Acta Adriat., 28 (1—2): 199—219 (1987)

YU ISSN: 0001 - 5113
AADRAY

Original scientific paper
UDC 639.2.081.211 (262.3)

BIOLOGICAL AND ECONOMIC ASPECTS OF MESH SIZE REGULATION IN THE MULTISPECIES DEMERSAL FISHERY OF THE ADRIATIC SEA

BIOLOŠKI I EKONOMSKI ASPEKT REGULACIJE SAKE U DUBINSKE POVLAČNE MREŽE (KOĆE) OBZIROM NA MNOGOVRSNA KOĆARSKA NASELJA JADRANSKOG MORA

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Taking into account present high level of exploitation of the Adriatic demersal resources regulative measure as application 40 mm cod-end mesh size by GFCM was recommended (1978) and accepted by member countries.

As far as this management measure is concerned, a series of selectivity experiments of the various cod-ends have been undertaken along the eastern Adriatic coast by covered cod-end technique, in order to assess and forecast short, mostly economic, and long-term effects especially of the 40 mm streched cod-end mesh size. Five populations: hake (*Merluccius merluccius* L.), striped mullet (*Mullus barbatus* L.), pandora (*Pagellus erythrinus* L.), horse mackerel (*Trachurus trachurus* L.) and Norway lobster (*Nephrops norvegicus* L.) were studied.

Considerations of the short-term effects of the 40 mm cod-end, i.e. number (biomass) of individuals that might be lost throughout of cod-end meshes (retained in the cover) per unit time of one hour pointed out, that in the Adriatic trawl multispecies fisheries with present economic difficulties, losses of U$ 8 to U$ 16 might constrain, further activities.

Calculations of the changes in yield per recruit (Y/R), assuming present level of exploitation of the studied stocks, either by changing size at first capture (C) or fishing mortality rate (F), gave such results that in all cases higher efficiency (eumetric catch) in management strategy would be realized by increasing 50% retention point (l_c) of the 40 mm cod-end. Increaments of (l_c) values to the optimum (C), except for horse mackerel population, would undoubtedly lead to economic loss. At the same time, results of cod-end mesh size selectivity experiments over the multispecies

demersal stocks in the Adriatic Sea noted that Beverton and Holt (1966) yield-isopleth diagram model is not so suitable approach. Regulation of total fishing effort should be an esential objective of the Adriatic trawl fishery policy.

INTRODUCTION

As a consequence of the intensive fishing effort in the Mediterranean trawl fishery (Pearse, 1980), especially in its north-western regions with wider continental shelf, a 40 mm streched cod-end mesh size was recommended by GFCM (6th Session 1978) and accepted by member countries.

In relation to such regulative measure for the Mediterranean trawl fishery some experimental studies on the selectivity of various cod-ends have been carried out (Report of the Third Session of the GFCM Working Party on demersal resources appraisal and exploitation, Athens 1972).

With regard to unit and shared Adriatic multispecies demersal resources this paper discusses results of various cod-end mesh sizes selectivity experiments undertaken along the eastern Adriatic coast in order to assess short and long-term effects of the application of the proposed 40 mm cod-end mesh size in the Adriatic commercial trawl fishery.

It has been tried, as well to forecast efficiency of the application of 40 mm cod-end mesh size in the Yugoslav trawl fishery respecting positive changes throughout the transition period in yield per recruit (Y/R) for four commercial populations by moving either size (age) at first capture (C) or fishing mortality rate (F) using Beverton and Holt (1957, 1966) technique.

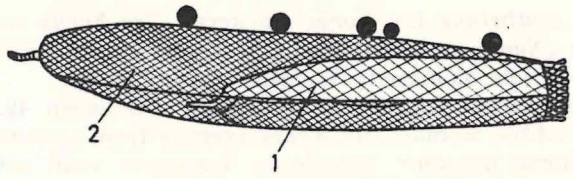
In the same time, under the scope of the experiments, it has been tried to appraise short-term effects of the 40 mm cod-end mesh size on length frequency distributions for five stocks, i.e. its lengths at first maturity and catch rate economic aspects.

MATERIALS AND METHODS

Experiments of cod-end selectivity characteristics along the eastern Adriatic coast were carried out in the region of Dalmacija with research vessel »Bios« (300 hp) and a commercial trawler »Jadran« II (300 hp) using only the covered cod-end technique (Fig. 1). Selectivity characteristics: 50% retention point (l_c), selection factor (b) and percentage of individuals retained in the following cod-ends were studied: polyamid cod-end of 40 mm knotless and with knots; 41 mm; 55 mm; 65 mm; 70 mm and cotton cod-end with knots of 51 mm respectively.

In all cases attachments of the polyamid top-side cover to cod-end of 18 mm and 4 mm were used (fig. 1).

Experiments were carried out mostly along the eastern Adriatic coast and channels of Dalmatia region over clay-loamy and muddy bottom sediments (Gamulin-Brida, 1974), i.e. between isobates 50 and 200 metres



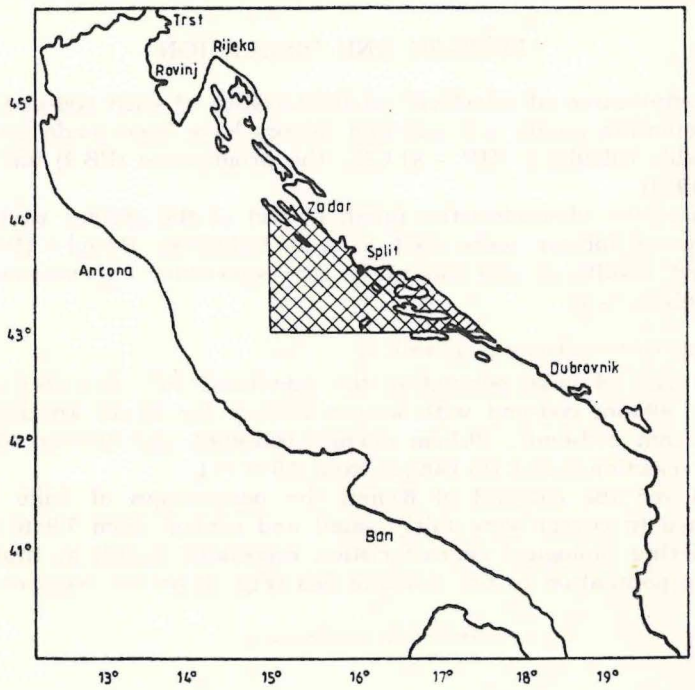


Fig. 1. Trawl fishing grounds along the eastern Adriatic coast where cod-end selectivity experiments were carried out, and diagram of attachment of cod-end topside cover (2) to cod-end (1) with floating balls

on the characteristic ichthyocenosis described earlier (Županović, 1961; Jukić, 1975).

