Acta Adriat., 23 (1/2): 431—440 (1982) YU ISSN: 0001—5113
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THE PROTECTION OF THE HAKE (*MERLUCCIUS MERLUCCIUS* L.) IN THE ADRIATIC SEA BY REGULATION OF THE LEVEL OF EXPLOITATION

ZAŠTITA POPULACIJE OSLIĆA (*MERLUCCIUS MERLUCCIUS* L.) U JADRANSKOM MORU REGULACIJOM NIVOA ISKORIŠTAVANJA

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Dealing with the statistical data of the total hake (*Merluccius merluccius* L.) annual catch in the Adriatic sea and corresponding estimated fishing effort for the period from 1959 to 1978 year using the concept of the production models; linear (Schaefer, 1954) and exponential (Fox, 1970), it has been tried to assess values od maximum sustainable yield (MSY) and optimal fishing effort (f_{OPT}), for management purposes.

Achieved values of maximum sustainable yield for the hake population in the Adriatic sea ranged: from 2.818 to 3.273 tons per year with corresponding fishing effort: from 54.348 to 62.632 fishing days per year.

Values of the total mortality coefficient (Z) obtained by Gulland's method (Gulland, 1968) for the period 1970—1979, equals ($Z = 0{,}79$) on the average. On the basis of bottom trawl selectivity experiments (Granić and Jukić, 1980), in Adriatic non selective trawl fishery, using approaches Beverton and Holt (1956) it has been estimated total mortality coefficient ($Z = 0{,}77$).

INTRODUCTION

The hake (*Merluccius merluccius* L.) population in the Adriatic sea is a part of demersal multi-species population over the continental shelf being exclusively exploited by bottom trawl nets, which resources have been intensely exploited after second World War because of the great market demand.

Because of its importance a number of ichtyologists have studied biology and ecology of the specie in the Adriatic sea (Karlovac, 1959; Jukić, 1972; 1975; Jardas, 1976; Mužinić and Karlovac, 1975; Županović, 1968). On the contrary to the mentioned studies this study deals with relationship between fishing intensity in the Adriatic sea bottom trawl fishery

and hake stock size. From such relations an attempt has been done to assess the maximum sustainable yield (MSY) of the population with corresponding optimal fishing effort (f_{OPT}).

MATERIAL AND METHOD

Fishery statistical data of the annual catches of the hake in the Adriatic for Yugoslavian part are obtained from Republic Department for Statistics, while for Italy Statistical Bulletin GFCM No. 2 (1978) and No. 3 (1979) were used.

Assessing abundance index of the hake population, as catch per unit effort ($\bar{U}$), statistical data of one Yugoslavian cooperative (»Jadran« — Split) were mainly used. These data has been considered as »representative sample« for yugoslavian trawl fishery because of the general characteristics: category of the trawl fleet (average 23—25 m length, 240 HP), intensity of fishing operation and fishing area, mostly in central open Adriatic.

On the same time, catch per unit effort data of mentioned cooperative have been used for estimation of total expended fishing effort in Adriatic hake trawl fishery (G u l l a n d, 1968) by relation:

$$f_e = C/\bar{U} \qquad (1)$$

where (f_e) represents estimated total fishing effort, (C) total annual catch and ($\bar{U}$) average catch per unit effort of the »representative sample«.

On the basis of the length frequency distribution of the hake population in the central open Adriatic (Ž u p a n o v i ć, 1968; J u k i ć, 1975) it has been stated that the greatest percentage of the hake population belongs from Ist to IIIrd year class.

Estimating relationship between fishing effort and abundance changes, recomendation given by G u l l a n d (1968) has been respected:

$$F = \frac{f_1 + f_2 + f_3}{3} \qquad (2)$$

i. e. the abundance index value in the observed year is the result of the average fishing effort from previous three years.

Stock assessment of the hake population in Adriatic sea is done by production models methodology (S c h a e f e r, 1954; F o x, 1970), which is based on the direct relationship between fishing effort, catch per unit effort, population growth and size.

In calculation of the total mortality coefficient (Z) two methods were used:

1. On the basis of monthly catch in central open Adriatic is applied equation (G u l l a n d, 1964):

$$Z_t = \ln \bar{U}_1/\bar{U}_2 \qquad (3)$$

where the time interval (t) comprises the period from beggining of summer (May—July), till next spring (April—May).

