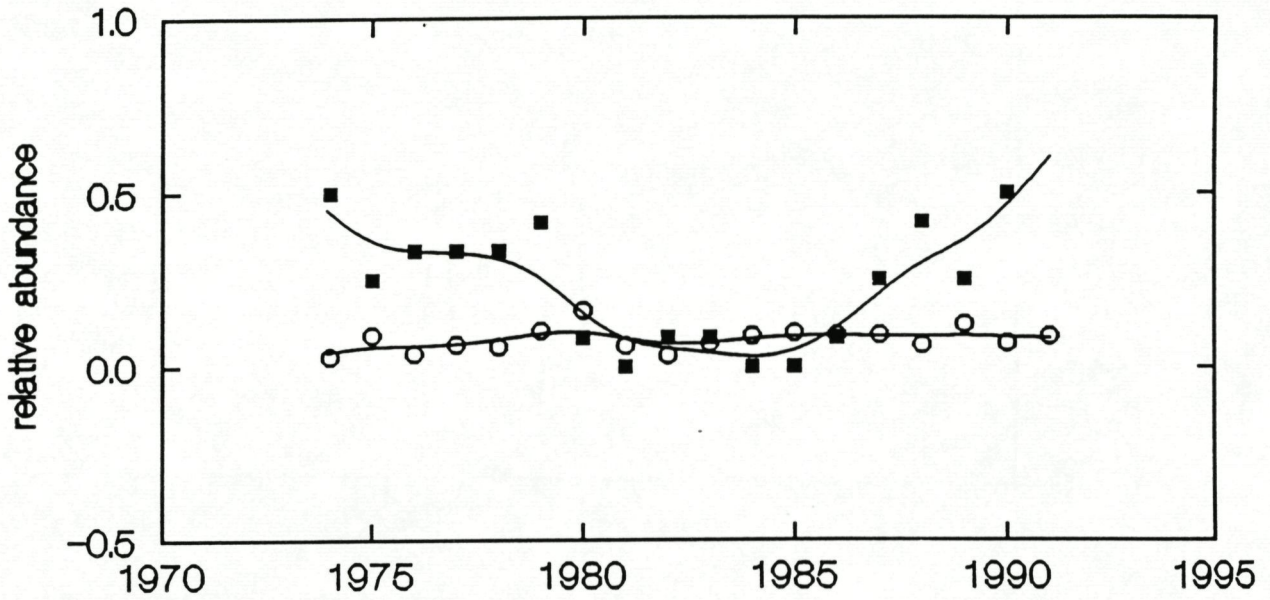


Fig. 19. Comparison of the smoothed trends in the sea mouse *Aphrodite aculeata* in the NIOZ-archive (open circles) and the RIVO-DLO by-catches (black squares).

