ESTIMATE OF DEMERSAL BIOMASS OF THE MONTENEGRIN SHELF (SOUTH ADRIATIC)

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ABSTRACT

Annual catch of demersal settlements per unit effort (CPUE) and their biomass were estimated from 1998 to 2000. Material was collected by trawl surveys. Area surveyed was about 60% of total Montenegrin shelf surface. Maximum sustainable yield (MSY) was estimated too. Average CPUE and biomass were two times lower than those estimated from the previous survey, performed in 1973. Moreover, the steep decline of CPUE and biomass from 1998 to 2000 was observed. Spatial distribution of biomass and efficiency of trawlers as a function of engine power were analysed too.

Key words: demersal settlements, biomass, Montenegrin shelf

PROCENA PRIDNENE BIOMASE NA ŠELFU CRNOGORSKOG PRIMORJA (JUŽNI JADRAN)

REZIME

Procene ulova po jedinici napora (CPUE), biomase pridnenih naselja i maksimalnog dozvoljenog nivoa korišćenja (MSY) vršene su u periodu od 1998. do 2000. godine. Materijal je sakupljan brodovima koćarima. Istraživanjima je bilo pokriveno oko 60% ukupne površine šelfa Crnogorskog primorja. Srednje vrednosti CPUE i biomase bile su dva puta manje u odnosu na jedinu prethodnu procenu, izvršenu 1973. godine. Nadalje, primećen je pad biomase od 1998. do 2000. godine. U radu su izneseni i podaci o prostornoj raspodeli biomase, kao i o efikasnosti brodova koćara u odnosu na snagu njihovih motora.

Ključne riječi: pridnena naselja, biomasa, šelf Crnogorskog primorja

INTRODUCTION

During previous surveys of demersal settlements in the Montenegrin shelf area (Karlovac 1959; Županović 1953, Regner *et al.*,) mostly relative biomass was estimated, obtained from the data on catch per unit effort. Lepetić

(1965) estimated demersal biomass in Boka Kotorska Bay. Since the Bay is ecologically significantly different from shelf area, so far, only one estimate of absolute biomass of the shelf exists, obtained from the survey performed in 1973 (Jukić 1983). Thus, the aim of this paper is to present the results of recent biomass estimates and to compare them with the previous data.

MATERIAL AND METHODS

Trawl surveys were performed from 1998 to 2000. Six commercial trawlers were engaged in these surveys. Their length ranged from 13.9 m to 25.3 m, and engine power from 144 to 515 kW. The area surveyed (surface that extended 1/3 of the distance of the most distant hauls from the coastline, measured with planimeter), was 2 293 km^2, about 60% of total Montenegrin shelf surface.

Total catch was weighed on board, baycatch being discarded.

Biomas was estimated with swept area method. Catch per unit surface (relative biomass) during each haul was calculated using formula:

$$Br = \frac{C_t}{s} \qquad (1),$$

where Br is the relative biomass per unit surface (km^2), C_t is catch per haul, and s is the area swept by the haul expressed in km^2.

Area swept by the haul was calculated with the equation:

$$s = O * D \qquad (2),$$

where O is the aperture of the trawl and D is the length of the path swept during the haul, both expressed in km.

O was estimated by the Buzki & Czaika's (1973) method using equations:

$$O_d = (r_2 - r_1) * l + r_1 \qquad (3),$$

where O_d is the spread of the doors, r_1 is distance between towing rope guides, r_2 is distance between towing ropes 1 m off the towing rope guides, and l is the length of towing ropes. Using the known spread of the doors (equation 3), aperture of the trawl can be calculated with the equation:

$$O = O_d \frac{L_t}{L_t + L_s} \qquad (4).$$

Here L_t is the length of trawl without codend and L_s is the length of sweepers.

Total biomass over the area surveyed was estimated with the method of Alverson & Pereira (1969) where:

$$B = A\frac{1}{n}\sum_{i=1}^{n}\frac{Br_i}{q} \qquad (4).$$

B is total biomass, A is the surface of area surveyed, Br_i is the i-th value obtained from equation (1), while q is average catchability coefficient.

Average value of q was taken for these surveys as a mean value of catchabilty coefficients estimated for *Pagellus erythrinus* (q = 0.181; Joksimović, 1999), species with limited distribution that has refugia on rocky bottoms and for *Merluccius merluccius* (q = 0.683; Regner & Joksimović, unpublished data), quasi randomly distributed species in the area. Thus, the value q = 0.432 was applied in equation (4).

