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STATISTICAL ANALYSIS OF CATCHES BY TRAWLING IN THE FISHING REGIONS OF THE EASTERN ADRIATIC IN 1951

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by

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INTRODUCTION

Through the more intensive development of trawling the decrease in the catches of individual species of demersal fish has already come about. On the basis of this, overfishing* was confirmed on various fishing grounds. In order to stop further devastation of the stocks of fish various scientific observations were carried out with the purpose of protecting stocks. In the past several such observations were made on the fishing grounds of the eastern Adriatic. So Gast (1918) stated when analysing the influence of motorization on the total catch in the Gulf of Rijeka, Kvarnerić and Velebit Channel, that overfishing in these regions cannot yet be fully discussed. D'Ancona (1926) maintaned that the optimum intensity of catch was reached in Kvarner** and that further intensive fishing on this ground could easily lead to an impoverishment of the sea. This really happened to the stocks of fish in the northern section of the Velebit Channel, where, according to Kotthaus and Zei (1938) the intensive trawling with nets led to a quantitative and qualitative decrease of catch and so to unprofitable fishing. The fishing grounds about the central Dalmatian islands and the Neretva Channel were explored by Zei and Sabioncello (1940). On the basis of the analysis of the stocks of fish in the waters of the central Dalmatian region, it was stated that they were similar to those in the Velebit Channel in density, whilst their quality was much poorer.

This paper gives the statistical analysis of catches by trawling on the fishing grounds of the eastern Adriatic (mainly in the channels and inshore waters) for the year 1951.

The records obtained are rather poor for the purpose of a more detailed statistical analysis. This bears weight particularly on the biological characteristics which refer to the growth, composition of stocks in relation to the size of fish, spawning etc., which are not taken into con-

* According to Russel (1939) overfishing means »the state in which the more you fish the less you catch«.

** Here Kvarner in the wider sense means the gulf between Istria and Velebit.

sideration at all. Because of this, particularly for the post-war period, i. e. the first one in which only fishermen have recorded their catches, we are not yet able to say anything definite. We can only assume the present quantitative composition of the fish stocks and also the eventual overfishing at least for those fishing regions in which to a certain extent periodical scientific researches were being carried out before the second World War.

Dr. T. Šoljan, director of the Institute of Oceanography and Fisheries, Split, my colleagues Dr. M. Buljan, prof. O. Karlovac. Eng. V. Križanec and my lady colleague prof. R. Mužinić helped me greatly with their suggestions and with biological and hydrographic data and I wish to take this opportunity to express my gratitude to them.

GEOGRAPHIC POSITION AND HYDROGRAPHIC CONDITIONS OF FISHING REGIONS*

By its geomorphologic composition, the rocky, channel-like eastern Adriatic coast differs essentially from the straight western Adriatic coast which is to a great extent silted up with alluvial soil. Concerning the hydrographic conditions in the Adriatic generally, the phenomenon of periodical fluctuations of salinity has been noticed, according to which every few years inflows of more saline waters from the Mediterranean occur in the Adriatic and cause differences in the salinity between individual years (Buljan, 1953). For the purposes of this paper the entire fishing grounds of the eastern Adriatic coastal waters were divided into several regions with regard to the different geographic position and hydrographic conditions and they are: the western Istrian region, Kvarner, the northern Dalmatian region, the central Dalmatian region, the southern Dalmatian region and the region off the Montenegrin Littoral.

Western Istrian Region

The western coastal waters of Istria (I) extend from Novigrad $45^0 19'$ N and $13^0 33'$ E to the Cape Kamenjak $44^0 46'$ N and $13^0 53'$ E, a distance of 36 Nm. The maximum depth varies from 40 to 44 m. The

* The integral mean T^0 and S‰ is calculated for individual fishing areas. The data were taken from the 1st, 2nd, 3rd and 4th voyage of »Vila Velebita« in 1913/14, several cruises of »Najade« in 1912, 1913 and 1914, from Ercegović (1939), Vatova (1948) and Gamulin (1948), as well as from the unpublished hydrographic data gathered by the »Hvar« research cruises fisheries biology in 1948—1949 and from M. Buljan and M. Marinković (unpublished data). Details of the mechanical composition of the sea-bed were taken from Morović (1951).

bottom consists of loamy clay sand. The mean monthly and yearly average T⁰ and S‰ near the islet Banjola (1 Nm from Rovinj) from 1937 to 1943 is as follows:

Table I. Off the Western coast of Istria (Vatova, 1948)
(Zapadna obala Istre)

Month *(Mjesec)*		I	II	III	IV	V	VI
Depth *(Dubina)*	T^0	9,8	8,8	9,2	11,2	14,5	18,2
0—29 m	S	37,5	37,6	37,5	37,4	37,5	36,9

Month *(Mjesec)*	VII	VIII	IX	X	XI	XII	M
Depth *(Dubina)*	20,8	21,6	20,7	19,4	16,4	13,0	15,3
0—29 m	36,7	36,3	36,7	36,8	37,3	37,3	37,1

The rivers along the north-western coast of the Adriatic affect the salinity on the surface not only to the south-east, but also to the western coasts of Istria at shorter intervals of time (Picotti and Vatova, 1942).

Kvarner Region

The Kvarner region extends from the most southern Cape of Istria to Srednja Vrata, between Premuda, Silba and Olib, and a line running from Srednja Vrata to Privlaka and Ljubač. It includes the Gulf of Rijeka, Kvarner, Velebit Channel and Kvarnerić.

The Gulf of Rijeka (II) is enclosed on the eastern side by Krk Island and on the northern and western sides by the Croatian Littoral and Istria. Through the Porozinski Channel it is connected on its south-western side with the Kvarner Channel and on the eastern side of Cres Island with the Krk Channel and Kvarnerić. Its length is 16 Nm and the maximum depth is 66 m. The bed consists of loam and clay.

Kvarner (III) is bordered by the eastern coast of the Istrian peninsula up to Plomina Bay on one side and by the islands Cres, Lošinj, Unije and Susak on the other. Its length is 45 Nm, the depth varies from 49 to 65 m. The bed on the north consists of clay loam and somewhat southwards, of clay sand.

The Velebit Channel (northern area, IV) lies between the islands Krk, Rab, Pag and the mainland and extends from the southern area of the

Tihi Channel to the south-eastern cape of Pag Island, a distance of 60 Nm. The bed in the north consists of clay, in the south of clay loam. The maximum depth is 83 m.

Kvarnerić (V) is bordered by the islands Krk and Plavnik on the north and the islands Cres, Lošinj, Sv. Petar na Iloviku etc. on the west. On the east it is bordered by the chain of islands which extend along the coast. The average length of the channel is 40 Nm. Its extreme depths vary from 73 to 91 m. The bed consists of loamy clay.

The Velebit Channel (southern area, VI) is the south-eastern continuation of the northern area. It extends from the south-eastern cape of Pag Island up to the Maslenica Channel. In the south-eastern area the average width of the channel is 2 Nm, but it gradually narrows to 3/4 Nm. Its depth varies from 13 to 54 m. The bed consists of loamy clay, clay loamy loam and in the southern area loamy clay and clay predominate.

The hydrographic data for the entire Kvarner region were collected from all the four voyages of »Vila Velebita«. The later data available are only those for the salinity and refer to the very bottom of the station for the month of June in 1951. The hydrographic conditions are as follows:

Table II. Data on T^0 and S‰ for the Kvarner Region according to »Vila Velebita« in 1913/14

(Podaci T^0 i S‰ za Kvarnersko područje prema »Vili Velebita« 1913/14)

		VIII 1913	XI 1913	II 1914	V 1914	
Gulf of Rijeka Station 1,2, 33 and 34 *(Postaja)*	T^0	17,8	15,9	10,3	11,7	
Depth 0—60 m *(Dubina)*	S	37,6	37,7	38,4	38,1	
		VIII	XI	II	V	VI 1951
Kvarner Station 36, 37a and 37b *(Postaja)*	T^0	19,7	16,1	10,1	14,1	—
Depth 0—50 m *(Dubina)*	S	38,4	37,7	38,3	37,8	37,8
		IX	XI	II	V	VI 1951
Velebit Channel *(northern area)* Station 27, 28, 29 and 30 *(Postaja)*	T^0	17,5	15,1	10,0	12,9	—
Depth 0—75 m *(Dubina)*	S	37,0	37,3	38,0	38,1	36,6

Table II. Data on T^0 and S‰ for the Kvarner Region according to »V i l a V e l e b i t a« in 1913/14

(Podaci T^0 i S‰ za Kvarnersko područje prema »Vili Velebita« 1913/14)

		VIII	XI	II	V	VI 1951
Kvarnerić Station 5, 5a, 6, 7 and 8 *(Postaja)*	T^0	16,1	15,6	10,8	12,9	—
Depth 0—93 m *(Dubina)*	S	37,7	38,1	38,5	38,1	37,2

		VIII	XI	II	V	VI 1951
Velebit Channel *(southern area)* Station 18, 19, 20, 21 and 22 *(Postaja)*	T^0	16,2	15,0	10,4	13,1	—
Depth 0—75 m *(Dubina)*	S	37,2	37,6	38,2	37,6	36,0

According to L o r e n z (1863) the entire Kvarner region is under the strong influence of the coastal waters, i. e. springs of fresh water, which is reflected in the lower temperature and salinity.

North Dalmatian Region

The Zadar-Žirje Channel (VII) extends from Privlaka, Kornati Islands to Mažirina Island, then south-eastwards towards the peninsula of Oštrica up to the Bay of Grebaštica. The length is 50 Nm, the depth varies from 45 to 81 m. The salinity in the Zadar Channel was 36,7 at a depth of 49 m, in June 1951.

Off the western coast of Kornati Islands towards the open sea (VIII).

This area runs along the western line of the Kornati Islands to the open sea. The depth varies from 65 to 155 m. The bed consists of loamy clay sand.

The area west of the Cape Ploče towards the open sea (IX).

This area is surrounded by the following points: the light-house Blitvenica, 16 Nm to the direction 270^0, from this towards the position $43^0\,30'$ N and $15^0\,13'$ E, from here to the position $43^0\,30'$ N and $15^0\,30{,}5'$ E, then 4,5 Nm southwards up to Cape Rat on Mali Drvenik Island. The maximum depth is 210 m. The bed consists of clay loam, loamy clay, loamy sand, clay and loamy clay sand.

The hydrographic conditions for the entire north Dalmatian region which are under the direct influence of the open sea are the following:

Table III. Data on T^0 and S‰ for the North Dalmatian Region according to the »H v a r« — Reports in 1948/49

(Podaci T^0 i S‰ za Sjeverno dalmatinsko područje prema ribarstveno-biološkoj ekspediciji »Hvar« 1948/49)

		III 1948	VIII 1948	IX 1948
Off the Western Coast of Kornati Islands Station 30 and 37 *(Postaja)*	T^0	12,7	14,0	18,8
Depth 0—125 m *(Dubina)*	S	38,1	38,2	38,3

		IV 1948	VI 1948	IX 1948	I 1949	II 1949
West of Cape Ploče Station 47, 48, 52, 53, 54, 57, 58, 62, 63, 67 and 72 *(Postaja)*	T^0	13,1	16,5	16,1	13,8	12,5
Depth 0—194 m *(Dubina)*	S	38,5	38,5	38,4	38,6	38,5

Central Dalmatian Region

The Split-Brač Channel and Bay of Kaštela (X).

This area extends from the islands Mali Drvenik and Šolta, Cape Raščatna on Brač Island and the mainland to the Bay of Vrulje, a distance of 42 Nm. The depth varies from 57 to 76 m. The bed in the Bay of Kaštela consists of loam and in the Split Channel of clay loam.

The Hvar Channel (XI) extends from along the southern coast of Brač Island to Makarska and along the northern coast of the Hvar Island, a distance of approximately 35 Nm. The width varies from $6^1/_2$ to $2^1/_2$ Nm west of Bol. In the middle of the channel the depth reaches 82 m.

The Korčula Channel (XII) is bordered by Hvar Island in the north, by the northern coast of Korčula Island in the south and extends to the Cape Lovište on the north-western area of the Pelješac Peninsula. Its length is 20 Nm, whilst the depth varies from 64 to 73 m. Towards the Neretva Channel its depth decreases rapidly.

The Neretva Channel (XIII) is the eastern continuation of the Korčula Channel and it is bordered on the south by the Pelješac Peninsula, and the eastern area of Hvar Island, and on the northern and north-eastern side by the mainland. In the middle of the channel the depth is 59 m, whilst in front of the mouth of the River Neretva it is 29 m. The length is 35 Nm. The bed at the mouth of the Neretva consists of coarse sand and in the middle of the channel, of sandy clay.

The hydrographic conditions in all the channels of the central Dalmatian region are considerably influenced by the coastal rivers. They are as follows:

Table IV. Data on T^0 and S‰ for the Central Dalmatian Region
(Podaci T^0 i S‰ za Srednjedalmatinsko područje)

		XII 1947	I 1948	II 1948	III 1948	IV 1948
Split-Brač Channel and Kaštela Bay (B u l j a n & M a r i n k o v i ć)	T^0	15,9	13,8	13,1	12,2	12,7
Depth 0—70 m *(Dubina)*	S	38,3	37,2	37,8	37,0	37,9

		VI 1948	VII 1948	VIII 1948	IX 1948
Split-Brač Channel and Kaštela Bay (B u l j a n & M a r i n k o v i ć)	T^0	15,6	16,9	17,3	18,2
Depth 0—70 m *(Dubina)*	S	38,2	37,9	38,2	38,2

		X 1947	XI 1947	XII 1947	I 1948	II 1948	III 1948
Cape Pelegrin Hvar Channel (B u l j a n & M a r i n k o v i ć)	T^0	19,0	17,9	16,7	14,6	13,0	13,2
Depth 0—75 m *(Dubina)*	S	38,4	38,5	38,7	38,2	38,3	38,3

		IV 1948	V 1948	VI 1948	VII 1948	VIII 1948	IX 1948
Cape Pelegrin Hvar Channel (B u l j a n & M a r i n k o v i ć)	T^0	14,6	15,8	16,4	16,8	17,2	17,6
Depth 0—75 m *(Dubina)*	S	38,6	38,5	38,5	38,5	38,6	38,7

		V 1912	VIII 1912	V 1913	III 1913	VIII 1913	XI 1913	II 1914
Korčula Channel »N a j a d e«, op. cit. Prof. V. Station 24	T^0	15,7	17,4	16,1	13,2	17,9	18,3	13,1
Depth 0—75 m *(Dubina)*	S	37,9	38,3	38,4	38,5	38,5	38,5	38,3

		VI 1939	IX 1947 (B u l j a n)
Neretva Channel (G a m u l i n, 1939) Station 18, 20 and 22 *(Postaja)*	T^0	18,6	21,7
Depth 0—40 m *(Dubina)*	S	37,2	37,5 (Depth 0—25 m)

South Dalmatian Region

The Lastovo Channel (XIV) is bordered on the north by the coast of Korčula Island and the islands Sušac and Kopist, and on the south by the Lastovo Islands. The width of the channel ranges from 7 to 10 Nm.

The Mljet Channel (XV) is the south-eastern continuation of the Lastovo and Pelješac Channel and lies between the Mljet Island and the south-western coast of the Pelješac Peninsula. Its length is 30 Nm and the depth varies from 48 to 86 m.

The Koločep Channel (XVI) is bordered by the mainland on one side aid by the islands Koločep, Lopud and Jakljan up to Veliki Vratnik on the other.

