STUDIA MARINA

Monograph Series No. 1

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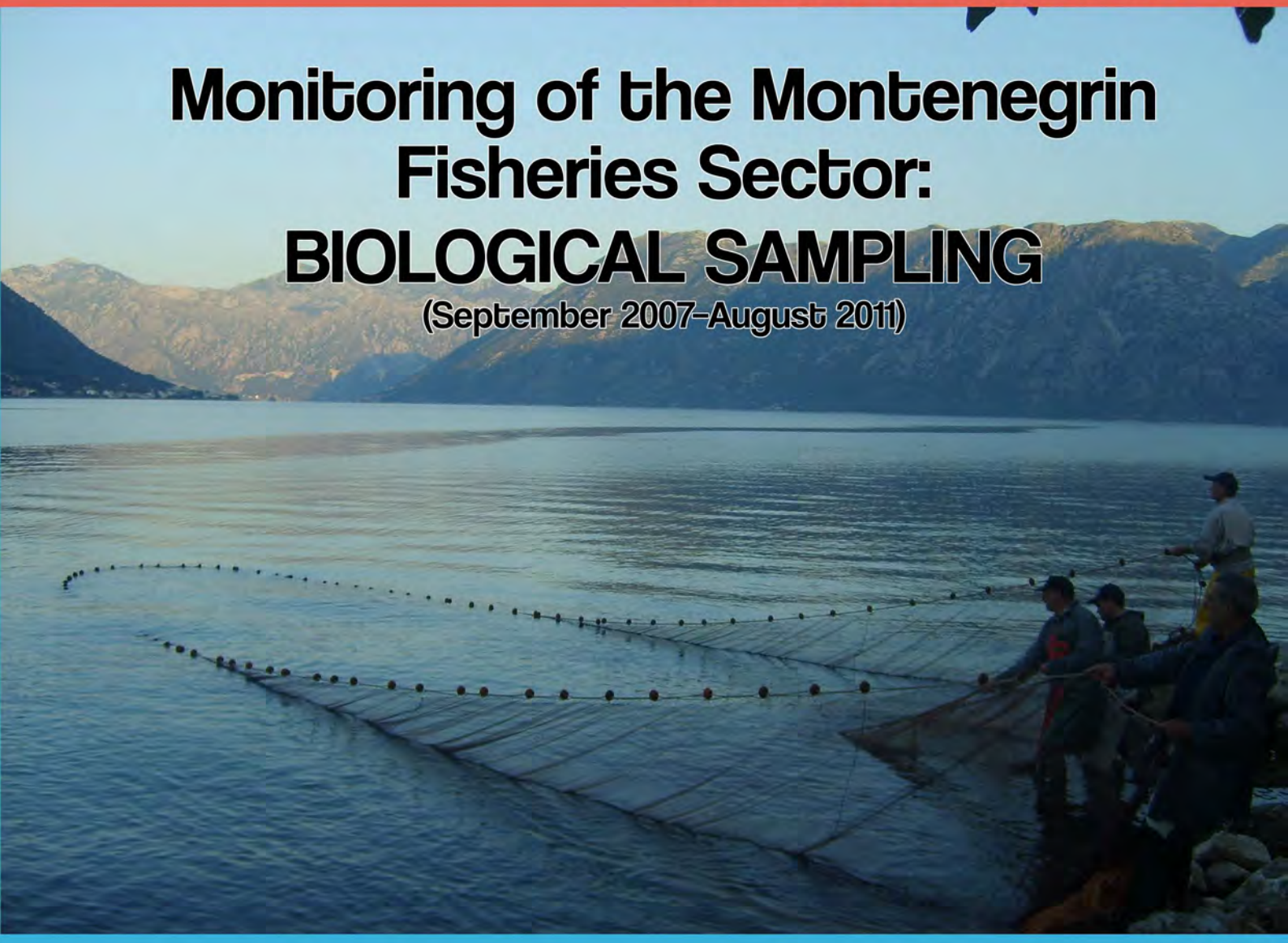
Monitoring of the Montenegrin Fisheries Sector: BIOLOGICAL SAMPLING

(September 2007–August 2011)



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(September 2007–August 2011)

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University of Montenegro

Kotor, Montenegro
2018

Contents

Preface

Monograph "Monitoring of fisheries sector in Montenegro: BIOLOGICAL SAMPLING (September 2007–August 2011)" is the result of biological sampling and monitoring of the fisheries sector in Montenegro during the period from September 2007 until August 2011, not including the period from September 2008 to August 2009. The monitoring was fully supported by the AdriaMed regional project of the Food and Agriculture Organisation (FAO) of the United Nations.

The monitoring was carried out along the Montenegrin coast, in three main fishing ports (Herceg Novi, Budva, Bar) and two ports of importance to small-scale fisheries (mostly beach seine nets; Kotor and Tivat).

The monograph presents the detailed results of fishery-biological analyses commonly used in fisheries data processing, for 16 species of fish, crustaceans and cephalopods. These include length frequency distribution by trimester, sex ratio and sex ratio by length, gonad maturity stages, estimation of length at first maturity, gonadosomatic index (GSI) and the length-weight relationship analysis

The document also provides a description of the fishery system in Montenegro during the duration of the monitoring, lists programme objectives, and provides a brief overview of operational units in Montenegrin fisheries sector, a pilot study done within the framework of the monitoring.

This monograph represents the second, revised edition of the document originally available as the FAO AdriaMed Technical Document No. 32, *"Report of the monitoring of the Montenegrin fisheries sector: BIOLOGICAL SAMPLING (September 2007–August 2011)"* which unfortunately, did not have important classification identifiers, such as the ISBN. Although, therefore, this is not the first time this document is available to scientists and the general public, it is likely that, with the inclusion of such identifiers, as well as the revised data on certain species and the addition of a new chapter ("Comparison of presented data with the existing data from the Adriatic area"), this revised edition will be able to make a more significant contribution to the understanding and future studies of fishery resources in general, and specifically to our knowledge of the Adriatic Sea.

Prof. dr. Nedo Vrgoč
Director of the Institute of
Oceanography and Fisheries, Split

Split, December 2017

Ikica, Z., M. Đurović, A. Joksimović, M. Mandić, O. Marković, A. Pešić, E. Arneri, L. Ceriola, N. Milone

Monitoring of fisheries sector in Montenegro: BIOLOGICAL SAMPLING (September 2007 – August 2011).

Abstract

This document introduces the results of the monitoring of the fisheries sector in Montenegro through fisheries dependent data collection, implemented in the framework of the FAO AdriaMed Project. The results of the data collection, the methods adopted and a description of the main biological features of the species sampled are provided. The sampling took place in three main fishing ports (landing sites) along the Montenegrin coast (Geographical Sub-Area 18): Herceg Novi, Budva and Bar. Catch and effort data on all active fleet segments in the sampling ports were gathered by interviewing the fishermen at the end of fishing trips. Data collection started in September 2007 with monthly samples (each month from a different ports). During the monitoring activities, samples of the most important fisheries target species (for quantity landed and economic value) were collected in order to investigate their main biological characteristics and of their occurrence in the catch: e.g. average size and size frequency distribution, sex ration, occurrence of sexual maturity stages in the commercial landings. Size at first maturity and length-weight relationship parameters were estimated. The biological monitoring was at the time of writing of this document the only national monitoring system covering catch and effort statistics at landing sites, which could support the fisheries administration in the adoption of responsible fisheries management strategies based on an ecosystem approach to fisheries.

1. Background information

The FAO Project AdriaMed provides support to the Adriatic countries in developing the necessary expertise and tools for the appraisal of the fisheries resources and of the main socio economic aspects related to the fisheries, so as to provide the basis for implementing an Ecosystem Approach to Fisheries.

Montenegro (Figure 1) joined AdriaMed in 2004 and since then the Project assisted the country in the establishment of a system for the fisheries resources evaluation and management. In this framework, during the 8th AdriaMed Coordination Committee (12–13 December 2006, Tirana, Albania), the country asked the Project's assistance to develop a system which enables the national experts to monitor the biological, economic and social aspects related to the fisheries.

As a follow up, a Pilot study on biological and socio-economic fishery data collection was scheduled and implemented in Montenegro by the Institute of Marine Biology of Kotor (Montenegro) in cooperation with the Ministry of Agriculture Forest and Water Management (Fisheries Directorate) and with the support of the FAO AdriaMed Project in the period September 2007–August 2008. The primary objective of the Pilot study was the establishment and implementation of a monitoring system for fisheries within a selected area, including biological, environmental, economic and social information applying the Operational Units concept.

The pilot study was developed on the basis of the existing monitoring practice and requirements in Mediterranean and European countries, in view of the future entering of the Country in the European Union (EU) and of the membership of Montenegro in the FAO General fisheries Commission for the Mediterranean Sea (GFCM). Moreover, for the definition of the biological part of the Pilot Study, to identify the targets species and to set the sampling protocol, the information in terms of fishing effort, commercial landings and economic aspects provided by the national official statistics were taken into consideration.

The preliminary report of the Pilot Study was presented at the 10th AdriaMed Coordination Committee meeting (Chioggia, Italy, 26–27 January 2009). During the meeting, the Montenegrin delegation highlighted the importance of the Pilot Study in gaining information on fisheries related basic statistics. The importance to continue in the fisheries data collection was also reiterated and the request to continue to support the study was formulated. In this context, with the support of AdriaMed, a "biological sampling" for the monitoring of the commercial fisheries in Montenegro was planned in cooperation with the Institute of Marine Biology of Kotor (Montenegro) and in coordination with the Ministry of Agriculture and initiated in September 2009. The biological sampling continued, with small interruption and on 12-monthly basis. The sampling scheme of the biological sampling was developed taking into account the main information and requirements of the main fisheries management international bodies (e.g. EU Data Collection Framework). In addition, the outcomes of the Pilot Study in terms of catch composition and quantities were taken into consideration in the initial planning of the following biological sampling. The sampling scheme and the target species of the biological sampling were also slightly modified according to the new requirements and

tendencies of the market and fisheries arisen in the previous year.

The activity currently represents the only catch/effort survey in place in the country. The data collected were used in the cooperative synergy found between the AdriaMed Project and the "EC funded IPA Project `Sustainable Management of Marine Fishery' in Montenegro" (Europeaid/128947/C/SER/ME) managed by the European Union Delegation to Montenegro to elaborate a draft proposal for a fisheries management plan for Montenegro.

The aim of this document is to provide a description of the activities carried out and on some results obtained from September 2007 to August 2011. In this document the objective and expected outcomes of the study, the methods adopted and a description of the main biological features of the species sampled are described. Some of the data collected during the biological sampling and reported in this document have been used to perform the first stock assessment analysis of demersal species in Montenegro by using analytical models.

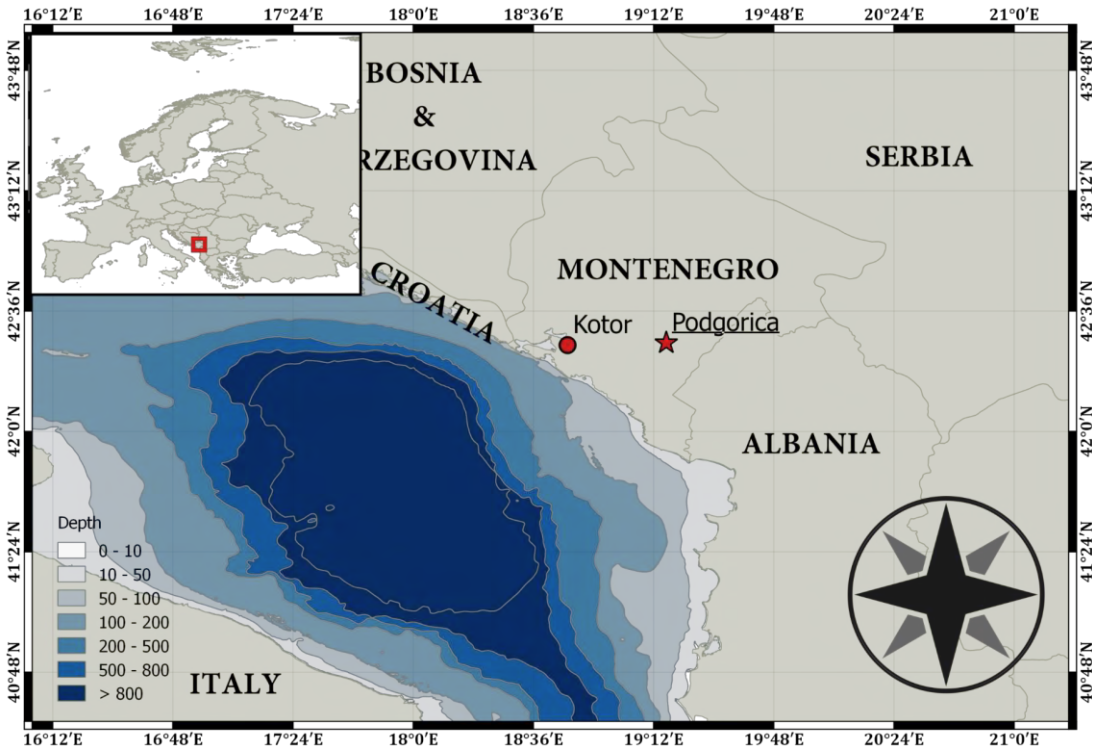


Figure 1. Montenegro

2. Introduction: Brief description of the fishery system in Montenegro

Up until early 2011, the Montenegrin fishing fleet numbered about 170 vessels (most of which were part of the small-scale fisheries). Non-small scale fishery vessels were assumed to include:

- 3 bottom trawlers >24 m LOA (two also licensed for mid-water trawling; all limited to the outside of 8 NM limit)
- 16 bottom trawlers
- 12 purse seiners
- 58 vessels in small-scale fisheries
- 10 vessels in subsistence fisheries (licences are valid until 22nd August, 2012, and will not be renewable afterwards).

In early 2011, according to the latest version of the Law on Marine Fisheries and Mariculture [1], new fishing licences were issued. According to the licences, the fishing fleet numbers 99 vessels in total, as follows:

- 3 bottom trawlers >24 m LOA (two also licensed for mid-water trawling; all limited to the outside of 8 NM limit)
- 16 bottom trawlers
- 12 purse seiners
- 58 vessels in small-scale fisheries
- 10 vessels in subsistence fisheries (licences are valid until 22nd August, 2012, and will not be renewable afterwards).

However, the total number of active fishing vessels is believed to be close to the pre-2011 number, as not all small-scale fishermen opted to obtain the fishing licence. The Ministry of Agriculture and Rural Development of Montenegro (the body responsible for the issuing of fishing licences) has estimated the maximum number of licences as follows:

- 6 licences for bottom trawlers with >24 m LOA (limited to the outside of 8 NM limit)
- 17 licences for bottom trawlers <24 m
- 20 licences for pelagic fisheries (including purse seiners and mid-water trawlers)
- 180 licences for small-scale fisheries
- 5 licences for shell collecting

Virtually all fishing activity of the Montenegrin fleet takes place within the 12 NM limit of national waters, including a directed trawl fishery inside the 3 NM limit[2] in the January-April period, when vessels are allowed to fish for karamote prawn (*Melicertus kerathurus*).

The main fisheries target species are the European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), and deep-water pink shrimp (*Parapenaeus longirostris*). Also important, but to a somewhat lesser degree, are the common squid (*Loligo vulgaris*), shortfin squid (*Illex coindetii*), octopus (*Octopus vulgaris* and *Eledone* spp.), and the Norway lobster (*Nephrops norvegicus*). Bogue (*Boops boops*) is not an economically important species, but is heavily represented in small-scale fisheries (trammel nets). Main target species for beach seine and purse-seine

[1] Official Gazzette of Montenegro, 56/2009 (available at www.sllistcg.me; in Montenegrin only)

[2] Normally, commercial fishing activity is forbidden inside the 3 NM limit/50 m depth

fisheries are the European pilchard (*Sardina pilchardus*) and European anchovy (*Engraulis encrasicolus*).

Fishing licences specify the type of fishing gear the holders can use. Catches in small-scale fisheries are taken using several types of fishing gear and target different groups of species:

- small purse seiners generally target pelagic fish,
- trammel netters, gillnetters and beach seiners target pilchard, anchovy, bogue, horse mackerel and bonito,
- bottom long-lines and various gear with hooks are used to catch hake, red mullet and rays,
- traps and tangle nets are used for catching lobster,

Chinese nets are used in Bojana River and its estuary for catching grey mullets and eels.

Estimates from a national study list the catch from this sector at around 1200 t per year.

The main characteristics of the fishing gear used by bottom trawlers, gillnetters, small purse-seiners, beach seiners, and long-liners in Montenegrin waters are given in Table 1, Table 2, Table 3, Table 4, and Table 5.

