Stud. Mar. 26(1): 33–46

UDC 597:639.3.034(497.16 Boka Kotorska) (047.31)

BOKA KOTORSKA BAY – SPAWNING AND NURSERY AREA FOR PELAGIC FISH SPECIES

Milica Mandić[1*], Mirko Đurović[1], Ana Pešić[1], Aleksandar Joksimović[1], Slobodan Regner[2]

[1] Institute of Marine Biology, University of Montenegro, Montenegro
[2] Institute for Multidisciplinary Research, University of Belgrade, Serbia
* e mail: mamilica@ac.me

ABSTRACT

The study of the qualitative composition of the early developmental stages of fishes, which was conducted from July 2006 to January 2009, showed that in the area of Boka Kotorska Bay a significant number of economically important fish species spawned. Among them, during the summer the largest number belonged to anchovy (Engraulis encrasicolus), then to the annular seabream (Diplodus annularis), mediterranean rainbow wrasse (Coris julis), sharpsnout seabream (Diplodus puntazzo) shore rockling (Gaidropsaurus mediterraneus), brown comber (Serranus hepatus) round sardinella (Sardinella aurita) while the sardine (Sardina pilchardus) was the dominant species in the winter samples. Sampling was done using Calvet net (modified PairOvet) at 18 stations which covered all parts of the bay.

The aim of this paper was to estimate whether the Boka Kotorska Bay is nursery and/or spawning area to a significant number of pelagic fish species, and if it is, to emphasize the importance of the implementing of specific measures of protection in order to preserve species diversity.

Key words: Boka Kotorska Bay, ichthyoplankton, spawning and nursery area

INTRODUCTION

Investigated area

Boka Kotorska Bay is one of the biggest bays in the Adriatic Sea. It is situated in the southern part of the eastern Adriatic coast in the contact zone between Montenegro and Croatia (Fig. 1).

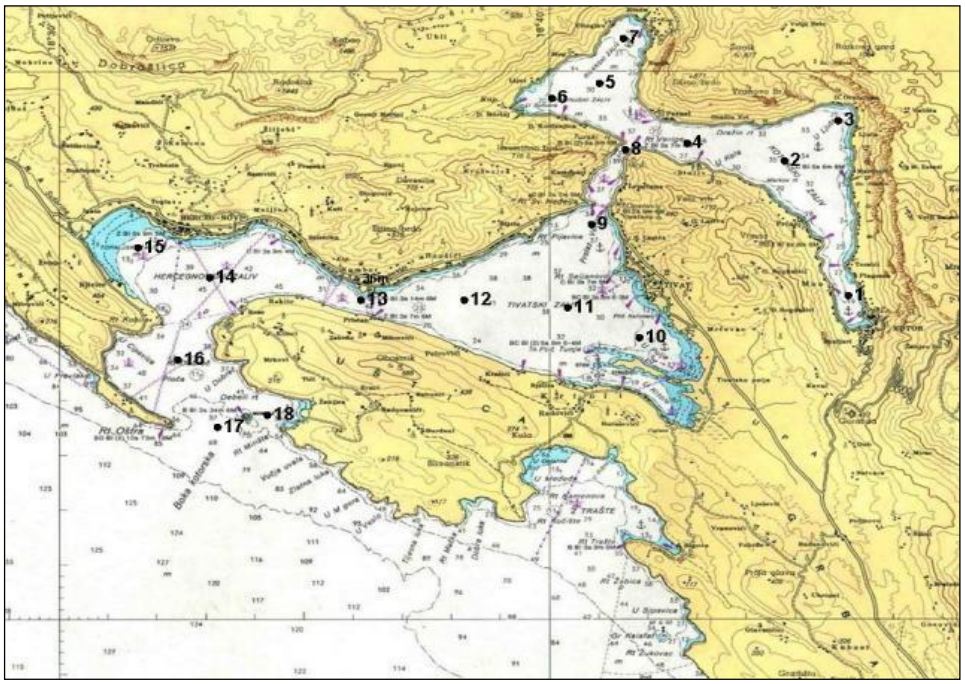

Figure 1. Boka Kotorska bay with investigated stations

The aquatorium of the Bay, with a total area of 87.3 km2, is divided into three parts: inner, central and outer part. The inner and central part are substantially influenced by freshwater inputs (submarine springs, rivers, streams, and precipitation), while the outer part is affected with the waters of the open sea.