Off the southern coast of Mljet Island (XVII).

This area extends to 20 Nm along the southern coast of Mljet Island to the open sea. The bottom consists of clay sandy loam.

The hydrographic conditions which are strongly influenced by the open sea are the following:

Table V. Data on T^0 and S‰ for the South Dalmatian Region

(Podaci T^0 i S‰ za Južnodalmatinsko područje)

		II 1912	V 1912	VIII 1912	III 1913	V 1913	VIII 1913	XI 1913	II 1914
Lastovo Channel »N a j a d e«, op. cit. Prof. V. Station 24	T^0	12,9	14,4	15,7	14,1	15,6	16,9	14,3	14,3
Depth 0—120 *(Dubina)*	S	38,2	38,2	38,3	38,8	38,5	38,6	38,5	38,5

		V 1947	IX 1947	XI 1947
Mljet Channel (B u l j a n)	T^0	15,7	14,9	19,2
Depth 0—75 m *(Dubina)*	S	37,5	38,5	37,7

		VI 1948	XI 1948
Off the Southern Coast of Mljet Island Research-Cruises of »Hvar« Station 126 *(Postaja)*	T^0	16,4	17,4
Depth 0—114 m *(Dubina)*	S	38,5	38,6

Montenegrin Littoral

The region off the Montenegrin Littoral (XVIII) extends from the Cape Oštri $42^0\,24'$ N and $18^0\,32'$ E, to the mouth of the River Bojana $41^0\,51'$ N and $19^0\,20'$ E. Its length is 50 Nm. The bed consists of clay. The hydrographic conditions on the surface are affected by the River Bojana. The data collected by Ercegović refer to the hydrographic conditions near the Cape Oštri in 1939.

Table VI. Data on T^0 and S‰ off the Montenegrin Littoral

(Podaci T^0 i S‰ za Crnogorsko primorje)

Off the Montenegrin Littoral Research-Cruises of »Hvar« Station 138, 139 and 143 *(Postaja)*		V 1948	VI 1948	XII 1948
	T^0	17,4	18,5	16,1
Depth 0—51 m *(Dubina)*	S	38,4	37,8	38,5
		XI 1939		
Cape Oštri (Ercegović)	T^0	19,2		
Depth 0—70 m *(Dubina)*	S	37,5		

MATERIAL AND METHODS

In this statistical analysis only the material from those fishing vessels which were giving us their reports during the year 1951 was dealt with. The data collected were obtained by the captains of various fishing vessels. The technique of the organization and collecting of statistical data is carried out in the following way: The Institute of Oceanography and Fisheries prints pocket pads with questionnaire forms and with all the necessary directions on how to fill them in, and distributes them to the captains of the vessels or leaders of fishing teams. The pads contain among other things the following data: the type of the vessel, the kind of gear, its size, the number of fishermen, the time of leaving and returning to port, the number of hauls and their duration, the weather conditions, the quantities of individual species of fish caught, expressed in kilos, the size of individual commercially more important species and notes on everything that happened in course of fishing. Having received these pads the captains of the vessels or the leaders of the fishing teams fill them in immediately after the catch according to the directions obtained on the spot. All the catches are accordingly sorted and registered directly by the producers after each haul, on the vessel itself, and their weights are estimated approximately. These estimated quantities and the fixed localities where the fish were caught were taken as the basis for our statistical analysis. The leaders of the teams deliver these completed forms to the administration of their enterprise or co-operative after their return to port. They examine them and send them directly to the Institute. The forms received are further classified according to the species, size of fish, fishing grounds, gear used, units of time, weather conditions, depths etc. by the »Department of Fisheries Statistics« in the Institute making investigations in this way on the abundance of individual stocks of fish as well as on the effectiveness of the gear used. For simplified use on the spot, the captains of the fishing vessels or leaders of teams received from the Institute special fishing charts on which the fishing grounds are given within statistical squares which are drawn over the channels and contiguous waters and referred to by a system of letters and numbers. The dimensions of each square are 10' longitude by 8' latitude and the area enclosed is approximately 80 square Nm. In most instances each area was fished out within its boundaries so that the stock density recorded for each was taken as the mean for that area. But for those areas which were trawled from one square into another, the mean was taken on the border between one and the other. Such an arrangement within and between the areas is given in the percentage and weight composition of the catches on Table XV.

The methods consisting of the analysis of variance, covariance, and the multiple regression, were adopted in the statistical analysis of the data obtained in this work.

The analysis of variance shows whether the composition of the stock on individual fishing grounds is significant or not. If the value obtained is significant (as was the case in our analysis) we can then deduce the significance of individual fishing grounds by virtue of the mean error of the difference $m_D = m\% \sqrt{2}$. The data on the catch of species and groups in Table XV are applied in a converted form for the analysis of variance of the composition of the stocks of fish. The logarithms of catch are given also for those localities where the particular species were not caught. This was found by means of the log $(N+1)$. One hour of trawling was taken as the unit of time. It was obtained by dividing the total catch with the hours of trawling for each of the fishing areas separately. In the biological and economic investigations of the density of individual fishing areas other units and methods are used. L u n d b e c k (1937) takes a day's fishing as a unit (Fangtag) for the biological-statistical analysis of the German »Hochseefischerei«. Ricker (1940) uses the »catch-per-unit-of-effort« method for the teoretical analysis of the density of the stocks and the possibility of their exploitation. Andreu and Rodriguez-Roda (1951) use in the analysis of trawling in Castellón the average fishing day (jornada media anual) as a unit. The British official statistics use the unit of 100 hours trawling for their trawlers. As we dispose of a very small number of hours of trawling for individual fishing areas, we are of the opinion that the unit of one hour's trawling will be the most suitable for this purpose. However, it is possible that a slight error may arise in averaging the catch for a unit of time, because of the probability that a catch may be heavier in the first part of a trawl, assuming an even distribution of fish on the bottom. Another disadvantage of this unit is that when the results of catches for a series of years are compared, it is not possible to follow the effect of various systems of trawling, which would be revealed by the amount of the average catch.

The analysis of covariance should show the possibility of a further exploitation of individual fishing regions on the basis of the coefficient of regression $b_1 = \frac{Sxy}{Sx^2}$. All the more important fishing regions are divided approximately into 5 equal areas. The coefficient of regression obtained indicates the relation which exists within individual fishing regions.

The multiple regression examines the relation existing between the number of vessels, hours of trawling and total catch for each individual fishing region. The equation: $Y = a + b_1 (x_1 - \overline{x_1}) + b_2 (x_2 - \overline{x_2})$ was used for this purpose.

QUALITATIVE AND QUANTITATIVE RELATIONSHIPS OF CATCHES IN THE FISHING REGIONS UNDER ANALYSIS

The catch of individual species and groups on the fishing grounds analysed is given in Table VII. *Gadidae, Mullidae, Maenidae* and *Selachia* represent 74% of the total catch fish and they occur more or less on all the fishing grounds. By quantity *Merluccius vulgaris* comes first and accounts for almost 37% of the total catch of fish. By quantity *Selachia* with 22% (of which 15% are *Rajidae* and 5% *Scylliidae*), *Gadus* sp. (*Gadus merlangus* and *capelanus*) with 6%, *Mullidae* with 5%, *Pediculati* with 5%, *Maenidae* with 3%, *Pagellus erythrinus* with 2% and *Zeus pungio* with nearly 1%, follow.

Apart from fish the various *Crustacea* and *Cephalopoda* are also of commercial importance in the catch, being edible; they represent about

Table VII. Weights and percentages of the catches of individual species and groups of fish, *Crustacea* and *Cephalopoda* on the fishing grounds analysed in 1951

(Težine i procenti ulova pojedinih vrsta i grupa riba, rakova i glavonožaca na analiziranim ribolovnim područjima 1951 godine)

	FISHES* (RIBE)	kg	%
Tresher Shark — Pas sabljaš	(*Alopecias vulpes* Bp.)	120	0,06
Dog-fishes — Morski psi	(oftenest: *Acantias vulgaris* Risso, *Galeus canis* Bp., *Mustelus laevis* Risso and *M. vulgaris* M. Hle).	1614	0,79
Rousettes — Mačke	(*Scyllium canicula* Cuv. and *S. stellare* Gthr)	11122	5,46
Angel-fish — Sklat	(*Squatina laevis* Cuv.)	192	0,09
Sting Rays — Žutulje	(*Trygon* var. sp.)	60	0,03
Eagle Rays — Golubi	(*Myliobatis aquila* Dum. and *M. bovina* Geoffr.)	1113	0,55
Rays — Raže	(*Raja clavata* L., *R. Montagui* Fowler and *R. miraletus* L.) . . .	29945	14,69
Skates — Voline	(*Raja macrorhynchus* Raf., *R. bicolor* Risso and *R. oxyrhyunchus* L.)	437	0,21
Torpedoes — Drhtulje	(*Torpedo* sp.)	643	0,32
Sturgeon — Jesetra	(*Acipenser sturio* L.)	281	0,14
Conger — Ugor	(*Conger vulgaris* Cuv.)	5	
Sprat — Srdjelica	(*Clupea sprattus* L.)	1023	0,50
Pilchard — Srdjela	(*Clupea pilchardus* Art. Walb.)	67	0,03
Lesser silver Smelt — Srebrnica	(*Argentina sphyraena* L.)	713	0,35
Cods — Ugotice	(*Gadus merlangus* L. and *G. capelanus* Risso)	12702	6,23
Hake — Oslić	(*Merluccius vulgaris* Flem.) . .	74890	36,74
Turbots — Oblići	(*Rhombus maximus* Cuv., *R. laevis* Gottsche and *R. megastomus* Nills)	135	0,07
Scald-fishes — Plosnatice	(*Arnoglossus* var. sp.)	883	0,43
Plaice — Iverak	(*Pleuronectes flesus* L.)	5	
Soles — Listovi	(*Solea* var. sp.)	621	0,31

* Local names have not been considered owing to their variety in individual fishing regions. For this purpose a transcription of the local names into technical terms was carried out. In order to compare them I used Šoljan (1948) and my own materials collected on the spot by method of autopsy. The nomenclature according to Carus was used.

FISHES (RIBE)		kg	%
Bass — Smudut	(*Dicentrarchus* labrax Jord. et Eigenm.)	1	
Comber — Kanjac	(*Serranus cabrila* Cuv.)	1	
Gira oštrulja	(*Smaris vulgaris* Bp.)	1901	0,93
Gira oblica	(*Smaris alcedo* Bp.)	3715	1,82
Red mullets — Trlje	(*Mullus barbatus* L. and *M. surmuletus* L.)	9289	4,56
Dogs-teeth — Zubatac	(*Dentex vulgaris* Cuv.)	146	0,07
Black Sea-bream — Kantar	(*Cantharus lineatus* Thomps.) .	96	0,05
Couch's Sea-bream — Pagar	(*Pagrus vulgaris* C. V.)	3	
King of the Breams — Arbun	(*Pagellus erythrinus* C. V.) . . .	3734	1,83
Crnoguz	(*Sargus vulgaris* Geoffr.) . . .	67	0,03
Špar	(*Sargus annularis* Geoffr.) . .	202	0,10
Bogue — Bukva	(*Box boops* Bp.)	107	0,05
Rock Perches — Škrpine	(*Scorpaena scrofa* L., *S. porcus* L. and *S. ustulata* Lowe)	7042	3,45
Gurnards — Lastavice (kokoti)	(*Trigla* var. sp.)	1846	0,91
Star-gazer — Bežmek	(*Uranoscopus scaber* L.)	22	0,01
Weevers — Pauci	(*Trachinus draco* L. and *T. radiatus* C. V.)	41	0,02
Grb	(*Umbrina cirrosa* Cuv.)	183	0,09
Scabbard-fish Zmijičnjak repaš	(*Lepidopus caudatus* White) . .	425	0,21
Mackerel — Skuša	(*Scomber scomber* L.)	75	0,04
John Dory — Kovač	(*Zeus pungio* C. V.)	1218	0,60
Horse Mackerels — Šnjuri	(*Trachurus Linaei* Malm., *T. mediterraneus* Ltkn. and *T. Cuvieri* Ltkn.)	4599	2,26
Gobies — Glamoči	(*Gobius* var. sp.)	35	0,02
Red Band-fish Mačinac crvenac	(*Cepola rubescens* L.)	11	0,01
Grey Mullets — Cipli	(*Mugil* var. sp.)	5	
Angler-fishes — Grdobine	(*Lophius parvipinnis* Cuv. and L. *piscatorius* L.)	9446	4,63
Miscellaneous — Sitniš	(*Variae pisces*)	23074	11,32
TOTAL — *UKUPNO*		203861	100,00

EDIBLE CATCH
(JESTIVI PRILOV)

	CRUSTACEA *(RAKOVI)*	kg	%
Norway lobster — Škamp	*(Nephrops norvegicus* L.)	46685	97,85
Spiny lobster — Jastog	*(Palinurus vulgaris* L.)	9	0,02
Kozica	*(Penaeus trisulcatus* Leach) . .	203	0,43
Spinous spider crab — rakovica	*(Maia squinado* Herb)	15	0,03
Miscellaneous — Razni rakovi	*(Species variae)*	798	1,67
TOTAL — *UKUPNO*		47710	100,00

CEPHALOPODA
(GLAVONOŽCI)

Poulp — Hobotnica	*(Octopus vulgaris* Lam.)	953	5,26
Muzgavac	*(Eledone moschata* Lam.) . . .	8221	44,77
Cuttle-fishes Sipe i sipice	*(Sepia* and *Sepiola* sp.)	6235	34,00
Squid — Lignja	*(Loligo vulgaris* Lam.)	2930	15,97
TOTAL — *UKUPNO*		18399	100,00

32% of the total catch. In the catch *Nephrops norvegicus* dominates with 98% of the *Crustacea,* whilst among the *Cephalopoda* the most frequent are *Sepia* and *Sepiola* sp. with 34%, *Loligo* sp. with 16%, *Octopus vulgaris* with 5% and *Eledone moschata* with 45%.

The biological data of all the foregoing species in the Adriatic are fairly poor. It is assumed that *Merluccius vulgaris* is to be found along the coast (mainly in the channels and coastal waters) until it is sexually mature; afterwards it migrates to depths where it spawns and remains there extensively. Zei (1949) mentions its biology: »We know for this species, that it spawns in deeper water, as at that time there is only a minimum number of mature samples in the inshore waters. The first sexual maturity is reached by the males at the length of 22 to 30 cm, which would correspond to the age-group »I«. The females spawn at an older age and the corresponding larger length than the males, although all the signs of the ovaries maturing make themselves apparent at a lower age, which corresponds to a body length of already over 30 cm«.

Other species such as *Gadus* sp., *Pediculati* and of *Selachia* the various *Rajidae* and *Scylliidae,* etc., are permanent residents, i. e. they usually stay on the same grounds and they have a small radius of movement which is very important for trawling.

The ratio between *Teleostea* and *Selachia* in the entire fishing region is approximately 3,5 : 1. Meanwhile, the quantitative relationship between the predators and those species which feed on invertebrates is 5 : 1. Various species of *Selachia* and the *Pediculati* are included in the predators. If we also add those species which develop a taste for cannibalism (e. g. *Merluccius),* then this proportion will be somewhat lower. The establishment of this proportion, at least approximately, in spite of the sealonal changes in the composition of the stocks, is of great importance from the biological and aslo from the commercial standpoint. This refers particularly to trawling, as by the rational and gradual elimination of the predators we can considerably increase the proportion at the expense of commercially less important species. Vice versa, if this proportion decreases, the stocks are less important. The experimeents by Ricker and Foerster (1948) with sockeye salmon of Cultus Lake are of special interest in this respect. They were exploring the effect on the production of the sockeye salmon by removing predators from the lake. On the basis of positive results they gave their opinion »that the favorable effect of removing predacious fishes from the has been a result of improved survival rather than of improved food supplies«.