Mesh size of the all cod-ends were measured with the I.C.E.S. mesh gauge, in wet condition, after the bottom trawls were used several times. Speed of the vessels during the experiments was 3.5 knots per hour in the case of the reserach vessel and 4.0 knots for the commercial boat.

Preliminary results of these experiments were reported at the 3rd session of the GFCM Working Party on demersal resources appraisal and exploitation (1972) and Jukić (1975) for the hake population only in the central open Adriatic.

Throughout the experiments attention was devoted mostly to commercially important populations in the trawl fishery of the Adriatic Sea: such as hake *(Merluccius merluccius* L.), striped mullet *(Mullus barbatus* L.), pan-

dora (*Pagellus erythrinus* L.), horse mackerel (*Trachurus trachurus* L.) and Norway lobster (*Nephrops norvegicus* L.). These species represent an important part of the edible biomase in Yugoslav trawl fishery.

In the open central Adriatic they represent between 49.6 and 80.6 percentages of the edible biomass (ten years average from commmercial landings) among which horse mackerel population dominates with yeraly percentages from 33.0 to 58.2%.

RESULTS AND DISCUSSION

The computation of selectivity characteristics of each cod-end, especially the 50% retention points and selection factors have been made using a small programmable calculator (HP — 41 CX), the programme (FB 2) has been used (PAULY, 1984).

Morphometric characteristics (girth factor) of the species studied, except for the Norway lobster, were used, as well, following P a u l y (1983).

Detailed results of cod-end mesh size selectivity experiments are presented in tables 1—8.

Merluccius merluccius L. (Table 1)

In the case of hake population the calculated 50% retention points are: 12.4 cm for 40 mm cod-end with knots; 12.0 cm for 40 cm knotless cod-end; 13.9 cm (41 mm cod-end); 19.7 cm (55 mm cod-end) and 26.8 cm (65 mm cod--end). The selection factor (b) ranges from 3.0 to 4.1.

Except for the cod-end of 65 mm the percentages of hake individuals lost (retained in cover) were fairly small and ranged from 7.9 to 13.9%.

Considering biological characteristics, especially length at first maturity, of the hake population in the Adriatic Sea (Fig. 2) on the basis of selectivity

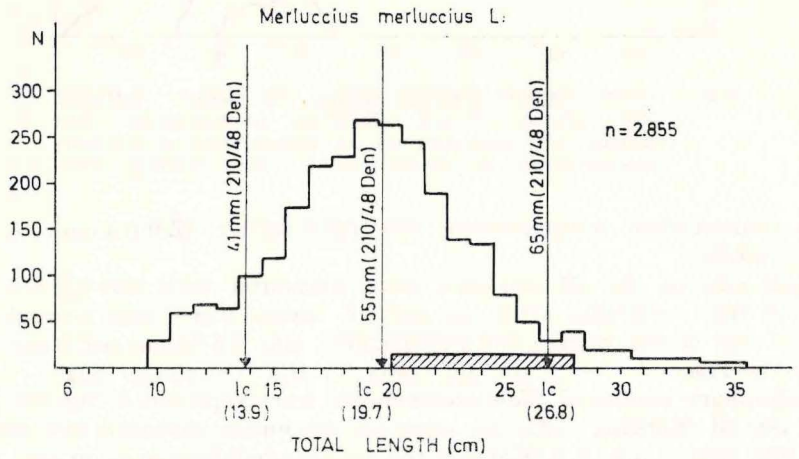


Fig. 2. Forecasts of possible implementation of the various cod-ends: 41 mm (210/48 Den), 55 mm (210/48 Den) and 65 mm (210/48 Den) on length frequency distribution lengths at first maturity ▩ p.p. the *Merluccius merluccius* L. population along the eastern Adriatic coast.

Table 1 - Results of the covered cod-end mesh size experiments concerning Hake (Nerluccius merluccius L.)population along the eastern Adriatic coast carried out by research "Bios"(300 hp) and comercial "Jadran"II(300 hp) vessels

Length (cm)	Cod-end A_1 41 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 55 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 65 mm 210/48 Den	Cover 18mm	Total	%	Cod-end B_1 40 mm 210/48 Den	Cover 4mm	Total	%	Cod-end B_2 40 mm 210/48 Den	Cover 4mm	Total	%
9	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1	-
10	-	-	-	-	-	1	1	-	1	-	1	-	-	10	10	-	8	10	18	0.44
11	-	1	1	-	-	1	1	-	1	-	1	-	6	13	19	31.0	20	18	38	0.55
12	4	-	4	-	3	1	4	75.0	-	1	1	-	7	7	14	50.0	32	21	53	0.60
13	2	2	4	50.0	2	2	4	50.0	-	3	3	-	10	1	11	90.0	32	11	43	0.74
14	4	5	9	44.4	8	18	26	30.8	3	15	18	16.7	16	1	17	94.4	23	8	31	0.74
15	11	5	16	68.8	7	28	35	20.0	3	26	29	10.3	19	1	20	95.0	21	1	22	0.95
16	18	4	22	81.8	18	28	46	39.1	3	43	46	6.5	30	-	30	100.0	31	1	32	0.97
17	27	2	29	93.1	18	30	48	37.5	7	56	63	11.1	43	-	43		35	-	35	100.0
18	28	4	32	87.5	21	41	62	33.9	7	64	71	9.9	34	1	35		30	1	31	0.97
19	38	2	40	95.0	25	47	72	34.7	15	74	89	16.9	47	1	48		19	-	19	100.0
20	41	2	43	95.3	46	48	94	48.9	12	74	86	14.0	26	-	26		16	-	16	
21	43	2	45	95.6	37	43	80	46.3	10	75	85	11.8	13	-	13		14	-	14	
22	37	3	40	92.5	52	42	94	55.3	10	69	79	12.7	16	-	16		16	-	16	
23	34	-	34	100.0	42	24	66	63.6	15	55	70	21.4	10	-	10		12	-	12	
24	18	-	18		34	12	46	73.9	16	42	58	27.6	9	-	9		6	-	6	
25	25	-	25		30	13	43	69.8	10	35	45	22.2	12	-	12		11	-	11	
26	13	-	13		26	4	30	86.7	10	18	28	35.7	5	-	5		8	-	8	
27	10	-	10		10	-	10	100.0	6	14	20	30.0	4	-	4		7	-	7	
28	5	-	5		6	2	8		4	8	12	33.3	1	-	1		3	-	3	
29	9	-	9		6	1	7		2	6	8	25.0	1	-	1		12	-	12	
30	2	-	2		8	-	8		3	3	6	50.0	1	-	1		5	-	5	
31	1	-	1		8	-	8		4	-	4	100.0	2	-	2		6	-	6	
32	2	-	2		2	-	2		2	1	3		2	-	2		2	-	2	
33	2	-	2		2	-	2		-	2	2		2	-	2		6	-	6	
34	-	-	-		2	-	2		3	-	3		-	-	-		1	-	1	
35	-	-	-		2	-	2		1	-	1		4	-	4		3	-	3	
36	-	-	-		-	-	-		-	-	-		1	-	1		1	-	1	
37	-	-	-		-	-	-		-	-	-		1	-	1		4	-	4	
38	-	-	-		-	-	-		1	-	1		1	-	1		2	-	2	
Total	324	32	406		415	386	801		149	684	833		323	36	359		386	72	458	
(l_c)				13.9cm				19.7cm				26.8cm				12.4cm				12.0cm
Coefficient correlation(r)				0.86				0.81				0.73				0.89				0.98
Selection factor(b)				3.4				3.6				4.1				3.1				3.0
%	lost	7.9				8.3				82.1				10.0				12.9		

