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Eelpout as an index of changes, in the fish community in the Gulf of Gdańsk from 1985 to 1999

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ABSTRACT

The results of experimental catches carried out in March from 1985 to 1999 in the Gulf of Gdansk are presented. Since 1985, the number of eelpout (Zoarces vivipar us L.) caught per trawl hour has increased from 0.3 to 373 kg. The fish have also extended their distribution within the area. The variability in spatial distribution was considered with respect to geographical position using the kriging geostatistical method. Ordination made by redundancy analysis (RDA) suggested a strong positive relationship between increased abundance of non-target species, especially eelpout, and the temporal gradient (with a one-year period).

INTRODUCTION

The benthic fish communities of the Gulf of Gdansk are under constant pressure from anthropogenic elements, of which the most significant are fishing and the influence of polluted water which flows into the bay mainly from the Vistula River. Fish communities also undergo natural changes caused by the dynamics of both biotic and abiotic factors in the marine environment. Only a few of the dozens of fish species which are found in the waters of the Gulf of Gdansk are of interest to fisheries; these will be referred to further as target species. Estimating these species' biomass and the dynamics of changes in ther distribution are normally the subject of research efforts. Knowledge of the remaining fish species, which are not of commercial interest, is fragmentary and is limited to sources independent of fisheries.

Eelpout (Zoarces vivipar us L.), a common species in the Gulf of Gdansk, is of marginal importance to Polish fisheries. In the 1930's catches of this fish were estimated to be approximately 50 tons annually, but in 1933 111 tons were caught: After the Second World War until the 1990's, due to a lack in demand, this species was caught only occasionally and was regarded as by-catch. It was recorded in the catch statistics along with other species under the category of "other sea fish" making it impossible to determine the eelpout catch magnitude. Beginning in the mid-1990's, catches of this species began to be recorded exactly. Since then, catches of 100 tons annually have been recorded, with the exception of 1997 when over 260 tons were caught. Studies aimed at estimating the distribution and population sizes of eelpout in the waters of the Gulf of Gdansk based on targeted research catches for determining the distribution of juvenile cod, flatfish, herring and sprat were begun by Draganik and Kuczynski (1993) and Netzel and Kuczyński (1995). These authors noted an increasing percentage of eelpout in research catches from several specimens at the beginning of the 1980's to several hundred kilograms at the beginning of the 1990's.

The current paper, based on data recorded from research catches, is a continuation of those mentioned above. The kriging method has been applied to evaluate changes in the eelpout distribution and population size in the waters of the Gulf of Gdahsk.

MATERIAL AND METHODS

Bottom trawl surveys were performed at 36 fixed stations grouped in 5 regions of the Gulf of Gdansk (Fig. 1). Catches were carried out at depths ranging from 20 to 100m along the isobaths at 1 Om intervals. The surveys were carried out in March each calendar year, except in 1986 and 1993. A detailed description of the P 20/25 herring bottom trawl is presented in Schultz and Grygiel (1984). Its theoretical horizontal opening is 10m, the vertical opening is 4m and the mesh size in the codend is 6 *mm* (bar length). The trawling speed was about 3 knots and the trawling time was 30 minutes. In total, 443 hauls were made in which 122,770 eelpout specimens were caught.

Spatial abundance from a set of samples was estimated by kriging. It is an interpolation method for additive regionalized variables. The interpolation value "y" is expressed as a linear combination of the neighboring values "x_i"

$$y = \sum_{i=1}^{n} a_i * x_i$$

Kriging takes into account the data values, their location and the degree of dependence or correlation between the data points. It also allows the uncertainty associated with each interpolated value to be quantified (Cressie 1991, Goodchild et al 1991). Calculations were done using IDRISI software (IDRISI 1999).