Species like *Clupea sprattus, Clupea pilchardus, Scomber scomber, Acipenser sturio, Dentex vulgaris, Box boops* are rare in catches whilst *Mugil* sp., *Dicentrarhus labrax, Conger vulgaris* and *Alopecias vulpes* are an exception. Others like *Argentina sphyraena* are less important and *Gobius* sp., *Cepola rubescens* with other trash are without any commercial value.

The relative density of all the commercially more important fish, the *Crustacea* and *Cephalopoda* in individual fishing areas is as follows:

Northern Adriatic Fishing Region

Off the western coast of Istria: *Gadidae* 14⁰/₀ (among these *Gadus merlangus* is fairly common); *Maenidae* 14⁰/₀, *Mullidae* 11⁰/₀, *Pagellus erythrinus* 17⁰/₀, *Selachia* 9⁰/₀ (of which *Rajidae* 4⁰/₀ and *Scyllidae* 4⁰/₀), *Dentex vulgaris* 1⁰/₀, *Pediculati* 3⁰/₀ and *Zeus pungio* to a small extent. Of the *Crustacea, Maia squinado* is the most frequent form, vhilst among the *Cephalopoda, Octopus vulgaris* and *Eledone moschata* to 16⁰/₀, *Loligo* sp. to 3⁰/₀ and *Sepia* and *Sepiola* sp. in negligible quantities.

The Gulf of Rijeka: *Gadidae* 35⁰/₀ (of these *Merluccius vulgaris* represents 34⁰/₀); *Mullidae* 3⁰/₀, *Maenidae* and *Pagellus erythrinus* occur in small quantities. *Selachia* are present in in high percentage and they represent over 15% of the total catch owing to the suspended exploitation of this area during the war until the impedimenta of war was cleared away. Of the *Selachia* 10% are *Rajidae* and 3% *Scyllidae*. *Pediculati* also occur in the high percentage of 11% and *Scorpaena* sp. up to 1%. Of the *Crustacea*, *Nephrops norvegicus* is the most abundant in the catch and amounts to 24%, whilst of the *Cephalopoda*, *Octopus vulgaris* and *Eledone moschata* are the most frequent with 2% and *Sepia* sp. in very small quantities.

Kvarner: *Gadidae* 24% (of which *Merluccius vulgaris* takes 21%); *Maenidae*, *Mullidae* and *Pagellus erythrinus* occur in very small quantities. *Selachia* are present in high percentage and they represent over 19% of the total catch, due to the closure to fishing during and after the second World War till 1951. Of the *Selachia*, *Rajidae* make up 14% and *Scyllidae* 4%. Of other species *Pediculati* occur to 1%. *Scorpaena* sp. to 3% and *Zeus pungio* in small quantities. Among the *Crustacea*, *Nephrops norvegicus* is fairly common and it represents 37% of the catch. Among the *Cephalopoda*, more frequent are: *Sepiola* sp. with 4%, *Octopus vulgaris*, *Eledone moschata* and *Loligo* sp. with 1%.

The Velebit Channel (northern area): *Gadidae* 30% (of which *Merluccius vulgaris* accounts for 22%); *Mullidae* occur in small quantities. *Selachia* are fairly common and they represent about 15% of the total catch. Of them *Rajidae* make up 13% and *Scyillidae* nearly 1%. The others are: *Pediculati* 6%, *Scorpaena* sp. 2%, whilst *Uranoscopus scaber* and *Rhombus* sp. are quite rare in a catch. Of the *Crustacea*, *Nephrops norvegicus* is the most frequent with 40% and of the *Cephalopoda*, *Octopus vulgaris* and *Eledone moschata* with 2% and *Sepiola* sp. with 1%.

Kvarnerić: *Gadidae* 43% (of which *Merluccius vulgaris* 38%), *Maenidae* 2%, *Mullidae* are negligible. *Selachia* 10%, of which *Rajidae* are 9% and *Scyllidae* in very small quantities. *Pediculati* are represented with a somewhat higher percentage of 6% and *Scorpaena* sp. with 5%, whilst *Zeus pungio* is fairly rare. Of the *Crustacea*, *Nephrops norvegicus* occurs with 22% and *Maia squinado* in small quantities. Among the *Cephalopoda* are *Sepiola* sp. with 2%, *Octopus vulgaris* and *Eledone moschata* with 2% and *Loligo* sp. in small quantities.

Argentina sphyraena and various *Triglidae* of the commercially less important fish, occur more frequently.

The Velebit Channel (southern area): *Gadies* 50% (of which *Merluccius vulgaris* 44%), *Maenidae* 4%, *Mullidae* 1%, *Selachia* 18%, of which *Rajidae* 12%, *Scyllidae* 3% and *Myliobatis* sp. nearly 1%. Then follow *Pediculati* 5%, *Scorpaena* sp. 4% and *Zeus pungio* in small quantities. Of the *Crustacea*, *Nephrops norvegicus* 3% and *Maia squinado* are a negligible percentage. Among the *Cephalopoda* the more common are: *Sepiola* sp. with 6%, *Eledone moschata* with 4% and *Loligo* sp. of which small quantities are caught.

Central Adriatic Fishing Region

The Zadar-Žirje Channel: *Merluccius vulgaris* 36%, *Mullidae* 3%, *Maenidae* which are quite frequent, represent nearly 15% of total catch, *Pagellus erythrinus* 2%, *Selachia* 15%, of which *Rajidae* 7% and *Scyllidae* 5%, whilst *Myliobatis* sp. and *Trygon* sp. occur in small quantities. Then follow *Pediculati* with 1%. Among the *Cephalopoda* the most frequent are: *Sepia* sp. with 12% and *Eledone moschata* with less than 1%.

Off the western coast of Kornati Islands to the open sea: *Gadidae* 23%, of which *Merluccius vulgaris* accounts for 18%. Then are represented: *Maenidae* with 2%, *Mullidae* with 5% and *Pagellus* sp. in small quantities. *Selachia* are fairly common and they represent 18% of the total catch, of them *Rajidae* make 3%, *Scyllidae* 14% and *Myliobatis* sp. less than 1%. The others are: *Zeus pungio* 6% and *Arnoglossus* sp. 3%. Of the *Crustacea, Nephrops norvegicus* is the most frequent with 4% and of the *Cephalopoda, Eledone moschata* with 1%.

Of the commercially less important species of fish *Argentina sphyraena* comes in with 4% and of the *Cephalopoda, Todarodes sagittatus* with 5%.

Area west of Cape Ploče to the open sea: *Gadidae* represent 36% of the total catch, of them *Merluccius vulgaris* makes 22% and *Gadus* sp. 14%. Then follow *Mullidae* 2%, *Maenidae* and *Pagellus erythrinus* 1%, *Selachia* 10% (of which 3% are *Rajidae* and 6% *Scyllidae* and *Trygon* sp. in very small quantities), *Pediculati* somewhat less than 1%, *Arnoglossus* sp. 2%, *Zeus pungio* 2%, *Lepidopus caudatus* 1% and *Solea* sp. in very small quantities. Of the *Crustacea, Nephrops norvegicus* is the most frequent with 2%, whilst of the *Cephalopoda, Eledone moschata* makes up 3% and *Loligo* sp. less than 1%.

Of the commercially less important species *Argentina sphyraena* 1% and considerable quantities of *Todarodes sagittatus* are fairly common.

The Split-Brač Channel and Bay of Kaštela: *Gadidae* represent 23% of the catch of which *Merluccius vulgaris* makes 20%. The others are: *Maenidae* 11%, *Pagellus erythrinus* 6%, *Selachia* 18% of which 11% are *Rajidae*, 6% *Scyllidae* and small quantities of

Myliobatis sp.; *Pediculati* less than 1%, *Zeus pungio* 2%, *Solea* sp. and *Scorpaena* sp. nearly 1%. Of the *Cephalopoda*, there are: *Eledone moschata* 7%, *Sepia* sp. 2% and *Loligo* sp. in negligible quantities. Of the commercially less important fish *Argentina sphyraena* and various *Triglidae* occur with 2%.

The Hvar Channel: *Gadidae* represent 20% of the catch, of which 14% is made up of *Merluccius vulgaris*. Others are represented by: *Maenidae* 10%, *Mullidae* 7%, *Pagellus erythrinus* 6%, *Selachia* 30%, of which *Rajidae* account for 17% and *Scyllidae* for 12%. Then follow *Pediculati* with 4%, *Scorpaena* sp. with 7% and *Zeus pungio* in small quantities. Of the *Cephalopoda*, *Eledone moschata* occur with 5% and *Loligo* sp. in negligible quantities.

The Korčula Channel: *Merluccius vulgaris* represents 19% of the catch. Others follow with *Maenidae* 11%, *Mullidae* 12%, *Pagellus erythrinus* 9%, *Selachia* 29% of which 13% are *Rajidae* and 13% *Scyllidae*, further *Pediculati* 5%, *Scorpaena* sp. 8%, *Zeus pungio* 3%, *Solea* sp. and *Squatina laevis* 1%. Among the *Cephalopoda*, *Eledone moschata* are most frequent with 2%.

The Neretva Channel: *Gadidae* represent almost 38% of the total catch, of them *Merluccius vulgaris* accounts for 37%. The others are *Maenidae* 5%, *Mullidae* 11%, *Pagellus erythrinus* 5%, *Selachia* 9% (of which *Rajidae* 6% and *Scyllidae* somewhat less than 1%), further *Solea* sp. 5%, *Scorpaena* sp. nearly 1%, *Arnoglossus* sp., *Zeus pungio* and *Trachinus* sp. 1%. Of the *Crustacea* the most frequent is *Penaeus trisulcatus* with 3%, af the *Cephalopoda*, *Eledone moschata* with 9%, *Loligo* sp. with 2%.

Southern Adriatic Fishing Region

The Lastovo Channel: *Merluccius vulgaris* represents 18% of the total catch. Others are *Maenidae* with 6%, *Mullidae* with 6%, *Selachia* with 42% (of which *Rajidae* 21% and *Scyllidae* 21%); further *Scorpaena* sp. with 14% and *Pediculati* with 6%.

The Mljet Channel: *Gadidae* represent 19%, of which *Merluccius vulgaris* accounts for 18%. Then follow *Maenidae* with 14%, *Mullidae* with 9%, *Pagellus erythrinus* with 2%, *Selachia* with 31%, *Solea* sp. with 2%, *Pediculati* with 1%, *Scorpaena* sp. with 13%, *Uranoscopus scaber*, *Zeus pungio* and *Squatina laevis* about 1% of the total catch. Of the *Cephalopoda*, *Eledone moschata* occur with 7% and *Loligo* sp. in negligible quantities.

T h e K o l o č e p C h a n n e l: *Merluccius vulgaris* is fairly frequent and it represents 20% of the total catch. Then follow *Mullidae* 6%, *Pagellus erythrinus* 9%, *Selachia* 30% (of which *Rajidae* 23% and *Scyllidae* nearly 7%); *Pediculati* 9% and *Trachinus* sp. in small quantities. Of the *Cephalopoda, Eledone moschata* are the most abundant with 13%.

Of the commercially less important fish various species of the *Triglida* to 3% are to be found.

O f f t h e s o u t h e r n c o a s t o f M l j e t I s l a n d t o t h e o p e n s e a: *Gadidae* represent 36% of the total catch (of these *Merluccius vulgaris* takes 26%); then follow *Maenidae* with 6%, *Selachia* with 30%, *Pediculati* with 6%. Of the *Cephalopoda, Eledone moschata* are the commonest with 4%, *Sepia* sp. and *Loligo* sp. with 4%.

O f f t h e M o n t e n e g r i n L i t t o r a l: *Merluccius vulgaris* represents 27% of the total catch. Then follow *Mullidae* with 8%, *Pagellus erythrinus* with 1%, *Selachia* with 27% (of which *Rajidae* make 14%, *Scyllidae* 8%, *Myliobatis* sp. almost 2% and *Torpedo* sp. 1%); then *Pediculati* 2%, *Solea* sp., *Squatina laevis, Zeus pungio, Trachinus* sp., *Centrina salviani* and *Arnoglossus* sp. 1% altogether. Of the *Crustacea* the most frequent is *Penaeus trisulcatus* with 1%, and of the *Cephalopoda, Eledone moschata* with 3%, *Sepia* sp. with 3%, *Loligo* sp. and *Octopus vulgaris* with 1%.

ANALYSIS OF STOCKS, FISHING AREAS AND FISHING GEAR

The analysis of variance was used to investigate the biocenothic relationships between stocks.* For this purpose converted values of catches of individual species and groups were taken.

Analysis of Variance of Stocks of all Fishing Areas
(Analiza varijance naselja ribolovnih položaja)

Source of Variation *(Varijanca)*	Degrees of Freedom *(Stupanj neov. varijanata)*	Sum of Squares *(Suma kvadrata)*	Mean Square *(Prosječna varijanca)*	z	P
Species	7	186,01514	26,57359	1,8594	< 0,001
Areas	98	367,29272	3,74788	0,8800	0,01
Error	686	442,39517	0,64489		
TOTAL	791	995,70303			

* The conception of stock in the statistical sense requires that the hypothetical stock should be understood and the representative samples as parts of this stock. In this work a preliminary attempt was made to obtain at least an approximate picture of the relative density of the stocks in the fishing areas analysed, by means of induction from the sample to the stock. Also in connection with this, the total catch by trawling on individual fishing grounds was treated as one stock. A similar attempt was made by M e r r i m a n and W a r f e l (1948).

The probability of less than 0,001 for species and 0,01 for the fishing areas indicates that the difference between the species and areas within the stocks is significant. This difference enabled us to continue investigation of the relative density of these stocks. It is obvious that the values obtained do not provide any definite proof of the obsolute density of the stocks in the fishing areas concerned, which displays constant fluctuations, being dependent on the intensity of fishing, natural mortality rate, recruitment and rapidity of growth of the populations. These values represent only quantities (expressed by weight) of the commercially more important species taken in a certain period of time and with the corresponding gear. The unit of time of one hour's trawling used has thus only a relative or comparative value, i. e. it serves as an equivalent of the catches.

Before we pass to the analysis itself, of the relative density in individual fishing areas per unit of time, two facts must be mentioned:

a) The number of vessels and the corresponding sizes of nets were not used equally throughout the year for all the fishing grounds.

b) The number of hauls also varied according to the fishing areas. The distribution of their frequency is shown on Table VIII.

Table VIII. Number of Vessels and Hauls for Individual Fishing Areas

(Broj brodova i poteza za pojedino područje lova)

Fishing Areas *(Područja lova)*	I	II	III	IV	V	VI	VII	VIII	IX
Vessels *(Brodova)*	8	5	14	11	16	5	2	3	9
Hauls *(Poteza)*	97	52*	187	157	269	59	58	19	142

Fishing Areas *(Područja lova)*	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
Vessels *(Brodova)*	6	3	5	5	2	4	2	1	6
Hauls *(Poteza)*	49	21	59	49	3	44	12	1	497

The table shows that in the fishing areas of the Lastovo Channel and off the southern coast of Mljet Island to the open sea, the number of hauls was very small to be regarded as representative.