Table 1. General characteristics of the sampling gear used by bottom trawlers in Montenegrin waters

Warp	1500-2000
Diameter (mm)	12
Doors	
Type 1	Rectangular (wood)
Type 2	Oval (iron)
Approx. dimensions (cm×cm)	155×135
Approx. weight (kg) 6	100-130
Chain (Libani)	
Diameter (mm)	50-70
Length (m)	90-150
Headrope	
Material	Polyamide
Diameter (mm)	12
Length (m)	42
Floats	
Diameter (mm)	200
Number	25
Footrope	
Material	Mixed rope
Diameter (mm)	30
Length (m)	45–55
Weight	
Weight (kg)	100-150
Net	
Material	Polyethylene (PVC)
Mesh size (mm)	40 (stretched)

Table 2. General characteristics of the sampling gear used by gillnetters in Montenegro

Material	Polyamide
Length (m)	80–120
Height (m)	3–4
Mesh size (mm)	25–40 (side)
Weight (kg)	8–10

Table 3. General characteristics of the sampling gear used by beach seines in Montenegro

Material	Polyamide
Length (m)	60–100
Height (m)	18–20
Mesh size (mm)	10 (side)
Weight (kg)	20–30

Table 4. General characteristics of the sampling gear used by small purse-seiners in Montenegro

Material	Polyamide
Length (m)	220
Height (m)	58
Mesh size (mm)	10 (side)
Weight (kg)	600

Table 5. General characteristics of the sampling gear used by long-liners in Montenegro

Hook (type and size)	Mustad 7–10
Mainline length (m)	600–1500
Mainline material and diameter (mm)	Playstic nylon, 1–6
Branch line length (m)	1–2.5
Branch line diameter (mm)	0.3–4
Distance between branch lines (m)	2–5
Bait	Small fish or cephalopods

3. Programme objectives

The study on biological and economic data collection and monitoring system in Montenegro was planned and carried out with the general aim of establishing a national monitoring system which would include all aspects related to the fishing activities: social, biological and economic. The experience gained during the study would enable the national experts to

collect biological, social and economic data regarding the entire fisheries sector, in order to help to integrate Montenegrin fisheries with the requirements of the regional and sub-regional bodies in terms of fishery resources assessment, management and conservation.

To this purpose, a monitoring system for the identification of the main fishing activities in terms of number of vessels and vessel characteristics, as well as the estimation of catch and effort characteristics of the main fishing segment operating in Montenegro was established, with the support of the FAO AdriaMed project. The monitoring system was also aimed at providing a description of the main resources exploited and landed by each fishing segment.

4. Materials and methods

4.1. Sampling area

Montenegro has a coastline of approximately 300 km in length, with three main fishing ports: Bar, Budva and Herceg Novi (Figure 2), and two minor landing sites, Kotor and Tivat.

For the purposes of the study, the fishing activities of the 3 main fishing ports were monitored on a monthly basis.

The ports were selected for their position and for the presence of almost all fleet segments (by fishing gear and vessel size) currently operating in the country in their fishing fleet: bottom trawlers, purse seiners, beach seiners, trammel netters, long liners.

The main characteristics of the three main fishing ports selected for the study (Herceg Novi, Budva, Bar) and two minor ports important for small-scale fisheries (Kotor, Tivat), as well as the data collected in these sites are given in Table 6

During the study, the information on catch and effort of the active vessels in the sampling port was collected by interviewing the randomly selected fishermen at the end of fishing trip. For the hook and lines, the total number of hooks is reported, irrespective of the actual number of fishing gear used.

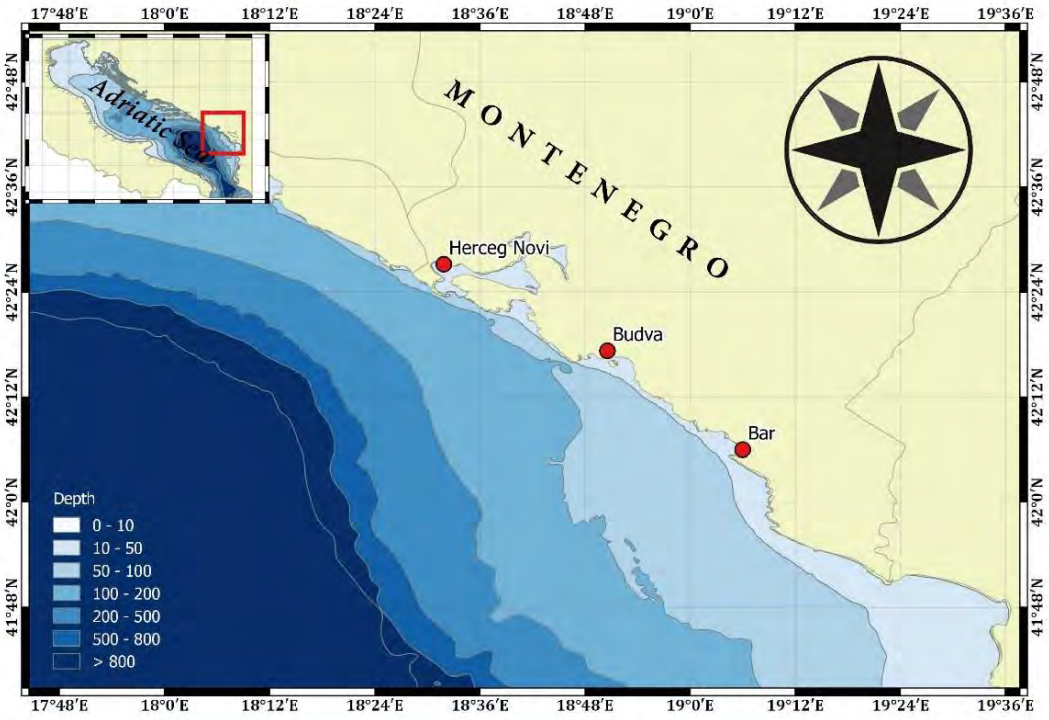


Figure 2, The coastline of Montenegro and the three main fishing ports: Herceg Novi, Budva, and Bar

Table 6. Estimated number of vessels and fishing tools in Montenegro in 2010/11

	Herceg Novi	Budva	Bar	Kotor/Tivat
Type of fishing vessels	Bottom trawlers Purse seiners Small purse seiners	Bottom trawlers Small purse-seiners Trammel netters Long-liners	Bottom trawlers Purse seiners Trammel netters Long-liners	Trammel netters Long-liners Small purse-seiners Beach seiners
Type of fishing gears	Surrounding nets Purse seines Seine nets Trawls Gillnets Entangling nets Hooks & lines	Surrounding nets Seine nets Trawls Gillnets Entangling nets Hooks & lines	Surrounding nets Seine nets Trawls Gillnets Entangling nets Hooks & lines	Surrounding nets Seine nets Gillnets Entangling nets Hooks & lines
Total No. of vessels	39	29	18	44
No. of vessels/fleet segment	Trawlers: 7 Purse-seiners:2 Small purse-seiners: 2 (1 trammel net) Trammel netters: 27 (20 hooks & lines) Beach seiners: 4 (1 trammel net)	Trawlers: 3 Purse-seiners: 0 Small purse-seiners: 2 Trammel netters: 25 (1 beach seine, 13 hooks & lines) Hooks & lines: 1	Trawlers: 8 Purse-seiners: 21 Trammel netters: 9 (2 hooks & lines)	Trawlers: 0 Purse-seiners: 0 Small purse-seiners: 2 (1 trammel net) Trammel netters: 36 (9 hooks & lines) Hooks & lines: 1 Beach seiners: 17 (9 trammel nets)
No. of fishing gears	Trawls: 7 Purse-seines: 2 Small purse-seines: 2 Gillnets: 35 Trammel nets: 17 Beach seines: 4 Hooks & lines: 5500 (bottom hooks 3700, pelagic hooks 1800) Traps & harpoons	Trawls: 3 Small purse-seines: 2 Gillnets: 25 Trammel nets: 22 Beach seine: 1 Hooks & lines 2300 (bottom hooks 2100, plagic hooks 100) Traps & harpoons: 1	Trawls: 8 Purse-seines: 1 Gillnets: 7 Trammel nets: 4 Hooks & lines: 400 (bottom hooks) Traps & harpoons: 2	Small purse-seines: 2 Gillnets: 57 Trammel nets: 17 Beach seines: 17 Hooks & lines: 1800 (bottom hooks 900, pelagic hooks 900) Traps & harpoons: 10

4.2. Applied methodologies: data collection and elaboration

4.2.1. Catch and effort

The sampling took place in three fishing ports (landing sites) along the Montenegrin coast (Geographical Sub-Area 18): Herceg Novi, Budva and Bar. To collect information on catch and effort, three stratification levels were considered:

- port (Herceg Novi, Budva, Bar),
- fleet segmentation (fishing gear)
- number of vessels per fleet segment (total number).

Catch and effort data on all active fleet segments in the sampling ports were gathered by interviewing the fishermen at the end of the fishing trip.

During the interviews, information on the main characteristics of the fishing gear and on the fishing operations was gathered. Information on gear included:

- trawls: characteristics of warp, doors, chains, headrope, floats, footrope, mesh size
- gillnets: material, length, height, mesh size
- long-lines: hook type and measure (size), mainline length, material and diameter, branchline (gangion, snood) length and diameter, distance between branchlines, information on bait.

Information on fishing operations included:

- duration of the last fishing trip (days or hours)
- number and duration of the hauls (for trawlers),
- number of hooks and the time they were in water (for long-liners),
- length, height and mesh size for gillnets and trammel nets
- number of traps and the time traps were set in water (for traps/pots)
- fishing area.

At the end of the interview, the following data regarding the catch was taken by direct observation:

- species landed
- number of boxes landed per species, and their approximate weight
- length classes of the main target species (according to the commercial categories reported in the main sampling data sheet format).

Each month different vessels were interviewed in order to obtain information from the largest possible number of vessels at the end of the study. Data on catch and effort was recorded on a sampling sheet which was divided in two sections, the first containing information on the fishing operations (effort) and the other dealing with the catch (type and weight of landed species).

The catch and effort data by species and vessels recorded during each sampling da were used to estimate the catch per day (total and by species) for all main fleet segments. According to this data, an approximate estimation of total catch per fleet segment per month per port and, tentatively, per year were obtained. Additionally, the total catch per species per trawler and purse seiner per month, as well as the yield per species (kg/h) and the catch per unit of effort (CPUE, kg/vessel) per day and per month was estimated according to the following procedures:

- **Average catch of sampled vessels per day:** sum of the total catch per vessel for each sampling day divided by the number of sampled vessels;
- **Total catch per day:** average catch of the sampled vessels per day, multiplied by the number of active vessels for that day;
- **Total catch per month:** total catch per day, multiplied by the number of fishing days per month;
- **Average catch by species per day:** sum of the total catch per vessel for each sampling day, divided by the number of sampled vessels;
- **Total catch per species per day:** average catch by species per day multiplied by the number of active vessels on that day;
- **Total catch by species per month:** total catch per species per day, multiplied by the number of fishing days per month.

Trawlers also had the yield per vessel and per species estimated:

- **Yield (kg/h) per vessel:** total catch (kg) per vessel divided by the number

of fishing hours (total time spent actively trawling);

- **Yield (kg/h) per species:** total catch (kg) per species, divided by the number of fishing hours (total time spent actively trawling).

Biological data

The biological samples of the main target species were taken in order to examine their biological characteristics. Biological sampling started in September 2007 with monthly samples (each month from a different port), as shown in Table 7. Samples were collected according to the sampling scheme that takes into account both the total official landing statistics provided and the main requirements of regional bodies in terms of fisheries monitoring.

Samples were taken from trawlers and from small-scale fishery vessels (gillnetter, beach seiners, long-liners), the amount of total catch was recorded (total weight for each species in the catch) and a sample of the catch was obtained from the fishermen. The list of samples species is given in Table 8.

Table 8. List of species sampled during the study

FISH	CRUSTACEANS
Boops boops	*P. longirostris*
Engraulis encrasicolus	
Lophius budegassa	CEPHALOPODS
Merluccius merluccius	*Eledone cirrhosa*
Mugilidae	*Eledona moschata**
Mullus barbatus	*Illex coindetii*
*Pagellus erythrinus**	*Loligo vulgaris*
Sarda sarda	*Sepia officinalis*
Sardina pilchardus	
Scomber japonicus	
Spicara spp.	
Trachurus mediterraneus	

* Species not sampled in 2007/2008 sampling period

In 2007/08 sampling period, the list included little tunny (*Euthynnus alleteratus*), smelts (*Atherina* spp.) and surmullet (*Mullus*

Table 7. Proposed sampling scheme for the September 2007-August 2011 sampling

Species	No. of samples/ year	No. of spec./ sample	No. of otolith samplings/ year	No. of otolith samples/ sampling
Engraulis encrasicolus	15	50	8	25
Sardina pilchardus	18	50	9	25
Boops boops	24	50	12	25
Sarda sarda	1	25	1	25
*Scomber japonicus**	5	50	4	25
*Eledone moschata**	4	50	N/A	N/A
Eledone cirrhosa	4	50	N/A	N/A
Illex coindetii	10	50	N/A	N/A
Loligo vulgaris	4	50	N/A	N/A
Lophius budegassa	5	25	5	25
Merluccius merluccius	15	50	10	25
Mugil cephalus	15	50	8	25
Mullus barbatus	9	50	6	25
*Pagellus erythrinus**	12	50	10	25
P. longirostris	10	50	N/A	N/A
Sepia officinalis	4	50	N/A	N/A
Spicara spp.	24	50	12	25
T. mediterraneus	9	50	6	25

* Species not sampled in 2007/2008 sampling period.

surmuletus), but the study has shown that these species are not present in any meaningful amount in Montenegrin fisheries, and were therefore replaced with common pandora (*Pagellus erythrinus*), chub mackerel (*Scomber japonicus*), and musky octopus (*Eledone moschata*).

The following data was recorded for each species:

- Total length (TL) for fish (precision 0.1 cm);
- Carapace length (CL) for crustaceans (precision 1 mm);
- Dorsal mantle length (DML) for decapod cephalopods (squids, cuttlefish) and lateral mantle length (LML) for octopod cephalopods (horned octopus, musky octopus) (precision 1 mm);
- Total body weight (TW), (0.01 g);
- Sex;
- Sexual maturity for all groups (with the exception of crustaceans) was determined according to the maturity scales proposed by MEDITS. For fish, a four-stage maturity scale was used (immature, maturing, mature and spent/resting, in stages 1, 2, 3, and 4, respectively). Cephalopods used a three-stage scale (immature [1], maturing [2], and mature [3]).
- A modified MEDITS scale was used for crustaceans: MEDITS sub-stage 2a was considered maturity stage 2 (maturing), and sub-stages 2b, 2c, 2d, and 2e were recorded as stage 3 (mature).

Otoliths were collected from fish for future growth and age studies.

This data collection scheme allowed for an estimation of size range and length frequency distribution of landings raised to the trimester of each sampling period, where possible.

Sex ratio is given as a number of males, females or unsexed individuals over the total number (the sum of males, females, and unsexed individuals), expressed as percentage.

Sex ratio by length is given as the number of males or females over a combined sum of the number of males and females, expressed as a proportion, for any given length category with a significant number of individuals (usually more than 10).

Length at first maturity was calculated using the linear regression on a ratio of mature individuals (MEDITS subcategories 2b and above) over the total number of sexed individuals for a given length category, transformed using the $\ln\left((1/P)-1\right)$ expression (where P is the proportion of mature individuals over the total number of sexed individuals for any given length class). The regression gives the parameters α (intercept) and β (slope) of the maturity ogive. These parameters are then used to calculate lengths at which 25, 50 and 75% of the population reaches sexual maturity ($L_{25\%}$, $L_{50\%}$, and $L_{75\%}$, respectively), according to the formulas:

$$L_{25\%} = \frac{(\alpha - \ln 3)}{\beta}$$

$$L_{50\%} = \frac{\alpha}{\beta}$$

$$L_{75\%} = \frac{(\alpha + \ln 3)}{\beta}$$

Maturity ogive is then estimated using the formula:

$$\frac{1}{1 + e^{(\alpha - \beta \cdot \mathrm{TL})}}$$

The gonadosomatic index is calculated according to the formula:

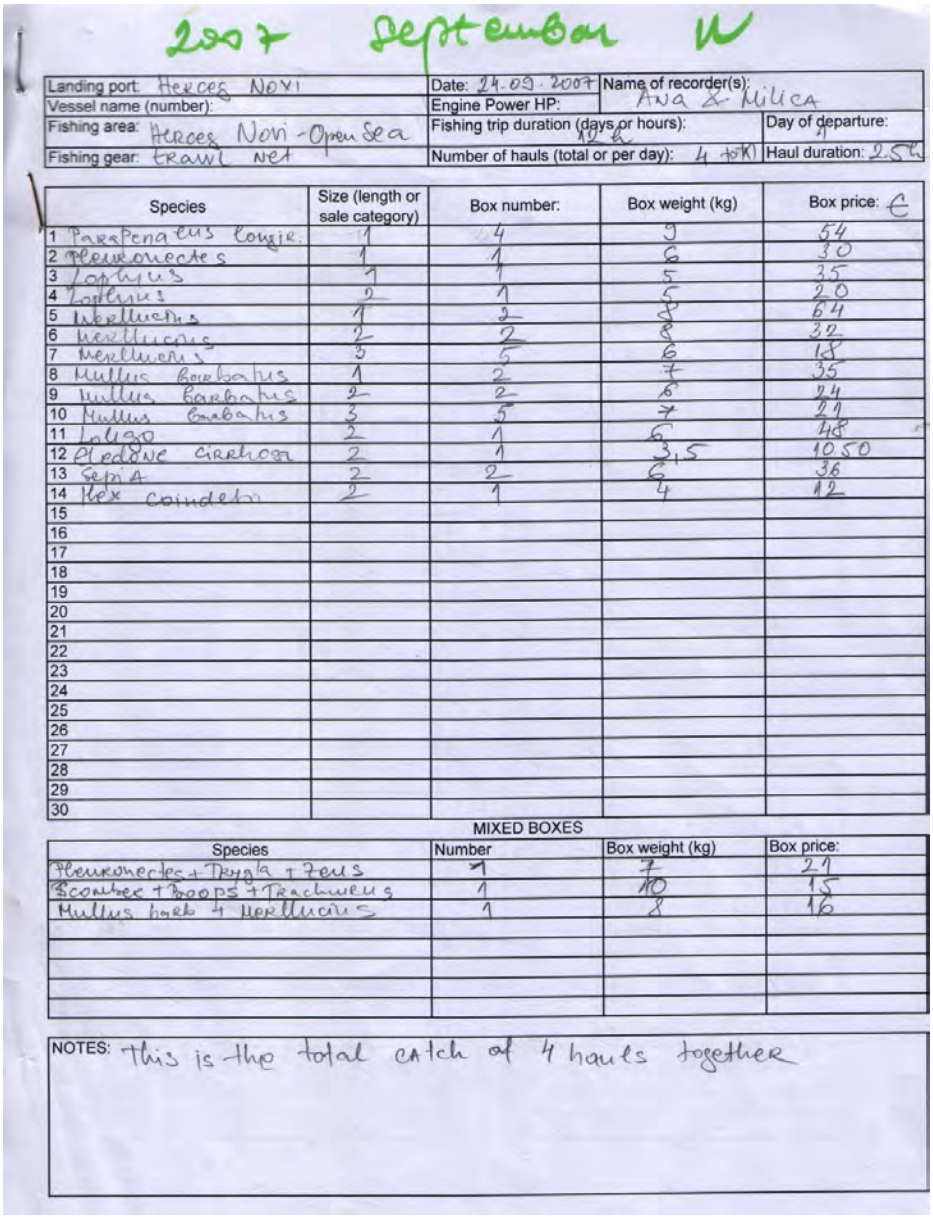
$$\mathrm{GSI} = \frac{\mathrm{W_G}}{\mathrm{TW}} \cdot 100,$$

Where $\mathrm{W_G}$ is gonad weigth (g) and TW stands for the total weight (g). The index is

calculated for each mature individual (MEDITS sub-stages 2b and above) separately, and then averaged by sex and month.

