Acta Adriat., 29 (1/2): 161—170 (1988)

YU ISSN: 0001—5113
AADRAY

UDK: 639.2 (262.35)
Original scientific paper

MULTIVARIATE ANALYSIS OF THE COMMERCIAL FISHERY OF THE NORTHWESTERN COAST OF GREECE, 1964—1981

MULTIVARIJANTNA ANALIZA KOMERCIJALNOG RIBOLOVA SJEVEROZAPADNIH OBALA GRČKE, 1964—1981.

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The fishery of the northwest coast of Greece is reviewed for 1964—1981. The mean annual (1964—1981) total catch amounted 1692 tons. Fish accounted for 96.2% whereas the proportion of cephalopods and crustaceans was very low, 2.1% and 0.8% respectively. Pilchard (*Sardina pilchardus*) dominated the landings with a mean annual catch of 440.5 tons, or 26% of the grand total. Pickarel (*Spicara* sp.) and horse mackerel (*Trachurus* sp.) made up 26% and 18.4% of the grand total respectively. Landings were analysed using complementary clustering and ordination techniques (multidimensional scaling). The analysis indicated that the composition of the catch changed greatly from 1964—1971 to 1972—1981. Two main groups were indicated by both techniques: 1) pickarel, anchovy, hake, blue-whiting, flatfish, bogue, salema and chub mackerel, which are characterized by an increase in the catches and relative proportions during 1972—1981 as compared to 1964—1971, and 2) red pandora, grey mullet, red and stripped mullet, pilchard, horse mackerel, crustaceans and cephalopods, which are characterized by a decline in the catches and the relative percentages in 1972—1981 as compared to 1964—1971. It is rather probable that large-scale changes in the hydrometeorology of the Mediterranean Sea, described by many authors, are rensponsible for this shift in the species composition of the catch.

INTRODUCTION

Available information on the fishery of the western coast of Greece is limited to data for the Patraikos Gulf and the lower part of the Ionian Sea (subarea 05, Fig. 1) (Stergiou, 1986a; Papaconstantinou *et al.*, 1987; Stergiou *et al.*, in press). In the present study, which is part of a review of the fishery in Greek waters undertaken by the author, information pertinent to the composition of the fishery, by main commercial species group, of the northwestern coast of Greece (Ionian Sea: subareas 03 and 04, Fig. 1), during 1964—1981, is presented and analyzed using multivariate techniques (cluster and ordination analysis). Data are taken from the National Statistical Service of Greece (1968—1985). This, together with data on the fishery of the Adriatic Sea and the remaining part of the Ionian Sea, will ultimately contribute to the understanding of the factors responsible for spatial aid temporal changes of fisherö resources and will enable us to make decisions for rational management.

MATERIAL AND METHODS

Data sources

The data to be analyzed here are time series of annual catches in subareas 03 and 04 (Ionian Sea, Fig. 1) taken from the National Statistical Service of Greece (1968—1985, 15 issues). Fishery catch statistics in Greek waters has been maintained on a monthly basis since January 1964 by the Statistical Service of Greece. For a better evaluation of the available data, the Greek waters have been divided into 16 fishing subareas, 03 through 18 (Fig. 1). Subareas 01 and 02 refer to the Atlantic ocean and the north coast of Africa respectively. Data are collected for each fishing vessel separately through the local custom authorities. For each vessel, a statistical questionnaire is provided showing the quantity of fish caught during the previous month (or that the vessel did not work). The catches of the inland waters and sport fisheries are not included in the grand total. In addition, since 1969, the catches of the small ring-netters, drifters and liners, with engine horse power less than 19HP have not been recorded by the local authorities (S t e r g i o u, 1986a).