Redundancy analysis (RDA) was used to evaluate the relationships between species abundance and considered environmental variables: depth, time and the geographic location defined as five regions of the Gulf of Gdansk. This multivariate analysis was used due to the length of the first axis in Hill's scaling in detrended correspondence analysis DCA, which reflects the total heterogeneity of the data. (Ter Braak and Šmilauer 1998). The value of this axis length was 2,647 leading to the conclusion that the approximation response of the species to the environmental variables by linear model would be appropriate for the data. Partial RDA was also applied to extract the percentage of variability which can be explained by one set of explanatory variables (Ter Braak and Smilauer 1998). The Monte Carlo permutation test was used to evaluate the significance of both the first axis and relationship with environmental variables. Calculations were done using CANOCO software (Ter Braak and Smilauer 1997).

RESULTS

The results of the investigation of the structure of benthic fish communities in the Gulf of Gdansk, presented in this paper as their percentage in research catches of target and non-target fish species catches, proved to be greatly variable over the course of the investigations. Until 1992, non-target fish species comprised from 5 to 15% of the total weight of the catches. In 1994, a significant rise in the percentage of these fishes was observed in the research catches to a level of 69%. Despite slight declines in the following years, the percentage of non-target fish remained at the constant level of 50 to 60% of the variable total catch mass (Fig. 2). The growth in the percentage of the above mentioned species group was the result of the expansion of one species - the eelpout. During the four-year period from 1992 to 1995, a more than ten-fold increase in the mass of the research catches was recorded. The number of eelpout caught per trawl hour has increased from 0.3 to 373 kg (from 1985 to 1995).

RDA analysis indicates that the first two variance axes on the ordination diagram explain 56% of the total species variance of benthic fish communities in the Gulf of Gdansk during the investigated period (Fig. 4). The temporal factor played the largest role in the variance of benthic fish communities and independently explains 35% of the total variance and all of the factors analyzed were determined to be statistically significant (Table 1). The results of the ordination diagram RDA analysis determined that there is a positive relationship between the increase in abundance of most non-target fish species and the temporal gradient. This relationship was most evident with eelpout, as the linear direction of growth in abundance is the closest to the direction which indicates the passing of years on the RDA diagram. It occurred that the temporal factor is also closely related to a great degree to one of the Gulf of Gdansk geographic locations - Region I. A negative relationship was observed between the temporal factor and such species as plaice and turbot as their abundance decreased with the passing of time. For the remaining two target species, cod and flounder, abundance was most influenced by either the depth factor (cod) or a combination of the temporal and depth factors (flounder).

The eelpout abundance distribution map drawn with the kriging method over several years, indicates that this fish species has expanded over time in the Gulf of Gdansk (Fig. 5). Until the end of the 1980's, the eelpout density indicators did not exceed the level of 50 specimens/ha. At the beginning of 1992, the value of the density indicators rose to above 1,250 specimens/ha. Simultaneously, the increase in abundance was accompanied by a widening of the area of occurrence of the analyzed species; the 1995-1997 period was the apogee of this during which the eelpout area of occurrence included 86% of the research area reaching depths of 90m. The largest concentration of fish were found in the geographical region of the Gulf of Gdansk marked with symbol I, partially in the region marked II and from 1988 in region V. The largest concentrations of eelpout moved between these two regions in certain years. In 1996-97 and 1999 high density indicators were also detected in region III, in its shallow part (to 50 m.).

DISCUSSION

The structure of benthic fish communities in the Gulf of Gdansk underwent changes during the investigation period (1985-1999s) mainly due to the expansion of eelpout, a species which is not under great fishing pressure. Although not as pronounced, a similar trend was observed by Heessen and Daan (1996) from 1970 to 1993 in North Sea fish communities; the percentage of non-target species in catches rose while the percentage of target species either fell or remained on a stable level. This leads to the conclusion that fisheries exploitation is one of the deciding factors influencing the state of fish communities (Dufour *et al*. 1995). This may cause changes in the exploited system by "pushing" it from one stable level to another, with a different species composition that is better adjusted to the environment and less affected by predatory pressure, including fisheries (8eddington 1984). From an economic point of view, this process is not beneficial for fisheries if the species which is expanding has little or no commercial value. The 15-year research period, upon which the results presented in this paper are based, is too short to draw conclusions regarding permanent changes taking place in the structure of the benthic fish communities in light of the rise of the percentage of eelpout in the catches. In the 1930's a similar situation occurred when catches of eelpout reached 111 tons (Anon 1936), followed by a fall two years later to 31 tons The variance in eelpout abundance was probably caused by the intense exploitation of the species forced by the periodic disappearance of sprat. It cannot be ruled out that eelpout abundance fluctuated greatly in the Gulf of Gdansk during the post-war period. This mat not have been registered due to a lack of interest in this species on the part of the fisheries or from the lack of information coming from standardized research catches independent from fisheries (conducted since 1962).