2. On the basis of the cod-end selectivity data of the bottom trawl net (G r a n i ć and J u k i ć, 1980), for no selective Adriatic trawl fishery using constants of growth equation (B e r t a l a n f f y, 1938) and formula (B e v e r t o n and H o l t, 1956) rought estimation of (Z) value was made:

$$Z = \frac{k\ (L - \bar{l})}{l - l_c} \qquad (4)$$

where (K) and (L) are the constants in the Bertalanffy equation, ($\bar{l}$) average catch length and (l_c) is 50% retained point.

RESULTS

With regard to statistical data of the hake annual trawl catch in the Adriatic sea in catch composition hake makes 4,2% of the total annual catch. In Italian trawl fishery it makes 3,8% while in Yugoslav trawl fishery, mostly undertaken along the eastern Adriatic coast, it makes in average 18,6%.

Changes in annual trends of italian and yugoslav hake fishery have similar pattern (fig. 1) with correlation coefficient (r = 0,937).

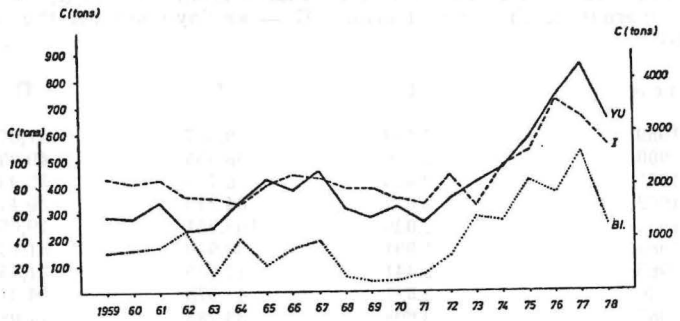

Fig. 1. Annual catch (C — tons) fluctuations of the hake (*Merluccius merluccius* L.) population in the Adriatic Sea regarding statistical information for: Yugoslavia (YU), Italy (I) and cooperative organization »Jadran« (Bl), for 1959/1978.

Annual catch of both, italian and yugoslav hake yields, as well as landings of the cooperative (»Jadran« — Split) mostly for the central open Adriatic have significant upward catch trend during period 1959—1978. This is much more significant if statistical data are divided in to two series: 1958—1969 and 1971—1978. The results set out in figure 1 show evident upward trend of the hake catches from 1971, in contrast to the previus period when the total catch was in continuous decrease.

Table 1. Calculated hake (*Merluccius merluccius* L.) catch trends in the Adriatic sea during: 1959—1968, 1971—1978 and 1959—1978

	1959—1968		1971—1978		1959—1978	
Catch by	Correl. coeff.	Mean increase	Correl. coeff.	Mean increase	Correl. coeff.	Mean increase
»Jadran« Split	—0,599	—2,179	0,714	8,886	0,540	2,424
YUGOSLAVIA	0,337	6,336	0,991	75,012	0,742	21,333
ITALIA	—0,229	—11,590	0,796	229,369	0,577	51,480
TOTAL ADRIATIC	—0,086	—5,255	0,835	304,381	0,630	72,843

Hake catches in the Adriatic sea with estimated fishing effort and the average values of the catch per unit effort, are shown in the table 2.

Total catch have ranged from 1.931 tons/year to highest value of 4.337 tons/year. Estimated total fishing effort has the highest value in 1963, 1968, 1969 and 1970 year but with the lowest abundance indices.

Generally, the trend of the fishing effort has slight decrease value with coefficient (b = —945,801). Catch per unit effort, as a measure of the popuiation abundance, has higher value (b = 2,28), especially after 1971, probably due to the use of more effective fishing gears, i. e. bottom trawl nets.

Table 2. Total annual catch (C — tons) of hake *Merluccius merluccius* L.) in the Adriatic sea with corresponding estimated fishing effort (f_e — fishing days) and average catch per unit effort ($\bar{U}$ — kg/day/boat) for the period 1959—1978

Year	C	f_e	$\bar{U}$
1959.	2.439	58.507	41,67
1960.	2.359	48.055	49,09
1961.	2.443	46.749	52,90
1962.	2.037	34.270	59,44
1963.	2.020	105.981	19,06
1964.	1.991	38.940	51,13
1965.	2.441	77.615	31,45
1966.	2.571	47.576	54,04
1967.	2.604	33.783	77,08
1968.	2.280	115.268	19,78
1969.	2.231	105.986	21,05
1970.	2.080	102.970	20,20
1971.	1.931	49.871	38,72
1972.	2.537	41.707	60,78
1973.	2.028	23.038	88,03
1974.	2.831	40.328	70,20
1975.	3.224	30.949	104,17
1976.	4.337	46.983	92,31
1977.	4.130	31.628	130,58
1978.	3.400	56.818	59,84