* In this region there were 3 fishing trips, but without the number of hauls having been marked down. According to the time spent 2 hauls were calculated for each trip and added to the total number of hauls.

Table IX. Catch per one hour's trawling and Relative Density of Stocks in various Fishing Areas*

(Ulov za 1 sat povlačenja i relativna gustoća naselja na različitim područjima lova)

Fishing areas *(Područja lova)*	Catch per one hour's trawling *(Ulov za 1 sat povlačenje)* Without correction *(Bez korekcije)* A	With correction *(Sa korekcijom)* B	A—B	Relative density *(Relativna gustoća)*	
I	22,44	25,11	—2,67	100	
II	16,81	19,39	—2,58	74,91	
III	21,51	24,52	—3,01	95,85	
IV	26,85	30,12	—3,27	119,65	S (d) = 4,74
V	30,32	33,76	—3,44	135,11	d = 0,26
VI	24,41	22,60	1,81	108,77	S (d^2) = 222,6918
VII	16,16	15,04	1,12	72,01	$\frac{1}{n}$ S (d^2) = 1,2482
VIII	47,28	40,57	6,71	210,69	S (d — $\bar{d}$) = 221,4436
IX	50,74	46,78	3,96	226,11	Vd = 13,02609
X	25,73	26,07	—0,34	114,66	V$\bar{d}$ = 0,722367
XI	22,55	23,75	—1,20	100,49	$s_{\bar{d}}$ = 0,85069
XII	33,33	33,16	0,17	148,53	t = 0,30563
XIII	21,17	27,88	—6,71	94,34	n = 17
XIV	45,89	45,29	0,60	204,50	
XV	35,24	34,47	0,77	157,04	P = 0,8—0,7
XVI	33,87	30,17	3,70	150,93	
XVII	31,30	28,89	2,41	139,49	
XVIII	29,63	22,92	6,71	132,04	

The period of one year was used in this analysis to compare the relative density of individual fishing grounds. It coincides accidentally with the natural biological cycle of the fish life. This period plays an important part not only from the biological, but also from the economic standpoint, because it makes possible a constant observation of changes in the existing quantity of fish, as well as of the relationship between the catches and the time spent on individual fishing grounds. The average catch per unit

* The Bay of Ljubač and the Krk Channel are left out of this analysis of elative density.

of time illustrates also the state of the stock of fish in a determined area in space and time. The decline or rise of this index is the measure of the increase or decrease of the quantity of fish on the respective fishing grounds caused by various factors. The nature and trend of these oscillations during the years may be best seen in following the catches per unit of time.

The catches on individual fishing grounds per one hours's trawling as their corresponding relative density are given on Table IX. The significant difference in the catches is $2 \times m\% \sqrt{2} = 6{,}41\%$.

If that value is used as the measure of the difference between individual fishing grounds and if the catch of the area I is taken to be 100, then the catches of the other 17 areas are as follows on Table IX.

The areas IX, VIII, XIV, XV, XVI XVII, XVIII, V, IV, X and VI have accrdingly the significant difference of 6,41% in relation to the area I, and the areas VII, III, XIII, II and XI are weaker.

This relative density, however, does not give a complete picture of the real state of the fish stocks. It contains a probable error arising from the greater concentration of large vessels on individual fishig grounds, their effectiveness of catch being greater per unit of time. That is to say, there is an evident proportion between the power of the motor including the corresponding size of the net on the one hand and the catch on the other. We shall find confirmation for this in Table X. The records were collected by the vessels which trawled in 1951 and they included 81,01% of the yield and 76,68% of the time spent by all the vessels which are the subject of this statistical analysis. The coefficient of correlation in the same table between the vessels of various HP and the catches per one hour's trawling is 0,858 and between the vessels and the catches per one HP is — 0,933. Both of these coefficients are significant as the value P is equal to or less than 0,01.

Table X. Catch per one hour's trawling and per one HP of vessels of various HP

(Ulov za 1 sat povlačenja i po 1 HP brodova različitih HP)

HP	30	50	80	110	160	180	250
$kg/1^h$	16,66	25,56	29,35	30,00	33,41	35,11	35,48
$1^h/HP$	0,55	0,53	0,36	0,27	0,21	0,19	0,14

The table shows that the increase of HP is not in proportion to the increase of catches per unit of time. The coefficient of variation of HP amounts to 59%, that of the catches to 22%. The difference between both coefficients of variation of HP/^{h}=2,80. The graphic demonstration of this relationship is given on Figure 1. It shows the typical downward and upward exponential trend which may be expected with vessels of various HP, when their catch per one hour's trawling is reduced to a constant percentage proportion. The coefficient of regression obtained for kg/HP out of that ratio equals 0,072, i. e. every increase of one HP will increase the catch for 0,072 kg. This coefficient of increase of 0,072 kg

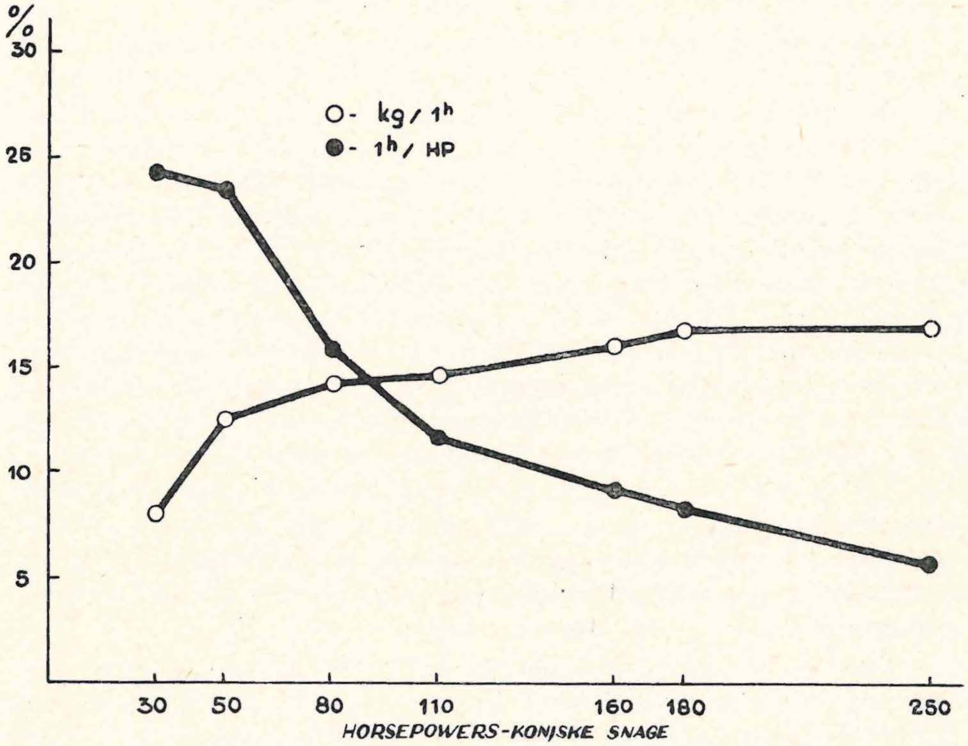


Figure 1. Catch per one hour's trawling and per one HP of vessels of various HP.
Slika 1. Ulov za 1 sat povlačenja i po 1 HP brodova različitih HP.

was taken to correct the error of one hour's trawling in various fishing areas (column 3 of Table IX).

The value corrected was obtained by using the formula:

$$k\,(x_p - \bar{x}_p)$$

where k is constant, x_p the average individual values of HP of individual areas and $\bar{x}_p$ the mean value of HP of all the areas.

Student's method was used to test whether the difference between both of the mean values (A and B) was justifiable.

The value obtained $P(t) > 0{,}30563 = 0{,}8—0{,}7$ (column 6 in Table IX) indicates that no significant difference exists between the normal and corrected value of the catch per unit of time.

Now a question automatically arises: what is the future of this relative density of the fish stocks in the channels and inshore waters on the fishing grounds of the eastern Adriatic? Will a further increase of catches result in a regression of catch per unit of time or not?

The statistical analysis of covariance was used for this purpose. The following channels were taken into consideration for the analysis: Kvarner, Kvarnerić, Velebit Channel (northern and southern area), Split-Brač Channel including the Bay of Kaštela, Korčula and Neretva Channel and Mljet-Koločep Channel. The coefficient of regression obtained $b_1 = —0{,}0001$ within the channels and inshore waters is not significant. This negligible negative coefficient of regression, however, shows in furter perspective that every increase of catch in the channels will result in a further decrease per unit of time. The number of vessels and the intensity of their fishing by the amount of time spent will in this process play an important part, because on these two factors depends greatly the magnitude of the total catch. The coefficients of multiple regression b_1 with $t(15) = 4{,}2737$ and $P = < 0{,}001$ for the number of vessels and b_2 with $t(15) = 3{,}1892$ and $0{,}01 > P < 0{,}001$ for the hours of trawling provide a clear proof of the dependence of the total catch on the number of ships and hours of trawling. Table XI and Figure 2 giving the data on the catches of fish per unit of time of one hour's trawling before and after the war for individual fishing areas also confirm this supposition.

The Bay of Rijeka showed a 3,3-fold increase per one hour's trawling. Futher study will show that this is due to the weight-increase of *Selachia* and in general to the increase of density of stocks owing to the cessation of fishing. That the reduced fishing really affected the increase in weight-density of the stocks was confirmed by the investigations of many authors after the second World War. Parrish (1947) cited that the average yield of haddock in the North Sea had increased by 5 times after the war-time reduction of fishing from 1938-1945. Margets (1947) asserted also that the English North Sea trawl fisheries had shown a 3,1-fold increase in the period from 1939—1945. Letaconnoux (1947) said, in connection with trawling in La Rochelle, that the catch had increased by 2,4 times in the period from 1937—1939 to 1946. D'Ancona (1950) stated that the total catch in the Northern Adriatic (under identical

Table XI. Catch of Fish per one Hour's Trawling and corresponding HP of Vessels having fished in Various Periods of Time

(Ulov ribe za 1 sat povlačenja i odgovarajući HP brodova sa kojima se lovilo u različitim periodima vremena)

Fishing area *(Područje lova)*	kg/1h		HP
Gulf of Rijeka *(Riječki zaliv)*	Kotthaus (Jan. 1938)	3,88	50 (1938)
	(Dec. 1951)	12,73	60 (1951)
Velebit channel (northern area) *(Velebitski kanal sjeverni dio)*	Kotthaus (June 1938)	15,90	50 (1938)
	Križanec* (Aug. 1947)	17,25	45 (1947)
	Križanec* (June 1950)	15,15	45 (1950)
	(June 1951)	9,20	50 (1951)
Kvarnerić *(Kvarnerić)*	Kotthaus (June 1938)	4,63	50 (1938)
	Križanec* (Sept. 1947)	26,78	45 (1947)
	Križanec* (June 1950)	16,86	45 (1950)
	(June 1951)	15,17	60 (1951)
Central Dalmatian Islands *(Srednje dalmatinsko otočje)*	Zei-Sabioncello (June 1939 and April 1940)	24,63	50 (1938)
	(Jan., Febr., March, April, June, Sept., and Oct. 1951)	23,81	aver. 50 (1951)

conditions of time, place and means) had increased by 50% approximately in the period from 1939/40 to 1946. The causes of this increase of density we must seek in the increase of the number of fish on individual fishing grounds, or, what is more probable, in the increase of the average length

* Unpublished data.

of fish in the stock due to the decrease of mortality and greater possibility of survival. This second cause is probably the reason for the increase of density of stocks in the Gulf of Rijeka in 1951. The example of the Gulf of Rijeka and Kvarner which were not trawled till 1951 may serve

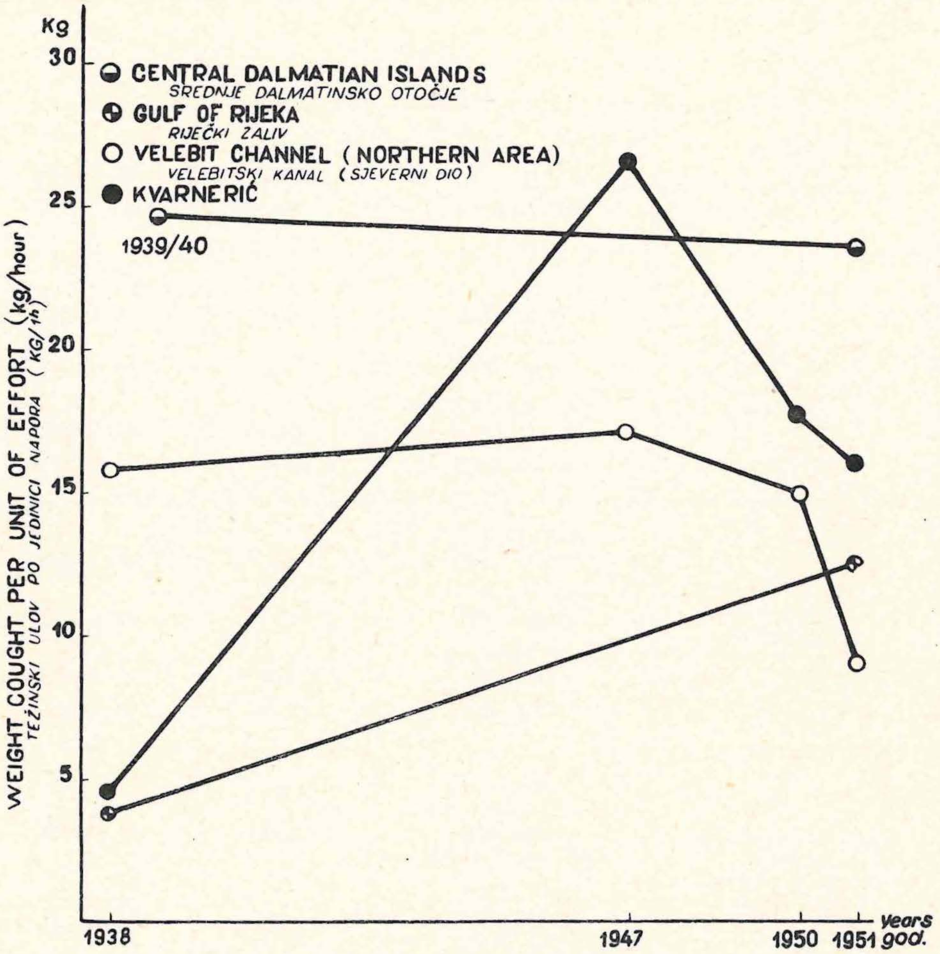


Figure 2. Catches of fish in 1 hour of trawling on individual fishing grounds in various periods of time.

Slika 2. Ulov ribe za 1 sat povlačenja na pojedinim položajima lova u različitim periodima vremena.

as a basis for proofs of density of stocks also in our other fishing areas after the war due to underfishing. But the post-war expansion of the trawling fleet in our channels and coastal areas had led rapidly to a decline in the catch which has dropped to the pre-war level. According to this, overfishing is to be really feared in our most important fishing areas.

Kvarnerić too showed an increase of catch per one hour's trawling, but ascribable to quite different causes than in the case of the Gulf of Rijeka. Almost less than one half the number of vessels (although relatively still much for this area) fished in this region as compared with before the war. The consequence of this decrease in the number of vessels is, in my opinion, the cause for the increase of catch per unit of time in this area of intensive trawling. Ricker (1940) came to a similar conclusion mathematically. On the basis of a theoretical analysis of the fishing intensity (»rate of exploitation«) and gear (»unit effort«), using the formula:

$$\frac{f_2}{f_1} = \frac{\log_{10} (1 - m_1)}{\log_{10} (1 - m_2)}$$

he demonstrated that »the larger amount of gear will catch relatively fewer fish than would the smaller, in the course of the season«.