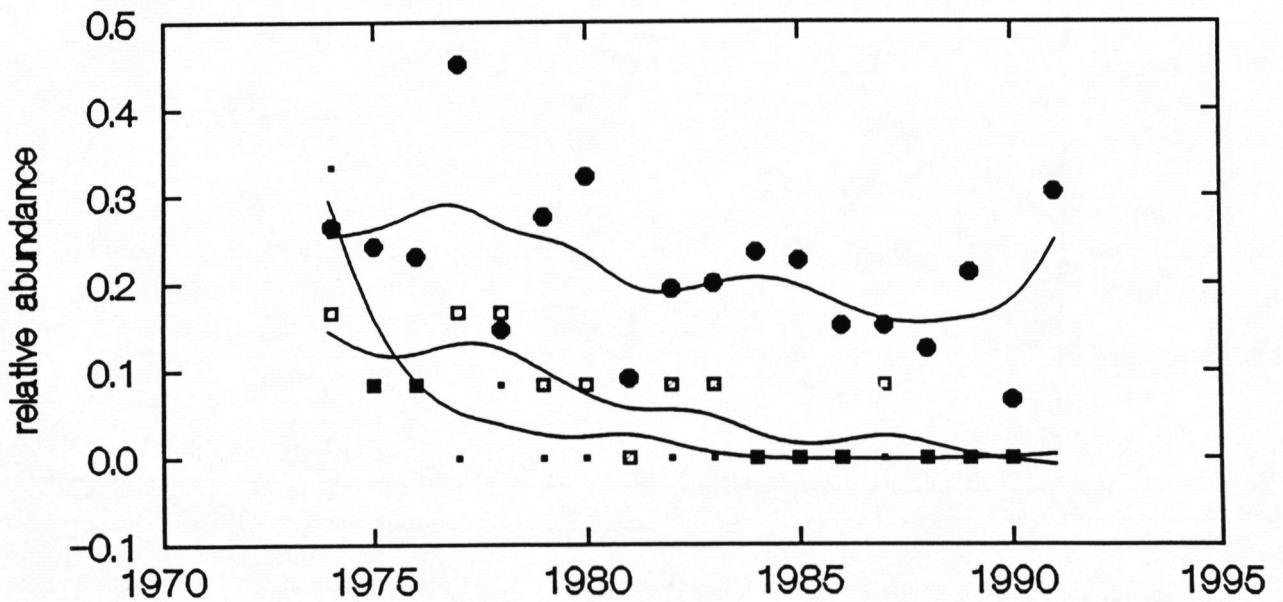


Fig. 20. Comparison of the smoothed trends in the group of sea urchin in the NIOZ-archive (small squares) and the RIVO-DLO by-catches (black circles and large squares).

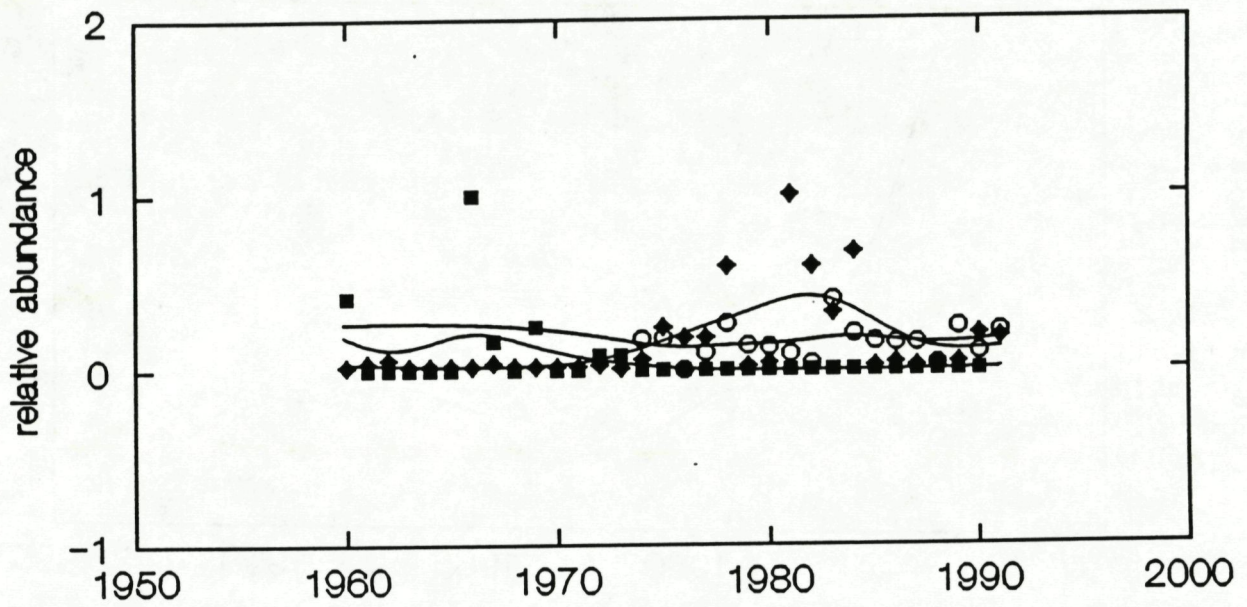


Fig. 21. Comparison of the smoothed trends in the edible crab *Cancer pagurus* in the NIOZ-archive (black squares), the RIVO-DLO by-catches (open circles) and the NIOZ kom-fyke (black diamond).