The funtional relation between catch per unit effort and fishing effort is very high, i. e. correlation coefficients are: linear correlation (r = —0,791)

and exponential correlation (r = —0,920), which leads to a conclusion that the empirical data can be better approximated by the exponential curve described by funtion: $U = U\infty\ e^{-bf}$, which comprises 84,6% of the data. On the basis of the trend of the catch per unit effort of the hake population and fishing effort (Fig. 2) it has been noticed that the values (f_e, $\bar{U}$) in the considered period oscillate around the population equilibrium state. From the data results that the annual hake catch has been near the equilibrium population yield, i. e. somewhat lower from the optimal value up to 1974 while after 1974 year higher of the maximum sustainable yield value.

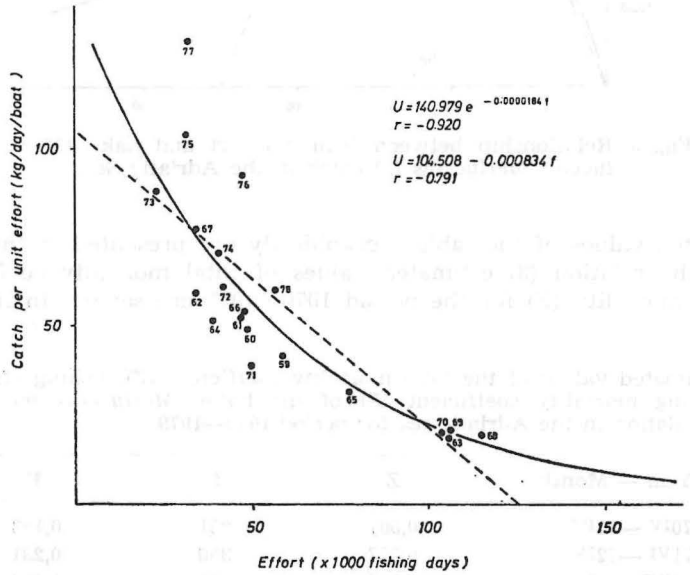

Fig. 2. Equilibrium state of the hake (*Merluccius merluccius* L). population in the Adriatic Sea.

Table 3. Estimated values of the relation between catch and fishing effort (C/f), maximum sustainable yield (MSY), optimal cacth per unit effort (f_{OPT}) and correlation coefficient (r) for hake (*Merluccius merluccius* L.) population in the Adriatic sea for 1959—1978

Parameters	Models	
	Linear	Exponential
Relation C/f	U = 104,508 — 0,000834f	U = 140,979 $e^{-0,0000184\,f}$
MSY	3.273	2.819
U_{OPT}	52,25	51,86
f_{OPT}	62.632	54.348
r	—0,791	—0,920
r^2	0,626	0,846

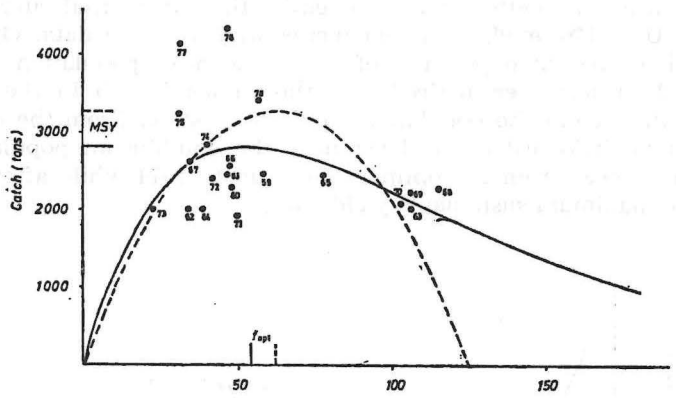

Fig. 3. Relationship between fishing effort and hake (*Merluccius merluccius* L.) catch in the Adriatic Sea.

Calculated values of the table 3 graphically are presented in the figure 3.

Using the relation (3) estimated values of total mortality coefficient (Z) and fishing mortality (F) for the period 1970—1979 are set out in the table 4.