Mutlivariate analysis

In order to identify any changes in the species composition of the fishery in subareas 03 and 04, multivariate analysis was performed, based on the general strategy proposed by F i e l d *et al.* (1982). The strategy involves logarithmic transformation of the data, construction of similarity matrices, and complementary clustering and ordination technique (multidimensional scaling). If the results of the two methods agree then discontinuities may be accepted as real (F i e l d *et al.*, 1982). Clustering was based on group average sorting, ordination on Kruskal's stress formula (K r u s k a l, 1964). Both techniques are based on logarithmically transformed biomass data and the Kruskal-Wallis measure of similarity (L e l a n d, 1986). Ordination was first performed in 3 dimensions and the resulting stress was used as a starting point for ordination in two dimensions. The adequacy of the ordination representation in 2 dimensions was checked by comparing the decrease in stress passing from 1 to 2 and 3 dimensions, and by checking the Shepard diagram (F i e l d *et al.*, 1982). Normal (years arranged into groups) and inverse (species arranged into groups) analyses were performed. Statistical analysis was conducted using the SYSTAT Statistical Package for IBM PC/ET.

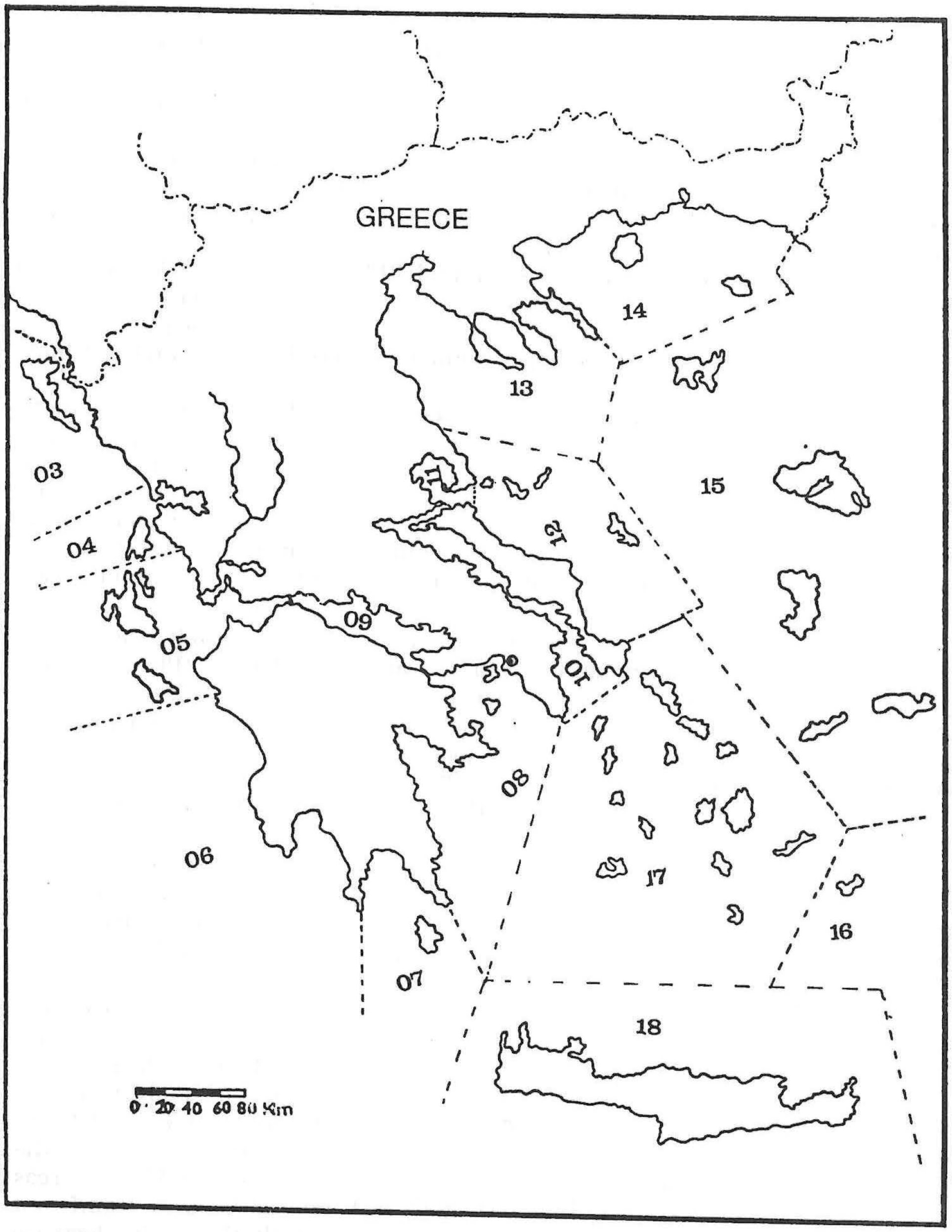

Fig. 1. Map showing fishing subareas in Greek waters.

RESULTS AND DISCUSSION

The mean annual (1964—1981) total catch amounted to 1692 tons (Table 1). The mean annual catch of subarea 04 (1021 tons) exceeded that of subarea 03 (626 tons) by a factor of 1.6 (Table 1). Fish made up the major part of the grand total, accounting for 96.2% or 1628 tons. The proportion of cephalopods and crustaceans was very low, 2.1% and 0.8% recpectively. Pilchard *(Sardina pilchardus)* dominated the landings in the area with a mean annual catch of 440.5 tons, or 26% of the grand total. Pickarel *(Spicara* sp.) and horse mackerel *(Trachurus* sp.) made up 26% and 18.4% of the grand total respectively (mean annual catch: 440.1 and 312 tons). Bogue *(Boops boops)* and salema *(Sarpa salpa)* represented 6.9% or 117.6 tons annually (Table 1). Hake *(Merluccius merluccius)*, blue whiting *(Micromesistius poutassou)*, red pandora *(Pagellus erythrinus)*, stripped mullet *(Mullus barbatus)* and red mullet *(Mullus