Similar to the situation in the 1930's when the role of predator was played by intensive fishing exploitation, the increase in the resources of this species in the Gulf of Gdansk in the 1990's can be explained as the result of decreased pressure from cod whose abundance began to drop in the late 1980's (Anon 1999). This is, however, quite a far-flung hypotheses and collecting reliable data to prove it would be difficult. Eelpout has rarely been identified as a component of the cod food base. Chrzan (1962) and Reimann (1955) did not confirm this species in the stomachs of cod they investigated. Zabchowski (1985) reported that the percentage of eelpout in the food base of cod is minimal. However, the same author reported (Załachowski et al 1990), that 14,700 tons of eelpout fell prey to cod in 1987. The majority of material presented in these papers originates from traditional cod fishing grounds in regions that are not eelpout habitats. In order to verify this last ascertation, a spatial distribution map of cod > 25cm *l.t.*, i.e. predators which could play a role in regulating the size of the eelpout stocks. The results of the comparative analysis of the distribution maps indicate that the highest concentrations of cod > 25cm *l.t.* in the Gulf of Gdańsk in the investigated period were located in different regions than the largest concentrations of eelpout (Fig. 6).

The influence of natural factors, biotic and abiotic, on the structure of the fish groups operate in such a variety of ways that, without exact data, it is best to express their net value in the form of the time gradient. The results of primary production investigations (Renk 1997) are especially cited at this point in the paper. Renk reports that from 1970 to 1996 a rise in primary production and plankton biomass took place in the Gulf of Gdansk. This is one of the factors, which indirectly -through trophic interdependencies – may have an effect on the structure of fish communities. Fishing exploitation in the basin is, however, a factor which complicates the relation between the evolved fish groups and the environment (Mahon and Smith 1989). The changes in the structure of fish groups observed in the current work are probably due to the influence of a combination of natural and anthropogenic factors which have created optimum conditions for the expansion of eelpout. The growth in the population of this species in the Gulf of Gdańsk has begun to interest commercial fisheries. With the low profitability of other, more valuable species, it can be expected that eelpout will become a target species.

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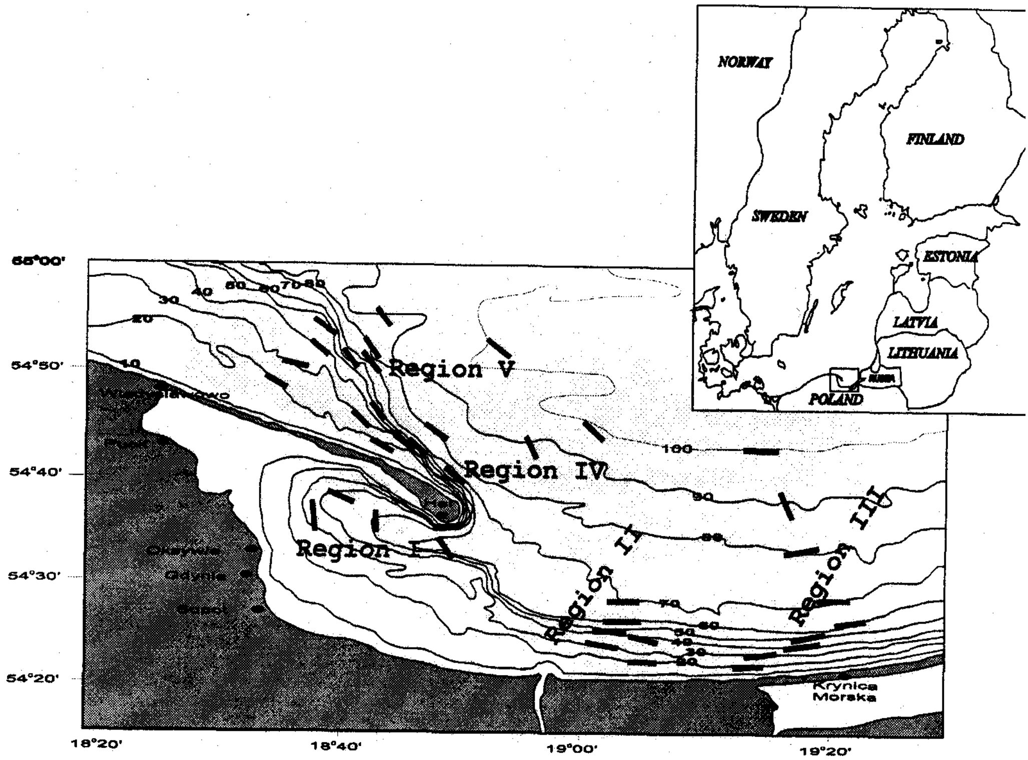
References