The Velebit Channel (northen area) tends to show a rapid decline in the catch per unit of time, which can be explained by the intensive trawling on this narrow and limited space in the post-war period.

The central Dalmatian region showed a slight decrease of catch per one hour's trawling, probably due to more intensive trawling in the Neretva Channel after the war, in relation to the pre-war period.

All the foregoing data confirm the fact that every increase of catch decreases the effectiveness per unit of time. This decrease of effectiveness per unit of time may very easily be connected with the indication of the optimum reached, the exceeding of which through excessive fishing affects harmfully the fish stocks. Whether this moment has really taken place, it is difficult to assert irrefutably. The comparison of the pre- and post-war data of the catches by trawling in the same fishing regions also failed to confirm this (Tables XII and XIII). Kotthaus (1938) analysing the state and development of trawling off our coast in the period from 1932 to 1936 quoted: »We have here the typical case of overfishing, which, in my opinion, is to be attributed to two main causes. In the first place the regions trawled are too restricted. It should be mentioned only that for example the area trawled in the Velebit Channel, being about 20 Nm long and at the most not even 3 Nm wide, has about 40 square nautical miles. There is no need for particular discussion to show that a stock which is fished throughout the year by several nets cannot be long maintained here. The same concerns the other fishing regions«.

If we make a comparison between catch in the same areas in 1950 and 1951 and that before the war and if we characterize overfishing according to Graham (1939) as a decrease of the total catch »as effort increases«, then Kotthaus, statement on overfishing will be doubtful.

The total catch in this case cannot thus be an indicaction of overfishing, because of a rise, but it is necessary to carry out a closer analysis, i. e. that of catch per unit of time and HP. If the mean values of the catch divided by HP from 1932 to 1940 and those of 1951 as well, then the ratio of catch to HP for these two different periods of time is 1,2 : 1. Now the ratio obtained gives quite a different picture of the state of the stocks in our channels and coastal waters before and after the war, without regard to the total catch. In addition, this ratio also speaks in favour of the smaller vessels which have smaller costs and they can accordingly be profitable with smaller catches. This is not the case with large vessels. For them a »limit of unprofitableness« (Graham) exists to a greater extent than for the small vessels. This limit compels them to leave the fishing grounds which for them are not profitable and to seek new ones or remain tied up in the port.

Table XII. Average Catch by Trawling in relation to the Total Catch from 1932 to 1940

(Prosječan ulov vučom u odnosu na cjelokupan ulov od 1932 do 1940 g.)

Year *(Godina)*	Total catch all species in tons *(Ukupan ulov svih vrsta u tonama)*	Cath by trawling in tons *(Ulov vučom u tonama)*	Cath by trawling as against total catch in % *(Ulov vučom prema ukupnom ulovu u %)*	Number of trawlers *(Ukupno vučara)*	Total number of vessels over 50 HP *(Ukupno brodova preko 50 HP)*
1932	7202,7	315,3	4,4	20	There were only 3 vessels over 50 HP for the entire period from 1932—1940. *(Za čitavo razdoblje od 1932-40 bilo je 3 broda preko 50 HP.*
1933	7133,7	263,8	3,7	21	
1934	7778,8	163,6	2,1	23	
1935	7440,9	161,2	2,2	21	
1936	6334,0	140,4	2,2	21	
1937	7189,1	144,9	2,0	18	
1938	8015,7	125,5	1,6	21	
1939	6299,8	152,9	2,4	24	
1940	8374,4	77,3	0,9	20	

Table XIII. Average catch by trawling in relation to the total catch in 1950 and 1951*

(Prosječan ulov vučom u odnosu na cjelokupan ulov 1950 i 1951 godine)

Month *(Mjesec)*	1950 Croatian Littoral	1950 Dalmatia	1950 Total *(Ukupno)*	1951 Croatian Littoral	1951 Dalmatia	1951 Total *(Ukupno)*
Jan.	22,5	65,5	88,0	28,4	69,1	97,5
Feb.	11,3	55,4	66,7	28,5	80,8	109,3
March	28,9	78,6	107,5	33,4	79,6	113,0
April	19,9	47,7	67,6	45,8	45,9	91,7
May	43,6	51,5	95,1	52,2	48,3	100,5
June	37,1	15,7	52,8	69,1	34,3	103,4
July	66,8	27,9	94,7	60,4	31,7	92,1
Aug.	60,5	18,5	79,0	56,0	50,7	106,7
Sept.	39,2	25,0	64,2	43,5	29,4	72,9
Oct.	41,5	36,8	78,3	30,6	112,8	143,4
Nov.	34,9	140,0	174,9	36,9	89,4	126,3
Dec.	34,3	79,8	114,1	42,5	115,9	158,4
Total tons: *(Ukupno tona)*	440,5	642,4	1082,9	527,3	787,9	1315,2
No. of vessels *(Ukupno brodova)* To 50 HP	6	4	10	8	4	12
No. of vessels *(Ukupno brodova)* Over 50 HP	15	26	41	17	29	46
Total catch of all species in tons *(Ukupni ulov svih vrsta u tonama)*	3081,5	14408,2	17489,7	2447,8	8827,7	11275,5
Catch by trawling as against total catch in % *(Ulov vučom prema ukupnom ulovu u %)*	14,3	4,5	6,2	21,5	8,9	11,6

* These data were put at our disposal by the Institute of Statistics and Reports f the Croatian Republic and we take this opportunity to record our gratitude.

Analysing the trawling in Castellón, Andreu and Rodríguez-Roda (1951) said about the effect of overfishing on various types of vessels: »It can be seen in trawling that overfishing affects more the profitableness of large vessels than of small«.

This economic law also made itself felt in the case of our large vessels. Their further fishing in the channels and coastal waters is completely unprofitable on the one hand, and on the other they destroy far more the already endangered stocks than the small vessels, taking into consideration the greater capacity of the motor, nets etc. There is no other solution to this problem than to prohibit further fishing to all the vessels over 80 HP (in some areas even over 50 HP) in the channels and coastal waters and to move them gradually to our open territorial waters, where the stocks, as this analysis shows, are more abundant than those in the channels and inshore waters. The direct result of this prohibition of fishing would be a quantitative improvement of the stocks in a short period of time, as the relationship between the weight and the length of the fishes usual in marine biology is

$$t = kd^3$$

(where k is constant), i. e. the weight equals the length cubed. These would be the results of the analysis of the stocks, fishing grounds and fishing gear of the trawling in the year 1951 in our channels and coastal areas.

EFFECT OF FISHING ON THE SIZE AND COMPOSITION OF FISH STOCKS

Much has been written about the effect of fishing intensity with trawl-nets on the composition and size of the stocks of fish. Various authors who dealt with this problem, agree that the development of trawling has had harmful consequences on the size and composition of the stocks. It will be sufficient to mention only several of these opinions in order to grasp the complexity of this problem.

Garstang (1900) upset the old conceptions on the inexhaustibleness of the sea, which up to then were fairly strong. He did this on the basis of statistical and experimental data on trawling for a series of years. From 1867 to 1892 (according to Mr. Alward) the total catch of fishing by trawling decreased by half and that of *Pleuronectes platessa* to a quarter of the initial catch. The cause for this constant decline of catch in the waters of Scotland, Garstang ascribed to the activity of man, i. e. to overfishing. Further investigations of the same problem led Heincke (1913) to the conclusion that the rapid development of otter-trawlers in the North Sea harmfully affected the populations of *Pleuronectes platessa* which resulted in a destruction of the adults and even to a greater extent of the young fish, then in a diminution of the populations, decline of catch and thus in evident overfishing.

The limitations imposed on the fishery during the first World War served at the same time as a good experiment on the fishing effect on the composition and size of the stocks. Johansen and Smith (1919) explored the effect of greatly reduced exploitation during the war on the quantity of *Pleuronectes platessa* in the eastern part of the North Sea. On the basis of an analysis they stated that the number of large plaice had increased in the region under observation, whilst the percentage of the small samples had decreased. This quantitative increase of large specimens was due to a greater frequency of older age-groups. Individuals of the same age were growing much more slowly during the war than before the war. The result of this increase in older age-groups was a richer catch in the years immediately after the war in the North Sea. This increased yield, however, did not last long. The intensified fishing immediately after the war rapidly emptied the accumulations of the war years, so that already in 1921 the average catch per unit of time approached the pre-war level (Russell, 1932 and Thursby-Pelham, 1939).

The phenomenon noticed by Johansen and Smith was explained by Petersen (1920) by means of his »thinning theory«. According to this theory »if the fishing is not intensive, the stock grows dense, but the individuals are hampered in their growth by this; if fishing is still more intensive the stock is thinned out, but the individuals more quickly, and the annual catch is greater«. The competition for food is the major condition for a more rapid growth of the fish, according to Petersen.

Russel (1932) gave the mathematical explanation of the »thinning problem« as well as its harmful effect on the marine population. In order to defend his argument Russell divided the entire available food for a stock into two parts: maintenance food and growth-food. The first part of the food is sufficient to ensure existence, the second to enable growth. The most favourable conditions for the fish growth and with this also for an increase of the productiveness of fishing are, according to Russell, »if the number and size of the fish are adjusted in such a way that the ratio of growth food to maintenance food is at a maximum, while all the food is consumed«.

The approximate theoretical solution of the overfishing problem is of later date. Hjort, Jahn and Ottestad (1932) and Graham (1939) used the sigmoid curve to define overfishing. Acording to it »the productiveness of a stock of fish depends on the effort used to exploit it; the productiveness is first increasing and then decreasing as the effort increases« (Graham, 1939). The solution of »the overfishing problem is to limit the amount of fishing, for the only real cure for fishing too much is — obviously — to fish less... such that the number caught multiplied by their average weight, is, and remains, at a maximum (Russell, 1939).

With the outbreak of the second World War, the fishing in many European countries was reduced to a minimum. The suspension of fishing from 1939 to 1945 provided the motive for repeated scientific investigation of the stocks. At a special meeting which took place in Copenhagen, this very problem was discussed. The various papers read by those who attended the meeting (Jensen, Mulicki, Margetts and Holt, Parrish and Letaconnoux), showed that the main effect of the war was the same, namely:

1. An increase of density of stock, frequently of the order of 3-fold, ascribable to greater survival to older ages.
2. Some changes in growth-rate, but insufficient to prevent the augmentation of the stock.

Gast (1918), D'Ancona (1922, 1926, 1934 and 1950) and Zei (1940, 1942 and 1949) dealt with the ecological problems and the biocenothic composition of the demersal stocks of fish in the Adriatic.

D'Ancona (1926, 1934 and 1950) on the basis of statistical data of the markets of Rijeka, Trieste and Venice (1926 and 1934) and of Trieste and Chioggia in 1950, analysed the effect of underfishing during the two world wars on the composition of *Selachia* and other species within the biocenosis. The result of this analysis showed that in the northern Adriatic the number of predators had multiplied, whilst on the contrary the plant- and invertebrate-feeding fish had decreased considerably. »A disturbance of the biological balance occurred between the predators and the non-predators« (D'Ancona, 1950).

The reationship between *Selachia* and *Teleostea* in the Gulf of Rijeka, Velebit Channel (northern and southern area) and Kvarnerić was investigated by Gast (1918), D'Ancona (1922) and Zei (1949). In their data we can closely follow how this relationship changed within the biocenosis side by side with the development of trawling in the course of time. Gast disposed of data covering the period from 11th June to 30th September in 1916 and the same period in 1917. During this period the Gulf of Rijeka and Velebit Channel (northern section) from Selce to Senj were fished intensively, whilst Kvarnerić and the Velebit Channel (southern section) were little exploited. D'Ancona used the statistical data of the market of Rijeka from 1914 to 1920. The large percentage of *Selachia* of 34,91% in these war years, particularly in the last year, 1918, in relation to the total catch of demersal fish, he explained as a consequence of the suspension of fishing during which the »biological balance« had changed within the biocenosis at the expense of *Teleostea*. Z e i (1949) also maintained the same view as G a s t for the Gulf of Rijeka and the Velebit Channel (northern area), i. e. that the percentage of *Selachia* in the Velebit Channel (southern area) was far greater than that in the northern area of the channel and Gulf of Rijeka, the cause for which he ascribed to the excessive fishing in the two latter in the course of the years.

The trawling stopped in 1941 with the declaration of war, the occupation of the eastern coast of the Adriatic and owing to the danger of operating in individual fishing areas because of mine-fields. This cessation lasted continuously till 1950 for Kvarner (in the narrower sense) on the line Plomina Bay — Cape Pečena; Crna Punta — Cape Zaglav and even till 1952 for the Gulf of Rijeka. Meanwhile, the Gulf of Rijeka was trawled 1 to 2 Nm off the coast in its eastern and western areas in 1951. Kvarnerić in the direction Cape Ercić—Baška, Sorinj—Dolfini and Kolovrat has been reopened to trawling since 1945.

The number of hauls was 52 in the Gulf of Rijeka, 187 in Kvarner and 269 in Kvarnerić in 1951.

The relationship between *Selachia*, *Teleostea* and edible catch in the fishing areas of the Gulf of Rijeka, Kvarner and Kvarnerić in 1951 (expressed in percentages) was as follows:

	Culf of R jeka	Kvarner	Kvarnerić
Merluccius vulgaris	33,80	21,08	39,03
Gadus sp.	1,68	2,69	5,11
Mullidae	3,37	0,18	0,06
Selachia	15,19	19,47	10,62
Species variae	18,79	14,16	18,39
Edible catch	27,17	42,45	26,79

Nephrops norvegicus represented 87, 53% of the edible catch in the Gulf of Rijeka 83,86% in Kvarner and 81,69% in Kvarnerić. Besides the weight, expressed in percentages, the data on the size of *Nephrops norvegicus* in Kvarner and Kvarnerić are also interesting. In these data the differences in the size between the areas which were not trawled at all (Kvarner) and those of intensive trawling (Kvarnerić) express themselves particularly. So in June 1951 the average number of *Nephrops norvegicus* was 18 in one kilo in Kvarner, and 50 in Kvarnerić (K a r l o v a c, 1953).

Another characteristic phenomenon (which will be discussed more later) can be noticed in the above- mentioned data in the same fishing areas. The Gulf of Rijeka and Kvarner showed a decrease of *Gadidae* by percentage and an increase of *Selachia* in contrast to Kvarnerić where it is opposite. This phenomenon of the decrease of *Gadidae* by percentage of increase of *Selachia* in proportion to the total post-war catch, was noticed also by other authors. D'A n c o n a (1950) mentioned a rapid increase of the percentage of *Selachia* during the second World War due to the suspension of fishing. Analysing the effect of the war on the composition of the fich stocks in La Rochelle, L e t a c o n n o u x (1947) established that the quantities of *Merluccius vulgaris* had slightly diminished by percentage, of *Gadus luscus*, considerably, whilst *Raja* sp. had increased in relation to the total catch before and after the war. M a r g e t t s (1947) too, stated a decrease of *Gadus merlangus* after the war in relation to the pre-ar period. This percentage decrease of the populations of *Gadus mer-ngus* M a r g e t t s explained »... may possibly be due to some of the her species increasing in numbers to a certain extent at the expense f this species«.