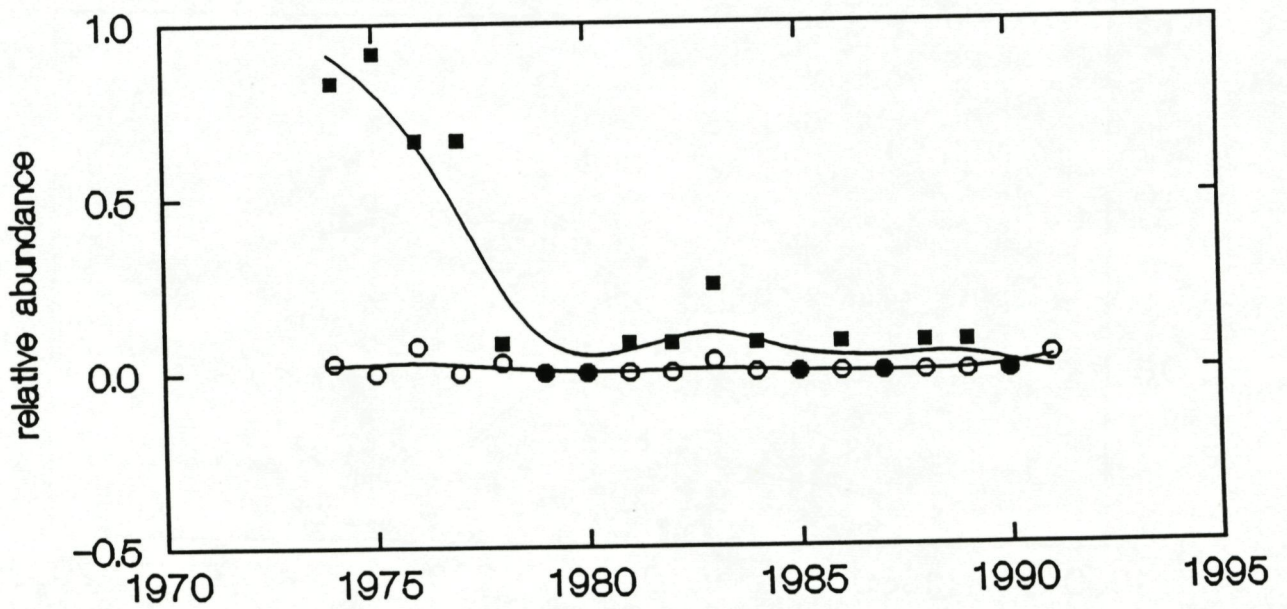


Fig. 22. Comparison of the smoothed trends in the swimming crab *Macropipus holsatus* in the NIOZ-archive (black squares), the RIVO-DLO by-catches (open circles).