The relation between the length, L (total length (TL) for fish, dorsal mantle length (DML) for decapod cephalopods, lateral mantle length (LML) for octopod cephalopods, and carapace length (CL) for crustaceans) and total weight (TW) of the specimens was determined according to the formula $\mathrm{TW} = a \cdot L^b$. Parameters a and b were estimated using ordinary least-square regression after transforming the data to base-10 logarithm ($\log \mathrm{TW} = \log a + b \cdot \log \mathrm{TL}$).

An example of the data sheet (2007 sampling) is provided in Figure 3.



2007 September IV

Landing port: Herceg Novi	Date: 24.09.2007	Name of recorder(s): Ana & Milica	
Vessel name (number):	Engine Power HP:		
Fishing area: Herceg Novi - Open Sea	Fishing trip duration (days or hours): 12 h		Day of departure: 1
Fishing gear: trawl net	Number of hauls (total or per day): 4 tokl		Haul duration: 2.5h

	Species	Size (length or sale category)	Box number:	Box weight (kg)	Box price: €
1	Parapenaeus longir.	1	4	9	54
2	Pleuronectes	1	1	6	30
3	Lophius	1	1	5	35
4	Lophius	2	1	5	20
5	Merluccius	1	2	8	64
6	Merluccius	2	2	8	32
7	Merluccius	3	5	6	18
8	Mullus Barbatus	1	2	7	35
9	Mullus Barbatus	2	2	6	24
10	Mullus Barbatus	3	5	7	21
11	Lulgo	2	1	6	48
12	Eledone cirrhosa	2	1	3,5	10,50
13	Sepia	2	2	6	36
14	Rex coindetii	2	1	4	12
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

MIXED BOXES

Species	Number	Box weight (kg)	Box price:
Pleuronectes + Trygla + Zeus	1	7	21
Sconber + Boops + Trachurus	1	10	15
Mullus barb + Merluccius	1	8	16

NOTES: This is the total catch of 4 hauls together

Figure 3. Interview data sheet from the 2007/2008 sampling period

5. Results

5.1. Catch and effort

The majority of samples were taken from trawlers, gillnetters and beach seiners. Trawlers are, in general, the largest and best equipped vessels in Montenegrin fleet, with overall lengths ranging from 7.1 to 29 m LOA, engine power in the 35 to 285 kW range, and GRT between 2.75 and 49 tonnes. The main characteristics of sampled trawlers in all three ports are given in Table 9.

Considering the catch and effort data per fleet segment, during the study period (September 2007 – August 2011, non-continuous), trawlers were the most active vessels with an average of 10–11 fishing days per month. Number of fishing days per month for some trawlers is given in Table 10 and Table 11. There is a slight decreasing trend in the average yearly number of fishing days noticeable in trawlers fisheries — in 2007/08 it was around 11, and in 2009/10 and 2010/11 it was about 10 fishing days per month. These numbers, however, should be taken with caution as the fishermen are often reluctant or unwilling to cooperate, and will provide data that is inaccurate or incorrect. Such small number of average fishing days per month

Table 9. Main characteristics of some of the sampled trawlers in all ports

Vessel name (registration no.)	Home port	Length overall (m)	Engine power (kW)	GRT (tonnes)
Ciklon	Bar	18.13	144	9.36
Jadranka	Bar	16.00	147	43.00
Milica	Bar	12.90	48	5.60
Stefan (BR–234)	Bar	11.10	147	8.00
Trio Mare	Bar	29.00	600	142.00
Nadežda	Bar	25.45	220	117.00
Vesna IV	Budva	21.39	285	49.00
Sv. Marko (38–TV)	Budva	12.26	110	9.78
Jovana (67–KT)	Herceg Novi	13.74	118	12.8
Katarina (HN–7)	Herceg Novi	13.15	180	25.00

Table 10. The number of fishing days per month of some of the sampled trawlers, 2009/10

Vessel	September 2009 – August 2010											
Name	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Jadranka	25	18	15	8	6	5	15	7	12	17	25	25
Vesna IV	22	10	7	4	3	6	18	13	10	15	25	28
Sv. Marko	3	5	4	1	—	3	—	5	5	6	14	9
Jovana	6	5	4	3	3	3	4	4	5	5	3	4

Table 11. The number of fishing days per month of some of the sampled trawlers, 2010/11

Vessel	September 2010 – August 2011											
Name	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Jadranka	21	15	13	7	4	5	15	—	—	17	—	25
Vesna IV	23	12	6	3	3	6	18	—	—	15	—	28
Sv. Marko	5	7	4	1	1	3	1	—	—	6	—	9
Jovana	4	5	3	2	3	3	4	—	—	5	—	4

Table 12. Total estimated average daily and monthly catch per fleet segment (September 2007 – August 2011)

Fleet segment	2007/08			2009/10			2010/11		
	No. of vessels	Avg. catch/day (kg)	Avg. catch/month (kg)	No. of vessels	Avg. catch/day (kg)	Avg. catch/month (kg)	No. of vessel	Avg. catch/day (kg)	Avg. catch/month (kg)
Gill netters <6 m LOA	40	800	8,000	40	800	8,000	40	650	6,500
Gill netters 6–12 m LOA	20	600	9,000	20	400	5,500	20	350	5,000
Seine netters <6 m LOA	30	3,100	25,000	30	4,000	32,000	30	2,250	18,000
Seine netters 6–12 m LOA	11	1,200	12,000	11	700	7,000	11	750	7,500
Long-liners	35	900	13,000	35	900	11,000	35	900	1,100
Trawlers 6-12 m LOA	3	400	4,200	3	—	—	2	—	—
Trawlers 12-24 m LOA	15	2,000	26,000	15	1,500	16,500	15	1,100	11,880
Trawlers >24 m LOA	2	550	8,200	4	800	12,500	3	300	4,320
Purse seiners 6-12 m LOA	6	400	3,500	6	400	3,700	11	400	4,100
Purse seiners 12-24 m LOA	2	200	3,200	2	300	5,000	2	400	5,000
TOTAL	**164**	**10,150**	**112,100**	**166**	**9,800**	**101,200**	**169**	**6,900**	**61,500**

can, however, be explained by bad weather conditions in winter, especially between December and February, and by vessel repairs and general lack of fishing resources during the summer period. In the 2010/11 sampling period, during the issuing of fishing licenses, the government of Montenegro didn't subsidize the fuel for fishing vessels (trawlers), and thus no trawler fisheries were recorded in the April-May period. In 2007/08 there was a single trawling vessel with over 24 m LOA, while in 2010–2011 period there were three such vessels active, and one inactive. Two of those three had experimental licences, starting from May 2010. No data is available for trawlers 6–12 m LOA.

Gill- and trammel netters averaged about 12.5 fishing days per month during the entire sampling period, while the beach seiners averaged about 6 fishing days per month. Purse seiners averaged only 1.4 fishing days per month.

Total estimated catch by gear and per fleet segment is shown in Table 12. General trend shows reduction in average daily and monthly catch, while the number of vessels was

slightly increased (from 164 in 2007/08 to 169 in 2010/11).

Average yield (kg/h) per trawling vessel is given in Table 13. The average yield value is directly related to the vessel size categories; vessels over 24 m LOA had higher yield values than smaller vessels. In 2007/08 and 2009/10 the difference was over 100%. Only in 2010/11 was this difference reduced so that the 12–24 m LOA trawlers had yield equal to about 74% of the >24 m trawlers yield.

Table 13. Average yield per trawler (kg)

	2007/08	2009/10	2010/11
Trawlers 6–12 m	13.96	—	—
Trawlers 12–24 m	14.71	13.20	9.77
Trawlers >24 m	30.16	27.11	13.22

Average monthly landings for gillnets, beach seines, and trawlers according to fleet segment and most important species, by sampling period, are given in Average fishing activity for some of the sampled vessels is given in Table 18, showing also their secondary fishing gear (if any). General trend shows a decrease in fishing days from 2007/08 through 2009/10 to 2010/11, although certain vessels (trawlers) showed a slight increase from 2007/08 to 2009/10.

Average daily catch, yield and economic value of landings of some of the sampled vessels are given in Table 19.

Average daily catch, yield and economic value of certain economically important species in Montenegrin trawler fisheries are given in Table 20. *L. vulgaris, S. officinalis* and *L. budegassa* fetched the highest price (7–10 €/kg), while market value of *M. merluccius, M. barbatus* and *P. longirostris* varied according to the port. Generally, Budva had higher prices than Bar and Herceg Novi.

Total number of samples (predicted and actually collected) for 2009/10 and 2010/11 is given in Tables 14, 15, and 16. These species accounted for over 50% of the total landings. *E. encrasicolus*, *S. pilchardus*, *M. merluccius*, *M. barbatus* and *P. longirostris* were the most landed species. Small gregarious pelagic fish, targeted by purse seiners, gillnetters and beach seiners, were generally more abundant in the landings compared to inshore and offshore demersal species, targeted mostly by trawlers and partially by gillnetters and long-liners. Pilchard and anchovy are mainly caught by beach seines, although smaller quantities are caught by gillnets. Bogue is caught mainly by gillnets for bogue (*"bukvara"*), but also by bottom trawlers. Highest catches were reported in the 2009/10 period. Picarel catches are generally low, as *Spicara* species aren't considered economically important in Montenegro, and are usually treated as discard. *Trachurus* spp. was mostly caught by beach seiners under 6 m LOA. Fish from the Mugilidae family is mainly caught by gillnets, although significant quantities are caught by beach seines. Occasionally (once or twice a year), particularly large landings are reported for Mugilidae, pilchard, and anchovy (>1000 kg).

M. merluccius consistently had the largest average yield per species per trawler (kg/h) (Table 17), followed by *M. barbatus*. *P. longirostris* showed an increase in landings, while the landings of *E. moschata* dropped in 2009/10 and 2010/11 compared to 2007/08.

Average fishing activity for some of the sampled vessels is given in Table 18, showing also their secondary fishing gear (if any). General trend shows a decrease in fishing days from 2007/08 through 2009/10 to 2010/11, although certain vessels (trawlers) showed a slight increase from 2007/08 to 2009/10.

Table 14. Average monthly gillnet landings (kg) of some sampled species

Species	2007/08		2009/10		2010/11	
	<6 m (26 ves.)	6–12 m (14 ves.)	<6 m (22 ves.)	6–12 m (14 ves.)	<6 m (22 ves.)	6–12 m (14 ves.)
E. encrasicolus	600	850	450	650	500	700
S. pilchardus	700	800	400	550	500	800
B. boops	900	1,000	1,700	5,000	900	3,700
Spicara spp.	900	850	450	350	400	400
Trachurus spp.	800	950	550	700	500	600
Mugilidae	600	1,100	4,500	1,000	2,000	1,400

Table 15. Average monthly beach seine and purse seine landings (kg) of some sampled species

Species	2007/08		2009/10		2010/11	
	<6 m (16 ves.)	6–12 m (9 ves.)	<6 m (12 ves.)	6–12 m (9 ves.)	<6 m (14 ves.)	6–12 m (4 ves.)
E. encrasicolus	4,000	4,000	6,300	3,300	5,200	2,400
S. pilchardus	3,100	3,000	4,300	5,900	4,900	4,200
B. boops	1,150	400	700	450	450	250
Spicara spp.	1,000	250	450	150	150	100
Trachurus spp.	800	800	1,100	800	800	600
Mugilidae	1,250	500	1,000	350	1,050	400

Table 16. Average yearly catch (kg) per species per trawler category

Species	2007/08		2009/10		2010/11	
	<6 m (12 ves.)	6–12 m (1 ves.)	<6 m (12 ves.)	6–12 m (3 ves.)	<6 m (13 ves.)	6–12 m (2 ves.)
E. moschata	1,600	250	877	40	350	50
I. coindetii	1,400	250	616	1,100	650	550
L. vulgaris	800	150	1,086	20	750	—
L. budegassa	1,200	250	1,621	550	1,400	1,100
M. merluccius	7,100	1,400	5,040	800	3,800	1,300
M. barbatus	3,500	800	3,350	700	2,300	550
P. longirostris	800	200	2,235	1,600	1,600	2,100
S. officinalis	850	200	840	—	700	—

Table 17. Average yield (kg/h) per species per trawler category

Species	2007/08		2009/10		2010/11	
	<6 m	6–12 m	<6 m	6–12 m	<6 m	6–12 m
E. moschata	1.11	1.67	0.56	0.09	0.70	0.60
I. coindetii	1.30	1.67	1.14	2.46	0.44	0.75
L. vulgaris	0.56	1.10	0.68	0.03	0.53	—
L. budegassa	0.83	1.74	1.17	1.18	1.16	1.54
M. merluccius	5.06	10.11	3.55	1.71	5.33	1.75
M. barbatus	2.56	6.07	2.37	1.49	1.47	0.77
P. longirostris	0.56	1.33	1.52	3.47	1.19	2.92
S. officinalis	0.60	1.33	0.55	—	0.46	—

Average daily catch, yield and economic value of landings of some of the sampled vessels are given in Table 19.

Average daily catch, yield and economic value of certain economically important species in Montenegrin trawler fisheries are given in Table 20. *L. vulgaris, S. officinalis* and *L. budegassa* fetched the highest price (7–10 €/kg), while market value of *M. merluccius, M. barbatus* and *P. longirostris* varied according to the port. Generally, Budva had higher prices than Bar and Herceg Novi.

Total number of samples (predicted and actually collected) for 2009/10 and 2010/11 is given in Table 21.