A_1 - experiments carried out by research vessel ; B_1 - experiments by commercial boat ; B_2 - knotless cod-end (italian type)

experiments results, it seems that cod-end of 65 mm with 50% retention point of 26.8 cm would have been, on short-term, effective protective measure but causing immediate losses of 82.1% of the hake individuals, ie. that escape throughout the cod-end mesh sizes.

Taking into account growth constants of the hake population in the Adriatic Županović, 1968; Flamigni, 1983) it has been tried to forecast possible long-term effects, in a transition period, for the Adriatic trawl fishery by movement either the size at first capture (C) or fishing mortality rate (F), assuming that for this and other studied populations natural mortality coefficient (M) ranges between 0.2 and 0.4. Calculation has bee made using Beverton and Holt (1966) yield tables. In all instances (Table 8) it has been obtained that significantly effective yield per recruit (eumetric yield) could be obtained (plus 312%) acting on the size at first capture i.e. increasing cod-end mesh size, than by decrasing fishing mortality rates (F) for the present rate of the hake's population exploitation. Similar findings for hake population in the Adriatic were stated by Otello and Jukić (1985), i.e. that it might be more convinient, for socio-economic reasons, to act on (l_c) value than on (F).

Assuming studies Garcia and Le Reste, 1981), that most marine exploitable stocks are never in equlibrium, it is to suppose that in the case of the Adriatic and thus Mediterranean, demersal stocks »immediate« or »long-term« restocking management approaches should be more foreseen throughout of the total fishing effort control and reduction.

Mullus barbatus L.

Selectivity experiments with various cod-ends on the striped mullet population have given the following 50% retention points: 11.4 cm for 40 mm co-end with knots; 11.6 cm for 40 mm knotless cod-end; 12.0 cm (41 mm cod--end); 18.0 cm (55 mm cod-end); 19.4 cm (65 mm cod-end) and 12.9 cm for cotton cod-end of 51 mm. Selection factors (b) range between 2.8 and 3.3 while for cotton cod-end it equals 2.5.

Calculated percentages of individuals lost (retained in cover) in the case of 40 mm and 41 mm cod-end varied from 8.0% to 29.9% while for 55 mm cod-end and 65 mm percentage of escapement amounted to 81.1% and 82.9%.

The biological and biometric characteristics of *M. Barbatus* population in the are described by Haidar (1970) and Arneri and Jukić (1985) Adriatic Sea. Its lenght at first maturity (Fig. 3) in connection to the selection characteristics of the 40 mm cod-end mesh size pointed out that application of the proposed cod-end in Adriatic trawl fishery for striped mullet population would be convenient measure for biological and short-term economic (number of individual losses) aspects.

Calculations of the long-term changes in yield per recruit (Y/R) by moving, especially, size at first capture in all cases (Table 8) provide a better yields per recruit for assumed values of (M) and (F) in the table, but in the case of 40 mm cod-end it seems that 50% retention point or (l_c) value should have been doubled (from C = 0.42 to C = 0.90), i.e. above the value of 65 mm cod-end what in the case of this population would cause total loss of individuals.

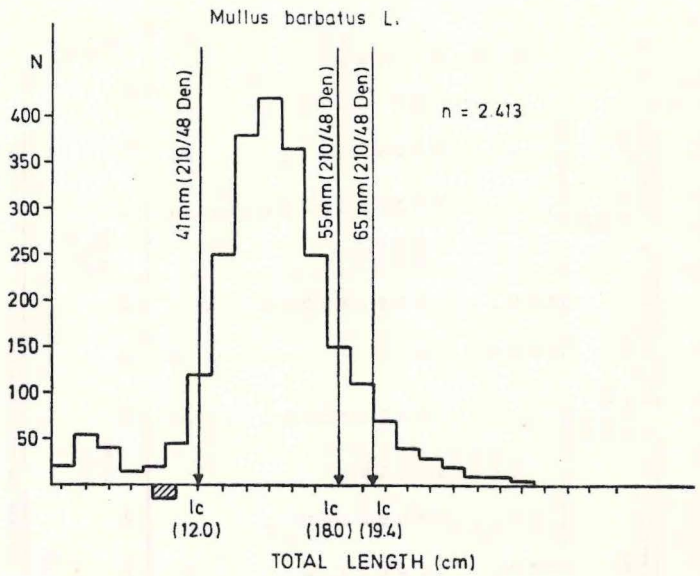


Fig. 3. — Forecasts of possible implementation of the various cod-ends: 41 mm (210/48 Den), 55 mm (210/48 Den) and 65 mm (210/48 Den) on lenght frequency distribution and length at first maturity ▩ of the *Mullus barbatus L.* population along the eastern Adriatic coast

Pagellus erythrinus L. (Table 3)

The 50% retention points obtained are: 11.8 cm for 41 mm cod-end; 12.2 cm for 51 mm cod-end (20/18 Nm); 16.4 cm (55 mm cod-end) and 20.5 cm for 65 mm cod-end. Selection faktors are from 2.4 to 3.2.

The application of the 40 mm cod-end mesh size in the Adriatic trawl fishery in connection to this fish population with its 50% retention point close to 11.8 cm body length would correspond to and I age-class (R i j a v e c, 1965), while the percentage of the individuals lost (retained in the cover) for this cod-end would be 7.6%. Considering length frequency distribution of this population in the studied area, especially its length at first maturity (fig. 4), it seems that proposed 40 mm cod-end mesh size would be an effective management measure.