Since data on annual catch and effort of Montenegrin fisheries do not exist, in their absence, maximum sustainable yield (MSY) was estimated with Gulland's (1970) model, rearranged for exploited biomass (Cadima after Troadec, 1977; Beddington & Cooke, 1983) where:

$$MSY = 0.2ZB \qquad (5),:$$

Z is instantaneous total mortality rate, and B is exploited biomass. As for q in equation (4), Z was taken as an average value of *Pagellus erythrinus* (Z = 0.82; Joksimović, 1999), and *Merluccius merluccius* (Z = 1.72; Regner & Joksimović, unpublished data), so Z = 1.27 was inserted in equation (5).

RESULTS AND DISCUSSION

Average annual catch per unit effort (CPUE) was 21.04 kg * h^{-1}. Inserting values of Br_i, q and A in equation (4), average relative biomass (Br) per unit surface of 0.447 tons * km^{-2}, absolute biomass of 1.03 tons * km^{-2}, and total biomass of the area surveyed of 2 372.6 tons were estimated.

Since Jukić (1983) took q = 1 for catchability coefficient, in order to compare data obtained with previous estimate, this value was also applied. Insertion of q = 1 in equation (4) gave biomass estimate of 1 025 tons. Since in the previous survey area covered was 3 177 km^2 (Jukić 1983), to make rough comparison, estimated biomass of 1 025 tons was multiplied by 3 177/2 293. In this way, biomass for surface of 3 177 km^2 was 1420 tons. CPUE in 1973 was 63.17 kg * h^{-1} (Jukić, 1983). So, the values of CPUE and biomass obtained from these recent surveys were 3 and 2.42 times smaller, respectively, than those obtained from the previous survey, performed in 1973.

Such a significant decrease of biomass since the last survey is rather the consequence of sudden increase of number of trawlers since 1991, than of eventual natural fluctuations. The fact is that during the period from 1948 through 1986 average CPUE was 0.137 kg * kW * $hour^{-1}$, with very low coefficient of variation CV = 32.31% (Regner *et al.*, 2000). During that period only one boat per year was trawling in this area. After 1991 the number of trawlers increased, reaching it's maximum of 36 vessels, in 1998. This corroborates assumption that suddenly intensified fishing, and, moreover, possibly overfishing, caused decrease of biomass.

On the other hand, although the number of trawlers and their fishing effort decreased since 1999 (21 vessel in 2000), decline of biomass from 1998 to 2000 was observed (Figure 1). From 2 641 tons in 1998, biomass fell down to 2 197 tons in 2000.

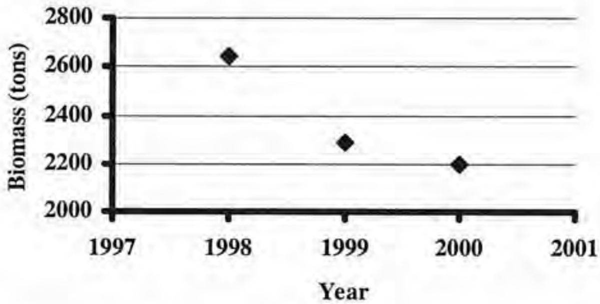

Figure 1. Annual demersal biomass of Montenegrin shelf estimates from 1998 to 2000.

This could hardly be explained by contemporary overfishing. There are two possible explanations for this decrease. The first is that during the period from 1997 – 1999 settlements were overfished, and that they need a certain period of time to recover. The second possibility is that some natural conditions have been changed.

Decrease of quantity of the hake, *Merluccius merluccius*, which was the main species in the catch until 1999, participating with 10.2% of the total catch, and increase of the pink shrimp (*Parapenaeus longirostris*) (Figure 2), speaks in favour of the latter assumption.

Inserting the estimated average biomass of 2 372.6 tons as variable B in equation (5), maximum sustainable yield (MSY) for this area was estimated to be 602.6 tons per year.

Jukić (1983) considered estimated biomass in 1973 as unexploited, "virgin", one. That was quite reasonable statement, because at that time only one trawler with only 70 fishing days per year was operating in this area. Therefore he estimated MSY with original Gulland's (1970) model for unexploited biomass.