Anon. 1936. Polskie Rybołowstwo Morskie VI (1933-1935). Sprawozdanie Morsk.Urzędu Ryb. I Morsk.Inst.Ryb., Gdynia.
Anon. 1999. Report of the Baltic Fisheries Assessment Working Group ICES C.M. 1999/ACFM: 15
Beddington, J.R. 1984. The responces of multispecies systems to perturbations [In]: Exploitation of Marine Communities. R.M. May (ed.). Life Science Research Report 32, Springer-Verlag, New York.
Chrzan, F. 1962. Pokarm i odzywianie sig dorsza w Zatoce Gdanskiej. Pr.Mor.Inst.Ryb. Gdynia, 9: 7-44
Cressie, N.AC., 1991. Statistics for Spatial Data. John Wiley&Sons Inc. New York.
Draganik, B., J.Kuczyński 1993. Spatial distribution of the flounder and viviparous eelpout in the insore waters of the Gulf of Gdansk. ICES C.M. 1993/ J:13
Dufour, V., J.-Y. Jouvenel, R.Galzin 1995. Study of Mediterranean reef fish assemblage. Comparisons of populations distributions between depths in protected and unprotected areas over one decade. Aquat. Living resour. 8: 17-25.
Goodchild, M., D.J.Maquire, D.W.Rhind 1991. Geographic Information Systems. Principles and Applications. Longman Scientific&Technical, New York,
Heedden, H.J.L., N.Daan, 1996. Long-term trends in ten non-target North Sea fish species. ICES J.Mar.Sci. 53: 1063-l 078.
IDRISI 1999. IDRISI 32 v.32.01. Programme for Geographic Information System. Clark Labs, Clark University, USA.
Mahon, R., R.W.Smith 1989. Demersal fish assemblages on the Scotian Shelf, Northwest Atlantic: spatial distribution and persistence. Can. J. Fish. Aquat. Sci. 46: 134-152.
Netzel, J., J.Kuczyński 1995. The abundances of flounder (P.flesus L.) and eelpout (Z.viviparous L.) in the Gulf of Gdańsk area estimated by swept area method. ICES C.M. 1995/J:30
Reimann, Z. 1955. Odzywianie się i pokarm mtodocianego dorsza (Gadus callarias L.) poludniowego Bałtyku. Pr.Mor.Inst.Ryb. Gdynia, 8: 171-l 86.
Renk, H. 1997. Produkcja pierwotna Zatoki Gdanskiej. Wyd. Uniw.Gdańskiego, Gdansk.
Schultz, N., W.Grygiel 1984. First results of intercalibration of young fish trawls used in the Baltic Sea by GDR and Poland. ICES C.M. 1984/ J:6
Ter Braak, C.J.F., P. Smilauer 1997. CANOCO for Windows v.4.02. Centre for Biometry Wageningen CPRO-DLO, Wageningen, The Netherlands.
Ter Braak, C.J.F., P. Smilauer 1998. Reference Manual and User's Guide to Canoco for Windows. Microcomputer Power, Ithaca, USA.
Zaiachowski, W. 1986. Amount and composition of food of cod (gadus morhua), in the southern Baltic in 1977-l 982. Acta Ichthyol. Piscat. 15 fasc.2: 95-115
Zaiachowski, W., J.Szypuła, S.Krzykawski, I.Krzykawska, 1990. Zależności troficzne pomiedzy głównymi gatunkami ryb uzytkowych w południowym Bałtyku w latach 1986-1989 (synteza). Akademia Rolnicza w Szczecinie, Instytut Ichtiologii [mimeo].