Long-term calcultions of the possible changes in yield per recruit (Y/R) by movement of the (C) and (F) values have pointed out to similar results like in the case of first two fish populations. Change in length at first capture would be better approach at the present rate of exploitation (Table 8). Respecting growth characteristics, present (C) value of 40 mm cod-end should be increased about 3.5 times to optimum C = 0.70.

Trachurus trachurus L. (Table 4)

Selectivity experiments with regard to horse mackerel population were carried out only by research vessel »Bios« in the middle open Adriatic (Jabu-

Table 2 - Results of the covered cod-end mesh size experiments concerning Striped Mullet(Mullus barbatus L.) population along the eastern Adriatic coast carried out by research"Bios"(300 hp) and commercial "Jadran"II(300 hp) vessels.

Length (cm)	Cod-end A_1 41 mm 210/4 Den	Cover 18mm	Total	%	Cod-end A_1 55 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 65 mm 210/48 Den	Cover 18mm	Total	%	Cod-end B_1 40 mm 210/48 Den	Cover 4mm	Total	%	Cod-end B_2 40 mm 210/48 Den	Cover 4mm	Total	%	Cod-end A_1 51 mm 20/18 Nm	Cover 18mm	Total	%
6	-	-	-		-	-	-		-	-	-		-	3	3		-	14	14		-	-	-	
7	-	-	-		-	-	-		-	-	-		-	24	24		-	32	32		-	-	-	
8	-	1	1		-	-	-		-	-	-		1	22	23	4.3	-	17	17		-	-	-	
9	-	1	1		-	-	-		2	-	2		2	5	7	28.5	-	4	4		-	-	-	
10	2	1	3		1	2	3	33.3	-	2	2		3	1	4	75.0	-	3	3		1	1	2	50.0
11	1	5	6	16.7	2	7	9	22.2	4	8	12	33.3	3	1	4	75.0	1	-	1		6	6	12	50.0
12	5	15	20	25.0	6	15	21	28.6	2	24	26	7.8	4	6	10	40.0	5	2	7	0.71	18	15	33	54.5
13	15	29	44	34.4	10	33	43	23.3	8	52	60	13.3	13	5	18	72.0	16	4	20	0.80	34	34	68	50.0
14	50	22	72	69.4	6	61	67	8.9	8	80	88	9.0	28	4	32	87.0	36	3	39	0.92	44	40	84	52.0
15	48	2	50	96.0	5	82	87	5.7	12	76	88	13.6	29	2	31	93.5	47	2	49	0.96	75	35	110	68.2
16	49	2	51	96.1	4	64	68	5.9	4	57	61	6.6	29	1	30	96.0	46	-	46	100.0	97	13	110	88.2
17	43	-	43	100.0	4	45	49	8.2	6	37	43	14.0	22	1	23	95.0	36	-	36		55	2	57	96.5
18	18	1	19		6	14	20	30.0	7	29	36	19.4	17	-	17		18	-	18		45	-	45	100.0
19	19	-	19		11	11	22	50.0	3	15	18	16.7	12	1	13		12	-	12		29	-	29	
20	10	-	10		11	1	12	91.7	4	9	13	30.8	7	-	7		12	-	12		13	+	13	
21	4	-	4		4	3	7	57.1	5	7	12	41.7	4	-	4		2	-	2		8	-	8	
22	6	-	6		2	1	3	66.6	5	5	10	50.0	3	-	3		-	-	-		9	-	9	
23	2	-	2		1	-	1	100.0	9	-	9	100.0	1	-	1		-	-	-		5	-	5	
24	4	-	4		1	-	1		2	-	2		-	-	-		1	-	1		2	-	2	
25	1	-	1		3	-	3		1	-	1		-	-	-		-	-	-		1	-	1	
26	-	-	-		2	-	2		1	-	1		-	-	-		-	-	-		-	-	-	
Total	332	29	361		79	339	418		83	401	484		178	76	254		232	81	313		442	146	588	
$\bar{L}_c$				12.0cm				18.0cm				19.4cm				11.4cm				11.6cm				12.9cm
Coefficient correlation(r)				0.95				0.70				0.67				0.84				0.97				0.92
Selection factor(b)				2.9				3.3				3.0				2.8				2.9				2.5
% lost		8.0				81.1				82.9				29.9				25.9				24.8		

A_1 - experiments carried out by research vessel ; B_1 - experiments by commercial boat ; B_2 - knotless cod-end(italian type)

Table 3 – Results of the covered cod-end mesh size experiments concerning Pandora(Pagellus erythrinus L.)population along the eastern Adriatic coast carried out by research vessel"Bios"(300 hp)

Lenght (cm)	Cod-end A_1 41 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 55 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 65 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 51 mm 20/18 Nm	Cover 18mm	Total	%
8	–	–			–	–	–		–	–	–		2	1	3	
9	–	2	2		1	3	4	25.0	–	6	6		6	19	25	24.0
10	9	34	43	20.9	4	53	57	7.0	7	59	66	10.6	17	44	61	27.9
11	17	23	40	42.5	5	101	106	4.7	3	83	86	3.6	26	59	85	30.6
12	34	16	50	68.0	3	82	85	3.5	4	86	90	4.4	26	37	63	41.8
13	106	13	119	89.1	9	107	116	7.8	7	119	126	5.6	47	73	120	39.2
14	188	4	192	97.9	38	193	231	16.5	27	213	240	11.3	154	73	227	67.8
15	203	2	205	99.0	40	163	203	19.7	17	166	183	9.3	154	16	170	90.6
16	146	1	147	99.3	45	86	131	34.4	13	115	128	10.2	152	4	156	97.4
17	143	–	143	100.0	115	44	159	68.0	29	113	142	20.4	108	2	110	98.2
18	104	–	104	114	124	16	130	87.7	23	82	105	21.9	98	2	100	98.0
19	77	–	77		64	6	70	91.4	19	42	61	31.1	67	–	67	100.0
20	43	–	43		36	2	38	94.7	21	19	40	52.5	35	–	35	
21	31	–	31		15	1	16	93.8	21	9	30	70.0	24	–	24	
22	20	–	20		14	–	14	100.0	14	4	18	77.8	17	–	17	
23	15	–	15		9	–	9		12	1	13	92.3	10	–	10	
24	19	–	19		7	–	7		4	4	8	50.0	15	–	15	
25	7	–	7		9	–	9		9	3	12	75.0	7	–	7	
26	1	–	1		7	–	7		1	–	1	100.0	3	–	3	
27	–	–	–		1	–	1		1	–	1		3	–	3	
28	–	–	–		–	–	–		–	–	–		–	–	–	
29	–	–	–		–	–	–		–	–	–		–	–	–	
30	–	–	–		1	–	1		–	–	–		1	–	1	
Total	1165	95	1258		536	857	1393		232	1121	1353		972	330	1302	
(l_c)				11.8cm				16.4cm				20.5cm				12.2cm
Coefficient correlation(r)				0.89				0.90				0.91				0.95
Selection factor(b)				2.9				3.0				3.2				2.4
% lost		7.6				61.5				82.9				25.3		