Table 4. Estimated values of the total mortality coefficient (Z), fishing effort (f) and fishing mortality coefficient (F) of the hake (*Merluccius merluccius* L.) population in the Adriatic sea for period 1970—1979

Year — Month	Z	f	F
70^{IV} —71^{III}	0,597	251	0,163
71^{VI} —72^{IV}	0,777	356	0,231
72^{VII}—73^{IV}	0,765	653	0,424
73^{VII}—74^{V}	0,954	594	0,386
74^{VII}—75^{II}	0,412	518	0,337
75^{VI} —76^{IV}	1,137	705	0,458
76^{V} —77^{IV}	0,566	641	0,417
77^{V} —78^{IV}	0,943	866	0,563
78^{VI} —79^{V}	0,956	706	0,459
Average	0,790	588	0,382
$r\ (Z/f) = 0{,}529$ $s^2Z = 0{,}04771$ $s^2 = 0{,}2184$ $s^2_f = 31584{,}395$ $s_f = 177{,}719$	$P > 0{,}2$ $< 0{,}1$	$q = 0{,}0006498$	$M = 0{,}408$

Relationship between total mortality coefficient (Z) and fishing effort (f) for Adriatic hake fishery has been presented in figure 4.

For the analysed period 1970—79 year, coefficient of fishing mortality (F) has significant upward trend (Fig. 5). Obtained results from equation (4) are presented in table 5.

Table 5. Estimated value of the hake population total mortality coefficient (Z) on the basis of bottom trawl cod-end mesh size selectivity experiment and population growth parameters in Adriatic non selective trawl fishery

$K = 0{,}12$	$L = 85{,}5$ cm	$\bar{l} = 23{,}0$ cm	$l_c = 13{,}2$ cm (40 mm Den)

$$Z = \frac{K\,(L - \bar{l})}{1 - l_c} = 0{,}77$$

DISCUSSION

Applying production model approach, two explicit assumptions should be accomplished, i. e. it should be stated relationship between average stock size and fishing effort as well as population growth and stock size.

In the case of hake population stock assessment studies in the Adriatic sea these two conditions are not at very high degree satisfied, probably, because of the following causes: first, average abundance indices and estimated total fishing effort in the Adriatic hake fishery have been assessed only on the base of good fut scarse statistical data informations of only one yugoslav cooperative organization »Jadran« — Split, whose trawl fleet mostly operate in the central open Adriatic (Jabuka pit), covering a smaller part of fishable stock. Second, trawl fishing ground in the centrale open Adriatic is charaterized by presence, throughout of the whole year, of »small« hake individuals (first and second year class) that make a bulk of commercial trawl catch and it might be considered as hake's main spawning and recruitment ground (Županović, 1968; Jukić, 1975).

With regard to mentioned conditions some finding might be explained. For intance, relationship between fishing effort and catch per unit effort for the period 1968—1971, in spite of maximum value of expended fishing effort,

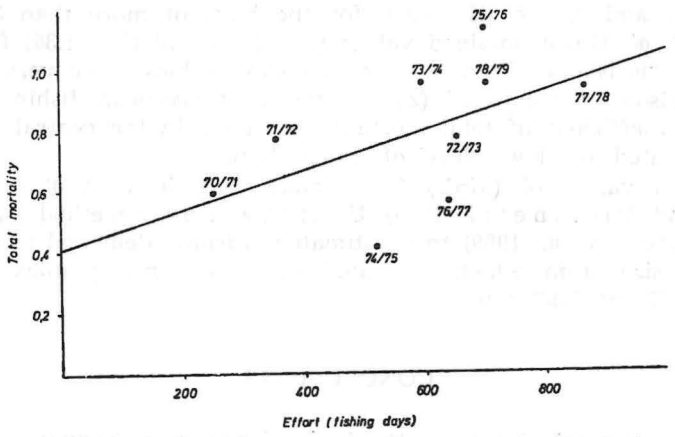

Fig. 4. Relationship between total mortality coefficient (Z) values and fishing effort for Adriatic hake (*Merluccius merluccius* L.) fishery during 1970/1979 year.

the lowest abundance index were noted (Fig. 3), probably because of unfavourable hydrographic conditions an its reflection to the general production properties (Pucher-Petković and Zore-Armanda, 1973).