Table 18. Fishing activity of some of the vessels sampled, by sampling period

Vessel name	Main gear	Second. gear (if any)	2007/08		2009/10		2010/11	
			Avg. fishing days/month	No. fishing days/year	Avg. fishing days/month	No. fishing days/year	Avg. fishing days/month	No. fishing days/year
Ciklon	OTB	—	13	156	16	192	14	166
Jadranka	OTB	LLS	11	132	16	192	14	166
Milica	OTB	—	13	156	16	192	14	166
Vesna IV	OTB	—	13	156	14	168	14	162
Sv. Marko	OTB	—	13	156	6	72	5	61
Jovana	OTB	—	13	156	5	60	4	45
Katarina	OTB	—	13	156	10	120	9	109
Trio Mare	OTB	PS1	—	—	20	240	15	177
Donatela	PS1	LLS	13	156	15	180	6	72
32–KT	SB	LLS, GNC	10	120	9	108	10	120

Table 19. Average daily catch, yield, and economic value of landings for some of the sampled trawlers

Vessel	2007/08			2009/10			2010/11		
	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)
Jadranka	135	742	15.4	137	883	12.3	211	1,123	23.4
Jovana	145	870	16.1	93	455	11.9	14	88	4.2
Katarina	160	960	17.8	102	552	12.2	149	1,007	16.6
Sv. Marko	140	770	15.6	138	757	13.4	126	955	10.9
Vesna IV	162	1,215	18.3	140	795	18.7	44	517	7.3

Table 20. Average daily catch, yield, and economic value of selected species in the port of Bar, by sampling period

BAR	2007/08			2009/10			2010/11		
Species	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)
E. cirrhosa	60	6.66	3.00	26	0.64	3.00	—	—	—
I. coindetii	54	6.00	4.00	95	2.11	4.00	26	0.58	4.00
L. vulgaris	30	3.33	6.00	27	0.62	7.00	37	1.11	7.00
L. budegassa	45	5.00	7.00	46	0.96	7.00	76	1.33	8.00
M. merluccius	273	3.33	4.00	126	2.50	4.00	262	8.89	4.00
M. barbatus	138	15.33	4.00	84	2.00	4.00	147	1.78	4.00
P. longirostris	30	3.33	5.00	81	1.63	7.00	95	1.89	8.00
S. officinalis	32	3.60	6.00	22	0.53	6.00	45	0.67	7.00

Table 21. Average daily catch, yield, and economic value of selected species in the port of Budva, by sampling period

BUDVA	2007/08			2009/10			2010/11		
Species	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)
E. cirrhosa	24	2.67	4.00	10	0.56	4.00	5	0.52	5.00
I. coindetii	27	3.00	5.00	11	0.58	6.00	3	0.17	6.00
L. vulgaris	15	11.67	10.00	7	0.43	8.00	6	0.60	10.00
L. budegassa	22	2.39	8.00	24	1.43	10.00	13	1.11	10.00
M. merluccius	136	15.06	8.00	73	4.74	5.00	45	2.57	5.00
M. barbatus	6	7.00	4.00	45	2.84	5.00	24	1.47	5.00
P. longirostris	15	1.67	8.00	32	2.18	10.00	14	1.00	10.00
S. officinalis	15	1.71	6.00	9	0.56	6.00	7	0.56	8.00

Table 22. Average daily catch, yield and economic value of selected species in the port of Herceg Novi, by sampling period

HERCEG NOVI	2007/08			2009/10			2010/11		
Species	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)	Avg. catch/ day (kg)	Yield (kg/h)	Value (€/kg)
E. cirrhosa	72	8.00	3.00	6	0.26	3.00	19	0.13	3.00
I. coindetii	69	7.67	4.00	15	0.51	3.00	18	0.58	4.00
L. vulgaris	39	4.33	10.00	20	1.19	7.00	22	0.21	8.00
L. budegassa	60	6.69	8.00	33	1.32	8.00	44	1.10	8.00
M. merluccius	364	40.39	5.00	91	3.96	4.00	180	3.15	4.00
M. barbatus	190	21.07	5.00	60	2.61	4.00	77	1.18	4.00
P. longirostris	42	4.67	5.00	23	1.16	6.00	52	0.59	8.00
S. officinalis	44	4.89	6.00	17	0.78	6.00	26	0.20	8.00

Table 23. Total number of samples examined in September 2009–August 2011 in Montenegrin waters, by different fishig gears

2009/10	No. of samples predicted	No. of samples collected	No. of samples collected			
Species			**Seine netter**	**Purse seiner**	**Trawl net**	**Fixed nets**
E. encrasicolus	15	15	15			
S. pilchardus	18	17	13	4		
B. boops	24	22			15	7
S. sarda	1	1		1		
M. barbatus	9	9			9	
M. merluccius	15	14			14	
Mugilidae	15	8				8
Spicara spp.	24	11			11	
L. budegassa	5	5			5	
P. erythrinus	12	4			4	
P. longirostris	10	10			10	
E. moschata	4	4			4	
E. cirrhosa	4	4			4	
I. coindetii	10	8			8	
L. vulgaris	4	3			3	
S. officinalis	4	2			2	
S. japonicas	5	4	4			
T. mediterraneus	9	8			8	
2010/11	**No. of samples predicted**	**No. of samples collected**	**No. of samples collected**			
Species			**Seine netter**	**Purse seiner**	**Trawl net**	**Fixed nets**
E. encrasicolus	15	11	11			
S. pilchardus	18	15	15			
B. boops	24	14			6	8
S. sarda	1	1	1			
M. barbatus	9	6			6	
M. merluccius	15	9			9	
Mugilidae	15	4				4
Spicara spp.	24	3			3	
L. budegassa	5	4			4	
P. erythrinus	12	4			2	
P. longirostris	10	6			6	
E. moschata	4	4			4	
E. cirrhosa	4	3			3	
I. coindetii	10	5			5	
L. vulgaris	4	3			3	
S. officinalis	4	2			2	
S. japonicas	5	5	1	4		
Trachurus spp.	9	8	2	1	3	2

5.2. Biological data

5.2.1. Description by species

Data collected for all sample species were analysed to describe the following parameters for each species:

- Length frequency distribution (LFD), by trimester for each sampling period (2007/08, 2009/10, 2010/11) pooled among fishing gear and raised to the landing of the trimester;
- Sex ratio, given as the number of females, males, or unsexed individuals over the total number of individuals, and expressed in percentages;
- Sex ratio of females and males by length frequency, given as number of females or males over the sum of males and females;
- Number and percentage of males and females divided by maturity stages according to the MEDITS scale;
- Length at first maturity (i.e. length at which 50% of the population is considered sexually mature; $L_{50\%}$), and at 25% ($L_{25\%}$) and 75% ($L_{75\%}$) of maturity, according to the classic logistic model;
- Gonadosomatic index (GSI), defined as the ratio of gonad weight (WG) and total body weight (TW). In order to calculate the gonadosomatic index, only sexed individuals falling into MEDITS sub-category 2b and higher were considered.
- The parameters of the length–weight relationship according to a power model $\mathrm{TW} = a \cdot L^b$ (TW – total weight, L – body length).

Parameters α (intercept) and β (slope) of the maturity ogive, and a and b of the length-weight relationship, were estimated through the least square method and are given in , Tables 22 to 25.

Table 24. Length at first maturity and maturity ogive parameters, by species (LML – lateral mantle length; ML – mantle length)

Species	Maturity ogive parameters		Length at maturity (cm/*mm)		
	α	β	$L_{25\%}$	$L_{50\%}$	$L_{75\%}$
B. boops	5.1951	0.3468	11.8	14.9	18.1
E. encrasicolus	16.0719	1.7368	8.62	9.25	9.89
L. budegassa	3.1647	0.1230	16.8	25.7	34.7
M. merluccius	5.0649	0.2058	19.3	24.6	29.9
M. barbatus	8.1726	0.6042	11.7	13.5	15.3
P. erythrinus	5.3822	0.3409	12.6	15.8	19.0
S. pilchardus	10.3049	1.0513	8.76	9.80	10.85
S. japonicus	12.4792	0.5816	19.5	21.5	23.3
E. moschata (LML)	4.9986	0.0703	55.5*	71.1*	86.8*
I. coindetii (ML)	7.4753	0.0614	103.9*	121.8*	139.7*
L. vulgaris (ML)	0.0057	0.0693	129.9*	129.9*	145.8*

Table 25. Length at first maturity and maturity ogive parameters for females, by species (ML – mantle length)

Species	Maturity ogive parameters		Length at maturity (cm/*mm)		
	α	β	$L_{25\%}$	$L_{50\%}$	$L_{75\%}$
B. boops	4.6510	0.3111	11.4	14.9	18.5
E. encrasicolus	16.7330	1.7848	8.76	9.38	9.99
L. budegassa	—	—	—	—	—
M. merluccius	5.9700	0.2257	21.6	26.5	31.3
M. barbatus	10.4727	0.7546	12.4	13.9	15.3
P. erythrinus	3.5273	0.2662	9.1	13.2	17.3
*P. longirostris**	4.1315	0.1827	16.6	22.6	28.6
S. pilchardus	8.1160	0.8657	8.11	9.37	10.64
S. japonicus	15.1141	0.6931	20.2	21.8	23.4
I. coindetii (ML)*	8.1062	0.0666	105.3	121.8	138.3

Table 26. Length at first maturity and maturity ogive parameters for males, by species (ML – mantle length)

Species	Maturity ogive parameters		Length at maturity (cm/*mm)		
	α	β	$L_{25\%}$	$L_{50\%}$	$L_{75\%}$
B. boops	4.6489	0.3244	10.9	14.3	17.7
E. encrasicolus	15.919	1.7580	8.43	9.06	9.68
L. budegassa	2.1869	0.0906	12.0	24.1	36.2
M. merluccius	4.3544	0.1789	18.2	24.3	30.5
M. barbatus	4.2088	0.3134	9.9	13.4	16.9
P. erythrinus	10.1511	0.5434	16.7	18.7	20.7
*P. longirostris**	—	—	—	—	—
S. pilchardus	10.2180	1.1066	8.24	9.23	10.23
S. japonicus	16.3157	0.7520	20.2	21.7	23.2
I. coindetii (ML)*	8.8812	0.0735	105.9	120.8	135.8

Table 27. Length-weight relationship parameters, by species and sex

Species	Length-weight relationship parameters			
	females		males	
	a	b	a	b
B. boops	0.0218	2.6903	0.0234	2.6641
E. encrasicolus	0.0025	3.3713	0.0036	3.2088
L. budegassa	0.0335	2.7450	0.0184	2.9262
M. merluccius	0.0039	3.1579	0.0044	3.1152
M. barbatus	0.0072	3.1167	0.0124	2.9115
P. erythrinus	0.0144	2.9345	0.0145	2.9293
*P. longirostris**	0.0116	2.0641	0.0106	2.0307
S. pilchardus	0.0073	3.0029	0.0076	2.9784
S. sarda	0.0019	3.4249	0.0006	3.7158
S. japonicus	0.0017	3.4827	0.0013	3.5627
E. cirrhosa	0.0044	2.4524	0.0024	2.5850
E. moschata	0.0183	2.1271	0.0083	2.3182
*I. coindetii**	0.00007	2.8373	0.00007	2.8709
*L. vulgaris**	0.0001	2.7738	0.0001	2.7387
*S. officinalis**	0.0013	2.4722	0.0009	2.5461

* length in mm

5.2.2. European hake (*Merluccius merluccius*)

During the entire sampling period, a total of 1596 specimens of European hake were sampled. In the 2007/08 sampling period, the greatest abundance in the landings was recorded in September, while in both 2009/10 and 2010/11 it was in March. The mean length of the sampled individuals was 21.3 ± 4.4 cm TL, with minimum and maximum length at 7.2 and 39.6 cm TL, respectively. The mean weight was 71.3 ± 50.5 g, with a minimum of 2.8 g and a maximum at 440 g.

Females ranged in length from 7.2 to 38.2 cm TL, with an average of 21.4 ± 4.7 cm TL. The weight ranged from 2.8 to 418.6 g, with an average 74.1 ± 39.3 g. The minimum and maximum lengths of males were 8.1 and 39.6 cm TL, respectively, with the average of 21.8 ± 4.1 cm TL. Minimum male weight was 3.3 g and maximum was 440.0 g. Average male weight was calculated at 73.8 ± 44.8 g.

Mode was between 17 and 20 cm TL in the 1st trimester 2007/08, between 15 and 19 cm TL in the 2nd trimester, between 17 and 22 cm TL in the 1st trimester 2009/10, at 22–25 cm TL in 2nd trimester, at 18–20 cm TL in the 3rd trimester, at 19 cm TL in the 1st trimester 2010/11, 20–23 in the 2nd trimester, and 18–22 cm TL in the 3rd trimester 2010/11. Length frequency distribution of hake by trimester and sampling period is given in Figure 4. Of the 1596 individuals in the total sample, 588 (37%) were females, 911 (57%) were males, and 97 (6%) were of undetermined sex. Sex ratio by sampling period is given in Table 28.

Table 28. European hake sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	41%	59%	0%
2009/10	37%	51%	12%
2010/11	32%	64%	5%

Figure 5 gives sex ratio by length for males and females. Males were dominant in almost all length categories.

The vast majority of specimens, both male (76%) and female (70%) were in gonad maturity stage 2. Table 29 gives the breakdown of hake gonad maturity stages by sex, as well as giving minimum and maximum length recorded for each maturity stage.

Length at first maturity ($L_{50\%}$) was calculated at 24.62 cm TL for the total sample (males and females together), 26.45 cm TL for females and at 24.33 cm TL for males (Figure 6).

The average monthly gonadosomatic index values reached their peak in June (for females, 2.85) and in September (for males, 1.59). Both sexes had their secondary peak in December (1.96 and 0.92, respectively) (Figure 7).

Length-weight relationship for males, females and for total sample showed power factor *b* to be consistently greater then 3, indicating allometric positive growth (Figure 8).

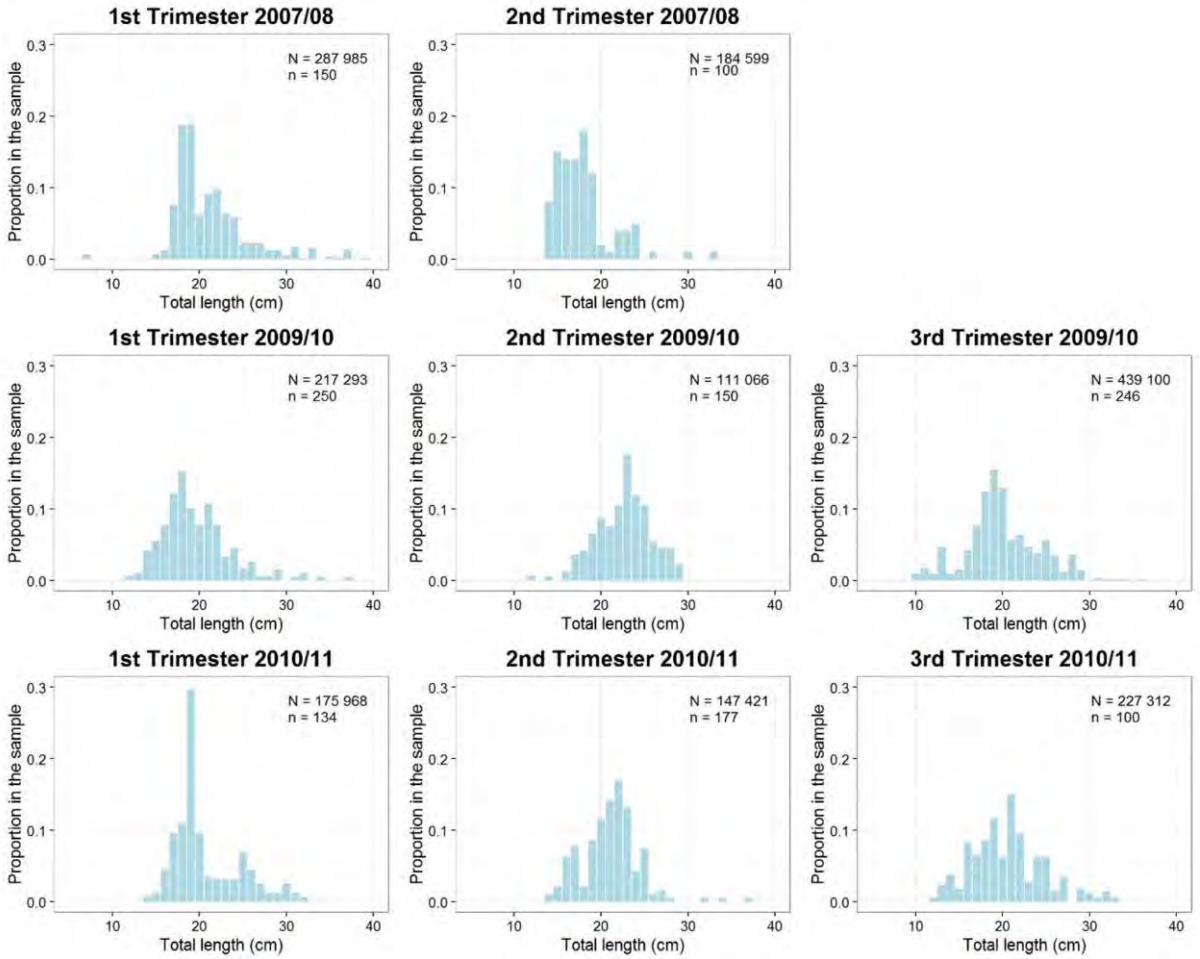


Figure 4. Length frequency distribution of hake by trimester (n – number of specimens in the sample, N – number of specimens raised to the landing of the trimester)

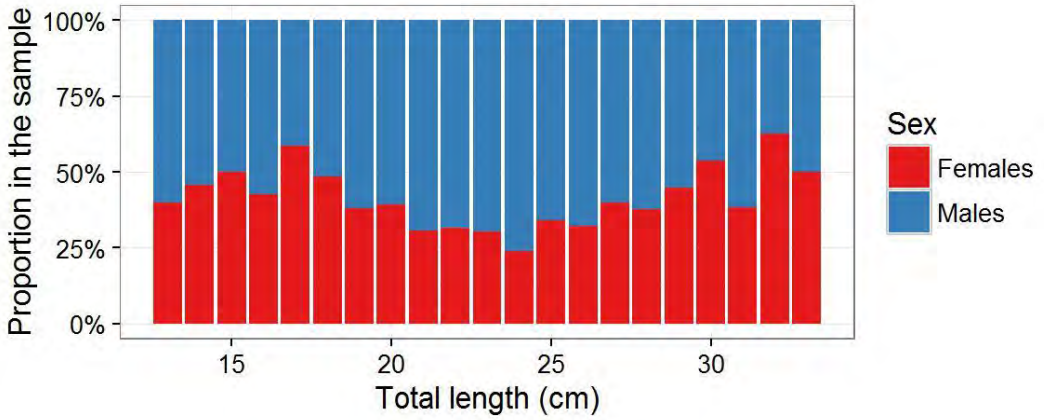


Figure 5. Sex ratio by length in the Montenegrin commercial catch of *M. merluccius*

Table 29. European hake gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	169	19%	8.1	30.0	145	25%	7.2	25.3
2	693	76%	9.8	39.6	410	70%	13.0	36.0
3	47	5%	10.9	37.9	30	5%	9.4	38.2
4	2	0%	16.1	20.4	2	0%	22.4	26.5
Total	911	100%			587	100%		