surmuletus)* represented a minor part of the total catch, 127 tons annually (7.5%). This must be related to the minor role of trawlers for both areas mainly due to the restricted continental shelf of the region. In general, trawlers account for less than 15% of the total catch in subarea 03, where the main part of the catch is attributed to seiners and other coastal boats. In subarea 04, less than 8% of the grand total is fished with trawlers. Here, the main part of the catch is attributed to purse-seiners (about 40%), seiners (about 26%) and other coastal boats (about 26%) (Stergiou, unpublished data).

The catches in subarea 05, for 1964—1981, have been compiled by Stergiou (1986a). The mean annual catch in that area amouted to 2210 tons, 44.4% of which was attributed to purse-seiners, 35% to trawlers, 11.5% to seiners and 12.6% to other coastal boats. Pilchard *(Sardina pilchardus)* and anchovy *(Engraulis encrasicholus)* made up 40% (850 tons) of the total catch, whereas hake *(Merluccius merluccius)*, blue whiting *(Micromesistius poutassou)*, red pandora *(Pagellus erythrinus)*, and *Mullus* sp. amounted to 240 tons (13%) annually.

Temporal variations in the catches displayed similar patterns of fluctuations in both areas, exhibiting maxima in mid 1960's and late 1970's and minima in 1975 (Table 1). The situation is different for subarea 05 where total catch manifested maxima in 1973 and 1981, minima in 1972 and 1979 (Stergiou, 1986a).

The results of the multivariate analysis of the catches per group during 1964—1981 are presented in Figures 2 and 3. Figure 2a is a dendrogram showing year affinities. Two main groups of years were distinguished: 1964—1971 (Group A) and 1972—1981 (Group B). The results of multidimensional scaling, delineating groups of years from the dendrogram (Fig. 2a), are shown in Figure 2b. This analysis gave essentially the same picture as the dendrogram. The resulting stress for the 2-D plot was low 0.04475, whereas it was 0.0934 and 0.0216 for the 1-D and 3-D respectively. A significant decline in passing from 1 to 2 dimensions together with the slight decrease of stress in passing from 2 to 3 dimensions suggest that the 2-D plot adequately portrays the relationship between years (Field *et al.*, 1982). The adequacy of the plot is also shown from the Shepard diagram (Fig. 2c) which