TABLE 1
The explained variability and the results of test of significance of explanatory environmental variables

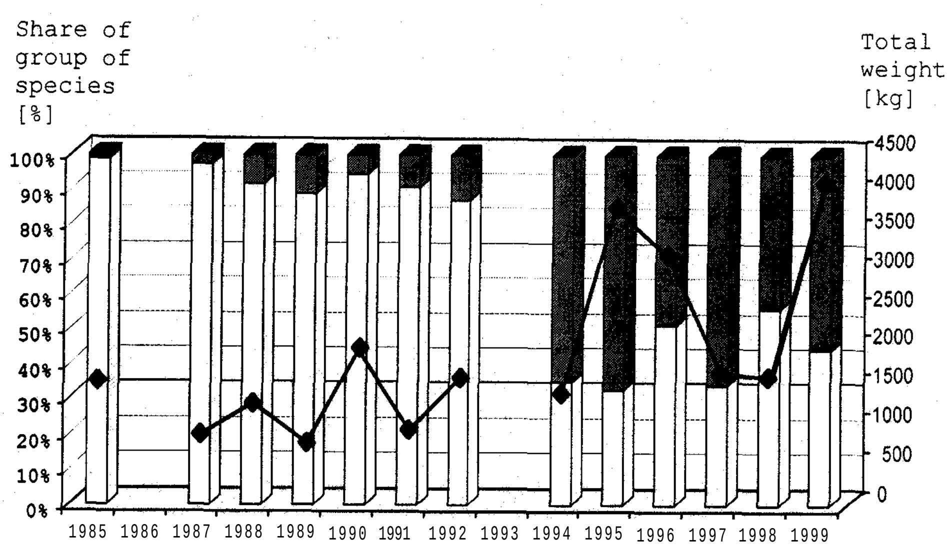
Environmental variable	Variability explained [%]	P
Time	35	<0,05
Depth	14	<0,05
Region	7	0,03
SUM	***56***	



Study area

Locality of samples

Fig. 1 Map of the Gulf of Gdańsk with trawling locations



Fish species

Non-target

Target

◆ Total biomass

Fig.2 Total weight and share of group of fish species recorded in the experimental bottom trawl catches in Gdańsk Bay in 1985-1999