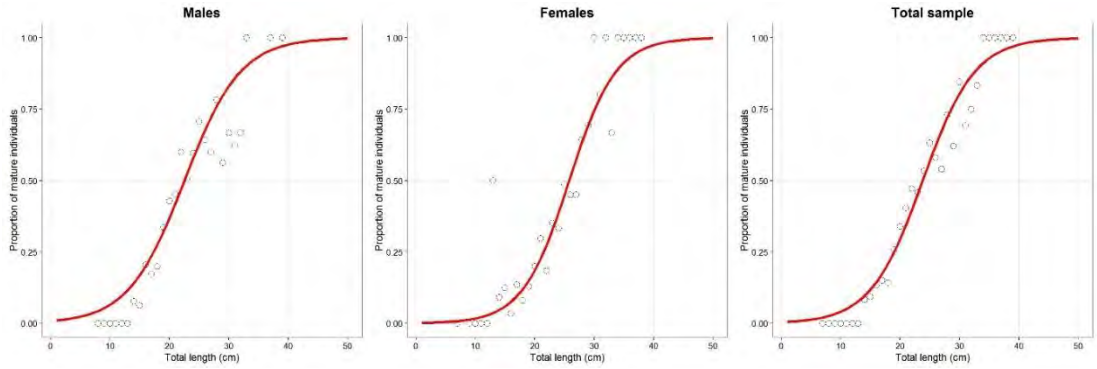


Figure 6. Maturity ogives for European hake males, females, and both sexes together

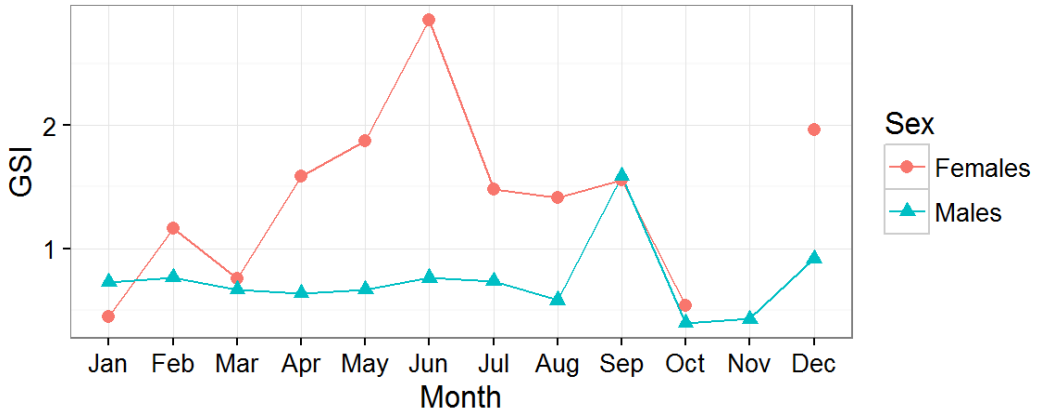


Figure 7. Gonadosomatic index of hake, by month and sex

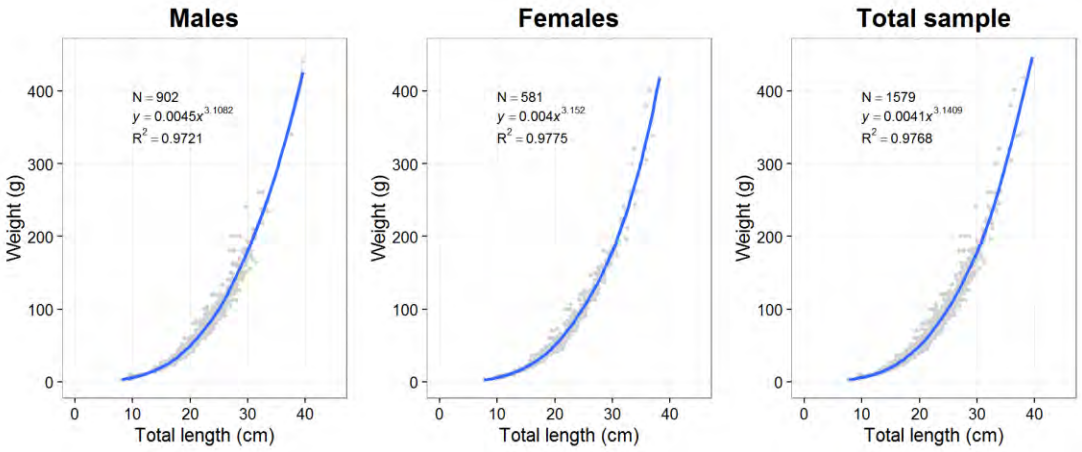


Figure 8. Length-weight relationship for European hake males, females, and for total sample

5.2.3. Red mullet (*Mullus barbatus*)

A total of 1191 individuals of red mullet were sampled during the entire sampling period. The greatest abundance in the catch in 2007/08 was in September, with the second highest record in March, which was the month with the highest abundance of red mullet in landings in both 2009/10 and 2010/11 sampling periods. The average length of sampled individuals was 15.0 ± 2.1 cm total length (TL), with the mean total weight (TW) of 35.8 ± 18.4 g TW. Length and weight ranges were 9.1–26.5 cm TL and 10.70–229.22 g TW, respectively.

Male length ranged from 9.1 to 21.5 cm TL (mean 13.4 ± 1.6 cm TL), with length from 10.7 to 123.8 g TW (mean 30.3 ± 11.2 g TW). Length of females was within the 10.7–26.5 cm TL range (mean 15.6 ± 2.2 cm TL), while weight ranged from 10.9 to 229.2 g TW (mean 40.8 ± 21.2 g TW).

Modes were between 12 and 15 cm TL in 1st trimester 2007/08, and at 13–15 cm TL in 2nd trimester; 13–15 cm TL in 1st trimester, 13–16 cm TL in 2nd, and 12–14 cm TL in 3rd trimester. In 2010/11, the mode was at 12–14 cm TL in 1st trimester, 13–15 cm TL in 2nd trimester, and 10–12 cm TL in 3rd trimester. Length frequency distribution of red mullet, according to trimester and sampling period is shown on Figure 9.

Of the 1191 sampled individuals, 478 (57%) were females, 482 (40%) were males, and only 31 (3%) were unsexed. Generally, females were dominant in all three sampling periods (53–60%), with unsexed individuals maintaining a token presence, at most (≤5%). Sex ratio by sampling period is given in Table 30.

Table 30. Red mullet sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	60%	39%	1%
2009/10	53%	42%	5%
2010/11	56%	41%	3%

In sex ratio by length frequency, females were also dominant (except at 12 and 13 cm), but their prevalence is particularly noticeable at and above 15 cm TL (Figure 10).

Most of the individual sampled were of MEDITS gonad maturity stage 2 (82% of females and 69% of males). Table 31 shows the detailed breakdown of number and percentage of males and females according to MEDITS gonad maturity stages.

Length at maturity ($L_{50\%}$) for red mullet was estimated at about 13.5 cm TL (13.8 cm TL for females, 13.4 cm TL for males) (Figure 11).

Gonadosomatic index of females peaked in April (5.35), while that of males reached its peak a month earlier, in March (1.94). Figure 12 gives monthly progression of the GSI for females and males.

Length-weight relationship for the total sample of red mullet showed the length-weight parameter b had a value slightly greater than 3 (b_{TOT} = 3.066). The positive allometric growth was slightly more pronounced in females ($b_{♀}$ = 3.1167), while males had b value lower than 3 ($b_{♂}$ = 2.3115) (Figure 13).

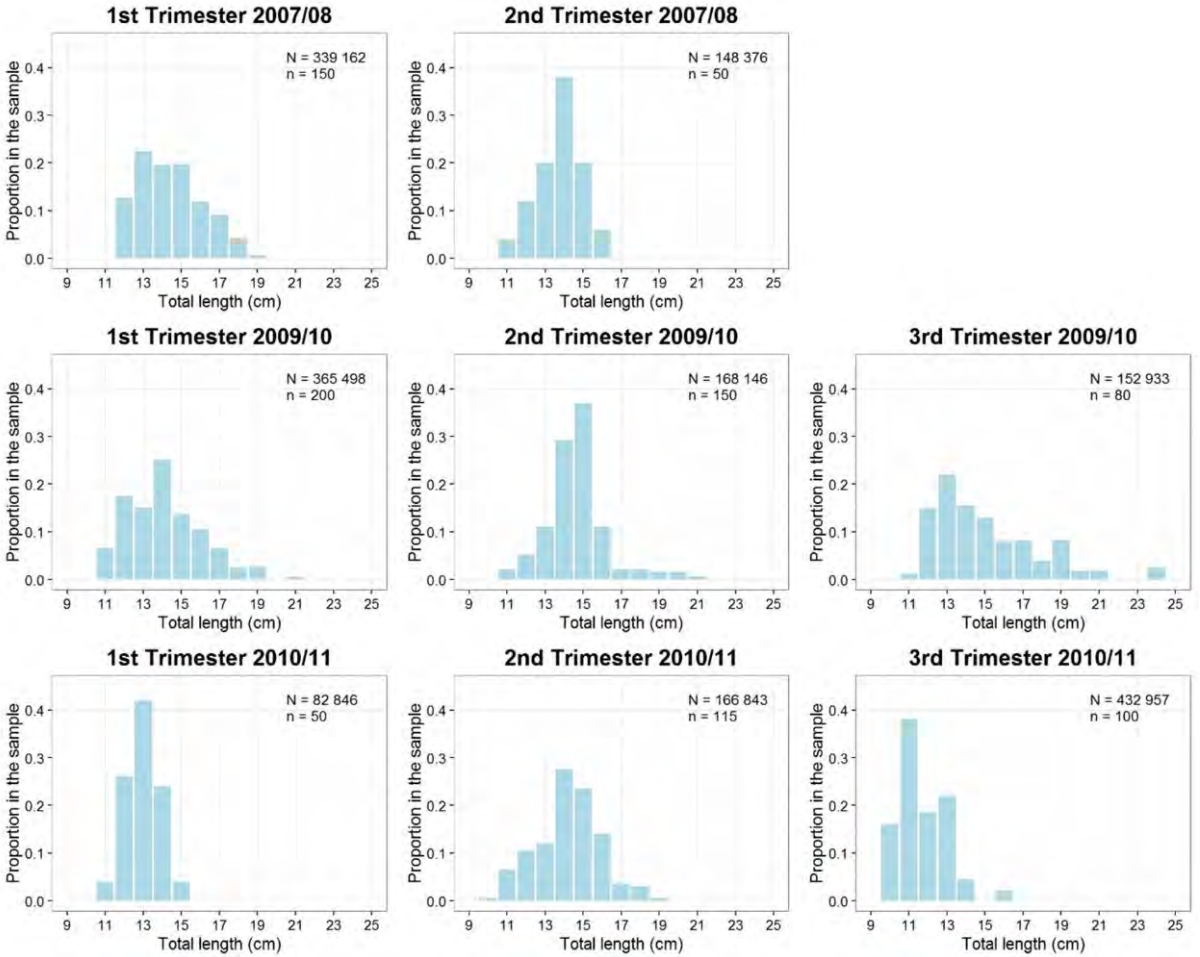


Figure 9. Length frequency distribution of red mullet by trimester (n – number of specimens in the sample, N – number of specimens raised to the landings of the trimester)

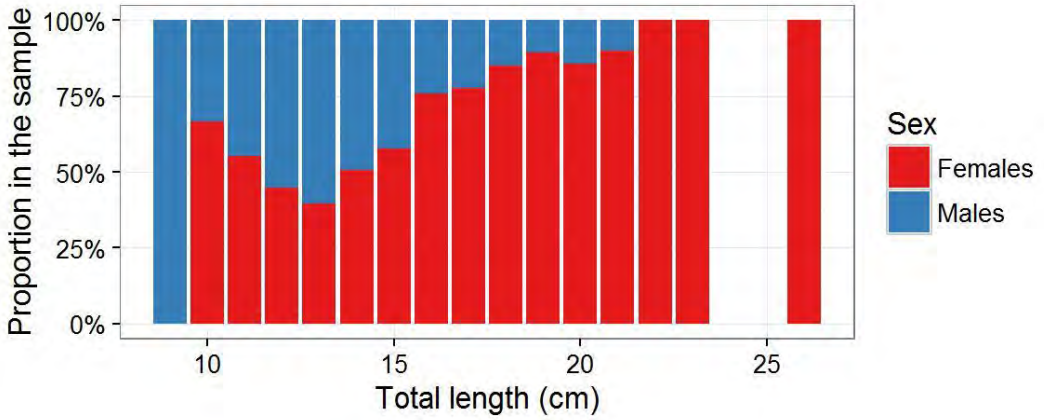


Figure 10. Sex ratio by length in the Montenegrin commercial catch of *M. barbatus*

Table 31. Red mullet gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	32	7%	9.1	17.5	33	5%	11.2	15.6
2	394	82%	11	21.5	470	69%	10.7	26.5
3	52	11%	12	16.4	135	20%	12.2	22.0
4	4	1%	14.5	15.2	40	6%	11.3	21.2
Total	482	100%			678	100%		

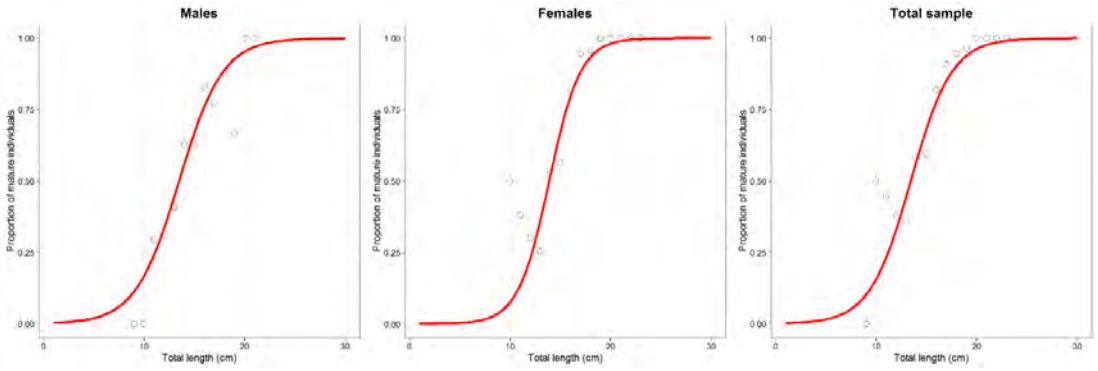


Figure 11. Maturity ogives for red mullet males, females and both sexes together

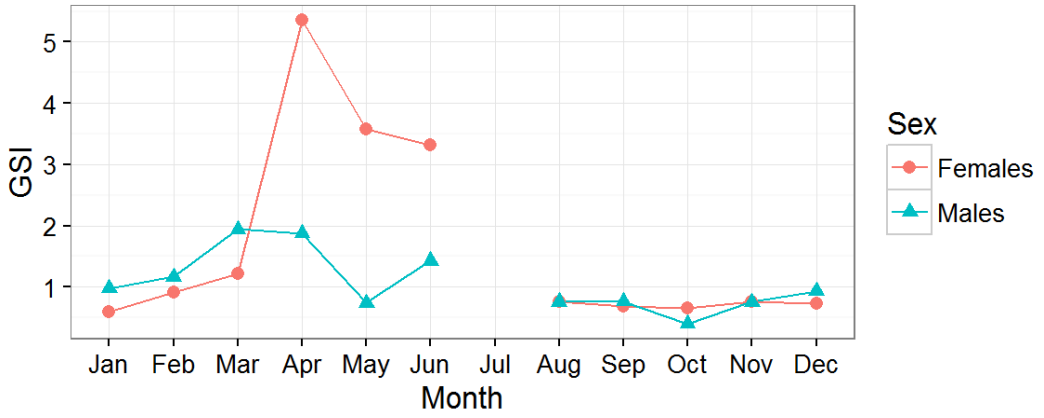


Figure 12. Gonadosomatic index of red mullet, by month and by sex

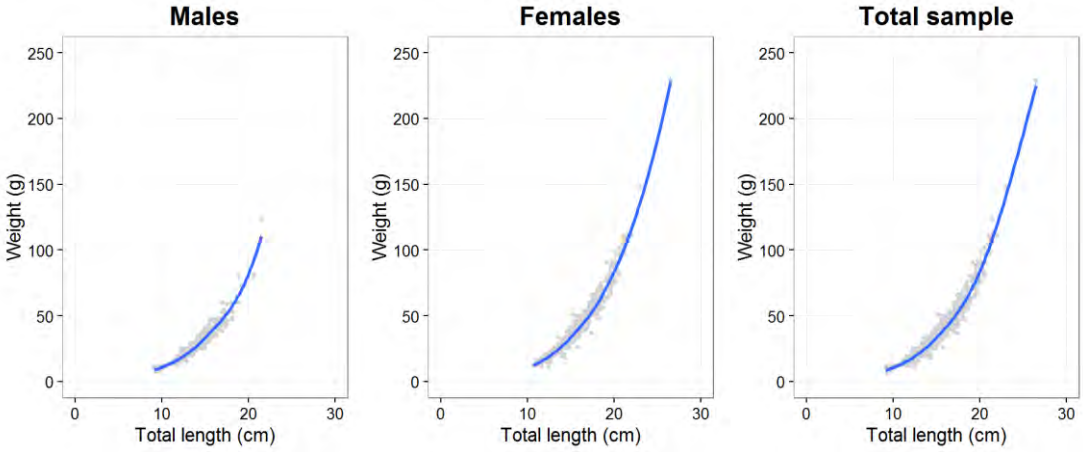


Figure 13. Length-weight relationship for red mullet males, females and for total sample

5.2.4. Deep-water pink shrimp (*Parapenaeus longirostris*)

A total of 1354 specimens of deep-water pink shrimp were sampled during the entire sampling period. The greatest abundance in landings of deep-water pink shrimp was recorded in September 2007 and 2009. During the 2010/11 sampling period, the greatest abundance was recorded in June 2011. The mean length of the sample was 25 ± 5 mm CL (min. 14 mm, max. 37 mm CL), while the average weight was estimated at 9.3 ± 3.9 g (min. 1.9 g, max. 23.0 g). Both males and females had minimum recorded length at 14 mm CL. Maximum for males was 32 mm CL, while that of females was 37 mm CL. Mean values were 21 ± 3 mm CL for males and 26 ± 4 mm CL for females. Female weight ranged from 1.9 to 23.0 g (mean 10.2 ± 3.6 g), and male weight from 2.0 to 10.6 g (average 5.05 ± 1.40 g).