The coast line of the Bay is 105.7 km long. At the west side to the entrance of the Bay lies the Cape „Oštra“, while at the eastern side Cape „Mirišta“, and the passage between them leads to the bay of Herceg Novi -

the first of four bays that together make up Boka Kotorska Bay. The Herceg Novi Bay continues to Tivat Bay through Kumbor strait, which continuing through the Verige strait to the Risan and Kotor Bay. Characteristic of the whole bay is relatively large depth of bays and straits. The maximum depth is 64 m (DerMap Project Report, 2011), while the depths of 40 to 45 m prevail in most parts of the bay. The average depth of all four bays is 27.6 m. Given the depth, the whole Bay of Kotor belongs to coastal or littoral system.

Ichthyoplankton composition in the Boka Kotorska Bay, which was thought to be nursery area for juveniles of many pelagic species, primarily sardines and anchovies, has been unknown so far. The first study of ichthyoplankton in the southern Adriatic Sea and part of the Boka Kotorska Bay goes back in 1966. (Merker, 1971) when spatial-temporal dynamics of sardine spawning was determined, and shortly thereafter study on the distribution and density of anchovy eggs in Boka Kotorsaka Bay (Merker & Vujoševic, 1972).

Investigations of the qualitative composition of ichthyoplankton on the eastern Adriatic coast with information on specific spawning areas of pelagic fishes were done by Gamulin & Hure (1983), Karlovac (1964, 1967), Vučetic (1971), Regner (1980, 1982), and Dulčić & Grebec (2000).

The importance of this research indicates that the greatest number of Teleostei, especially marine species, lays eggs in the water column, and in most species that lay eggs on the bottom, larvae and postlarve are planktonic. Success in the growth and survival of ichthyoplankton decisively affects dynamics of fish populations, and therefore the study of these developmental stages is one of the main tasks of fisheries biology.

MATERIAL AND METHODS

All plankton material was collected by vertical tows with Calvet (modified PairOVET) net. Calvet net was originally designed by the CalCOFI (California Cooperative Oceanic Fisheries Investigations) to determine the production of anchovy eggs and populations of similar species. The net has a cylinder with diameter of 25 cm, the total mouth opening 0,098 m² and a mesh size of 0.160 um. The net was towed vertically at a speed of 0.5 to 1 m/s, from 5 meters above the maximum depth to the sea surface. Ichthyoplankton material was collected in July 2006, December 2006, April 2007, August 2007, April 2008, July 2008, October 2008 and January 2009. The reason that sampling was not done in autumn 2006 and 2007 and the winter of 2007 is the malfunction of the research vessel. Ichthyoplankton samples were taken at 18 stations in the Bay (Fig. 1) and stored in a buffered solution of 2.5% formaldehyde. Selected stations covered deepest places in the Bay, places which are strongly influenced by the inflow of fresh water, as well as parts of the bay with a significant currents (Verige) or the influence of the open sea (Cape Mirišta and Mamula).

Ichthyoplankton material was sorted using binocular NIKON SMZ 800, equipped with MOTIC camera. Ichthyoplankton determination was made to species level, and in cases where it was not possible determination was done just to genus.

RESULTS

On the entire study area it was found 1116 eggs and 258 larvae and postlarvae. Total of 35 species, 28 genera and 18 families were identified.

The results are presented as a percentage of the most numerous species, while "others" included species that were found at only one or two research stations and whose number was very small.

Sparidae family was represented by 8 species, followed by the family Carangidae, Serranidae, Scombridae and Callionymidae that were presented with 3 different species. Families Clupeidae, Labridae, Bothidae and Gadidae were represented by two species, while all the other families that were found during the survey: Engraulidae, Trachinidae, Moronidae, Ophichthidae, Lotidae, Mugilidae and Scorpaenidae were represented by a single species. Species of the family Gobiidae and Triglidae were not determined due to lack of adequate literature.