The percentage relationship, expressed by weight, between *Selachia* nd *Teleostea* is given in Table XIV and Figure 3, and that between *Gadidae* and *Selachia* on Figure 4.

This table shows the weight proportion of *Selachia* and *Teleostea* in those fishing areas which were trawled either intensively, moderately intensively, or not at all.

The Gulf of Rijeka which was not fished for almost 10 years, showed a considerable increase in *Selachia* and commercially unimportant fish and a decrease of *Gadidae* and commercially important fish in the post-war period. This phenomenon is the more important, considering that just the Gulf of Rijeka was the most intensively fished in the inter-war period.

Before the war, the Velebit Channel (northern area) was moderately intensively exploited in the area south of Senj, whilst north of Senj trawling was prohibited. Since the war the area north of Senj to Crikvenica has been also trawled intensively. The percentage of *Gadidae* has increased, particularly in the southern part of the channel, that of the other commercially more important fish has decreased and that of the unimportant fish has increased. In the area north of Senj, where before the war trawling was prohibited, there are more *Selachia* and commercially unimportant fish and less *Gadidae* than in the southern area.

Kvarnerić showed an increase of *Gadidae* and decrease of *Selachia* and other commercially more important fish. The same case obtains in the region around the central Dalmatian islands.

Table XIV. Percentage relationship between *Selachia* and *Teleostea* in various Fishing Areas

(Procentualni odnos između Selachia i Teleostea na različitim ribolovnim područjima)

Groups of fish *(Grupe riba)*		Gulf of Rijeka	Velebit Channel (north. area)	Kvarnerić	Velebit Channel (south area)	Central Dalmatian Islands	Annual average *(Godišnji prosjek)*
Selachia *Landovina*	Gast* (1916/17)		6,53		41,93		15,55
	D'Ancona** (1918/20)						26,14
	Zei (1938/40)	6,80	17,73	16,40	43,00	22,80	21,35
	Križanec (1947)		26,84	33,34	36,20		32,12
	1951	19,14	27,67	14,31	21,90	21,14	20,83
Gadidae *Ugotice*	Zei (1938/40)	62,70	47,77	35,60	21,25	18,10	37,08
	Križanec*** (1947)		38,39	47,88	34,04		40,10
	1951	44,71	53,01	61,17	60,13	27,90	49,38
Other com. impor- tant fish**** *(Ostale gospodarski važnije ribe)*	Zei (1938/40)	22,00	27,07	25,50	30,75	50,20	30,90
	Križanec*** (1947)		27,16	12,14	24,77		21,36
	1951	19,08	11,32	10,73	11,57	36,87	17,91
Com. unim- portant fish *(Gospodarski nevažne ribe)*	Zei (1938/40)	9,50	7,43	22,50	5,00	8,90	10,67
	Križanec*** (1947)		7,61	6,64	4,99		6,41
	1951	17,07	10,39	13,79	6,40	14,09	12,35

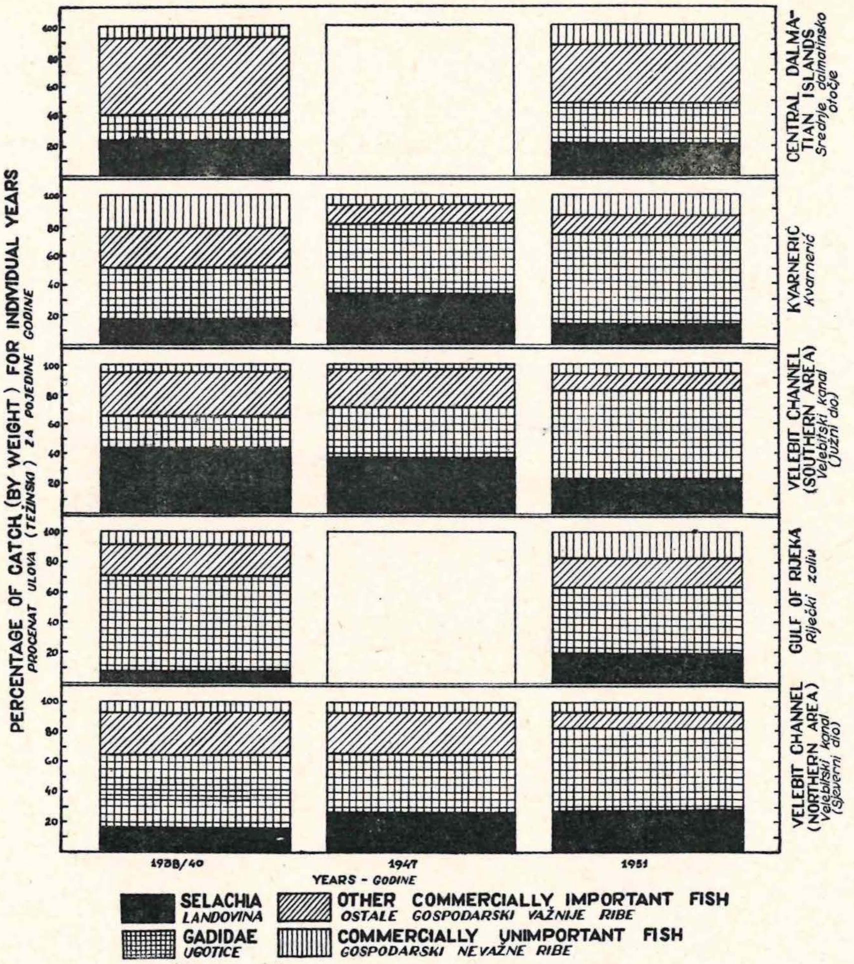
* The mean value of the catches was taken for individual days in various months. Of the *Teleostea*, *Lophius* sp. are classified under *Selachia*.

** These data, said D'Ancona, may be considered as fairly reliable. [redacted]

*** Unpublished data.

**** Of the commercially more important fish in the Gulf of Rijeka *Lophius* sp. represented 65,37%, in the Velebit Channel (northern area) 67,94%, in Kvarnerić 47,10% ,in the Velebit Channel (southern area) 33,40% and in the region of the central Dalmatioan islands 6,3%.

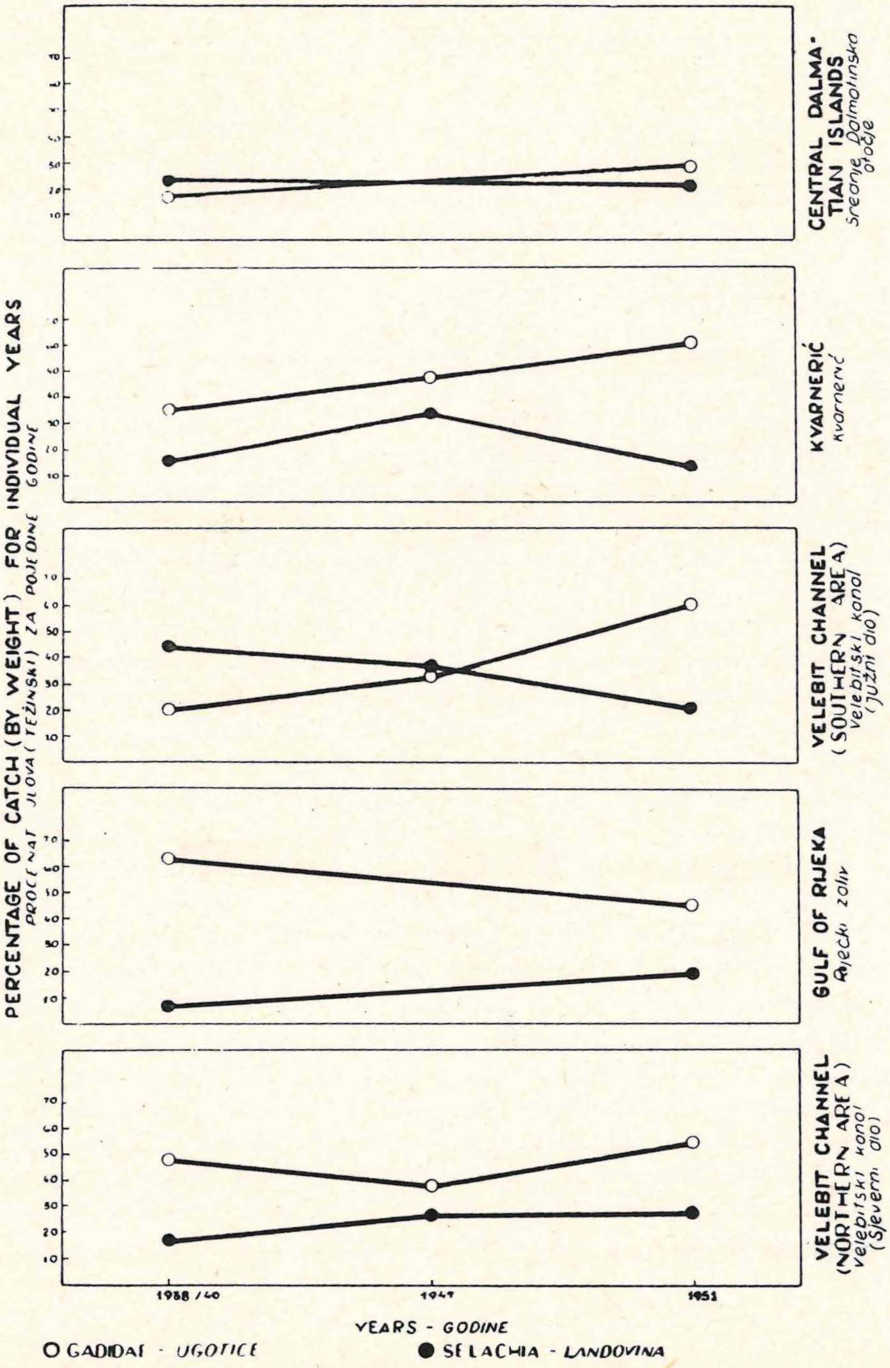
Figure 3. Graph showing the quantitative relationship between individual groups of fish on the fishing grounds analysed. No data are available on the catches in the Gulf of Rijeka and the fishing region around the Dalmatian islands in 1947.
Slika 3. Grafički prikaz kvantitativnog odnosa između pojedinih grupa riba na analiziranim područjima lova. Za riječki zaliv i srednje dalmatinsko otočje nema podataka za 1947. godinu.



The Velebit Channel (southern area) is particularly characterised by the composition and size of fish stocks before and after the war. Before the war trawling was prohibited. G a s t (1918) verified a large percentage of *Selachia* in this area, the cause for which he saw in the reduced fishing which enabled them to develop undisturbed. After the second World War we have the opposite phenomenon. Instead of prohibition, several vessels from 50 to 180 HP have trawled intensively in this area. This narrow area

Figure 4. Quantitative relationship expressed in percentages between *Gadidae* and *Selachia* on individual fishing grounds. No data are available on the catches in the Gulf of Rijeka and the fishing region around the Dalmatian islands in 1947.

Slika 4. Kvantitativan odnos izražen u procentima između Gadidae i Selachia na pojedinim ribolovnim područjima. Za riječki zaliv i srednje dalmatinsko otočje nema podataka za 1947. godinu.



(the largest width is about 2 Nm) has been excessively exploited and the direct result has been a quantitative derangement within the stocks. The percentage (by weight) of *Gadidae* has increased by 280%, that of *Selachia* decreased by 50% and of the other commercially more important fish by 40% in relation to the pre-war period. The average length of *Merluccius vulgaris* decreased from 27,3 cm (1938) to 23,4 cm (1951), i. e. by 3,9 cm.

The present state of the fish stocks in the channels and coastal waters off the eastern coast of the Adriatic shows a constant tendency towards an increase of the percentage of *Gadidae* by weight and a decrease of *Selachia,* possibly due to intensified trawling in the post-war period.

The reduction of *Selachia* and the decrease of the average length of *Merluccius vulgaris* (propably of older age-groups) may to a certain extent reflect even positively on the stock itself from the standpoint of fishery. The natural mortality, incurred by the predators *(Selachia)* inter species and cannibalism *(Merluccius vulgaris)* intra species, decreases, vhilst the surviving species have more possibility of growing faster and of greater survival. But every further unreasonable increase of fishing intensity in a narrow and limited space, as is the case in our channels and coastal waters, has a bearing on the question of endangering the existence of these stocks. To justify this hypothesis it is sufficient to compare Kvarner and Velebit Channel (southern area) in 1951 in order to perceive at once the seriousness of this fact. Kvarner was intact till 1951. Only in that year trawling started, but solely along the south-eastern coast of Istria, north-western coast of Cres Island and in the Cres Channel. In the middle of the channel in the locality from $45^0\ 01'$ N and $14^0\ 11{,}5'$ E to $45^0\ 04'$ N and $14^0\ 12{,}5'$ E only one haul was carried out in June 1951 by a trawler of 250 HP. The catch per one hour of trawling in that haul was 85 kg of fish. The average length of *Merluccius vulgaris* amounted to 28,34 cm and there were 75,3% specimens over 25 cm (according to Zei this is the border-line between the young and grown-up patterns). In the Velebit Channel (southern area) the average length of *Merluccius vulgaris* was 27,3 cm when trawling was prohibited, and in 1951 being the effect of the more intensive post-war trawling in this area, only 23,4 cm with 59,3% samples over 25 cm. The tendency of the average length decreasing within the population of *Merluccius vulgaris* was apparent not only in these two channels, but also in the others. The following data confirm this. In the Velebit Channel (northern area) *Merluccius vulgaris* had an average length of 21 cm in 1938; 27,5 cm in 1947 and 23 cm in 1950. Kvarnerić 20,2 cm in 1938 to 1940; 29,12 cm in 1947 and 25,70 cm in 1950.

This constant reduction of the mature patterns in the existing stocks after the second World War, as well as the recruitment reduced to a minimum, will inevitably reflect negatively on the total catch in the course of time. Accordingly the intensity of fishing by trawling, particularly in the limited and enclosed areas, should have a limit of exploitation allowed. This limit, however, may be exceeded and momentarily increase the total catch, as was the case with our trawling in 1950 and 1951, but at the expense of immature and commercially unimportant fish. But if this unreasonable policy in our fishery with trawl-nets is to be continued, then in several years we shall unavoidably have the following result. The stocks will shrink more and more, the average length of the individuals will be decreasing and the recruitment reduced almost to an insufficient minimum. In order to avoid this black outlook in time, various preventive measures should be introduced which would make possible a reasonable exploitation of the fish stocks and set the lowest limit of how much to take of a stock and not endanger it seriously. There are several such theoretical suppositions by various authors who dealt with the problem of the optimum catch and of setting the limit of a stock to be highest exploited.

So Baranov (1918) tried first to define the fishing theory by means of the differential equation of growth and mortality.

Russell (1931) offered several purely theoretical considerations on the possibilities of a reasonable exploitation of stocks. He illustrated this by the formula:

$$S_2 = S_1 + (A + G) - (C + M)^*$$

where S_2 (the state of the stock at the end of the year) will be $>$ or $<$ S_1 according to whether $(A+G) >$ or $< (C+M)$. Expressed in words this reads: if in one year more is taken $(C+M)$ than is allowed by the natural recruitment $(A+G)$, then the weight of the total catch will decrease. If the process is reversed, i. e. the recruitmeent greater than the catch, then stock will increase. However, the ideal of a maximum sustained yield is imposible in practice. Apart from the fishing operations it is dependent on other factors which are not subject to human activities. Analysing the influence of man's activity and the possibility of regenerating the stock, Hjort, Jahn and Ottestad (1932) confirmed this thought of Russell with the words: »When dealing with the problem of the influence of fishing operations upon the stock it is always very necessary to assume that

* A = The increment due to the total weight of recruits
G = The corresponding growth increment
M = The total loss of weight by mortality
C = The weight caught

there may be a great many latent possibilities in nature«. Russell found the only solution of this problem in the attempt of adjusting every year the fishing intensity to the variations of the stocks, with reference to individual species of fish and special fishing grounds.