A_1 – research vessel

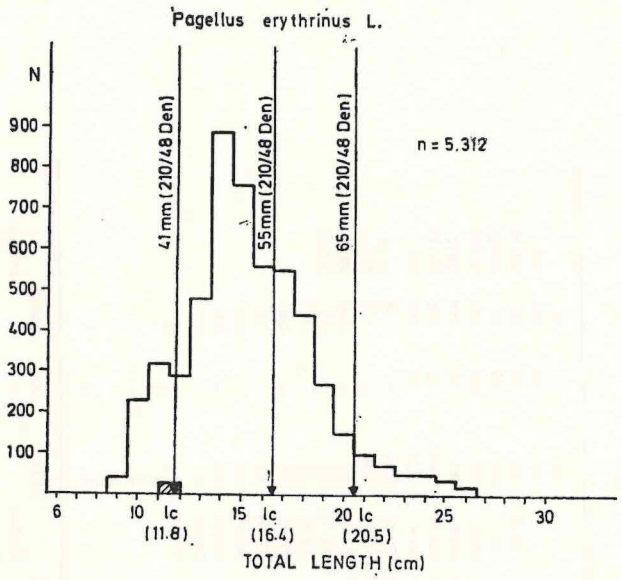


Fig. 4. Forecasts of possible implementation of the various cod-ends: 41 mm (210/48 Den), 55 mm (210/48 Den) and 65 mm (210/48 Den) on length frequency distribution and length at first maturity ▩ of the *Pagellus erythrinus* L. population along the eastern Adriatic coast

ka pit). Polyamid cod-ends of 41 mm, 55 mm and 65 mm were studied. The 50% retention points are: 17.0 cm (41 mm); 21.0 cm (55 mm) and 27.7 cm (65 mm) with selection factors from 3.8 to 4.3.

The value of 50% retention point of the 40 mm cod-end mesh size equals about 17.0 cm. It seems that this size of the cod-end, as far as length at first maturity is concerned, would be protective one and that only 6.4 percentage of the individuals would be lost.

Considering fish population dynamics parametres and growth characteristics of the horse mackerel in the Adriatic Sea (Alegria-Hernandez, 1983), it seems that at the present level of exploitation (E), size at first capture (C) for a cod-end of 40 mm is close to the maximum yield per ceruit (Table 8).

Nephrops norvegicus L. Table 5)

This associated species with other demersal stocks in the open central Adriatic, prevails mostly on clay-loamy bottom sediments and of lower sea temperatures (O. Karlovac, 1953; Jukić, 1971). It is one of the main subject of the trawl fishery in the Adriatic. Selectivity cod-end experiments were conducted only by research vessel with cod-ends of: 41 mm, 55 mm and 65 mm. The following values of 50% retention points were obtained: 5.7 cm

Table 4 - Results of the covered cod-end mesh size experiments concerning Horse Mackarel(Trachurus trachurus L.) population along the eastern Adriatic coast carried out by research vessel "Bios"(300 hp)

Length (cm)	Cod-end A_1 41 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 55 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 65 mm 210/48 Den	Cover 18mm	Total	%
15	1	-	1		-	-	-		-	1	1	
16	-	4	4		-	2	2		-	5	5	
17	8	6	14	57.4	3	21	24	12.5	-	23	23	
18	4	3	7	57.1	13	48	61	21.3	-	39	39	
19	25	2	27	92.6	22	49	71	31.0	1	48	49	2.3
20	38	2	40	95.0	23	34	57	40.4	5	36	41	12.2
21	53	1	54	98.1	41	31	72	66.9	-	34	34	
22	71	1	72	98.6	50	18	68	73.6	2	30	32	6.3
23	37	1	38	97.4	38	10	48	79.2	-	6	6	
24	26	-	26	100.0	27	4	31	87.1	-	8	8	
25	14	-	14		13	-	13	100.0	1	6	7	14.3
26	4	-	4		1	-	1		1	2	3	33.3
27	1	-	1		2	-	2		2	1	3	66.7
28	-	-	-		1	-	1		-	1	1	
29	2	-	2		2	-	2		2	-	2	100.0
30	5	-	5		2	-	2		4	-	4	
31	-	-	-		-	-	-		3	-	3	
32	2	-	2		2	-	2		-	-	-	
33	-	-	-		-	-	-		-	-	-	
34	-	-	-		-	-	-		1	-	1	
35	1	-	1		-	-	-		2	-	2	
36	-	-	-		-	-	-		1	-	1	
37	-	-	-		-	-	-		1	-	1	
38	-	-	-		1	-	1		-	-	-	
Total	292	20	312		241	217	458		26	240	261	
(l_c)				17.0cm				21.0cm				27.7cm
Coefficient correlation(r)				0.81				0.98				0.60
Selection factor(b)				4.2				3.8				4.3
% lost		6.4				47.4				92.0		

A_1 - research vessel

Table 5 – Results of the covered cod-end mesh size experiments concerning Norway lobster(Nephrops norvegicus L.)population along the eastern Adriatic coast carried out by research vessel "Bios"(300 hp)

Length (cm)	Cod-end A_1 41 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 55 mm 210/48 Den	Cover 18mm	Total	%	Cod-end A_1 65 mm 210/48 Den	Cover 18mm	Total	%
5	4	–	4		2	2	4	50.0	–	2	2	
6	9	–	9		23	5	28	82.1	7	10	17	41.2
7	26	10	36	72.2	82	23	105	78.1	26	41	67	38.8
8	65	13	78	83.3	207	67	274	75.5	72	134	206	35.0
9	75	8	83	90.4	311	65	376	82.7	113	179	292	38.7
10	77	5	82	93.9	339	40	379	89.4	139	168	307	45.3
11	70	3	73	95.9	294	24	318	95.5	165	91	256	64.5
12	36	1	37	97.3	188	–	188	100.0	88	45	133	66.2
13	29	–	29	100.0	99	–	99		57	19	76	75.0
14	13	–	13		64	–	64		40	6	46	87.0
15	14	–	14		44	–	44		38	3	41	92.7
16	5	–	5		29	–	29		15	–	15	100.0
17	2	–	2		23	–	23		6	1	7	
18	2	–	2		10	–	10		3	–	3	
19	2	–	2		2	–	2		1	–	1	
20	–	–	–		1	–	1		–	–	–	
Total	429	40	469		1655	289	1944		770	699	1469	
(l_c)				5,7cm				6.5cm				10.3cm
Coefficient correlation(r)				0.93				0.59				0.95
Selection factor(b)				1 .2				1.2				1.6
% lost		8.5				14.9				47.6		