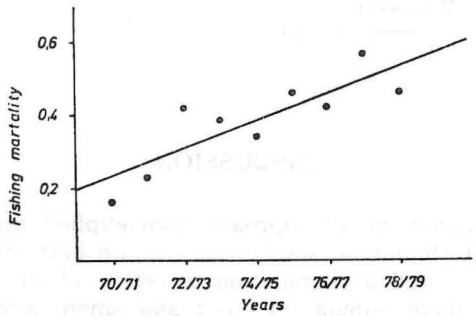

Fig. 5. Trend of fishing mortality (F) values during 1970/1979 year.

On the basis of cohort analysis of the hake population in the central Adriatic Županović (1968), estimated coefficient of the total population mortality (Z = 0,79) for the period 1956—1966.

Analysis of the cod-end selectivity experiment of bottom trawl and abundance index changes, for the period 1970—1979 with (Z) values of (Z = 0,79) and (Z = 0,77) show that coefficient of total population mortality have not changed very much during last twenty year. Is seems that the level of exploitation of the hake in the central open Adriatic has remained, more or less, stable.

In the areas of the west Mediterranean, in studies of influence of trawl fishery to the hake population, Robles *et al.* (in Lopez-Veiga, 1979) obtained values (Z = 0,94 for the age groups 1 and 2; (Z = 3,42) for age groups of 2 and 3, and (Z = 0,60) for the hake of more than 3 years old. Bruno *et. al.* (1978) obtained values (Z = 1,29) and (Z = 1,36) for the hake in the Balearic islands. They consider achieved values to be very high.

Comparison of values of (Z) for the Mediterranean fishing regions, it seems that coefficient of total mortality for hake in the central Adriatic sea might be related to a lower level of exploitation.

Obtained values of (MSY) for a hake coincide with other approaches (Jukić and Piccinetti, 1979). Using trawl-survey methodology (Alverson and Pereyra, 1969) they estimated Adriatic demersal resources standing stock size from which evaluated hake is standing stock size ranges between 3.657 and 7.383 tons.

CONCLUSIONS

Stock assessment studies of the hake (*Merluccius merluccius* L.) population in the Adriatic sea, for the period 1959—1978, have pointed out the following:

— Maximum sustainable yield (MSY) of the hake population in the

Adriatic sea varies from 2.819 tons/year (exponential model) and 3.373 tons/year (linear model), with optimal fishing effort between 54.349 (exponential model) and 62.638 (linear model) fishing day/year.

— Calculated yield values, especially in case of the exponential model are somewhat higher, except for the period 1974—1978, that the actual catch.

— Taking into consideration the actual catch values especially during last five years, it might be concluded that the catch amount and the fishing effort are not likely to increase, i. e. these values more or less tend to oscilate around the optimal yield values of the hake population size in the Adriatic sea.

REFERENCES

Alverson, D. L. and W. T. Pereyera. 1969. Demersal Fish Exploration in the Northeastern Pacific Ocean — An Evaluation of Exploratery Fishing Methods and Analitical Approaches to Stock Size and Yield Forecasts. J. Fish. Res. Bd. Canada, 26 (8): 1985—2001.

Bertalanffy, L. von. 1938. A quantitative theory of the organic growth (inquiries on growth laws II). Hum. Biol., 10 (2): 181—213.

Beverton, R. J. H. and S. J. Holt. 1956. A review of methods for estimating mortality rates in exploited fish population, with special reference to sources of bais in catch samples. Rapp. P.-V. Reun. Cons. int. Explor. Mer Medit., 140 (1): 67—83.

Bruno, J., P. Oliver, A. Astudillo, X. Pastor et E. Daroca. 1979. Contribution a la connaissance de la biologie du Merlu (*Merluccius merluccius* L.), et du Rouget (*Mullus surmuletus* L. et *Mullus barbatus* L.). Rapp. P.-V. Reun. Comm. int. Explor. Mer Medit., 25/26 (10): 79—86.

Fox, W. W. 1970. An exponential surplus yield model for optimizing exploited fish populations. Trans. Amer. Fish. Soc., 99 (1): 80—88.

Granić, B. and S. Jukić. 1982. Protection of demersal resources of the Adriatic Sea, with references to hake (*Merluccius merluccius* L.) population, by means of cod-end mesh size regulation. Ichthyologia, 14 (1) : 1—11.

Gulland, J. A. 1968. Manual of methods for fish stock assessment Part I. Fish population analysis. FAO Fish. Tech. Pap., 40 (2): 97 p.