The percentage share in the total ichthyoplankton composition in July 2006 (Fig. 2) indicates the dominance of anchovy (*Engraulis encrasicolus*), but a significant percentage belongs to species *Coris julis* and *Diplodus annularis*.

In December 2006 (Fig. 3), when intense spawning of sardine was observed, this species constituted 64% of the total composition of ichthyoplankton. In addition to sardines, *Scomber scombrus* took important percentage of the total composition; and very interesting finding was unusual occurrence of anchovy eggs (Mandić *et* al., 2012).

In April 2007, the highest percentage in the total ichthyoplankton composition belongs to anchovy, sardine and white seabream (Fig. 4).

Samples from August 2007. (Fig. 5) indicate already known dominance of anchovy with almost 50 percent in total ichthyoplankton composition.

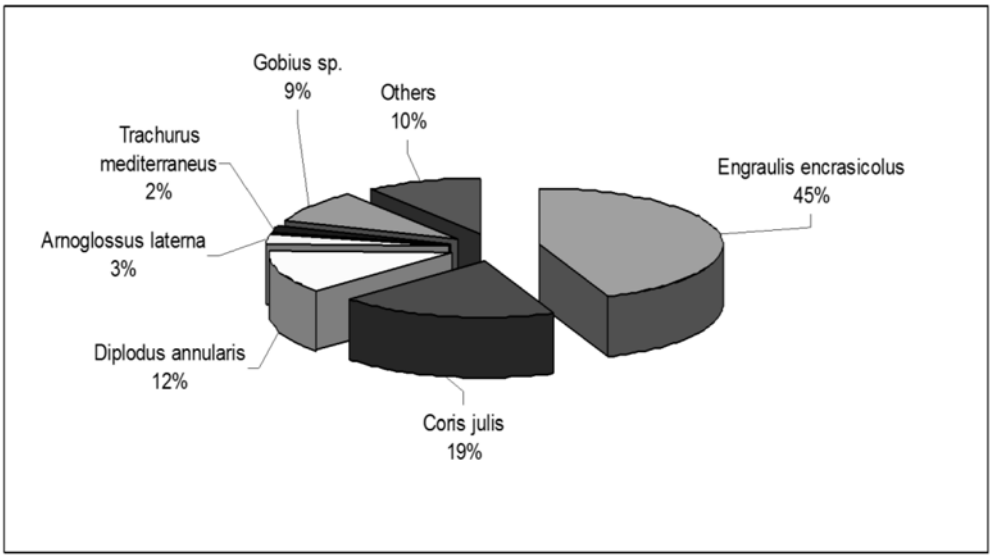

Figure 2. The percentage share of the total species of ichthyoplankton in July 2006

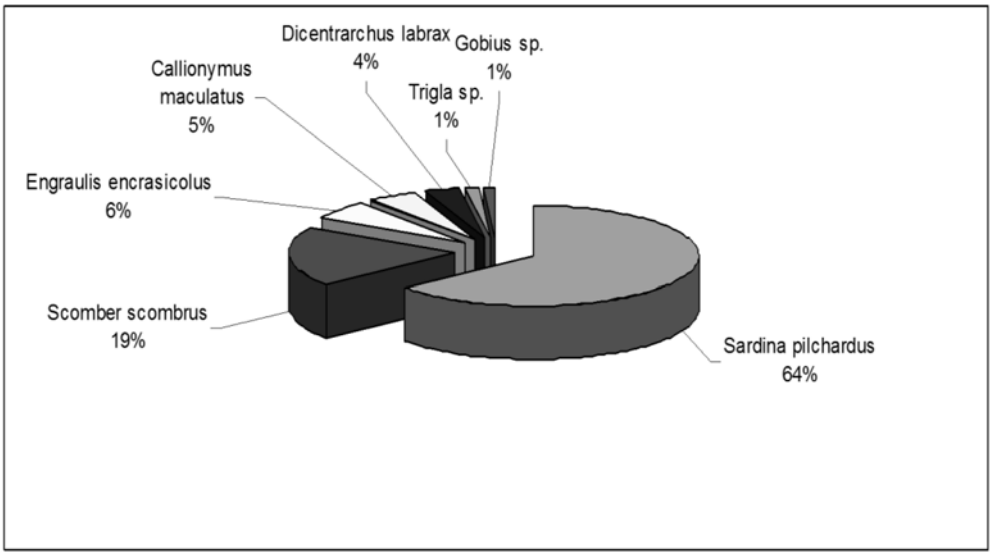

Figure 3. The percentage share of the total species of ichthyoplankton in December 2006