In 2007/08, modes were at 18–20 mm CL and 24–27 mm CL in 1st trimester, and at about 20 mm CL and 30 mm CL in 2nd trimester. In 2009/10, there were three modes in 1st trimester, at 17–19 mm CL, 21–23 mm CL, and 28–30 mm CL, two in 2nd: 24–27 mm CL and 29–32 mm CL, and two in 3rd, at 22–26 mm CL and 31–34 mm CL. Length frequency distribution in 2010/11 was somewhat irregular, making modes somewhat difficult to determine. In 1st trimester, they could be at 16–20 mm CL, 23–29 mm CL, and 34–36 mm CL; in 2nd trimester 21–27 mm CL and at 28–30 mm CL, and at 16–18 mm CL and 20–24 mm CL in 3rd trimester.

Figure 14 gives length frequency distribution of deep-water pink shrimp by trimester and sampling period.

Of the total sample (1354), 1106 (82%) were females and 248 (18%) were males. There were no unsexed individuals. Females were consistently more numerous than males (78–84% of the sample) (Table 32).

Table 32. Deep-water pink shrimp sex ratio by sampling period

Sampling period	Females	Males
2007/08	78%	22%
2009/10	83%	17%
2010/11	84%	16%

The majority of females was in gonad maturity stage 2 (92%) (MEDITS scale), while only 8% were in stage 1. Minimum and maximum carapace length at each maturity stage are given in Table 33.

At lengths between 16 and 19 mm CL males were more dominant in the sample, while at all other length females dominated the sample. At lengths of above 28 mm CL, females are almost exclusively present in the sample (Figure 15).

Length at first maturity for females of deep-water pink shrimp was estimated at around 22.6 mm CL (Figure 16).

The gonadosomatic index of deep-water pink shrimp females shows a peak in May (2.17), followed by a sudden drop and the lowest point in June (1.17). Secondary peak is reached in December (2.01), with the second lowest point in January (1.23) (Figure 17).

Length-weight relationship of deep water pink shrimp shows values of the power coefficient b to be significantly lower than 3 (b_{TOT} = 2.331, $b_{♀}$ = 2.0641, $b_{♂}$ = 2.0307), meaning a negative allometric growth (Figure 18).

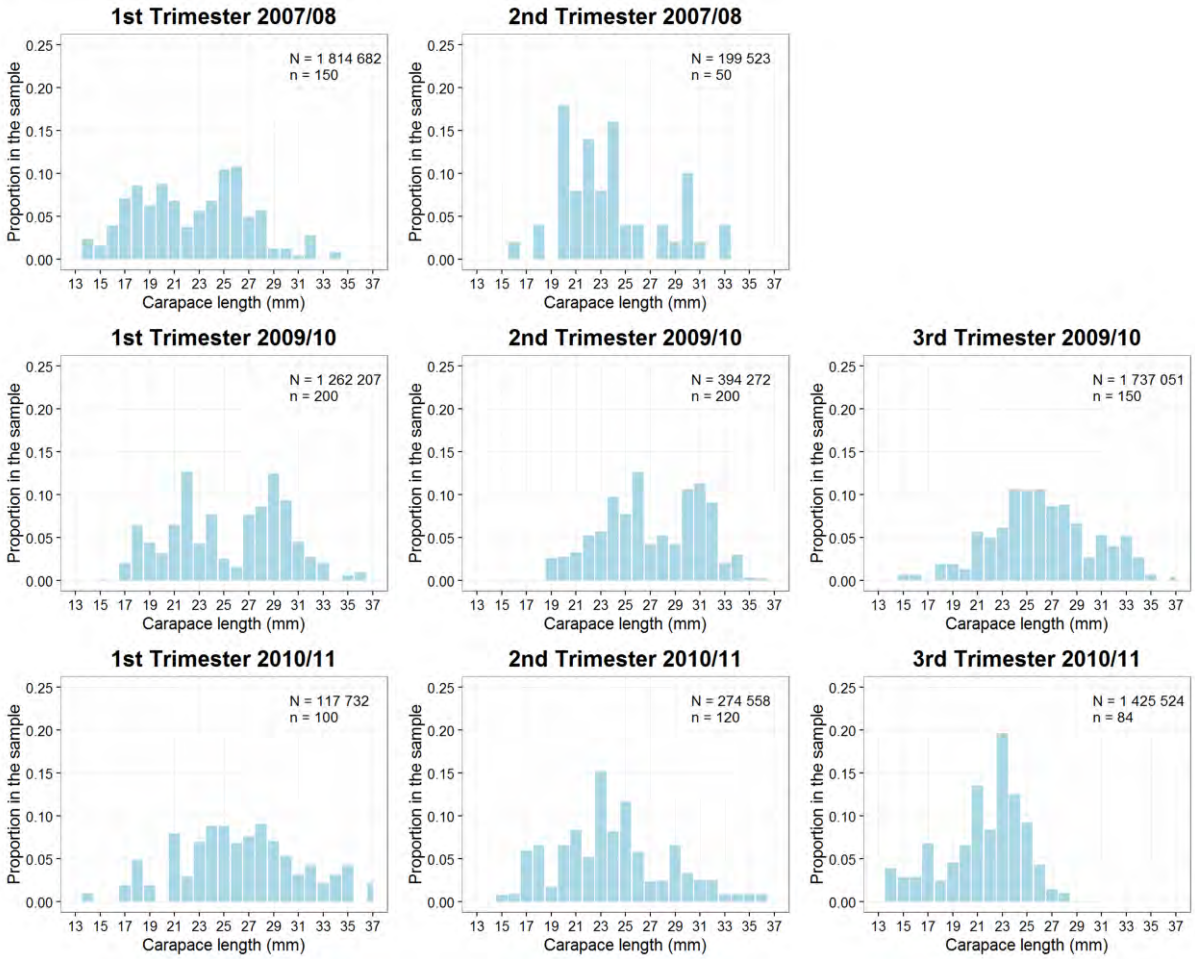


Figure 14. Length frequency distribution of deep-water pink shrimp by trimester (n – number of specimens in the sample, N – number of specimens raised to the landing of the trimester)

Table 33. Deep-water pink shrimp female gonad maturity stages

Maturity stage	Females			
	No.	%	CL	
			min	max
1	92	8%	14	32
2	1008	92%	14	37
Total	1100	100%		

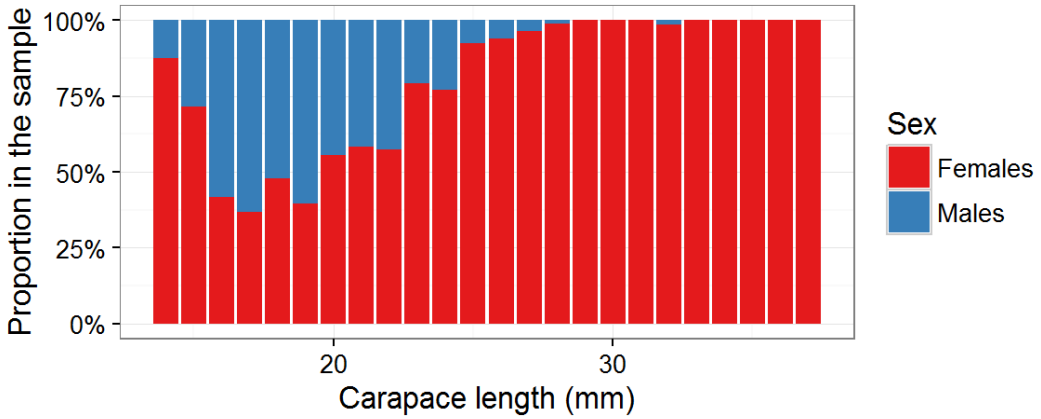


Figure 15. Sex ratio by length in the Montenegrin commercial catch of *P. longirostris*

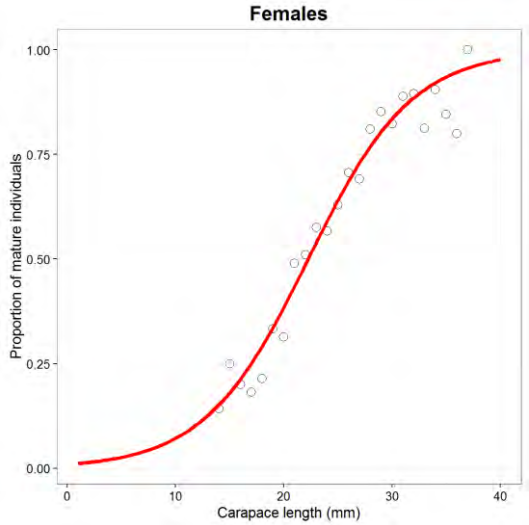


Figure 16. Maturity ogive for deep-water pink shrimp females

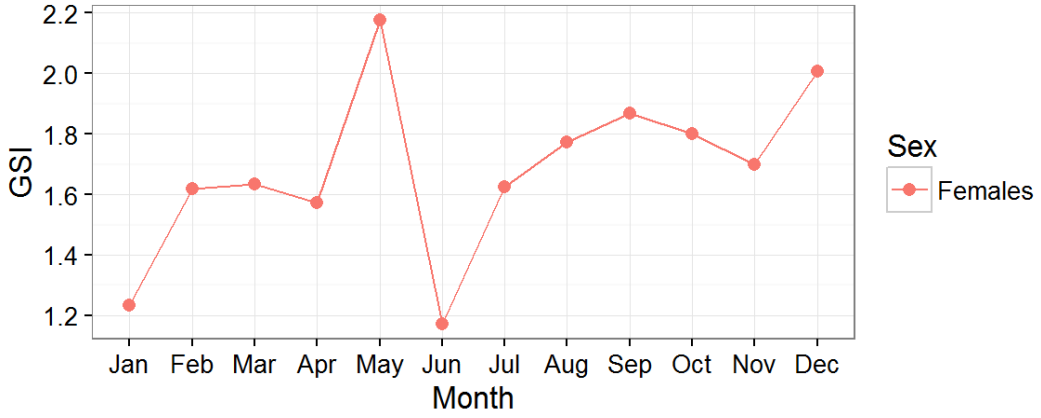


Figure 17. Gonadosomatic index of deep-water pink shrimp females

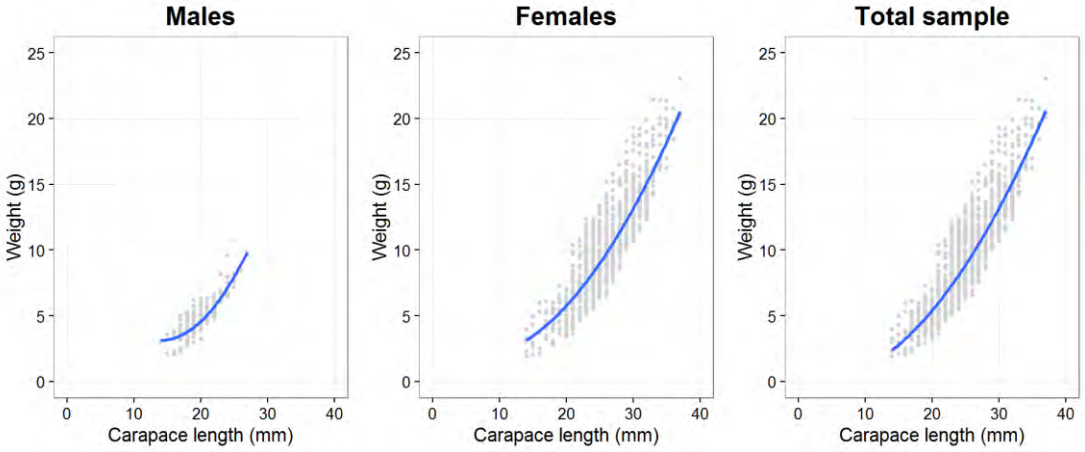


Figure 18. Length-weight relationship for males, females and for total sample of deep-water pink shrimp

5.2.5. European anchovy (*Engraulis encrasicolus*)

A total of 2086 specimens of European anchovy were sampled in the sampling period. The greatest abundance of European anchovy in the landings was in September during the 2007/08 sampling period, and in April during the 2009/10 and 2010/11 sampling periods. Length of the sampled individuals ranged from 5.0 to 14.4 cm TL (average of 10.0±1.4 cm TL), while the weight was in the 0.66–20.96 g range, with an average of 6.2±2.9 g. Minimum and maximum length of females was 6.5 and 14.4 cm TL, respectively, and averaged at 10.2±1.3 cm TL. Weight was in the 1.30–20.96 g range (average of 6.6±2.9 g). Males were, on average, of similar length at 10.1±1.2 cm TL (7.5–13.2 cm TL) and slightly lighter in weight at 6.4±2.5 g (from 2.64 to 14.7 g).

Length frequency distributions were predominantly unimodal, with modes at 8–9 and 9–10 cm TL for the 1st and 2nd trimester of 2007/08, respectively. In 2009/10, the modes were at 8–9 cm TL (1st trimester), 8 cm TL (2nd trimester), and at 11 cm TL (3rd trimester). In 2010/11, modes were between 7 and 9 cm TL in 1st trimester, between 9 and 11 cm TL in 2nd trimester, and between 10 and 12 cm TL in 3rd.

Length frequency distribution of European anchovy by trimester and sampling period is given in Figure 11

There were 1229 females in the sample (59%), 668 males (32%), and 189 unsexed individuals (6%). Females strongly outnumbered the males in each of the sampling periods, as shown in Table 33.

Table 33. European anchovy sex ratio by sampling period

Sampling period	Females	Males
2007/08	60%	40%
2009/10	68%	32%
2010/11	67%	33%

Generally, females were more numerous at each length class, as shown in Figure 20.

The majority of individuals in the sample were of gonad maturity stage 2 (53% of males and 60% of females), with a significant number in stage 1 (25% of both males and females) (Table 34).

Length at first maturity was estimated at 9.3 cm TL for the total sample, or at 9.4 cm TL for females and 9.1 cm TL for males (Figure 21).

The gonadosomatic index of both sexes peaked in May (4.74 for females, 4.97 for males), with a secondary peak in August (4.62 for females, 3.99 for males). (Figure 22).

In length-weight relationship, the parameter *b* was consistently higher than 3 for males ($b_{♂} = 3.2088$), females ($b_{♀} = 3.3713$), and total sample ($b_{TOT} = 3.2980$) (Figure 23).