A_1 – research vessel

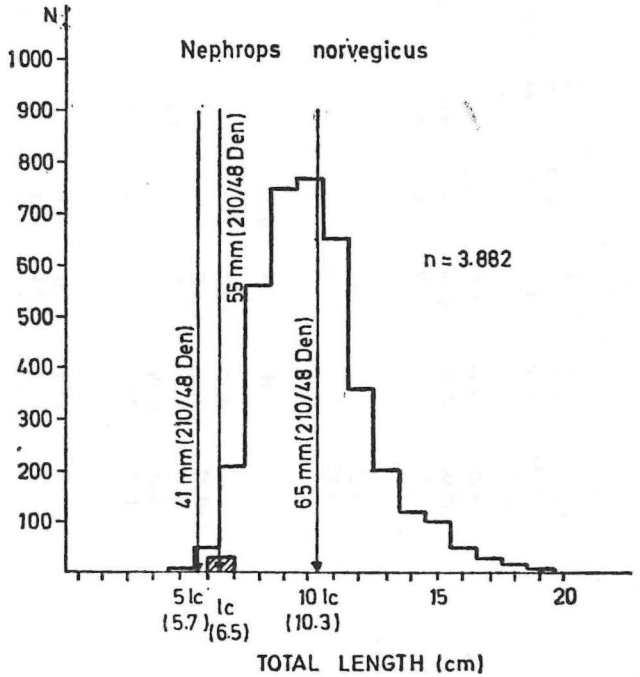


Fig. 6. Forecasts of possible implementation of the various cod-ends: 41 mm (210/48 Den), 55 mm (210/48 Den) and 65 mm (210/48 Den) on length frequency distribution and length at first maturity ■ of the Norway lobster *(Nephrops norvegicus* L.) population along the eastern (central part) Adriatic coast

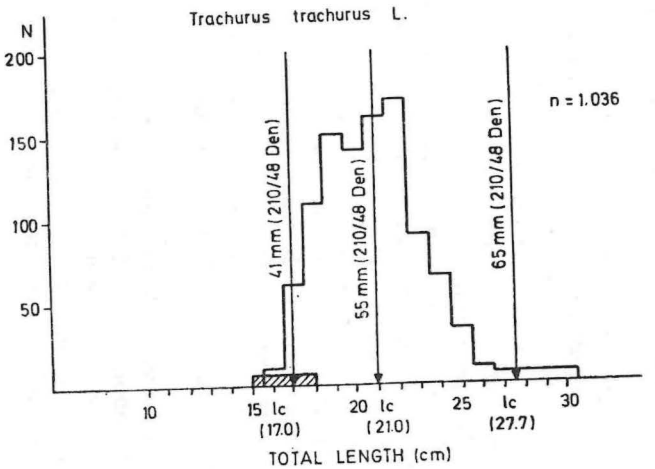


Fig. 5. Forecasts of possible implementation of the various cod-ends: 41 mm (210/48 Den), 55 mm (210/48 Den) and 65 mm (210/48 Den) on length frequency distribution and length at first maturity ■ of the *Trachurus trachurus* L. population along the eastern Adriatic coast

(41 mm cod-end), 6.5 cm (55 mm) and 10.3 cm (65 mm cod-end) with selection factors from 1.2 to 1.6.

Comparisons of the length frequency distribution of the Norway lobster population, especially size (lenght) at first maturity, to the selection characteristics of 40 mm cod-end mesh size, have pointed out (Fig. 6) that a bigger cod-end mesh size in Nephrops trawl fishery is needed. A cod-end mesh size of 65 mm or even 55 mm would be better protective measures causing individual losses of 14.9 and 47.6 percentage.

Long-term effects changes of the yield per recruit are not studied because of the lack of informations, mostly population growth constants.

Using the nomogram (girth factor) technique, described by Pauly (1983), it has been tried to calculate values of selection factors and 50% retention points (Table 7). It has been found that results obtained by means of nomogram do not differ very much from those obtained by means of covered cod-end experiments and in some instances, such as lack of research vessel or other facilities, preliminary information concerning selection characteristics of the, either towing or fixed fishing gears, might be obtained by this convenient technique.

Under the scope of covered cod-end mesh size selectivity experiments, especially with regard to application of the proposed 40 mm cod-end mesh size, economic aspects were briefly considered as well. For such studies only a commercial boat »Jadran« II (300 hp) was used and only effects of 40 mm (with knots and knotless) and 70 mm cod-ends were studied. It has been

Table 6 — Results of immediate economic effects in commercial trawl fishery along the eastern Adriatic coast by applying different cod-end mesh sizes on commercial vessel »Jadran« II (300 hp) October 1984

	Cod-end		Knotless cod-end		Cod-end	
Species and groups (after Šoljan)	40 mm 210/48 Den	Cover 4 mm	40 mm 210/48 Den	Cover 4 mm	70 mm 210/48 Den	Cover 4 mm
CHONDRICHTHYES	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
Scyliorhinus canicula (L.)	46.00	0.30	16.50	—	10.60	0.50
Scyliorhinus stellaris (L.)	10.50	—	8.50	0.32	9.30	—
Triakidae						
Mustelus mustelus (L.) and Mustelus asterias Cloq.	13.10	—	19.80	—	—	—
Raja clavata L.	25.40	—	4.50	—	5.50	—
OSTEICHTHYES						
Conger conger (L.)	—	0.40	1.05	0.12	—	—
Gadus ((Trisppterus) minutus L.	—	0.17	1.05	—	—	—
Merlucius merlucius (L.)	180.37	0.63	42.50	0.30	26.50	13.80
Zeus faber L.	3.34	—	5.15	—	3.50	—
Pagellus erythrinus (L.)	5.85	0.29	—	—	—	—
Boops boops (L.)	1.35	0.57	—	—	1.05	—
Centracanthidae						
Maena maena (L.) and Maena smaris (L.)	16.00	1.05	2.00	0.10	2.45	—
Mullus barbatus L.	12.95	1.16	11.80	0.03	5.40	5.70