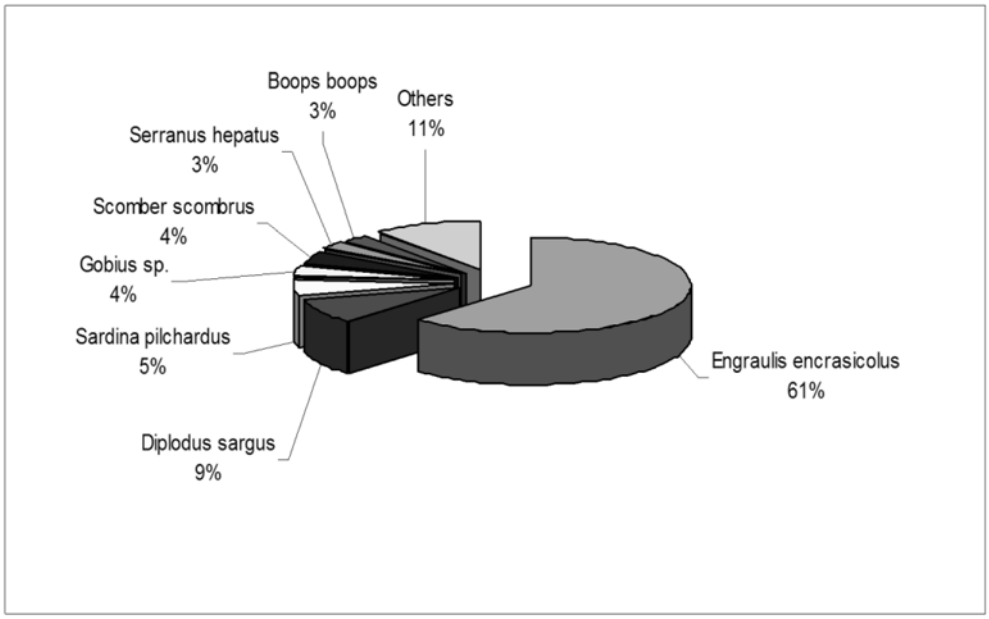

Figure 4. The percentage share of the total species of ichthyoplankton in April 2007

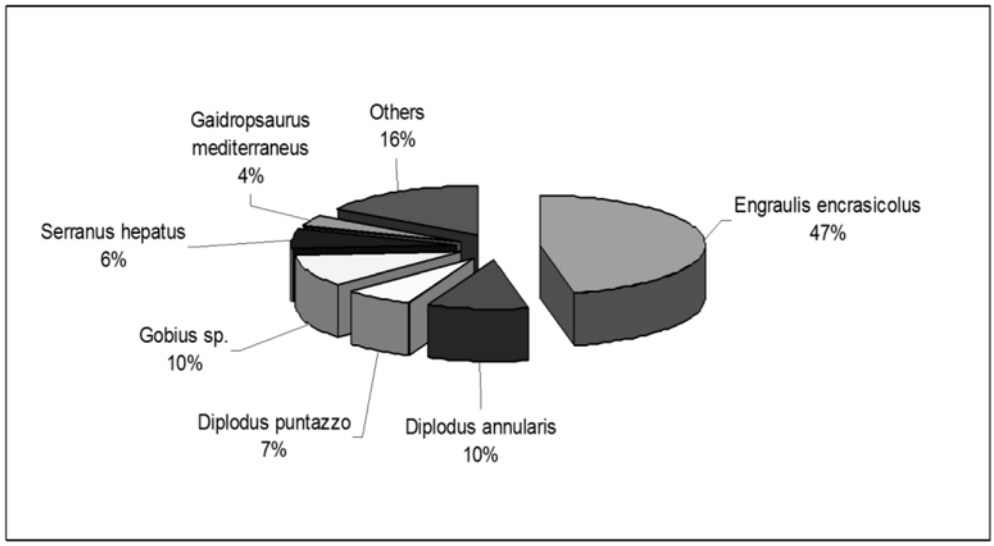

Figure 5. The percentage share of the total species of ichthyoplankton in August 2007