Jardas, I. 1976. Contribution to the knowledge of the biology of the hake in the Adriatic Sea. Rev. Trav. Inst. Peches Marit., 40 (3—4): 615—618.

Jukić, S. 1972. Ishrana oslića *(Merluccius merluccius)* bukve *(Boops boops)*, trlje *(Mullus barbatus)* i arbuna *(Pagellus erythrynus)* u Kaštelanskom zaljevu. Acta Adriat., 14 (4): 40 p.

Jukić, S. 1975. Trawl fishing grounds in the central Adriatic. Acta Adriat., 17 (1): 82 p.

Jukić, S. and C. Piccinetti. 1978. Standing stock estimation and yield per exploitable biomass (YEB) forecast of the Adriatic edible demersal resources. Inv. Pesq., 43 (1): 273—282.

Karlovac, O. 1959. Exploration of fish stock and edible invertebrata carried out by trawling in the open Adriatic. Repports »Hvar« cruises-researches into fisheries biology, 1948—1949, 5 (1): 203 p.

Lopez-Veiga, J. 1970. Hake fishery off Galicia (NW Spain): an example of a very overexploited fishery. Inv. Pesq., 43 (1): 161—170.

Mužinić, R. and O. Karlovac. 1975. On the food preference of the Adriatic hake, *Merluccius merluccius* (L.). Acta Adriat., 17 (7): 47 p.

Pucher-Petković, T. et M. Zore-Armanda. 1973. Essai d'evaluation et pronostic de la production en fonction des facteurs du melieu dans l'Adriatique. Acta Adriat., 15 (1): 39 p.

Schaefer, M. B. 1954. Some aspects of the dynamics of population important to the management of commercial marine fisheries. Inter-Amer. Trop. Tuna Comm. Bull., 1 (2): 27—56.

Županović, Š. 1968. Study of hake *(Merluccius merluccius)* biology and population dynamics in the central Adriatic. Stud. Rev. gen. Fish. Coun. Medit., 32: 24 p.

ZAŠTITA POPULACIJE OSLIĆA (*MERLUCCIUS MERLUCCIUS* L.) U JADRANSKOM MORU REGULACIJOM NIVOA ISKORIŠTAVANJA

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KRATAK SADRŽAJ

Populacija oslića (*Merluccius merluccius* L.) u Jadranskom moru od posebnog je značaja za komercijalni ribolov, i predstavlja jedinstveni eksploatacioni stock ribe iskorištavan od talijanskih i jugoslavenskih ribara.

Kako između intenziteta ribolova i veličine populacije postoji funkcionalna ovisnost, koja se direktno očituje na visini ribolovne smrtnosti populacije, a time i na sveukupni rast (produkcije) populacije, to smo u radu nastojali da utvrdimo ovu povezanost i na osnovu takvih podataka procjenimo optimalni biološki nivo iskorištavanja (MSY — Maximum sustainable yield) oslića u Jadranskom moru, kao i odgovarajući optimalni intenzitet ribolova (f_{opt}), za potrebe pravilnog gospodarenja.

Studija obuhvata statističke podatke ukupnog ulova oslića u Jadranu, s odgovarajućim, izračunatim, ribolovnim naporom, za vremensko razdoblje 1959—1978. godine, u kojoj su korišteni produkcioni modeli; linearni (Schaefer, 1954) i eksponencijalni (Fox, 1970).

Izračunato je, da pri relativno stalnom trendu ribolovnog napora (b = = —945,801), ulov po jedinici napora, tj. abundancija oslića u Jadranu posjeduje tendenciju rasta (b = 2,28). Abundancija populacije u odnosu na ribolovni napor posjeduje visoku statističku signifikantnost, s vrijednostima koeficijenata korelacije, linearni (r = —0,79), eksponencijalni (r = —0,92), te signifikantnost koeficijenta regresije ($P < 0,01$) u oba slučaja (sl. 2). Izračunate vrijednosti optimalnog nivoa iskorištavanja (MSY) oslića u Jadranskom moru kreće se od 2.818 do 3.273 tone, uz odgovarajući ribolovni intenzitet (f_{opt}) od 54.348 do 62.632 ribolovna dana u godini (sl. 3). Ocjenjeni koeficijent ukupne smrtnosti populacije (Beverton i Holt), 1956) iznosi (Z = 0,77), odnosno (Z = 0,79) prema Gulland-ovom metodu.