Table 6 — Continues

Carangidae						
Trachurus trachurus (L.)	3.50	0.42	—	—	—	—
Trachurus mediterraneus Stdr.	4.00	0.45	3.50	0.13	8.25	5.80
Pleurgnectiformes						
(E. linguatula, A. laterna)	7.45	1.48	3.70	0.63	1.00	7.60
Lophiidae						
Lophius piscatorius L. and Lophius budegassa Spin.	21.52	—	11.40	—	8.50	—
Mixed fish mostly nonedible (S. hepatus, B. ocellaris, G. niger jozo, C. rubescens, L. cavillone, A. cuculus, E. gurnardus)	12.20	44.05	10.40	4.50	5.70	27.40
CEPHALOPODA						
Eledone moschata (Lam.)	20.17	13.30	10.90	2.95	5.80	—
Sepia officinalis (L.)	1.80	0.95	—	—	—	—
Total (kg) only edbile	379.30	21.07	142.35	9.08	85.85	—
Towing timed (minutes)	300 4 knots	—	120 4 knots	—	120 4 knots	—
Non-edible trawl catch (kg)	530		230		170	
Catch per unit effort (kg/hour)	75	4	71	2	44	17
Ratio (cod-end/cover)	5.9		16.7		1.6	
Loose per hour (in U$)		16		8		68

Average market price ((January, 1987) of 1 kg mixed demersal species about 4 U$ dollars

Table 7. Selection factors (b) and 50% retained points of studied fish populations obtained by means of nomogram (Pauly, 1983); girth factor (maximum girth/total length)

Species name	Cod-end (mm)	Girth factor	Selection facor (b)	50% retained points (cm)	YU legislative minimum size limits (cm)
Merluccius merluccius L.					
	40 with knots	0.48	3.4	13.6	20
	40 knotless			13.6	
	41 with knots			13.9	
	55 with knots			18.7	
	65 with knots			22.1	
Mullus barbatus L.					
	40 knotless	0.59	2.8	11.2	12
	40 with knots			11.2	
	41 with knots			11.5	
	55 with knots			15.4	
	65 with knots			18.2	
	51 (20/18 Nm)			14.3	
Pagellus erythrinus L.					
	41 with knots	0.70	2.6	10.7	14
	55 with knots			14.3	
	65 with knots			16.9	
	51 (20/18 Nm)			13.3	
Trachurus trachurus L.					
	41 with knots	0.48	3.4	13.9	—
	55 with knots			18.7	
	65 with knots			22.1	
Nephrops norvegicus L.					
		—	—	—	10

Table 8. Illustration of the calculation of % changes in yield/recruit for four commercially important species in Adriatic trawl fishery from the tables Beverton and Holt (1966). Results of the cod-nd mesh size selectivity experiments of 40 and 41 mm. Movments of the values of the size at first capture and fishing mortality rate providing the maximum Y/R assuming M = 0.2 and M = 0.4

1. *Merluccius merluccius* L.	40 mm cod-end with knots (l_c = 12.4 cm; b = 3.1)	
M =	L = 85.0 (K = 0.12/Z = 1.13) 0.2	0.4
	a) change in size at first capture	
Present C = .14	From C = .14 to C = .58	From C = .14 to C = .54
	From Y' = .010418 to	From Y' = .018632 to
Predicted change in Y/R	Y' = .042913	Y' = .040515
	+ 312%	+ 117%
	b) change in fishing mortality rate	
Present C = .14	From F/M = 4.00 to F/M = .667	From F/M = 1.86 to F/M = .667
	From Y' = .016033 to	From Y' = .018632 to
	Y' = .025010	Y' = .025010
Predicted changeg in Y/R	+ 140%	+ 34%
2. *Mullus barbatus* L.	40 mm cod-end with knots (l_c = 11.4 cm; b = 2.8)	
M =	L = 27.0/K = 1.8/Z = 1.64 0.2	0.4
	a) chamge in size at first capture	
Present C = .42	From C = .42 to C = .90	From C = .42 to C = .84
	From Y' = .179956 to	From Y' = .273339
	Y' = .405861	Y' = .372157
Predicted change in Y/R	+ 126%	+ 36%
	b) change in fishing mortality rate	
Present C = .42	From F/M = 9.00 to F/M = 1.86	From F/M = .00 to F/M = 1.86
	From Y' = .179956 to	From Y' = .2 to
	Y' = .285357	Y' = .285357
Predicted change in Y/R	+ 59%	+ %
3. *Pagellus erythrinus* L.	41 mm cod-end with knots (l_c = 11.8 cm; b = 2.9)	
M =	L = 60..0/K = 0.20 /Z = 1.10 0.2	0.4

Present C = .20	a) change in size at first capture From C = .20 to C = .70 From Y' = .032914 to Y' = .102236 + 210%	From C = .20 to C = .52 From Y' = .018275 to Y' = .032041 + 75%
Predicted change in Y/R		
Present C = .20	b) change in fishing mortalitö rate From F/M = 4.00 to F/M = .818 From Y' = .032914 to Y' = 062169	From F/M — 1.86 to F/M = .818 From Y' = .018275 to Y' = .021833
Predicted change in Y/R	+ 89%	+ 19%
4. *Trachurus trachurus* L.	40 mm cod-end with knots (l_c = 17.0 cm; b = 4.2)	
M =	L = 37.6/K = 0.22/Z = 0.54 0.2	0.4
Present C = .46	a) change in size at first capture From C = 46 to C = .64 From Y' = .083460 to Y' = 09422 + 14%	From C = .46 to C = .38 From Y' = .022804 to Y' = 023250 + 2%
Present C = .46	b) change in fishing mortality rate From F/M = 1.86 to F/M = 1.86	From F/M = .333 to F/M = 2.33 From Y' = .022804 to Y' = .039178
Predicted change in Y/R	For present C, F is optimal	71% (F) should be increased

tried preliminarly to forecast possible losse in edible biomass, thus money, tried preliminarly to forecast possible losses in edible biomass, thus money, per unit time in studied trawl fishing ground respecting: stock composition, biometric characteristics of demersal and semi-demersal populations. It has been found out that applying 40 mm cod-end, either with knots or knotless (Table 8), instantaneous of the biomass would range between 8 to 16 USA $ per unit time (one hour). This biomass of the edible organisms mostly was composed of *Cephalopoda* group.

This economic biomass loss per unit time is almost equal to the value of oil consumption. In multispecies trawl fishehry the Adriatic Sea with presently limited size of the commercial stocsk, application of 40 mm cod-end in certain areas along the eastern coast might directly constrain areas along the eastern coast might directy constrain further fishing operations and might create a delicate socio-economic problems among the fishermen.

CONCLUSION AND RECOMMENDATIONS

Preliminary results of various con-end mesh size experiment carried out along the eastern Adriatic coast by research and commercial vessels with covered cod-end technique, considering short and long-term management effects, have pointed out the following:

Considering only short-term effects of the application of 40 mm cod-end mesh size on length at first maturity of the studied populations, it has been found that this proposed cod-end would be effective measure only for: *Mullus barbatus, Pegellus ervthrinus* and *Trachurus trachurus* populations, while for the other species: *Merluccius merluccius, Nephrops norvegicus* and species of *Chondrichthyes* group should be larger.