Table 1. Catches in tones and percentages by main species of the north western coast of Greece (fishing subareas 03 and 05) 1 = *Merluccius merluccius* and *Micromesistius poutassou*, 2 = *Engraulis encrasicholus*, 3 = *Pagellus erythrinus*, 4 = *Spicara flexuosa* and *Spicara smaris*, 5 = *Sardina pilchardus*- 6 = *Mullus barbatus* and *Mullus surmuletus*, 7 = flatfish, 8 = *Boops boops* and *Sarpa salpa*, 9 = *Mugil sp.*, 11 = *Trachurus* sp., 12 = other fish, 13 = cephalopods, and 14 = crustacea.

YEAR	TOTAL	FISH	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1964	2136.7	1977.8	28.7	10.4	43.8	433.3	713.7	116.4	2.1	83.0	105.9	2.0	71.6	376.6	76.3	72.9
1965	2424.9	2303.8	32.3	37.0	35.4	384.2	755.9	102.3	4.5	116.4	118.4	12.8	248.3	487.8	64.7	24.9
1966	2215.0	2114.2	27.2	35.8	34.5	404.4	855.3	92.8	2.9	111.8	92.6	4.8	91.4	382.1	54.9	24.5
1967	2058.4	1933.1	32.3	14.5	40.1	433.5	608.6	97.5	2.7	97.1	119.3	9.1	43.3	471.2	59.5	29.7
1968	2044.6	1909.8	31.3	21.4	52.5	425.3	555.4	106.7	2.5	112.2	152.6	4.8	47.7	443.6	69.4	19.2
1969	1910.2	1793.3	40.1	3.9	48.5	397.3	432.7	93.6	3.5	136.0	115.8	4.2	84.4	476.1	55.2	18.9
1970	1416.4	1368.8	38.2	11.2	30.5	506.2	285.7	51.5	1.1	83.0	47.3	10.0	104.8	199.7	32.5	14.7
1971	1816.5	1778.1	32.2	30.1	20.2	453.3	694.2	52.4	1.6	87.2	35.2	8.0	88.5	281.7	23.8	8.1
MEAN	2002.8	1897.4	32.8	20.5	38.2	429.7	612.7	89.2	2.6	103.3	98.4	7.0	97.5	389.9	54.5	26.6
%		94.7	1.6	1.0	1.9	21.5	30.6	4.5	0.1	5.2	4.9	0.3	4.9	19.5	2.7	1.3
1972	1540.5	1504.2	29.2	56.1	18.6	409.3	454.8	39.9	0.9	109.6	21.5	5.4	139.2	220.4	32.6	3.0
1973	1108.0	1093.8	19.6	13.3	9.6	454.6	206.5	24.3	2.2	125.5	10.4	8.7	68.7	150.6	13.6	0.4
1974	1053.6	1036.7	23.3	53.0	11.9	439.4	187.0	33.3	0.7	97.8	7.5	0.7	54.5	129.3	12.1	3.1
1975	635.3	629.9	9.0	8.8	6.2	252.4	156.4	20.2	2.5	32.6	4.8	4.5	21.8	110.9	3.2	2.0
1976	991.6	971.2	22.2	126.9	17.2	344.6	190.1	32.2	1.7	90.2	3.0	9.9	18.8	117.7	14.8	2.3
1977	1714.7	1686.0	38.6	64.8	39.7	518.7	453.4	48.3	8.4	116.9	22.4	22.0	134.5	218.3	26.1	2.6
1978	1998.9	1962.0	50.6	144.3	41.7	630.3	448.2	52.8	8.2	156.8	9.8	12.3	62.3	344.7	31.9	5.0
1979	1939.4	1913.3	45.7	318.4	22.5	584.8	330.1	62.7	4.7	184.4	15.2	4.8	51.8	288.2	24.3	1.8
1980	1903.0	1804.8	66.6	93.2	19.1	424.0	313.4	74.7	18.1	193.3	43.1	17.9	74.3	529.0	25.0	11.3
1981	1545.1	1525.6	44.9	21.3	26.6	432.6	279.5	54.8	2.7	182.6	13.2	11.6	73.9	381.9	17.3	2.2
MEAN	1443.0	1412.8	35.0	90.0	21.3	449.1	301.9	44.3	5.0	129.0	15.1	9.8	70.0	249.1	20.1	3.4
%		97.9	2.4	6.2	1.5	31.1	20.9	3.1	0.3	8.9	1.0	0.7	4.8	17.3	1.4	0.2
MEAN	1691.8	1628.1	34.0	59.1	28.8	440.5	440.1	64.2	3.9	117.6	52.1	8.5	82.2	311.7	35.4	13.7
%		96.2	2.0	3.5	1.7	26.0	26.0	3.8	0.2	6.9	3.1	0.5	4.9	13.4	2.1	0.8