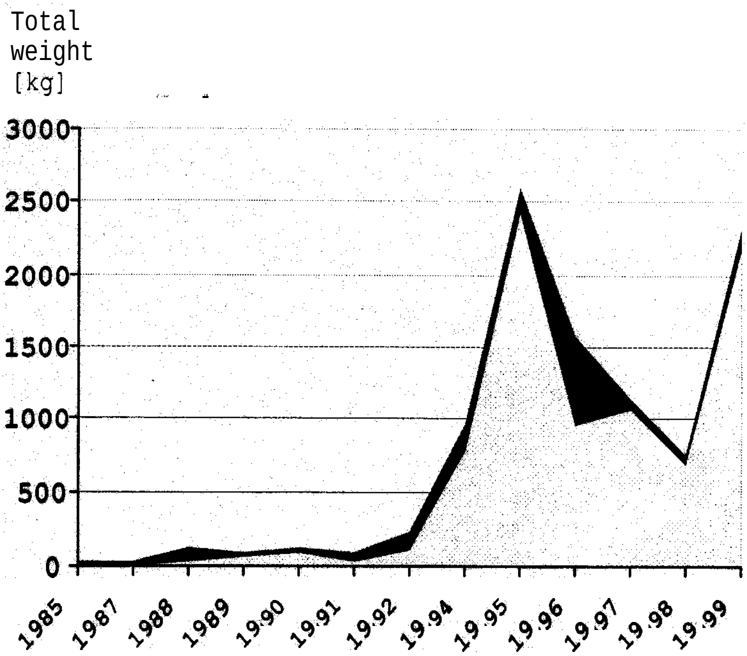
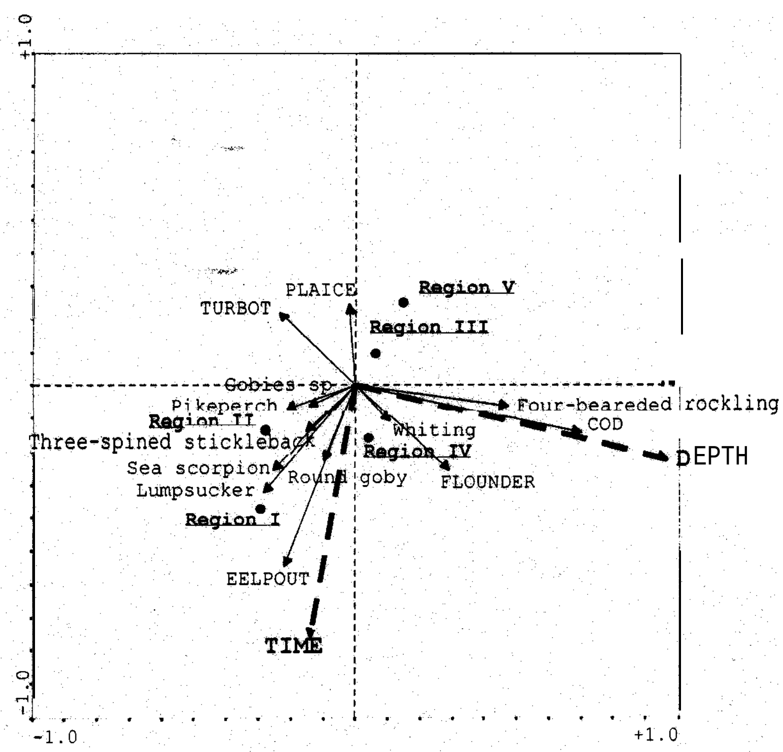


Fig.3 Total weight of non-target fish species and eelpout recorded in the experimental bottom trawl catches in Gdańsk Bay in 1985-1999



Considered environmental factors:

● Region II Qualitative variable (regions of Gulf of Gdańsk)

Quantitative variables (time and depth)