Thompson and Bell (1934) applied in practice the theoretical suppositions. The purpose of this application was to fix the most favourable intensity of fishing in order to attain as permanent a yield as possible. After the great depression of the yield in the Pacific halibut in 1931, progressive limitations of its exploitation were introduced in 1932 and 1933. The result of these restrictions was positive. The »catch per set a unit of gear« had increased considerably, whilst the total catch remained constant. But in later investigations this reduction of effort resulted also in an increase of the total catch (Reports of General Meeting of 1951). The biological factors of growth and natural mortality rate were also taken into consideration. They stand in reciprocal relationship to the fishing intensity, which is very important from the practical standpoint. According to Thompson and Bell the limitation of the fishing intensity »implies not only the production of more young in the course of time, but a greater yield from existing stock«.

Graham (1935) corrected Thompson and Bell's theory, but later in 1952 he himself admitted its value.. He started from an entirely practical assumption, namely, will the limitation of the fishing rate of cod, haddock and plaice in the North Sea affect favourably the yield or not, if they are given the possibility of being a year older? Recruitment (R) and speed of growth (G) are here taken as being constant. The results obtained proved to be theoretically justifiable. A slight limitation of fishing would really a further decline of catch, which would temporarily decrease, but then increase considerably, in a few years, whilst the productions costs would be much smaller. Bückmann (1940) used Graham's argumentation in his analysis of the optimum catch and the law of organic growth. Bückmann in contrast to Graham took the biological moments into consideration and thus completed his supposition. According to him the variations in the growth, the speed of growth, the recruitment and the natural mortality are in biological connection with the size of the stock, which again from its side varies according to the intensity of fishing. »The consistent catch, which sets in after a certain time of constant fishing intensity, is equal to the recruitment, i. e. the organic growth of the catch exceeded the recruitment, the stock would diminish« and vice versa.

Herrington (1948) defined the optimum yield as a result of the maximum sustained recruitment. According to him, to attain this the number of the older fish in a stock must be diminished within the limits required for »good spawning and minimum intraspecific competition«. New England (Area XXII South) was taken as the example to confirm this thesis.

As it may be seen from the above-mentioned theoretical observations, the problems of the optimum catch and fishing intensity are not only sheer arithmetical operations of subtracting a number of individuals, but their correct solution necessitates the knowledge of the potential possibility of the growth and reproduction of the population. Accordingly, the analysis of stocks demands the thorough study of many factors, which directly or indirectly affect their qualities.

This refers also to the composition and size of fish stocks in our channels and coastal waters. It is difficult to say anything concrete on whether overfishing has occurred in them as a result of the post-war intensive trawling, owing to the lack of complete and reliable statistical data on the catch in the past few years. The fact is that in 1951, in relation to 1938/40 and 1947, the relative quantities of *Selachia* decreased considerably and those of *Gadidae* increased. If our supposition on their causal connection is justifiable, then just this condition may serve as an indication of the more intensive trawling after the war. However, owing to the lack of closer biological and ecological information on the mean size, growth, sexual maturity, spawning ,migrations etc. we are not in a position to assert, but only to assume, that the optimum catch was attained and exceded in our channels and inshore waters, i. e. that overfishing occurred.

In order to justify the need of this preliminary work on the urgent protection of the stocks of fish in our most important fishing areas, we intend to carry out further combined statistical and direct investigations of the stocks, which will slow this more concretely.

CONCLUSIONS

This preliminary paper does not attempt to arrive at any definite conclusions. That is left for a continuous and more detailed qualitative and quantitative analysis of fish stocks. The conclusions which may be drawn from this statistical analysis are the following:

1. The relative density of fish stocks in our open territorial waters is greater than in the coastal waters and channels. This is the more important in that our more intensive post-war trawling is still carried out in coastal waters and channels.

2. A slight decrease in catch per unit of time has been observed in this more intensive trawling. In order to build up the fish stock it would

be necessary to prohibit trawling by ships of over 80 HP (in some regions over 50 HP), at least for a short period.

3. Any increase in the amount of fish taken from inshore waters and channels may result in a further regression per unit of effort. The number of vessels and the amount of time spent, which show a constant tendency to increase, may speed up this process.

4. Underfishing in some regions during, or even after, the second World War changed the quantitative proportions within the composition of stocks in individual fishing regions. The predators have multiplied whilst the number of plant-eaters and those which feed on invertebrates has decreased considerably.

5. The more intensive post-war trawling has changed the relative amounts within the stocks. The quantities (by weight) of the *Gadidae* have increased considerably and those of *Selachia* have decreased in the annual average. This applies particularly to the southern area in the Velebit Channel.

6. The average lenght of *Merluccius vulgaris,* our most important commercial species in deep-sea trawling, is constantly decreasing through the years, as shown by periodic investigation.

7. It would be necessary to carry out as speedily as possible, the qualitative and quantitative examinations of the fish stocks in the channels and inshore waters of our most important fishing regions. In this way the real situation could be determined and the possibility of overfishing be eliminated in time.

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APPENDIX

I. The Analysis of Variance

The calculation of the sum of squares of different components of the variance is as follows:

1. Total variance — Degrees of Freedom

$$Sx^2 - \frac{(Sx)^2}{N} \qquad N - 1$$

2. Variance of species

Sum of squares	Degrees of Freedom	Mean square
$\frac{Sx_{s1})^2 \quad (Sx_{s2})^2}{n_a} + \ldots - \frac{(Sx)^2}{N}$	$S - 1$	$\frac{1}{S-1}\left[\frac{(Sx_{s1})^2 + (Sx_{s2})^2}{n_a} + \ldots - \frac{(Sx)^2}{N}\right]$

3. Variance of areas

Sum of squares	Degrees of Freedom	Mean square
$\frac{(Sx_{a1})^2 + (Sx_{a2})^2}{n_s} + \ldots - \frac{(Sx)^2}{N}$	$A - 1$	$\frac{1}{A-1}\left[\frac{(Sx_{a1})^2 + (Sx_{a2})^2}{n_s} + \ldots - \frac{(Sx)}{N}\right]$

4. Error

Sum of squares

$$\left[\left(Sx^2 - \frac{(Sx)}{N}\right)\right] - \left(\begin{matrix}\text{Var. of species} \\ + \text{Var. of areas}\end{matrix}\right)$$

Degrees of Freedom

$$(N - 1 - [(n_s - 1) + (n_a - 1)]$$

Mean square

$$\frac{1}{(N-1) - [(n_s - 1) - (n_a - 1)]} \left(\begin{matrix}\text{Sum of} \\ \text{squares}\end{matrix}\right)$$

Whether the differences are significant may be best tested by using the values of Fischer:

$$z = \tfrac{1}{2} \log_e \frac{\sigma_1}{\sigma_2}$$

where σ_1 and σ_2 are the mean squares of those components which are compared.

x = single observation
x_a = catches for each area
x_s = catches for each species
n_s = number of species
n_a = number of areas
N = total number of observations

II. The Analysis of Covariance

To calculate the sums of products and the sums of squares of deviations the following formulae were employed:

$$Sx^2 = X^2 - \frac{(SX)^2}{N}$$

$$Sxy = SXY - \frac{(SX)\ (SY)}{N}$$

$$Sy^2 = SY^2 - \frac{(SY)^2}{N}$$

The analysis of variance was used to test whether the regression coefficient was significant. For the sum of squares from the regression line $y' = b_1 x$ we have:

$$S\,(y - b_1\,x)^2 = Sy^2 - 2\,b_1\,Sxy + b_1^2\,Sx^2$$
$$b_1 = Sxy/Sx^2.$$

III. Multiple Regression

The calculation of regression on two or more independent or dependent variates is done by means of the multiple regression. The multiple regression equation is employed for this purpose:

$$Y = a + b_1\,x_1 + b_2\,x_2 \ldots + b_n\ x_n$$

The method of estimating the partial regression coefficients b_1 and b_2, as well as Vb_1 and Vb_2 has been introduced by Fischer. If S denotes the sum of all observations, then the two equations for estimating b_1 and b_2 are:

$$b_1\ S\,(x_1)^2 + b_2\ S\,(x_1\,x_2) = S\,(x_1\,y)$$
$$b_1\ S\,(x_1\,x_2) + b_2\ S\,(x_2)^2 = S\,(x_2\,y)$$

Fischer used a simplified formula in order to avoid the solving of simultaneous equations.

$$b_1 \; S(x_1^2) + b_2 \; S(x_1 x_2) = 1, \quad 0$$
$$b_1 \; S(x_1 x_2) + b_2 \; S(x_2^2) = 0, \quad 1$$

The double solution of these equations can be written in the form:

$$b_1 = c_{11}, \qquad c_{12}$$
$$b_2 = c_{12}, \qquad c_{22}$$

c_{11} and c_{12} being the values of b_1 and b_2 in the first pair of equations and c_{12} and c_{22} being the values of b_1 and b_2 in the second pair of equations. The partial regression coefficients are obtained in each individual case by calculating $S(x_1y)$ and $S(x_2y)$ and inserting them into the formulae:

$$b_1 = c_{11} \, S(x_1y) + c_{12} \, S(x_2y)$$
$$b_2 = c_{12} \, S(x_1y) + c_{22} \, S(x_2y)$$

The sum of squares of deviations y from Y is as follows:

$$S(y - Y)^2 = S(y)^2 - b_1S(x_1y) - b_2S(x_2y)$$

$$V_y = \frac{S\,(y - Y)^2}{n - 3}$$

$$s_{1b} = \sqrt{V_{b1}} = \sqrt{c_{11}\,Vy}$$

$$s_{b2} = \sqrt{V_{b2}} = \sqrt{c_{22}\,Vy}$$

$$t = \frac{b_1 - 0}{s_{b1}}$$

$$t = \frac{b_2 - 0}{s_{b2}}$$

Table XV. Weights and percentages of the catches
Težine i procenti ulova vučom na

Fishing areas (square) *Položaj lova (kvadrat)*	PISCES							
	Merluccius vulgaris *Oslić*		Gadus div. sp. *Ugotice*		Smaris sp. *Gire*		Mullus sp. *Trlje*	
	kg	%	kg	%	kg	%	kg	%
B 27			36	3,48	156	15,09	125	12,08
C 26	591	40,60	11	0,75				
C 27	16	18,83						
C 28	1150	31,38	78	2,12	13	0,36	178	4,86
C 29/C35	365	18,95	168	8,71			19	0,99
B33	54	20,46	9	3,33	34	12,88	17	6,43
B34			155	3,60	905	21,03	467	10,86
B35	381	24,20	75	4,76	18	1,14	50	3.18
B35/E5	30	6,45	210	45,16	35	7.53	130	27.95
C32	1611	19,28	502	6,00	1	0 01	2	0,02
C32 F2	656	26,62	109	4,42				
C33	4740	33,29	471	3,30	313	2,20	1	
C32/F3	275	16,10						
C33/F3	84	19,13						
C28/C33	30	37,50						
C35	1187	21,99	486	9,00				
C35/C36	1563	19,02	845	10,29			8	0,10
C36	228	17,75	80	6,22				
E2			70	42,17				
E5	45	19,23	60	25,64			65	27,78
F2	468	15,61						
F3	1156	18,68	3	0,04				
F3/F4	1205	53,01						
F4	18343	39,85	2132	4,63	782	1,70	10	0.02
F4/F10	1018	36,60	143	5,14				
F5	154	36,32	22	5,19	54	12.73		
F5/F6	637	11,68	402	7,36			4	0,08
F6	1562	25,40	168	2,73				
F7	2	5,89	2	5,89	2	5,89	5	14.70
F8/F9	674	54,76			10	0,81	31	2,51
F9	1035	34,93	127	4,29				
F10	330	24,48	116	8,61	5	0,37	3	0,22
F11/F17	235	52,10	32	7,10				
F11/F12	160	31,31	125	24,47				
F12	423	29,96	159	11,27			10	0.70
F12/F18	357	27,96	127	9,95			24	1,88
F15/F16	439	51,46			45	5.28	23	2,70
F17	11	20,75	10	18,87				
F18	195	56,69	55	15,99				
G13	770	52,02	170	11,49			10	0.68
F24	765	40,94	126	6,75	120	6,42	4	0.21
G19	95	44,40	15	7,00				
G19/G20	110	47,83	25	10,87				
G20	1515	47,08	53	1,64	245	7.61	38	1,19
G25	911	40,75			270	12,08	30	1,34
G26	115	41,22			40	14.34		
G32	188	24,20			165	21.23	54	6,95
K8	87	11,86	40	5,44			56	7.62
K9	188	23,70	55	6,93	28	3,53	19	2,40
K10	9	15,25			8	13,56	5	8,48
K12	200	24,19			18	2,18	70	8,46

by trawling on the fishing areas analysed in 1951

analiziranim položajima lova 1951. g.