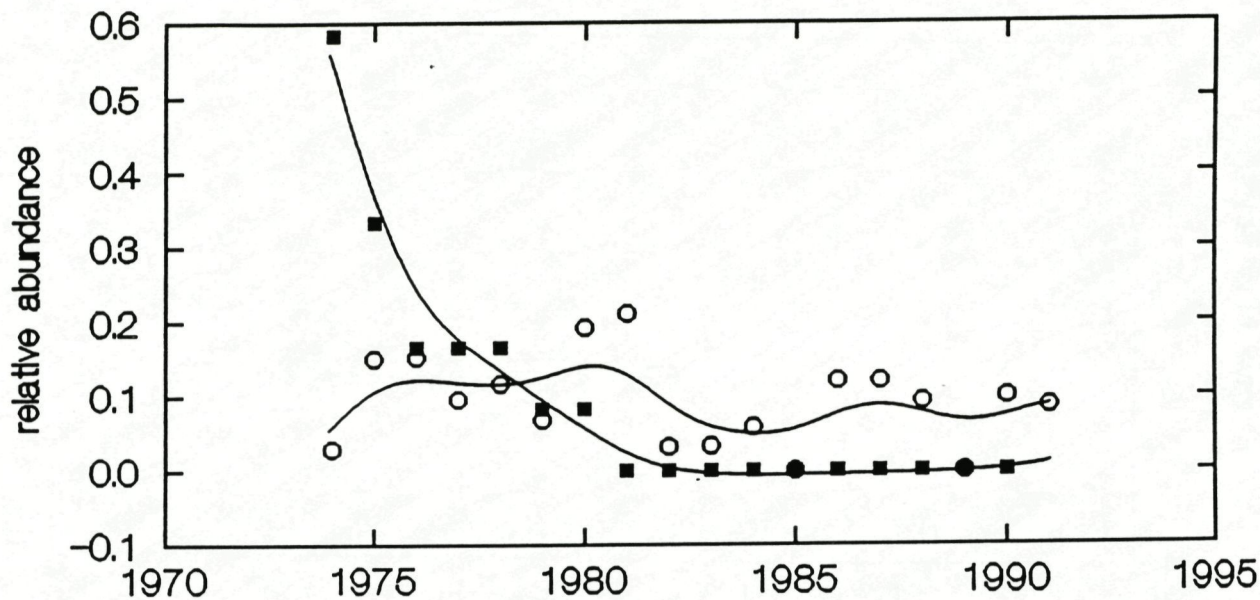


Fig. 23. Comparison of the smoothed trends in the masked crab *Corystes cassivelaunus* in the NIOZ-archive (black squares), the RIVO-DLO by-catches (open circles).

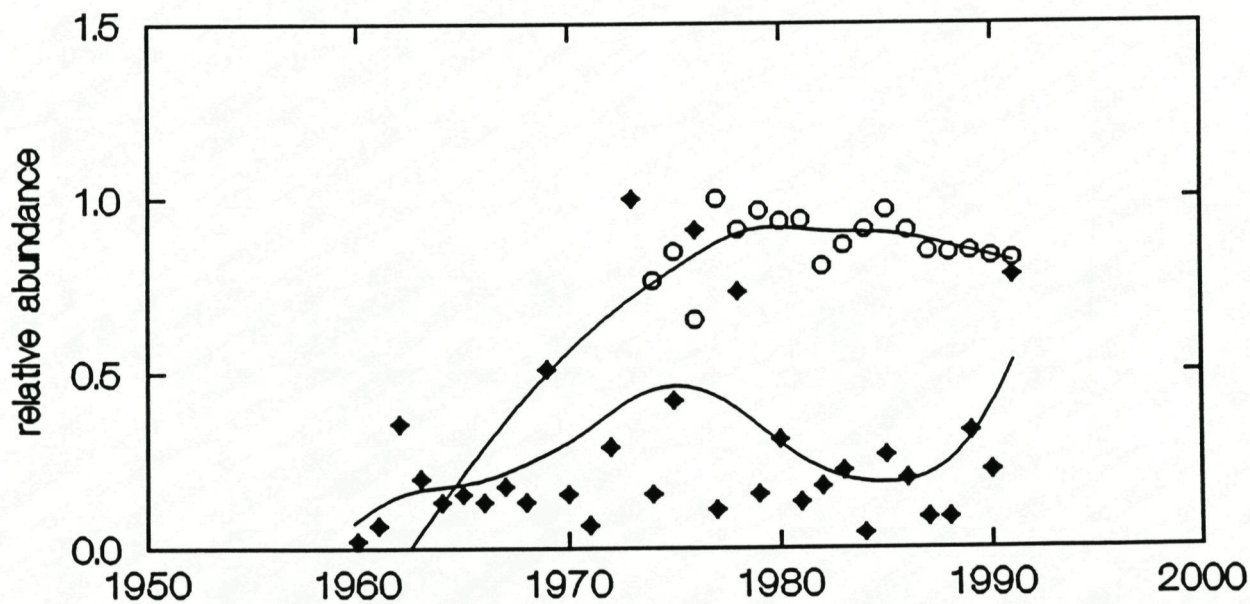


Fig. 24. Comparison of the smoothed trends in the swimming crab *Cancer pagurus* in the NIOZ kom-fyke (black diamond) and the RIVO-DLO by-catches (open circles).

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