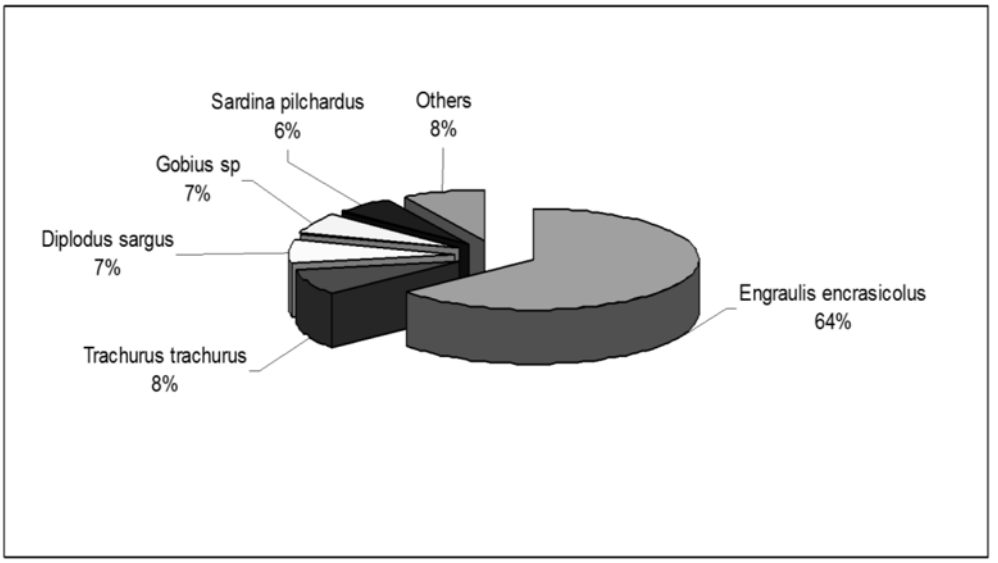

Figure 6. The percentage share of the total species of ichthyoplankton in April 2008

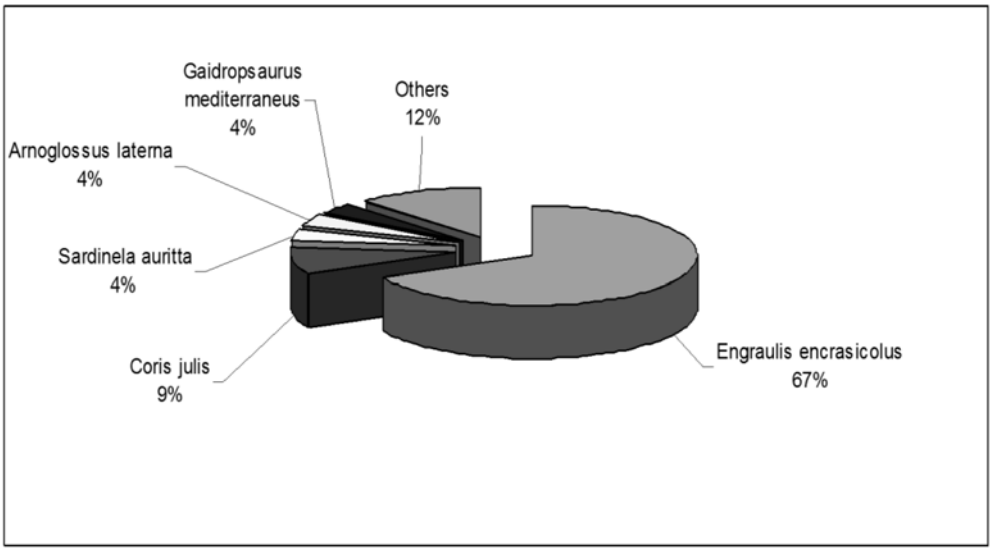

Figure 7. The percentage share of the total species of ichthyoplankton in July 2008

In the samples from April and July 2008 (Figs. 6 and 7) qualitative composition of ichthyoplankton did not varied significantly compared to the previous year. The dominance of anchovy was significant and higher

than in all the previous months of investigation, while the other species were found in much smaller but significant percentages.