is a plot of distances against input similarities or dissimilarities. The residual variability about the regression line is small (Fig. 2c).

Cluster and ordination results for the species analysis (inverse analysis) are shown in Fig. 3. Stress was 0.207, 0.102 and 0.057 for the 1-D, 2-D and 3-D plots. Two main groups were indicated by both techniques: 1) pickarel, anchovy, hake, blue-whiting, flatfish, bogue, salema and chub mackerel (Group A) which are characterized by an increase in the catches and relative proportions during 1972—1981 as compared to 1964—1971, and (2) red pandora, grey mullet, red and stripped mullet, pilchard, horse mackerel, crustaceans and cephalopods (Group B) which are characterized by a decline in the catches and the relative percentages in 1972—1981 as compared to 1964—1971. It is important to note that the pelagic species are clustered into two main groups with respect to years: pilchard-horse mackerel and anchovy-chub mackerel. This is found in agreement with the fhifts observed

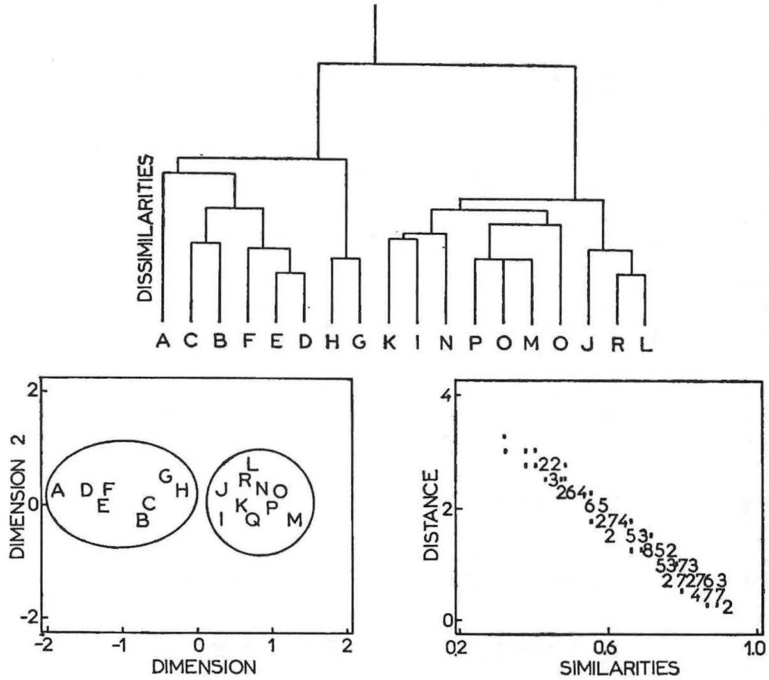

Fig. 2. Dendrogram (a), multidimensional ordination (b) and Shepard diagram (c) showing classification of years into main groups. A = 1964, B = 1965, C = 1966 etc.

in the abundance of small pelagic fish in the Mediterranean (L a r r a n e t a, 1980; H e r n a d e z, 1983; B a s *et al.*, 1985; S t e r g i o u, 1986) and other areas of the world ocean (S o u t e r and I s a a c s, 1974; L a s k e r, 1985).