Table 34. European anchovy gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	180	25%	7.5	11.4	343	25%	6.5	12.3
2	439	60%	7.5	13.1	729	53%	7.3	13.7
3	101	14%	8.3	13.2	246	18%	7	14.4
4	7	1%	9.4	12.8	50	4%	8.5	13.5
Total	727	100%			1368	100%		

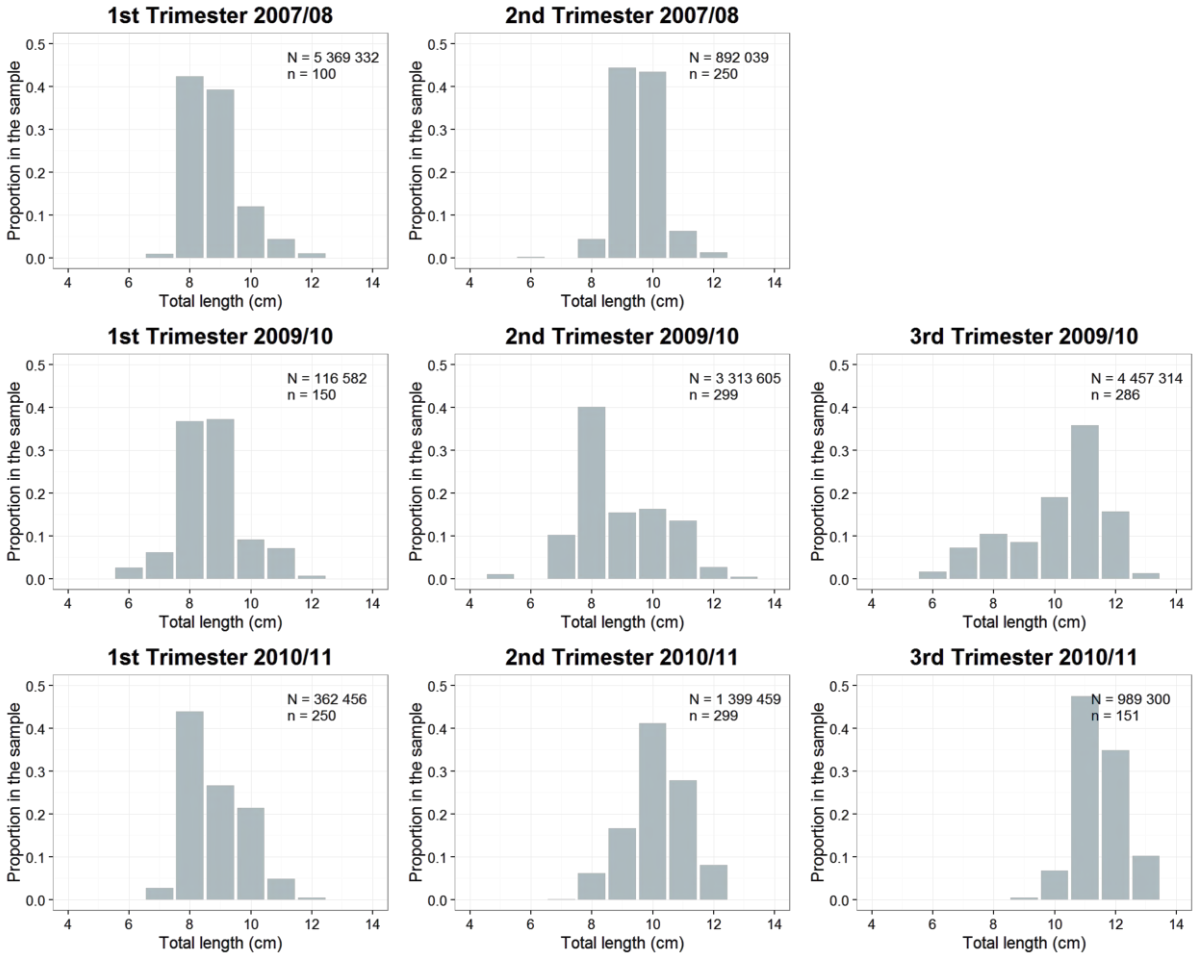


Figure 19. Length frequency distribution of European anchovy by trimester (n – number of specimens in the sample, N – number of specimens raised to the landing of the trimester)

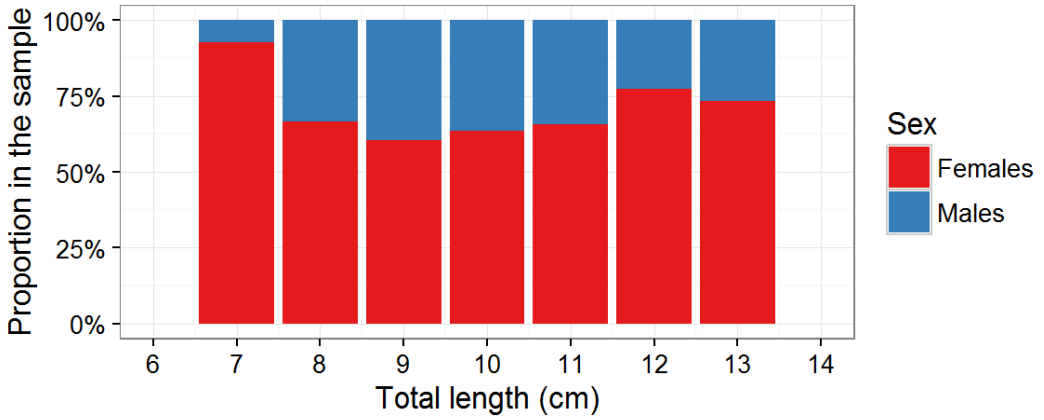


Figure 20. Sex ratio by length in the Montenegrin commercial catch of *E. encrasicolus*

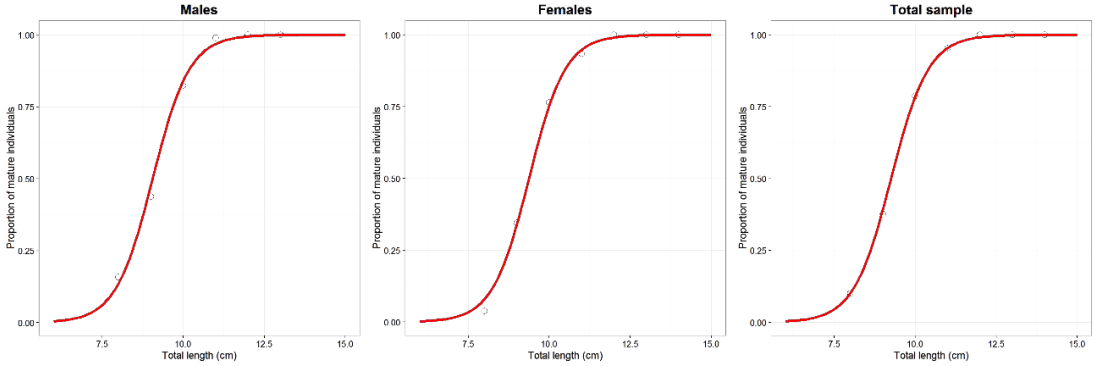


Figure 21. Maturity ogives for European anchovy males, females and both sexes together

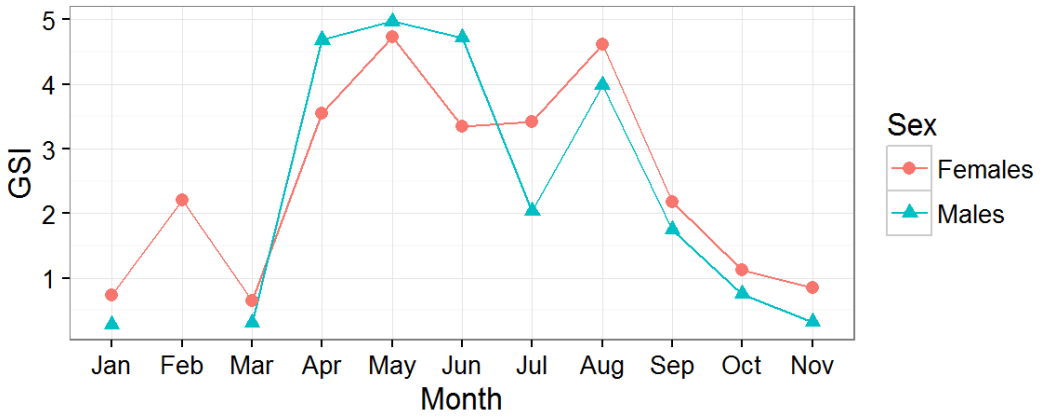


Figure 22. Gonadosomatic index of European anchovy, by month and by sex

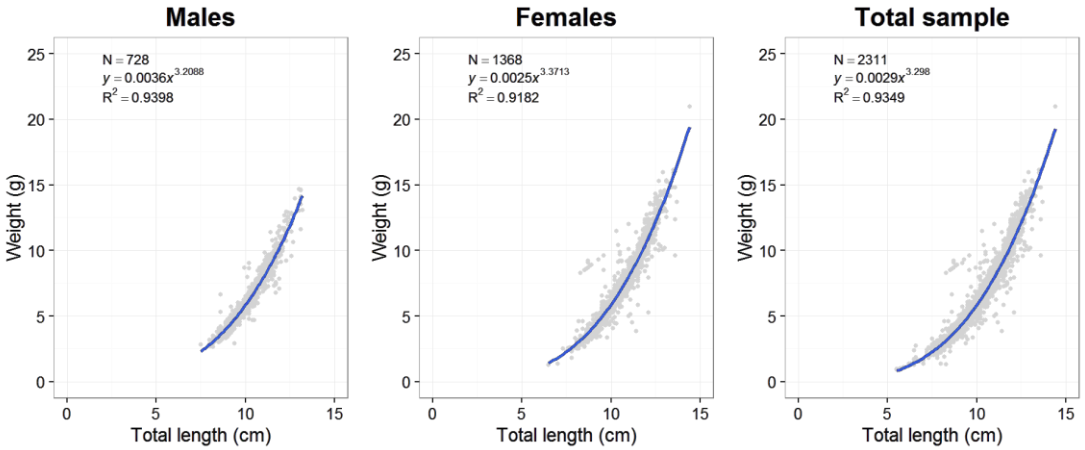


Figure 23. Length-weight relationship for males, females and for total sample of European anchovy

5.2.6. European pilchard (*Sardina pilchardus*)

The total sample of European sardine had 2274 individuals, with an average length of 13.0±2.1 cm TL (6.4–23.0 cm TL) and weight of 17.3±7.9 g (1.7–46.6 g). Males ranged from 7.3 to 16.8 cm TL (average 13.1±1.8) in length, and from 3.3 to 35.1 g in weight, with an average of 16.9±6.6 g. Females had slightly lower minimum (7.1 cm TL) and higher maximum (23.0 cm TL) length, and averaged at 13.4±2.0 cm TL. Weight of females was in the 3.2 to 46.6g range, with an average of 18.8±8.3 g. The greatest abundance in 2007/08 sampling period was in October, in May in 2009/10 (although there was a recorded landing of over 1000 kg in July, but this was taken as an extraordinary circumstance), and in February in the 2010/11 sampling period.

In 2007/08, mode was at 10–12 cm TL in 1st trimester, while the length frequency distribution in 2nd trimester was bimodal, with modes between 9 and 11 and 13 and 15 cm TL. In 2009/10, mode was at 14–16 cm TL in 1st and 2nd trimester, and at 7–9 cm TL and 12–14 cm TL in 3rd. In 2010/11, it was at 10–12 cm TL in 1st trimester, 12–14 cm TL in 2nd, and at 9–11 cm TL in 3rd trimester.

Length frequency distribution of European pilchard by sampling period and trimester is shown in Figure 24.

In the total sample (2274 individuals), there were 1126 (50%) females, 1036 (46%) males and 112 unsexed individuals (5%). The breakdown of sex ratio by sampling period is given in Table 34.

Table 34. European pilchard sex ratio by sampling period

Sampling period	Females	Males
2007/08	52%	48%
2009/10	48%	52%
2010/11	55%	45%

According to length frequency distribution, females dominated at most length frequencies, except at 9, 10, 13 and 14 cm TL, where the males were more numerous, but with an overall sex ratio close to 1:1 (Figure 25).

Most specimens in the sample were in gonad maturity stage 2 (69% of males and 50% of females). About 17% of males were in stage 1, whereas 29% of females were in the spawning stage (3). Number of specimens in the post-spawning stage (4) was below 5% for both sexes (Table 35).

Length at first maturity (in the October–April period) was estimated at 9.8 cm TL for the total sample, and at 9.37 cm TL for females and 9.23 cm TL for males (Figure 36).

Females had the highest value of gonadosomatic index in November (4.76), with a secondary peak in January (4.64), whereas for the males the situation was reversed — a peak in January (4.17), an a secondary peak in November (3.96) (Figure 37).

The coefficient *b* for the total sample was estimated at 3.0528. The value of length-weight parameter *b* for females was slightly higher than 3 (3.0029), but *b* for males was lower than 3 (2.9784) (Figure 38).

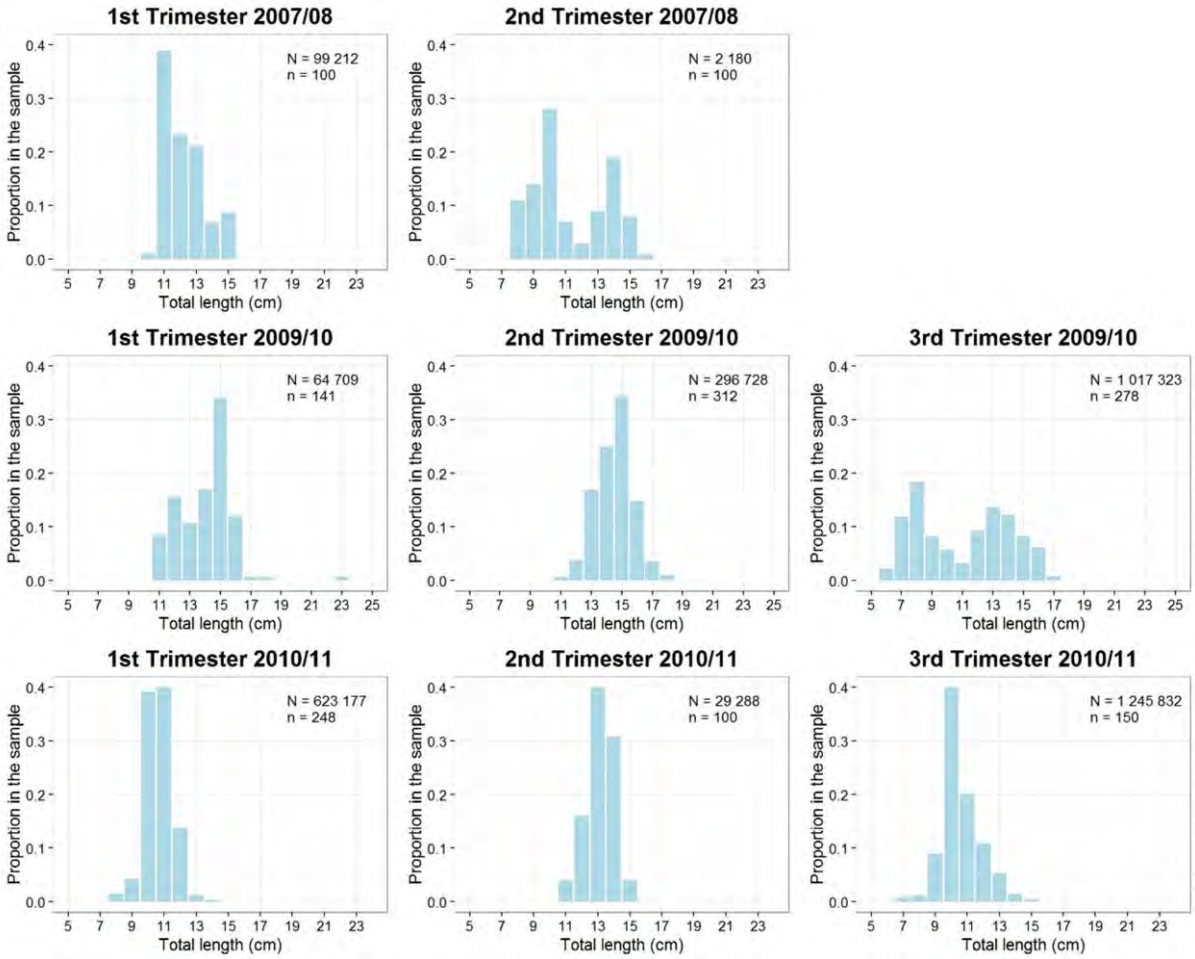


Figure 24. Length frequency distribution of European pilchard by trimester (n – number of specimens in the sample, N – number of specimens raised to the landing of the trimester)

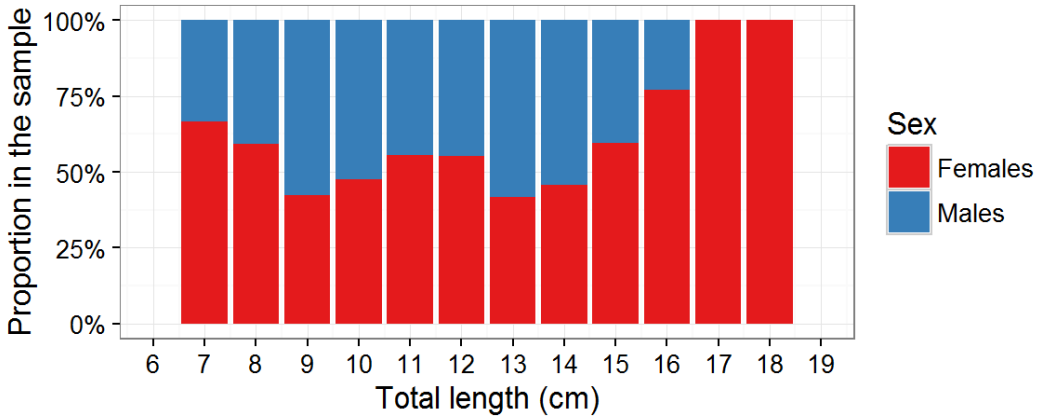


Figure 25. Sex ratio by length in the Montenegrin commercial catch of *S. pilchardus*

Table 35. European pilchard gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	173	17%	7.3	15.7	190	17%	7.1	15.2
2	719	69%	8.8	16.8	562	50%	8.3	18.3
3	124	12%	10.4	16.7	331	29%	8.6	23.0
4	20	2%	11.3	15.6	42	4%	9.2	16.9
Total	1036	100%			1125	100%		

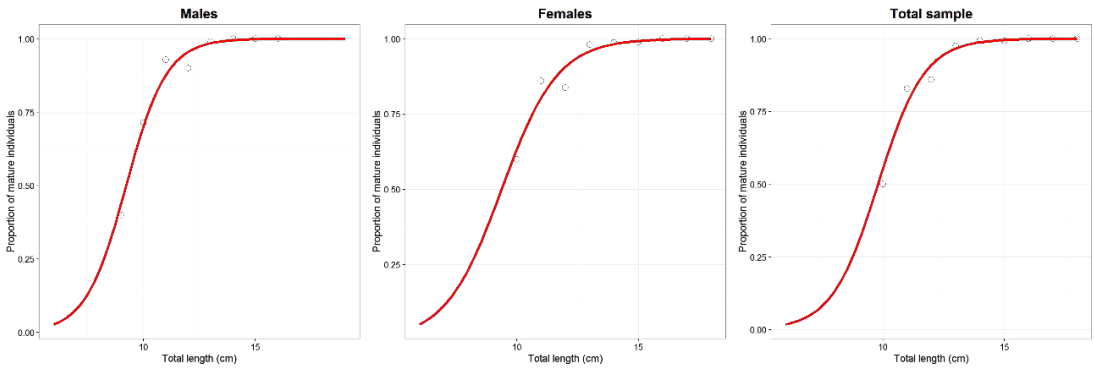


Figure 36. Maturity ogives for European pilchard, females and both sexes together