For that reason, the recent estimate of MSY cannot be compared with the previous one.

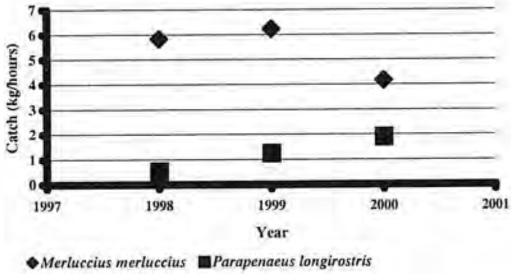

Figure 2. The relationship of the hake, *Merluccius merluccius*, and the pink shrimp, *Parapenaeus longirostris*, in catch composition from 1998 to 2000.

Spatial distribution, obtained from average data on all hauls performed, showed maximal concentration of relative biomass, more than 25 kg hour^{-1}, in the area between Budva and Bar, to the isobath of about 100 m (Figure 3).

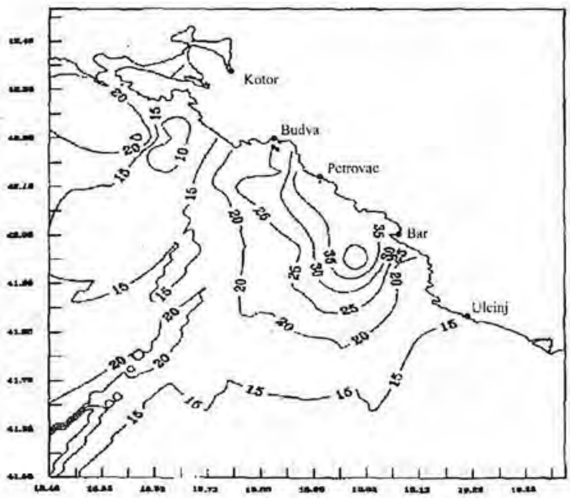

Figure 3. Distribution of relative biomass (kg h^{-1}) in the investigated area.

Another additional concentration of biomass (> 20 kg hour^{-1}) was in front of entrance of the Boka Kotorska Bay, extending to the isobath of 150 m.

Since both zones of higher biomass concentrations are situated in the uniformed biocenosis of coastal terrigenous mud (Gamulin – Brida, 1983), it seems that they do not depend primarily on the characteristics of the bottom.

The first one may be possibly caused by hydrographic conditions, eddies or fronts. High biomass values were found there during all three years of investigation. Moreover, Merker (1971) found spawning centres of sardine, *Sardina pilchardus*, during the spawning season in the year 1967, just in the same area. Thus, it seems that supposed hydrographic conditions are steady enough to maintain favourable conditions for substantially long time. The second zone may be caused by outflow of the waters from the Boka Kotorska Bay - richer with nutrients than the waters of the open sea. These assumptions have to be confirmed by detailed hydrographic investigations of this area.

In the zone between Ulcinj and Bojana river mouth, which stretches up to the border of shelf (Figure 3), biomass was very low, less than 15 kg $hour^{-1}$. In this area small, immature fishes of all species prevail in the catches. The same situation was observed in investigations performed in that area during the year 1986, at the time when intensity of trawling was very low (Regner *et al.*, 2001). Thus, this area is obviously favourable for the young individuals of all species, and it may be concerned as the important nursery ground.

Finally, the efficiency of trawlers used for these surveys, correlated with engine power, was also analysed. Average catch per hour showed significant positive linear relationship with trawler's engine power:

$$CPUE_{kg/hour} = 10.04 + 0.0419\ kW;\ r = 0.84,\ P < 0.05$$

But, there was no incerase with engine power when the CPUE was expressed as catch per kW hour (Figure 4).

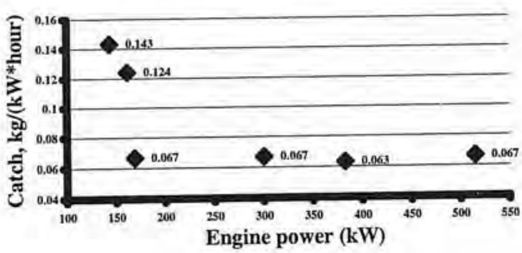

Figure 4. Relationship between CPUE (kg/kW hour) and engine power of the trawlers.