The analysis indicated that the composition of the catch changed greatly from 1964—1971 to 1972—1981. Although this shift may be related to the fact that catches of small coastal boats (small ring-netters, drifters, liners with HP < 19HP) have not been recorded since 1969, this does not seem probable for the following reasons. Firstly, the proportions of the catch per species group attributed to these boats are similar, to a great extent, for all groups concerned (S t e r g i o u, unpublished data). Secondly, from Table 1 it is evident that catches declined on a steady basis from 1965 through 1975.

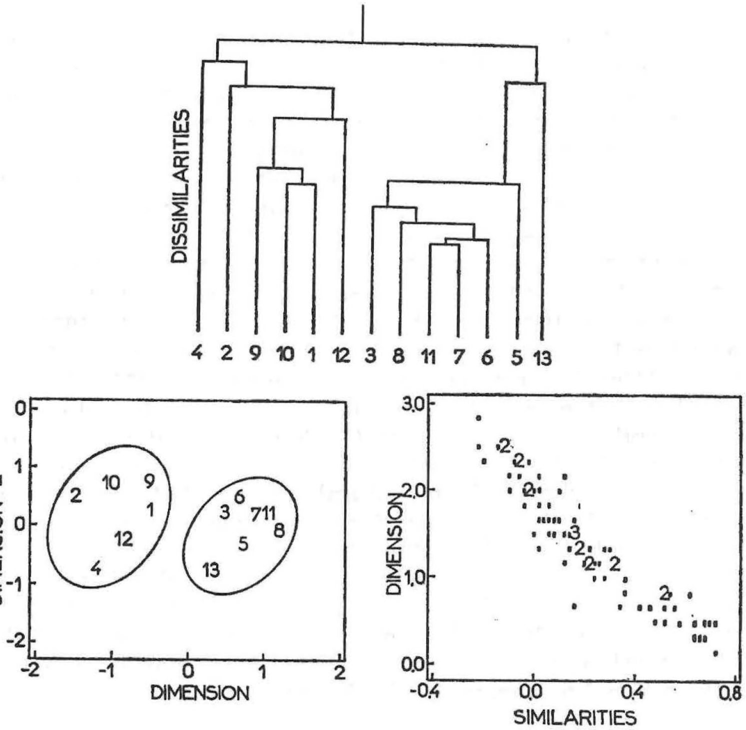

Fig. 3. Dendrogram (a), multidimensional ordination (b) and Shepard diagram (c) showing classification of species into main groups. 1 = *Merluccius merluccius* and *Micromesistius poutassou*, 2 = *Engraulis encrasicholus*, 3 = *Pagellus erythrinus*, 4 = *Spicara* sp., 5 = *Sardina pilchardus*, 6 = *Mullus barbatus* and *Mullus surmuletus*, 7 = *cephalopods*, 8 = *crustacea*, 9 = *flatfish*, 10 = *Boops boops* and *Sarpa salpa*, 11 = *Mugil*. sp., 12 = *Scomber* sp., and 13 = *Trachurus* sp.

It is rather probable that large-scale changes in the hydrometeorology of the Mediterranean Sea, described by many authors (Z o r e - A r m a n d a, 1963, 1969a, 1969b, 1971; F l o c a s and A r s e n i — P a p a d i m i t r i o u, 1974; B u l j a n and Z o r e - A r m a n d a, 1979; F i e u x *et al.*, 1979; B e t h o u x and I b a n e z, 1979; S t r a v i s i, 1984), are associated to these temporal variations in the composition and the level of the catches. For instance, time series of climatic data at Trieste, Italy, indicate that air temperature, precipitation and sunshine were lower in 1970s than in 1960s (S t r a v i s i, 1984). It has been maintained (Z o r e - A r m a n d a, 1963, 1969a, 1969b, 1971; P u c h e r -