Ichthyoplankton composition in October 2008 and January 2009 was not presented graphically due to a very small number and abundance of species.

DISCUSSION

Three-year study of composition of ichthyoplankton in the Boka Kotorska Bay showed the presence of a significant number of different species. This is the first study concerning the species diversity of ichthyoplankton in this part of the south Adriatic coast.

Research has indicated that during the whole investigated period in the summer season dominated anchovy (*Engraulis encrasicolus*), mediterranean rainbow wrasse (*Coris julis*) and annular seabream (*Diplodus annularis)*, while in winter the dominant species were sardine (*Sardina pilchardus*) and mackerel (*Scomber scombrus*). During the spring, the dominant species were anchovies, annular seabream and white seabream (*Diplodus sargus)*. Considering that during the entire period of study in the same seasons, dominated the same species, this phenomenon leads to the conclusion that Boka Kotorska Bay is a very important nursery and spawning area for those species. On the other hand, this cannot be applied for the sardines, as the planktonic stages of this species were found in large numbers only in December 2006.

The greatest number of different species was found during the summer, which indicates that most of the species spawn at this time of the year. This is consistent with previous studies on the abundance and diversity of ichthyoplankton, which showed that the late spring and early summer is transitional period for spawning of Mediterranean fish species,

when the diversity of species and their abundance is highest (Sabates, 1990; Maso & Sabates, 1992; Sabates & Olivar, 1996; Somarakis *et al*., 2002).

A relatively small number of eggs and larvae found throughout the study period is consequence of the type of the net that was used. The Calvet net is primarily designed for qualitative sampling of anchovy eggs. Compared with the results of previous studies of the qualitative composition of ichthyoplankton in the Adriatic (Regner, 1980; 1982, Dulčić & Grebec, 2000) it can be concluded that the diversity of ichthyoplankton in the Boka Kotorska Bay is high.

The study on length frequencies of anchovy showed that in the Boka Kotorska Bay live mostly young anchovies. The survey conducted from September 2008 to September 2009 (on a monthly basis) showed that the majority of sampled individuals belonged to the length frequencies from 8.5 to 10 cm, while in the subsequent year (September 2009 until September 2010) this value was between 8.5 and 11 cm (FAO AdiaMed Biological Sampling Report, 2011). Basing on the results of that research, and the results of this study which showed the dominance of anchovy in ichthyoplankotn samples, it can be concluded that after reaching first sexual maturity young anchovies spawn in the Bay, and then probably migrate to the open sea, continuing their life cycle (Mandić *et al*., 2011). In support of this is the fact that the catch of anchovies and sardines in the Boka Kotorska Bay performed by beach seines with mesh size of 6 mm (Official Gazette of Montenegro 08/11), when mostly juvenile specimens are caught (Pešić *et al* ., 2011, Đurović *et al*., 2012).

Studies on sardine migration to feeding and spawning areas, have shown that populations of sardines, upon reaching sexual maturity, move to the areas where favourable hydrographic conditions prevail. In this way,

sardine avoids even the most productive areas of the northern Adriatic due to unstable hydrological conditions during the winter. After spawning in the early spring they migrate towards productive areas to search for food (Stirn & Kubik, 1974; Regner *et al*., 1987; Tičina *et al.*, 2000). Varangolo (1964) found the eggs of sardines in Chioggia and Venice in May and early June, which led him to the conclusion that the presence of eggs in this period was probably the result of migration of adult individuals from the waters of the eastern Adriatic.

The Boka Kotorska Bay is very rich in freshwater runoffs, which are most intense during the winter and the spring. They significantly affect the change in salinity, especially in the surface layer, and also the water temperature. Knowing that sardine "search" for favourable hydrographic conditions for spawning, and based on the results obtained, it can be concluded that the Boka Kotorska Bay is not a significant spawning area of sardine but it is likely to be nursery area for postlarvae and juveniles.