Calculations carried out for yield per recruit (Y/R) analysis for four species, based on the parametres estimated by the various authors, under two different assumptions (M = 0.2) and (M = 0.4), in connection to 40 mm cod-end mesh size, in all cases brought forward preliminary management ideas that changes in size at first capture (C) would be more effective measure for Adriatic trawl fishery on long-term basis. Assuming that Adriatic demersal stocks are away of the equlibrium state due to the ffact of high level of the exploitation, recommendations that might be based in management policy only acting on (C) neglecting fishing mortality rate (F) could be erroneous.

Application of 40 mm cod-end mesh size with knots in Adriatic trawl fishery along the eastern coast, as a short-term effect in economic sence under the present economic difficulties, especially in cooperative sector, might produce further diffficulties.

Results of the cod-end mesh size experiments especially, with possible application of 40 mm cod-end mesh size to Adriatic multispecies demersal stocks, have pointed out that achievement of an »a priori« concept as it is proposed 40 mm cood-end, without considerations of the two other important factors: total fishing effort and economic (cost-benefit) relationships might be biased.

Respecting data in Tabble 8, ie. logn-term calculation gf the changes of the yield per recruit, in the case of Adriatic multispecies demersal resources Beverton and Holt (1966) model techinque is very difficult to apply, so that in this case an »average solution« is needed.

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Accepted: April 2, 1987

S. Jukić and C. Piccinetti
Biological and economic aspects of mesh size regulation
Acta Adriat., 28 (1/2) : 199—219 (1987)

BIOLOŠKI I EKONOMSKI ASPEKT REGULACIJE SAKE U DUBINSKE POVLAČNE MREŽE (KOĆE) OBZIROM NA MNOGOVRSNA KOĆARSKA NASELJA JADRANSKOG MORA

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KRATKI SADRŽAJ

Posljedicom intenzivnog ribolova u poslijeratnom razdoblju u koćarskom ribolovu Sredozemlja, Generalni savjet za ribarstvo Sredzemlja (GFCM) je na svojoj 6. plenarnoj sjednici donio odluku, a sve su članice odluku i prihvatile, da se u koćarskom ribolovu Sredozemlja na sakama dubinske mreže obavezno uvedu oka mrežnog tega od 40 mm, dijagonalno mjereno oko.

U vezi ove preporuke, respektirajući kvantitativno i kvalitativne karakteristike koćarskih naselja istočne obale Jadranskoga mora, uglavnom teritorijalnog mora Jugoslavije, tokom zadnjih nekoliko godina izvršeni su intenzivni eksperimenti procjene selektivnosti različitih tipova dubinskih povlačnih mreža (koća), posebice njihovih saka u odnosu na gospodarski najvažnije populacije: oslić *(Merluccius merluccius* L.), trlja blatarka *(Mullus barbatus* L.), rumenac *(Pagellus erythrinus* L.), saruna *(Trachurus trachurus* L.) i škampa (*Nephrops norvegicus* L.).

Koristeći tehniku pokrovne sake (slika 1), selektivne karakteristike u slijedećih saka su ispitivane: polyamidne sake od 40 mm, sa i bez čvorova, 41 mm; 55 mm; 65 mm; 70 mm, te pamučne sake od 51 mm s čvorovima. U eksperimentima selektivnosti učestvovali su istraživački brod m/b »Bios« (300 KS) i komercijalni koćar »Jadran« II (300 KS).

Za sve navedene sake utvrđene su selekcione konstante: 50%-na točka selektivnosti sake u odnosu na ispitivanu populaciju, ili (l_c) vrijednost, selekcioni faktor sake (b), kako za veličinu sake tako i vrstu mrežnog tega. Osim toga, na osnovu dobijenih rezultata selektivnosti, posebice preporučene i usvojene mjerne veličine sake od 40 mm, nastojalo se je utvrditi: trenutačan efekat primjene ove sake u koćarskom ribolovu u Jadranu, kao i dugotrajan proces poboljšanja koćarskog ulova analiziranih vrsta te ekonomski aspekt mogućeg gubitka jestive biomase. Rezultati nalaza prikazani su u tablicama 1—8.

Na osnovu dobijenih rezultata eksperimenata selektivnosti moguće je zaključiti slijedeće: da primjene sake veličine oka od 40 mm, u odnosu na prvu spolnu zrelost ispitivanih populacija, u trlje blatarke, rumenca i saruna ima pozitivan (zaštitni) trenutačni efekt, dok u slučaju ostale dvije populacije: oslića, škampa kao i vrsta riba iz skupine *Chnodrichtyes* (hrskavićave ribe) veličina oka sake trebala biti viša. Računanja višegodišnjeg pozitivnog efekta (eumetrijski ulov) primjene sake od 40 mm (Tablica 8), pri postojećoj razini iskorištavanja koćarskih naselja u Jadranu ukazuju da bi se u svim slučajevima količine ulova mogle bitno povećati, od plus 14% (sarun) do plus

312% (oslić) uz uvjet, da se znatnije poveća veličina oka na saki koće, odnosno vrijednost 50%-ne točke (l_c). Ovi prinosi bi bili znatno viši, u strategiji pravilnog gospodarenja, nego što bi bile vrijednosti regulacije ukupnog ribolova (ribolovnog intenziteta). Kako je u svim svjetskim morima smanjenje obimnosti i srednje dužine populacije direktna poslijedica visokog stupnja iskorištavanja, to i u slučaju jadranskih koćarskih naselja ovu činjenicu nebi trebalo zanemariti, te politiku zaštite koćarskih naselja isključivo tretirati regulacijom (povećanjem) oka na saki dubinske povlačne mreže.

Ekonomska analiza rentabilnosti primjene sake od 40 mm u komercijalnom ribolovu uzduž istočne obale Jadranskog mora (Tablica 6) pokazuje da se pri primjeni sake, sa i bez čvorova, u jedinici vremena od 1 sata gubi jestiva biomasa od 2 do 4 kilograma, uglavnom vrste skupine *Cephalopoda*-glavonošci, a time i novčani iznos od 8—16 US dolara.

Obzirom na biološku raznovrsnost demersalnih (koćarskih) populacija Jadranshog mora, razinu iskorištenosti i socio-ekonomski položaj ribara, rezultati nalaza selektivnosti sake dubinske povlačne mreže od 40 mm, ukazuju da postojeći globalni modeli optimalnog iskorištavanja (Beverton and Holt, 1966) nisu uvijek primjenjivi, i da se dugoročna rješenja za Jadransko more trebaju zasnivati na biološkim i ekonomskim pokazateljima, pri čemu gospodarski najinteresantnije vrste riba trebaju imati prioritet.