-Petković *et al.*, 1971) that in periods of increased air pressure gradient over the eastern Mediterranean the water exchange between its basins intensifies, and, as a result, the salinity, nutrient content, temperature and primary productivity of the Adriatic Sea, and, in fact, of the whole eastern Mediterranean basin, rise. In addition, the species composition of the phytoplankton community changes along with variations in the hydrometeorological environment. However, changes in the species composition of phytoplankton, on which larvae of pelagic fish feed, affect larval mortality rate, and, hence, recruitment and abundance in subsequent years, may also be related to the shift in abundance between some members of the pelagic fish community (Pucher-Petković, *et al.*. 1971; Pucher-Petković and Zore-Armanda, 1973; Larraneta, 1981).

A considerable work devoted to the relation of climate and fisheries and the importance of abiotic factors as regulators of abundance and distribution of marine organisms for various areas of the world ocean (see reviews by Hjort, 1914; Jensen, 1939; Clark *et al.*, 1975; Cushing and Dickson, 1976; Cushing, 1981; Leggett *et al.*, 1984) and the Mediterranean (e. g. Županović, 1968; Pucher-Petković *et al.*, 1971; Pucher-Petković and Zore-Armanda, 1973; Regner and Gačić, 1974; Stergiou 1986c; Stergiou and Zouroudis, 1986; Stergiou, in press 1) implies that more attention must be given to the subject.

However, anthropogenic pressure (fishing) ii recent years seems to play an important role in the distribution and abundance of populations and may disguise, or be superimposed on, natural changes (Stergiou in press 2). This strongly reveals the necessity for monitoring marine ecosystems on a monthly (or annual) basis, both the abiotic (temperature, salinity, currents, nutrients, etc.) and biotic components (productivity, distribution, abundance, spawning periods, extent of spawning beds, distribution and abundance of larvae, etc.). This will ultimately contribute to the assessment of the relative impact of natural and anthropogenic changes on marine populations and, hence, to the rational management of fishery resources.

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Accepted: April 13, 1988

MULTIVARIJANTNA ANALIZA KOMERCIJALNOG RIBOLOVA SJEVEROZAPADNIH OBALA GRČKE, 1964—1981.

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KRATKI SADRŽAJ

Daje se pregled ribolova sjeverozapadnih obala Grčke za razdoblje 1964—1981. Srednji godišnji ulov dosegao je 1692 tone (1964—1981). U ukupnom ulovu riba čini 96,2% dok je postotak glavonožaca i rakova vrlo mali, 2,1% odnosno 0,8%. Srdela *(Sardina pilchardus)* prevladava u lovinama sa srednjim godišnjim ulovom od 440,5 tona ili 26%. Girice *(Spicara* sp.) učestvuje u ukupnom ulovu sa 26% a šnjuri *(Trachurus* sp.) sa 18,4%. Lovine su analizirane kluster analizom i objektivnom analizom. Analize su pokazale da se sastav lovina veoma promijenio od 1964—1971. do 1972—1981. Obje su metode pokazale da postoje dvije glavne grupe: 1) grupa koja sadrži girice, brgljuna, oslića, ugoticu, plosnaticu, bukvu, salpu i lokardu i koja je karakteristična po tome da je njihov ulov i učešće u ukupnom ulovu porastao u periodu 1972—1981. u odnosu na raniji period; 2) grupa koja sadrži arbuna, ciple, trlju kamenicu, trlju, srdelu, šnjura, rakove i glavonošce kod koje je u periodu 1972—1981. ulov opao isto kao i relativno učešće pojedine vrste. Hidrometeorološke promjene velikih razmjera do kojih je došlo u području Sredozemlja, a koje su opisali brojni autori, vrlo vjerojatno su uzrok ovim promjenama u sastavu lovina.