The best known nursery area of small pelagic species in Adriatic is Gulf of Manfrendonia (Marano, 2000), while large nursery and spawning area for anchovy exists in the northern part of Adriatic coast - off the Po river (Picinetti *et al*., 1980).

Studies on distribution and abundance of anchovy eggs in the Boka Kotorska Bay showed that the Bay is natural spawning and nursery area of this species (Merker & Vujoševic, 1971, Mandic *et al*., 2011). Based on the results of this study it can be assumed that the Bay is spawning area for a number of pelagic fish species that are found in plankton samples. Ichthyoplankton surveys of the qualitative composition on the monthly basis should be continued in order to confirm these assumptions, together with analysis of hydrographic data to determine the influence of various

environmental factors on the beginning and the duration of spawning seasons in this, very specific and environmentally sensitive Adriatic Bay.

CONCLUSIONS

Research on ichthyoplankton composition pointed out significant level of species diversity in the area of Boka Kotorska Bay. Although studies on anchovies and sardines are most numerous, not only in Adriatic, but in whole Mediterranean, very little research is related to spawning and nursery areas of other pelagic fish species. We believe that it would be of great importance to introduce certain measures to protect the Bay (or at least its parts) in order to maintain species diversity at the same level. From a management perspective, small-scale conservation planning requires the identification of sensitive areas in which species have a high likelihood of long-term persistence, areas of particular importance for the maintenance of the fish resources.

REFERENCES

Đurović, M, Pešić, A., Regner, S., Joksimović, A., Mandić, M., Kasalica, O., Ikica Z. & Krpo-Ćetković, J. (2012). Daily otolith increments and growth rate of juvenile anchovy, *Engraulis encrasicolus* (Linnaeus, 1758), in the south-eastern Adriatic Sea. *Acta Adriat*. 53(3): 331 – 340.

DerMap Project Report (2011). Satellite Spectral Analyses of the Bay of Kotor, Montenegro 2010-2011. 94 p.

Dulčić, J. & Grbec, B. (2000). Composition and temporal fluctuations of ichthyoplankton community in the Kornati archipelago and Murter sea, eastern Adriatic. Vie et Milieu, 50: 163-170.

FAO AdiaMed Biological sampling Report (2011). Preliminary report of the Project to implement monitoring system for the fisheries sector in Montenegro, applying the Operational Unit concept: BIOLOGICAL SAMPLING (III year). 12th

Meeting of the AdriaMed Coordination Commettee. Ljubljana, Slovenia, 1-2 March 2011. 152 p.

Gamulin, T. & Hure, J. (1983). Mriješćenje i mrijestilišta riba u Jadranskom moru (*Sardina pilchardus, Engraulis encrasicolus, Scomber scombrus, Sardinella aurita* i *Sprattus sprattus*). Acta Adriat. 24(1/2): 97-131.

Karlovac, J. (1964). Mriješćenje srdele (*Sardina pilchardus* WALB.) u srednjem Jadranu u sezoni 1956-1957 (Spawning of sardine (*Sardina pilchardus* WALB.) in middle Adriatic in season 1956-1957). *Acta Adriat*. 10(8): 3-40.

Karlovac. J. (1967). Etude de I'ecologie de lasardine. *Sardina pilchardus* Walb., dans la phase planctonique de sa vie en Adriatique moyenne. *Acta Adriat*. 13(2). 109.

Mandić, M., Đurović, M & Regner, S. (2011). Spawning habitat and biomass estimatzion of anchovy (Engraulis encrasicolus) in Boka Kotorska bay. *Stud. Mar*., 25(1): 83-100.

Mandić, M., Regner, S., Krpo-Ćetković, J. & Joksimović, A. (2012). Unusual occurrence of anchovy (*Engraulis encrasicolus*, Linnaeus 1758) eggs in December 2006 in the Boka Kotorska Bay (Adriatic Sea). *Acta Adriat*. 53(1): 133-137

Marano G. (2000). Piccoli pelagici: valutazione della biomassa (1984-1996). Biol. Mar. Med. 7 (4):59-70.