Fig. 4 Ordination diagram of the RDA

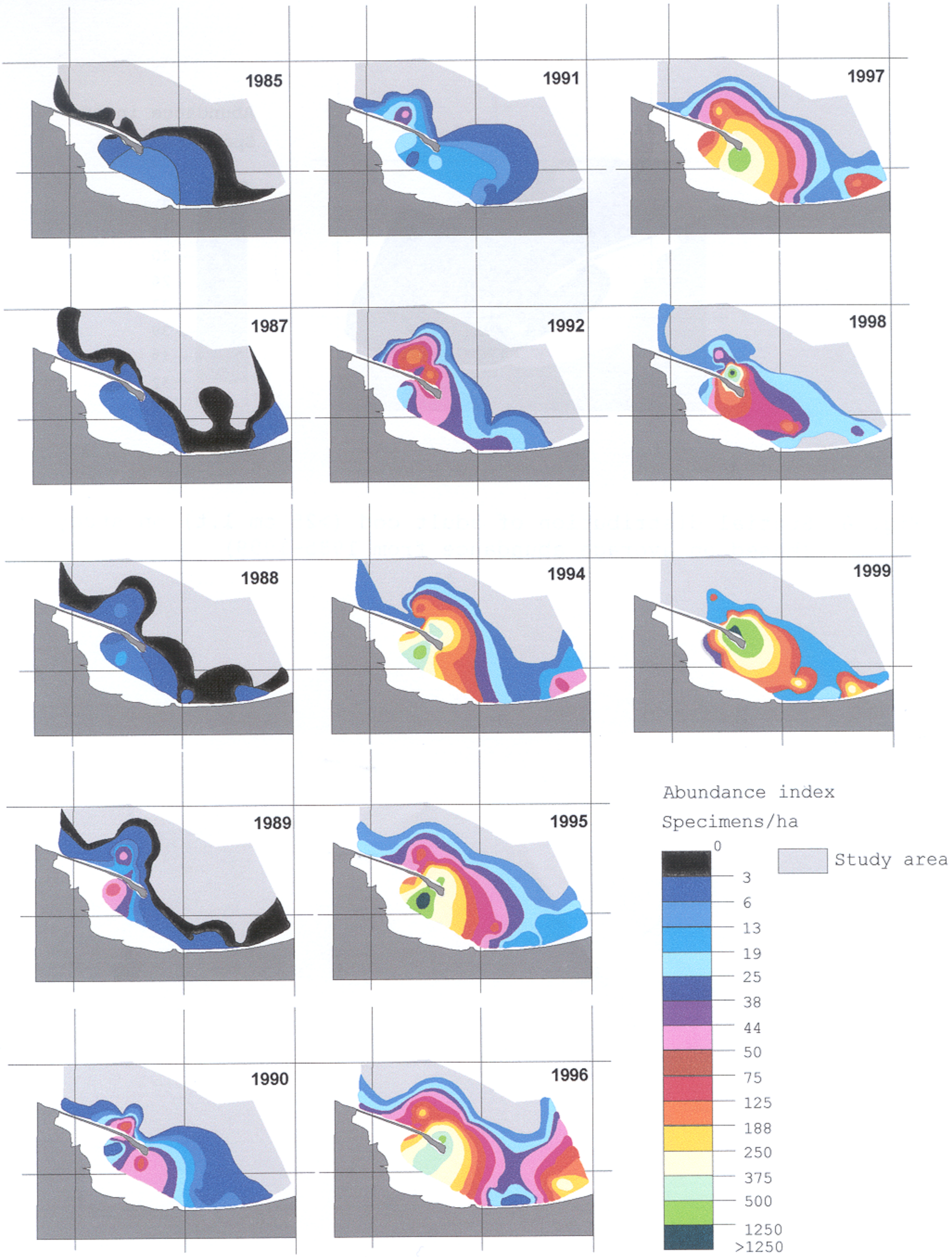


Fig. 5. Eelpout spatial distribution in the Gulf of Gdańsk in 1985-1999

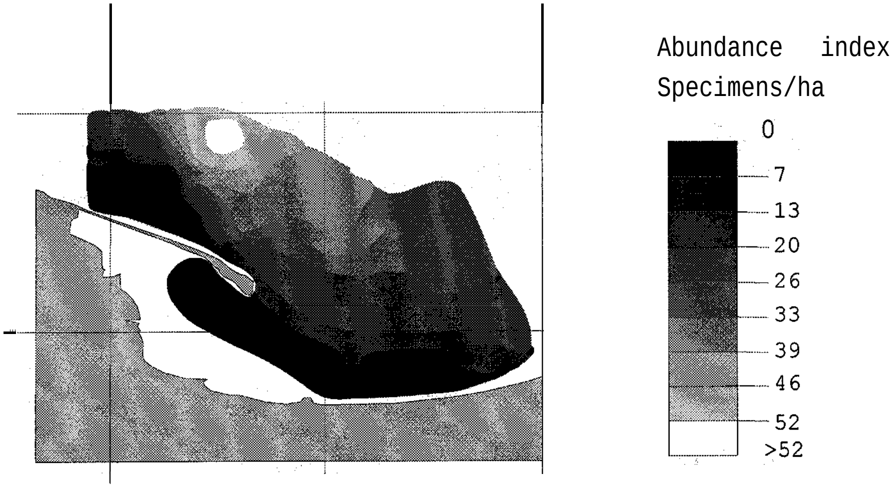


Fig. 6 Spatial distribution of adult cod (>25 cm l.t) on study area
(based on average abundance from 1985-1999)