Moreover, vessels with smaller engine power ranging from 144 to 169 kW were more efficient than these with engine power between 300 and 515 kW (Figure 4).

The engine power is directly connected with fuel consumption, which makes important part of total cost of operations of trawlers.

Trawler with 515 kW engine realised the catch bigger than the trawler of 300 kW in only 60% of the hauls. Thus, it seems that there is no sense to use engines stronger than 300 kW in the investigated area.

CONCLUSIONS

Significant decrease of demersal biomass in Montenegrin shelf area regarding previous estimate, performed 25 years ago, can be accounted for the sudden increase of number of trawlers from 1991 on. On the other hand, decrease of biomass observed from 1998 to 2000, together with change of the structure of the catch – decrease of hake and increase of pink shrimp – might be the consequence of eventual environmental changes.

Spatial distribution showed two areas of biomass concentrations, which also might be more affected by hydrographic factors than by characteristics of the bottom.

The zone between Ulcinj and Bojana river mouth is obviously nursery ground, so particular attention should be paid to the fishery management of that area.

To confirm aforementioned suppositions about hydrographic influences on both recent biomass decrease and spatial distribution, detailed hydrographic investigations of Montenegrin shelf area should be performed, as soon as equipment necessary for these investigations is acquired.

Analysis of efficiency of trawlers showed that engine power of approximately 300 kW is, possibly, the best compromise for exploitation of the Montenegrin shelf demersal resources.

REFERENCES

Alverson, D. L. and W. T. Pereira (1969): Demersal fish exploration in the Northeastern Pacific Ocean – An evaluation of exploratory fishing methods and analytical approaches to stock size and yield forecasts. J. Fish. Res. Bd. Canada. **26(8)**: 1985 - 2001.

Beddington, J. R. and J. G. Cooke (1983): The potential yield of fish stocks. FAO Fish. Tech. Pap., **242**: 47pp.

Bucki, F. and W. Czajka (1973): Badania rozwarcia poziomego wlokow. Biuletin Morskiego Institutu Rybackiego, **5 (19)**: 20 - 23p.

Gamulin – Brida, H. (1983): La cote de Crna gora – une partie spécifique de la mer Adriatique a l'egard des biocenoses benthiques et leur protéction. Studia Marina, **13-14**: 205 – 214.

Gulland, J. A. (1970): The fish resources of the Ocean. FAO Fish. Tech. Pap., **97**: 425pp.

Joksimović, A. (1999): State, Structure and Exploitation Level of Red Pandora, *Pagellus erythrinus* (Linnaeus, 1758), Population in the Montenegrin Coastal Waters. M. Sc. Thesis, Faculty of Natural Sciences, University of Kragujevac: 73p.

Jukić, S. (1983): Demersal resources in South Adriatic (Crnogorsko primorje) and its maximum sustainable yield. Studia Marina, **13-14**: 155 - 165.

Karlovac, O. (1959): Exploration of fish stocks and edible Invertebrata carried out by trawling in the open Adriatic. Reports of the "Hvar" 1948-49 cruises, **5(1)**: 203pp.

Lepetić, V. (1965): Composition and seasonal dynamics of ichthyobenthos and edible invertebrata in Bay of Boka Kotorska and possibilities of their exploitation. Studia Marina, **1**: 127pp.

Merker, K. (1971): Quelques observations preliminaires á la récherche des localites de ponte de la sardine (*Sardina pilchardus* Walb.) dans la region de l'Adriatique meridionale. Studia Marina, **5**: 61 – 74.

Regner, S., A. Joksimović and S. Mandić (2000): The state of marine fisheries from 1997 to 1999 and perspectives for further development. Savremeno Ribarstvo Jugoslavije. IV Jugoslovenski simpozijum "Ribartsvo Jugoslavije", Vršac, 20. – 22. septembar 2000., Monografija: 9 – 18.

Regner, S., N. Kovačević and A. Joksimović (2001): Relative abundance of demersal resources in Bar - river Bojana mouth area (Montenegrin shelf). Journal of Scientific Agricultural Research, **60(210)** (in press).

Troadec, J. – P. (1977): Méthodes semi-quantitatives d'évaluation. FAO Circ. Pêches, **701**: 131 – 141.

Županović, Š. (1953): Statistical analysis of catches by trawling in the fishing regions of the Eastern Adriatic in 1951. Acta Adriat., **5(8)**: 55pp.