Merker, K. (1971). Some preliminary observation on findings of spawning areas of sardine (*Sardina pilchardus* WALB.) in South Adriatic area.(in Montenegrin). Studia Marina, No 5, pp 61-74. *Hydrobiologia* 612: 185-199 p.

Merker, K. & M. Vujošević (1972). Density and distribution of anchovy (*Engraulis encrasicolus* L.) eggs in the Bay of Boka Kotorska (in Serbo-Croatian). *Poljoprivreda i šumarstvo*, 18: 15-27.

Pešić, A., Đurović, M., Joksimović, A., Regner, S., Simonović, P. & Glamuzina, B. (2010). Some reproductive patterns of the sardine, *Sardina pilchardus* (Walb, 1792), in Boka Kotorska Bay (Montenegro, southern Adriatic Sea). *Acta Adriat*., 51(2): 159 – 168.

Piccinetti C, Piccinetti-Manfrin G, Specchi M (1980). The spawning of anchovy (Engraulis encrasicolus L.) in the north and central Adriatic Sea. Mem Biol Mar Oceanogr (Suppl) X: 259–267.

Regner, S. (1980). The larval stages of fish in the Kaštela Bay. *Acta Adriat*. 21(2):123-136.

Regner, S. (1982). Investigations of qualitative and quantitative composition of the larval fish stages in the plankton at the high sea of the central Adriatic. *Stud. Mar.*, 11-12: 45-60.

Regner, S.,Regner, D., Marasović, I. & Kršinić, F. (1987): Spawning of sardine, *Sardina pilchardus* (Walbaum, 1792), in the Adriatic under upwelling conditions. *Acta Adriat*. 28 (1/2): 161-198.

Sabates, A. (1990). Distribution pattern of larval fish populations in the Northwestern Mediterranean. *Mar. Ecol. Prog. Ser,* 59: 75-82.

Sabates, A. & Maso, M. (1992). Unusual larval fish distribution pattern in a coastal zone of the western Mediterranean. *Limnol. Oceanogr.,* 37(6): 1252-1260.

Sabates, A. & Olivar, M.P. (1996). Variation of larval fish distributions associated with variability in the location of a shelf-slope front. *Mar. Ecol. Prog. Ser.,* 135: 11-20.

Sinovčić, G. (1998). Distribution of juvenile anchovy *Engraulis encrasicolus* (L.) in an estuarine habitat and influence of year-class strength on its catch value. Bilješke – Notes No 79. Institute of oceanographies and fisheries. Split. 9 p.

Sl. List Crne Gore 08/11 (2011): Pravilnik o osnovnim konstruktivno-tehničkim karakteristikama, načinu upotrebe, vremenu, namjeni, količini i vrsti ribolovnih alata i opreme koja se smije upotrebljavati u velikom i malom provrednom ribolovu: 24 p.

Somarakis, S., Koutisikopoulos, C., Machias, A., & Tsimenides, N. (2002). Applying the Daily Egg Production Method to small stocks in highly heterogeneous seas. *Fish. Res*., 55: 193-204.

Štirn, J., & Kubik, L. (1974). Prispevek k poznavanju migracij in obsega populacij sardele in inčuna v severnem Jadranu., *Acta Adriat*. 16(24): 401-422.

Tičina, V., Ivančić, I. & Emrić, V. (2000). Relation between the hydrographic properties of the nothern Adriatic Sea water and Sardine (*Sardina pilchardus*) population schools. *Periodicum Biologorum*, 102: 181-192.

Varangolo, S. (1964). Variazioni diurne della presenza degli stadi di sviluppo di alcuni Teleostei marini nel plancton de Chioggia. *Boll.Zool*., 31: 1037-1047.

Vučetic, T. (1971). Fluctuations à long terme du macrozooplancton dans l'Adriatique centrale: oeufs de *Sardina pilchardus* Walb., *d'Engraulis encrasicholus* L. et larves de differentes poissons. *Arch. Oceanogr. Limnol*., 17(2): 141-156.