RIBE						Crustacea and Cephalopoda		TOTAL
Pagellus erythrinus *Arbun*		Selachia *Landovina*		Variae pisces *Razna riba*		Edible catch *Jestivi prilov*		*UKUPNO*
kg	%	kg	%	kg	%	kg	%	
166	16,05	65	6,29	246	23,80	240	23,21	1034
		108	7,41	601	41,28	145	9,96	1456
		15	17,65	8	9,41	46	54,11	85
26	0,70	670	18,29	345	9,41	1205	32.88	3665
		41	2,12	259	13,44	1075	55,79	1927
22	8,34	10	3,79	50	18,93	74	28,04	270
706	16,40	199	4,62	746	17,34	1125	26,15	4303
395	25,07	463	29,40	119	7,55	74	4,70	1575
		10	2,16			50	10,76	465
		1947	23,30	951	11,39	3342	40,00	8356
		643	26,09	149	6,06	907	36,81	2464
		1073	7,54	2258	15,86	5384	37,81	14240
		295	17,27	355	20,79	783	45,84	1708
		48	10,93	77	17,54	230	52,40	439
		10	12,50			50	50,00	80
		1018	18,86	498	9,22	2209	40,93	5398
		971	11,81	582	7,09	4246	51,69	8215
		350	27,23	132	10,28	495	38,52	1285
		10	6,02	25	15,07	61	36,74	166
40	17,10			15	6,41	9	3,84	234
		461	15,38	506	16,88	1563	52,13	2998
		901	14,56	1151	18,60	2979	48,12	6190
		394	17,34	517	22,75	157	6,90	2273
		3849	8,36	8185	17,79	12728	27,65	46029
		316	11,36	314	11,30	990	35,60	2781
		31	7,31	92	21,70	71	16,75	424
		544	9,96	352	6,44	3519	64,48	5458
		879	14,30	801	13,02	2739	44,55	6149
4	11,76	14	41,17	5	14,70			34
		214	17,39	121	9,83	181	14,70	1231
		645	21,77	410	13,83	746	25,18	2963
		268	19,88	266	19,73	360	26,71	1348
		137	30,38	27	5,99	20	4,43	451
		115	22,50	77	15,07	34	6,65	511
		495	35,06	171	12,11	154	10,90	1412
		385	30,14	258	20,20	126	9,87	1277
		168	19,70	24	2,81	154	18,05	853
		26	49,05	6	11,32			53
		26	7,56	31	9,01	37	10,75	344
		277	18,71	122	8,24	131	8,86	1480
		288	15,40	487	26,06	79	4,22	1869
		25	11,68	39	18,22	40	18,70	214
		75	32,60	8	3,48	12	5,22	230
		485	15,07	294	9,13	588	18,28	3218
45	2,01	421	18,82	284	12,70	275	12,30	2236
		51	18,28	13	4,66	60	21,50	279
15	1,93	10	1,29	250	32,18	95	12,22	777
		156	21,26	355	48,37	40	5,45	734
4	0,50	113	14,25	268	33,80	118	14,89	793
		19	32,20	11	18,64	7	11,87	59
220	26,60	155	18,74	84	10,15	80	9,68	827

Table XV. Weights and percentages of the catches
Težine i procenti ulova vučom na

Fishing areas (square) *Položaj lova (kvadrat)*	PISCES							
	Merluccius vulgaris *Oslić*		Gadus div. sp. *Ugotice*		Smaris sp. *Gire*		Mullus sp. *Trlje*	
	kg	%	kg	%	kg	%	kg	%
K14	50	14,37					35	10,06
K15	605	20,30	502	16.83			29	0,98
K15/K16	1518	22,02	779	11,30			132	1,91
K16	2389	14,68	3015	18,53	63	0,39	329	2,02
K17	387	20,19	410	21,39				
K18	143	15,13	20	2,11	58	6,13	136	14,40
L15	79	36,74			31	14,41	10	4,66
K22/K23	691	57,10					6	0,50
K23	1065	33,62	215	6,79				
K23/K24	785	49,38						
K24	225	35,43						
L19	8	21,05					3	7,90
L20	105	14,88	30	4,25	189	26,77	76	10,76
L21	37	10,09			115	31,33	33	9,00
L22	19	15,83			16	13,33	13	10,83
L23	606	19,20	96	3,04	300	9,50	226	7,17
L24	215	32,62	38	5,77			234	35,50
L27	39	16,19	5	2,07			46	19,09
L28	223	12,57	87	4,90	221	12,45	82	4,61
L29	34	22,81					20	13,42
L33	178	16,97			170	16,20	97	9,25
L33/34	85	14,29			90	15,12	85	14,29
L34	670	20,72			253	7.82	367	11,36
L35	15	12,50			15	12,50	10	8,33
L36	86	16,44			68	13,00	85	16,25
M32	470	30,66			70	4,56	299	19,50
M33	706	42,81	15	0,90	95	5,77	58	3,51
R1	40	16,00			20	8,00	20	8,00
R2	146	12,70			224	19,50	104	9,06
R3	244	14,79	1	0,07	227	13,76	172	10,42
Q12	20	23,52						
R9	221	47,52	8	1.72			29	6,23
R10	13	26,00	5	10,00	3	6,00		
R11	153	11,96	4	0,31	30	2,34	84	6,57
R12	436	26,15			22	1,32	105	6.30
S22	14	20,29					5	7,24
S23	190	24,64					83	10,76
S29	298	20,79					236	16,46
S30	242	28,40					42	4,92
S36	46	28,40						
S30/T31	83	22,80					15	4,12
T31	4217	29,20					693	4,80
T31/Y2	2368	33,49					215	3,04
Y1	584	16,30					313	8,73
Y1/Y2	118	31,80					23	6,20
Y2	2128	26,06					738	9,03
Y2/Y3	1536	32,82					639	13,66
Y3	3997	24'38					1904	11,61
TOTAL *UKUPNO*	74890	27,75	12702	4,71	5547	2,05	9289	3,44

by trawling on the fishing areas analysed in 1951
analiziranim položajima lova 1951. g.

RIBE						*Crustacea* and *Cephalopoda*		TOTAL
Pagellus erythrinus *Arbun*		Selachia *Landovina*		Variae pisces *Razna riba*		Edible catch *Jestivi prilov*		*UKUPNO*
kg	%	kg	%	kg	%	kg	%	
		37	10,63	139	39,94	87	25,00	348
		231	7,75	781	26,20	933	27,94	2981
		492	7,14	1798	26,09	2174	31,54	6893
		1735	10,66	4121	25,31	4626	28,41	16278
		139	7,25	342	17,84	639	33.33	1917
148	15,66	289	30,58	136	14,40	15	1,59	945
5	2,32	38	17,68	40	18,60	12	5,59	215
		206	17,02	70	5,79	237	19,59	1210
		249	7,87	658	20,78	980	30,94	3167
		105	6,60	145	9,12	555	34,90	1590
		70	11,02	60	9,45	280	44,10	635
8	21,05	16	42,10	3	7,90			38
65	9,21	165	23,38	65	9,21	11	1,54	706
44	11,99	48	13,07	75	20,43	15	4,09	367
		40	33,33	19	15,84	13	10,84	120
175	5,55	640	20,29	743	23,55	369	11,70	3155
		24	3,65	78	11,84	70	10,62	659
		86	35,68	65	26,97			241
131	7,39	491	27,66	430	24,57	104	5,85	1775
		61	40,94	21	14,10	13	8,73	149
		292	27,84	255	24,31	57	5,43	1049
95	15,97	215	36,13	25	4,20			595
400	12,38	855	26.44	673	20,81	15	0,47	3233
		45	37.50	19	15,83	16	13,34	120
7	1,33	185	35,38	46	8,80	46	8,80	523
61	3,98	76	4,96	309	20,16	248	16,18	1533
82	4,98	200	12,12	344	20,87	149	9,04	1649
		100	40,00	45	18,00	25	10,00	250
45	3,91	380	33,08	135	11,75	115	10,00	1149
7	0,42	555	33,63	350	21,21	94	5,70	1650
		40	47.06	20	23,53	5	5,89	85
		83	17,85	111	23,88	13	2,80	465
		15	30,00	10	20,00	4	8,00	50
85	6,64	450	35,15	356	27,81	118	9,22	1280
181	10,86	440	26,40	269	16,14	214	12,83	1667
		30	43,48			20	28,99	69
		205	26.59	263	34,11	30	3,90	771
		418	29,15	436	30,40	46	3,20	1434
10	1,18	315	36,98	199	23,35	44	5,17	852
11	6,80	115	31,60	132	36,27	19	5,21	364
		38	23,45	54	33,33	13	8.02	162
147	1,01	3711	25.70	4421	30,60	1254	8,69	14443
		1792	25.33	2134	30,18	563	7,96	7072
130	3,62	1102	30.75	1145	31,95	310	8,65	3584
		89	23,99	119	32,08	22	5,93	371
216	2,65	2294	28,10	2240	27,43	550	6,73	8166
		1238	26,46	839	17,94	427	9,12	4679
38	0,24	4484	27,35	4448	27,12	1525	9,30	16396
3734	1,38	44813	16,60	52137	19,32	66798	24,75	269910

STATISTIČKA ANALIZA LOVINA VUČOM NA RIBOLOVNOM PODRUČJU ISTOČNOG JADRANA 1951

Šime Županović

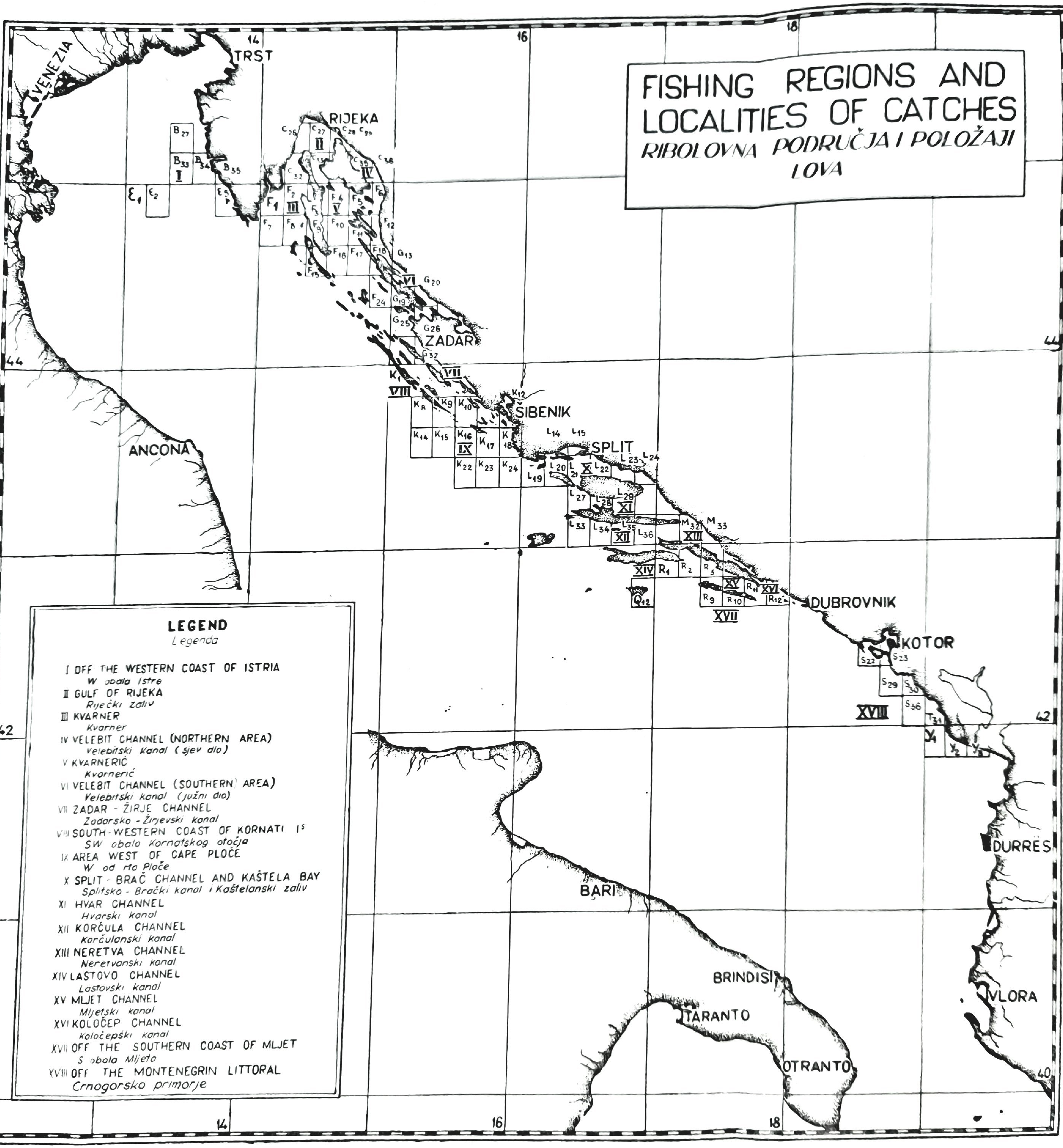
Institut za oceanografiju i ribarstvo, Split

Kratak sadržaj

U ovom je radu data statistička naliza lovina vučom na ribolovnom području istočnog Jadrana (uglavnom kanala i priobalnog pojasa) za 1951. g. Dobiveni su podaci dosta oskudni za detaljniju statističku analizu. To naročito vrijedi za biološke i ekološke karakteristike, koje se odnose na rastenje, sastav s obzirom na veličinu, mriješćenje i drugo, koje nisu uzete u razmatranje. Na osnovu toga, ovaj preliminarni rad ne pretendira ni na kakove definitivne zaključke. To je zadatak jedne kontinuirane i detaljnije kvalitativne i kvantitativne analize stanja ribljih naselja. Zaključci, koji se mogu izvesti iz ove statističke analize bili bi slijedeći:

1. Relativna gustoća naselja naših otvorenih teritorijalnih voda veća je od one u kanalima i priobalnom pojasu. To je utoliko važnije, što intenzivnije poslijeratno vučarenje kod nas ima još uvijek kanalski i priobalni karakter.
2. Opaženo je neznatno opadanje ulova po jedinici vremena u poslijeratnom intenzivnijem vučarenju. Zbog osvježenja populacija bilo bi potrebno, barem za kraći period vremena, zabraniti vučarenje u kanalima i priobalnom pojasu svim brodovima preko 80 KS (u nekim područjima i onima iznad 50 KS).
3. Svako daljnje povećavanje ulova u kanalima i priobalnom pojasu može da izazove njegovu daljnju regresiju po jedinici napora. Broj brodova i količina utrošenog vremena, koji pokazuju stalnu tendenciju porasta, mogu ubrzati taj proces.
4. Lovostaja za vrijeme (a u nekim područjima i nakon) Drugog svjetskog rata, izmijenila je kvantitativni odnos sastava naselja pojedinih područja lova. Namnožile su se ribe grabežljivice, dok je naprotiv broj biljoždernih riba, kao i onih, koje se hrane beskičmenjacima, znatno opao.
5. Intenzivnije poslijeratno vučarenje izmijenilo je kvantitativni odnos unutar naselja. Količine (težinski) *Gadidae* sp. u godišnjem prosjeku znatno su se povećale, a kod *Selachia opale*. To naročito vrijedi za Velebitski kanal (južni dio).

6. Prosječna dužina *Merluccius vulgaris,* kao naše ekonomski najvažnije vrste u dubinskom ribolovu povlačnim vrežama, stalno opada tokom godina u periodima izvršenih ispitivanja.
7. Bilo bi potrebno što hitnije sprovesti kvantitativna i kvalitativna ispitivanja naselja u kanalima i priobalnom pojasu naših najvažnijih ribolovnih područja, kako bi se na taj način moglo ustvrditi njihovo faktično stanje i eventualno na vrijeme spriječiti mogućnost prelova.


FISHING REGIONS AND LOCALITIES OF CATCHES
RIBOLOVNA PODRUČJA I POLOŽAJI LOVA
LEGEND
Legenda
I OFF THE WESTERN COAST OF ISTRIA
W obala Istre
II GULF OF RIJEKA
Riječki zaliv
III KVARNER
Kvarner
IV VELEBIT CHANNEL (NORTHERN AREA)
Velebitski kanal (sjev dio)
V KVARNERIĆ
Kvarnerić
VI VELEBIT CHANNEL (SOUTHERN AREA)
Velebitski kanal (južni dio)
VII ZADAR - ŽIRJE CHANNEL
Zadarsko - Žirjevski kanal
VIII SOUTH-WESTERN COAST OF KORNATI Is
SW obala Kornatskog otočja
IX AREA WEST OF CAPE PLOČE
W od rta Ploče
X SPLIT - BRAČ CHANNEL AND KAŠTELA BAY
Splitsko - Brački kanal i Kaštelanski zaliv
XI HVAR CHANNEL
Hvarski kanal
XII KORČULA CHANNEL
Korčulanski kanal
XIII NERETVA CHANNEL
Neretvanski kanal
XIV LASTOVO CHANNEL
Lastovski kanal
XV MLJET CHANNEL
Mljetski kanal
XVI KOLOČEP CHANNEL
Koločepski kanal
XVII OFF THE SOUTHERN COAST OF MLJET
S obala Mljeta
XVIII OFF THE MONTENEGRIN LITTORAL
Crnogorsko primorje
VENEZIA
TRST
RIJEKA
ZADAR
ŠIBENIK
SPLIT
DUBROVNIK
KOTOR
ANCONA
DURRES
BARI
BRINDISI
TARANTO
OTRANTO
VLORA
14
16
18
44
42
40