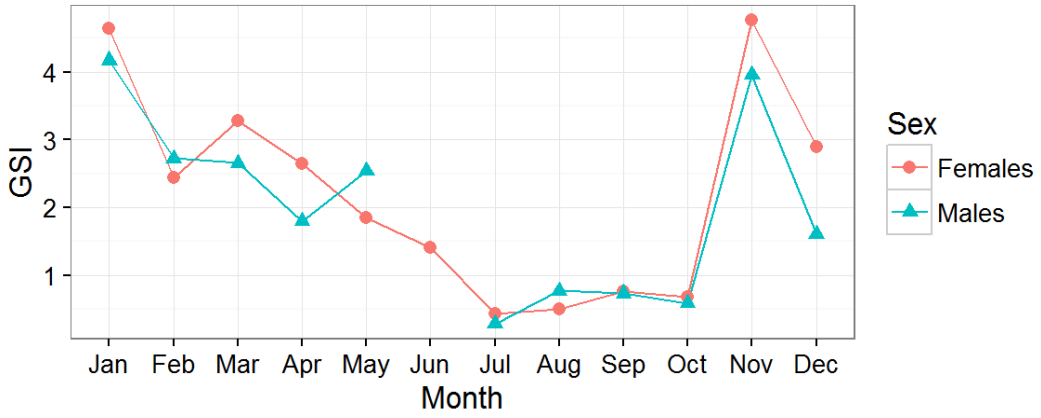


Figure 37. Gonadosomatic index of European pilchard, by month and by sex

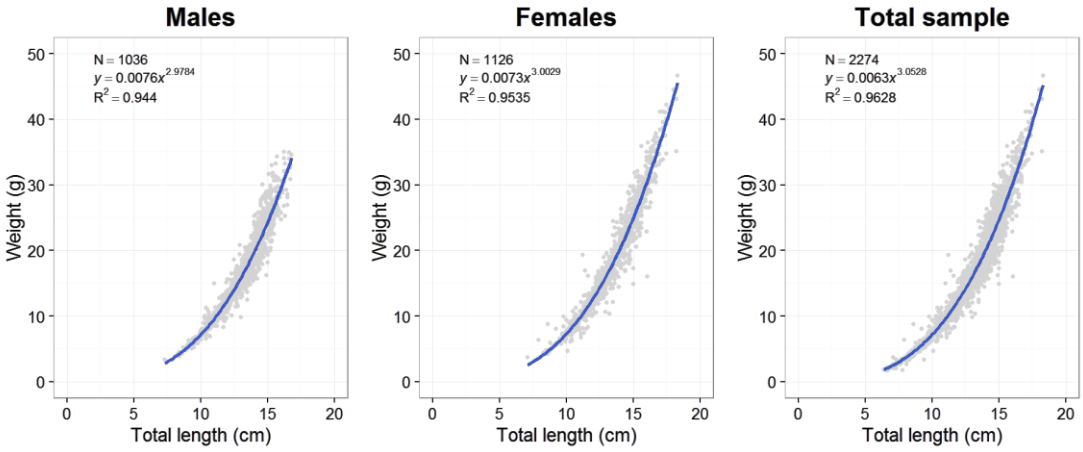


Figure 38. Length-weight relationship for males, females and for total sample of European pilchard

5.2.7. Bogue (*Boops boops*)

During the sampling period (2008–2011, non-continuous), a total of 2428 individuals of bogue were sampled. Minimum and maximum length for the entire sample were 9.0 and 33.3 cm total length (TL) (average of 16.0 ± 2.7 cm TL), and the extremes of the weight range were 6.0 and 423.0 g, with an average of 40.1 ± 20.9 g.

Length and total weight (TW) of males were within 9.9–33.3 cm TL and 6.0–423.0 g TW ranges, with averages estimated at 15.9 ± 2.7$ cm TL and 39.2 ± 23.3 g TW, respectively. Female minimum length was 10.0 cm TL, and maximum 29.9 cm TL, with an average of 16.1 ± 2.7 cm TL. Weight was in 9.3–156.3 g TW range, with a mean value of 40.9 ± 19.4 g TW.

In trawl landings, in 1st trimester 2009/10, the mode was between 13 and 16 cm TL, between 17 and 19 cm TL in 2nd trimester, and between 16 and 19 cm TL in 3rd. In 2010/11, it was at 16–18 cm TL in 1st trimester, 15–17 cm TL in 2nd, and 15–19 in 3rd trimester. In gillnet landings, the mode was between 17 and 19 cm TL in 2009/10, and at 13–15 cm TL and 17–19 cm TL in 2010/11. In beach seine landings, the mode was between 16 and 19 cm TL in 2009/10, and at 12–14 cm TL and 17–19 cm TL in 2010/11. In 2007/08, the modes were between 11 and 14 cm TL and between 16 and 18 cm TL in 1st trimester, between 12 and 14 cm TL in 2nd, and between 13 and 15 cm TL in 3rd.

The greatest abundance of bogue in landings was in April in 2007/08, and in March for both 2009/10 and 2010/11 sampling periods.

Figure 39 gives length frequency distributions of bogue trawl catches for 2009/10 and 2010/11 sampling periods, by trimester, raised to the trimester. Figure 40 gives length frequency in gillnets and beach seine bogue samples for the two sampling periods. Due to the limited samples from gillnets and beach seines and the lack of catch data for small-scale fisheries, it was not possible to raise those samples to the trimester, or even to the total catch. They are presented as a total sample. Figure 41 gives length frequency distributions of bogue in 2007/08 sampling period. In 2007/08 no records were made regarding fishing gear the sample was taken from. Therefore, no raising was possible, and the total sample is presented on the chart.

Out of the total 2428 individuals, 1405 (58%) were female, 956 (39%) were male, and 67 (3%) were unsexed. Sex ratio by sampling period is given in table Table 35.

At length frequencies up to and including 13 cm TL males were more dominant in the samples, and at lengths above 13 cm females become more dominant (Figure 42).

Individuals in gonad maturity stage 2 were the most dominant in the sample (55% of males, 70% of females), followed by those in stage 3 (28% of males, 20% of females) (Table 36).

Length at first maturity was estimated at 15.0 cm TL for the total sample, and at 14.9 cm TL for females and 14.3 cm TL for males (Figure 43).

Gonadosomatic index for both males and females peaked in February ($GSI_{♂}$ = 4.17$, $GSI_{♀}$ = 4.07$) with a gradual drop afterwards (Figure 44).

Exponent *b* of the length-weight relationship was consistently lower than 3, for the total sample (2.6797) females (2.6903), and males (2.6541) (Figure 45).

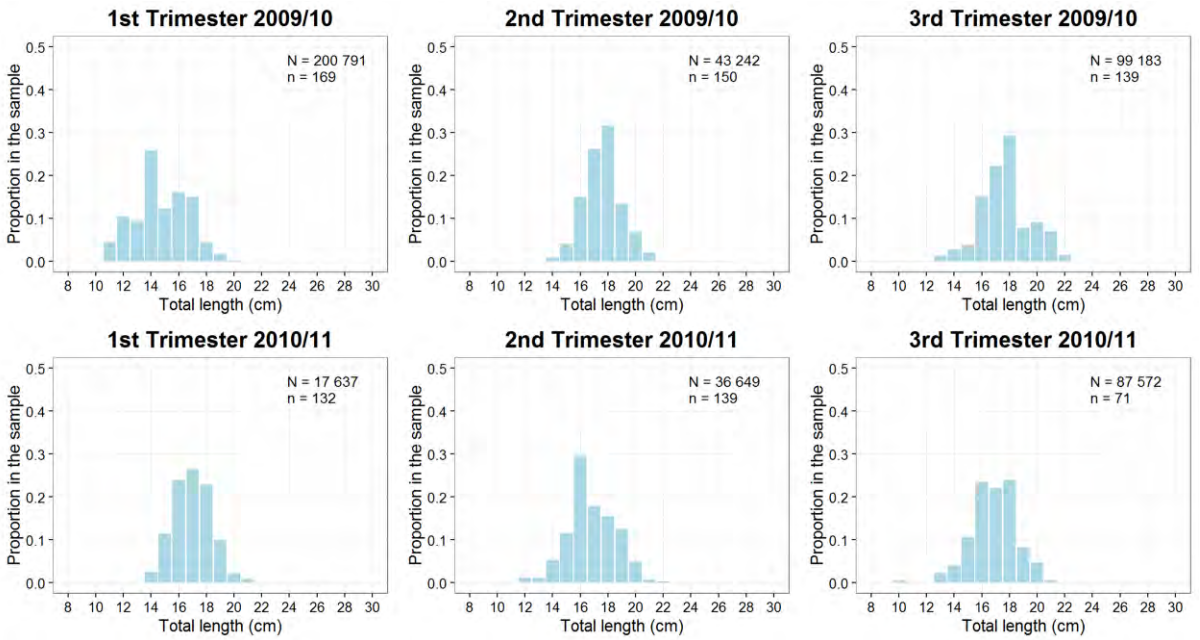


Figure 39. Length frequency distributions of bogue in trawl landing in 2009/10 and 2010/11 sampling period, by trimester (n – number of specimens in the sample, N – number of specimens raised to the trimester)

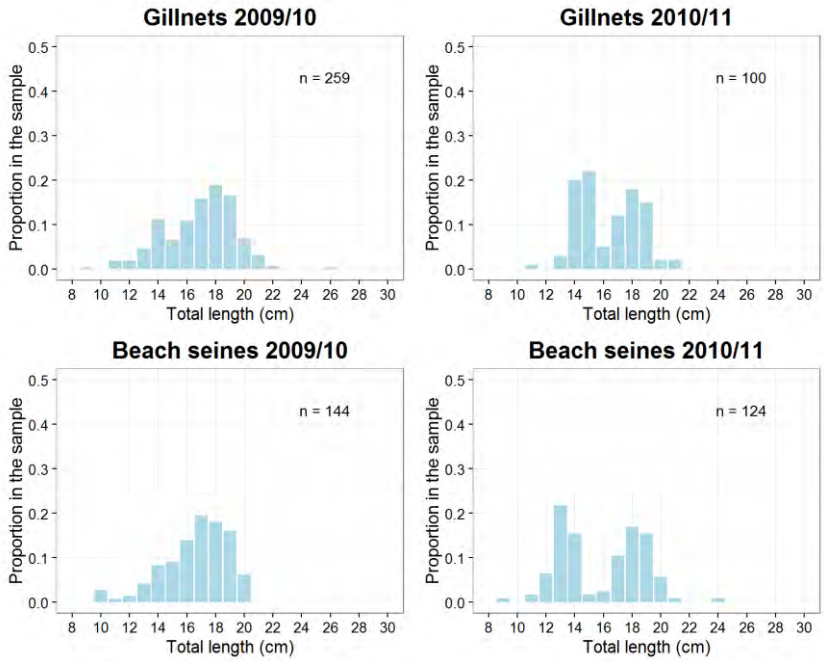


Figure 40. Length frequency distributions of bogue in gillnet and beach seine catches, for 2009/10 and 2010/11 ampling periods (n – number of individuals in the sample)

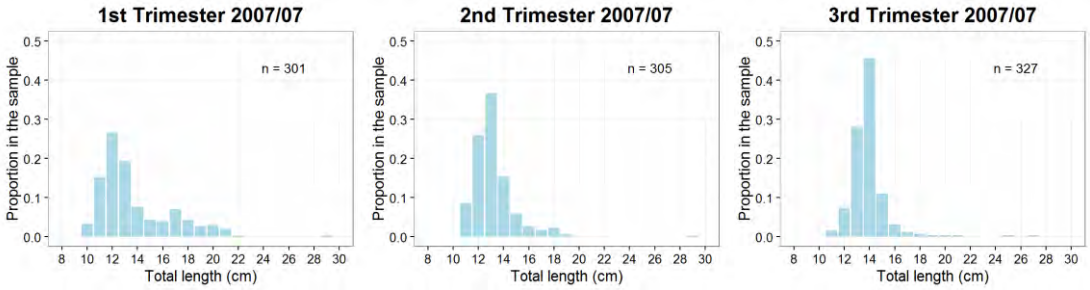


Figure 41. Length frequency distribution of bogue in landings for 2007/08 sampling period, by trimester (n – number of individuals in the sample)

Table 35. Bogue sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	57%	42%	1%
2009/10	57%	38%	5%
2010/11	60%	37%	3%

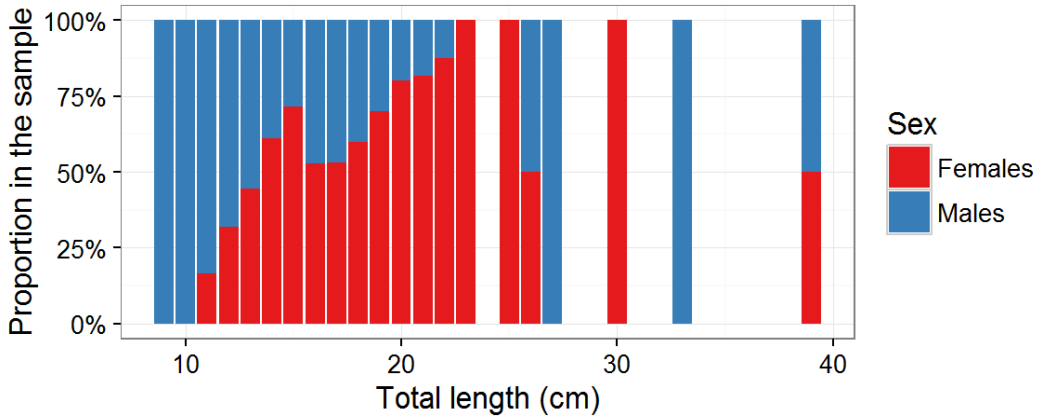


Figure 42. Sex ratio by length in the Montenegrin commercial catch of *B. boops*

Table 36. Bogue gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	151	16%	9.9	19.9	134	10%	10.0	29.2
2	513	55%	10.6	27.9	975	70%	10.5	29.9
3	263	28%	11.2	39.8	280	20%	11.7	38.9
4	8	1%	13.6	20.1	6	0%	13.7	20.5
Total	935	100%				100%		

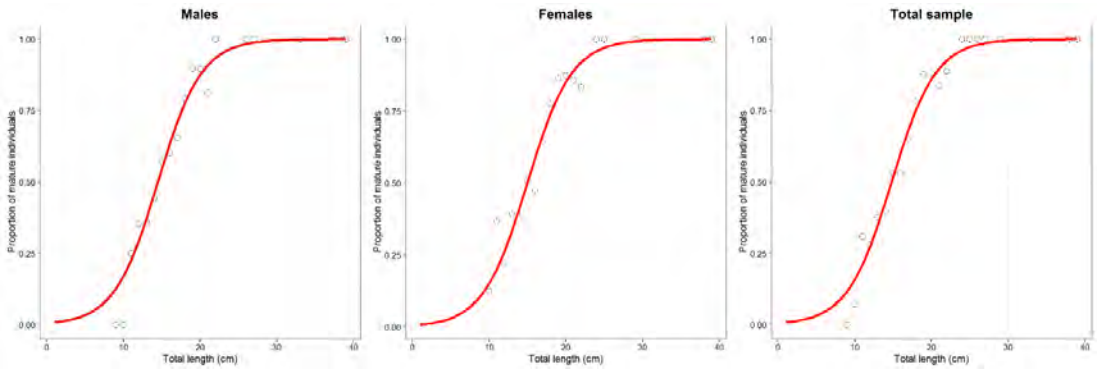


Figure 43. Maturity ogives for bogue males, females, and both sexes together

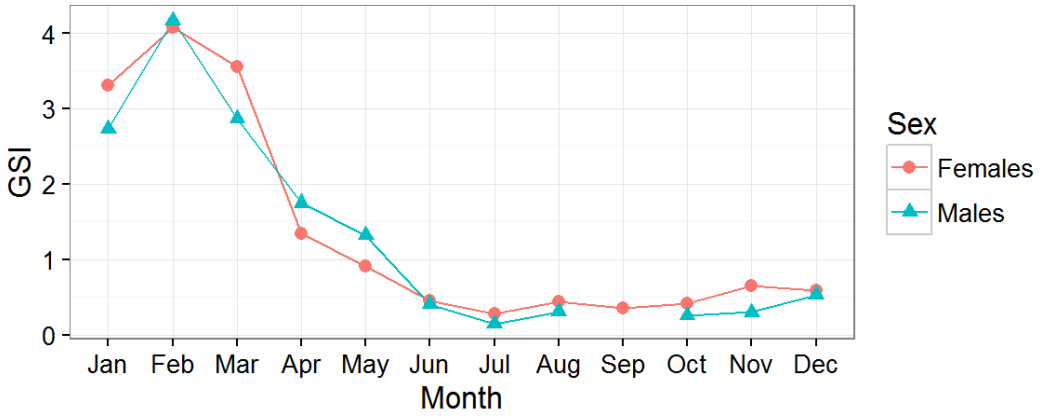


Figure 44. Gonadosomatic index of bogue, by month and sex

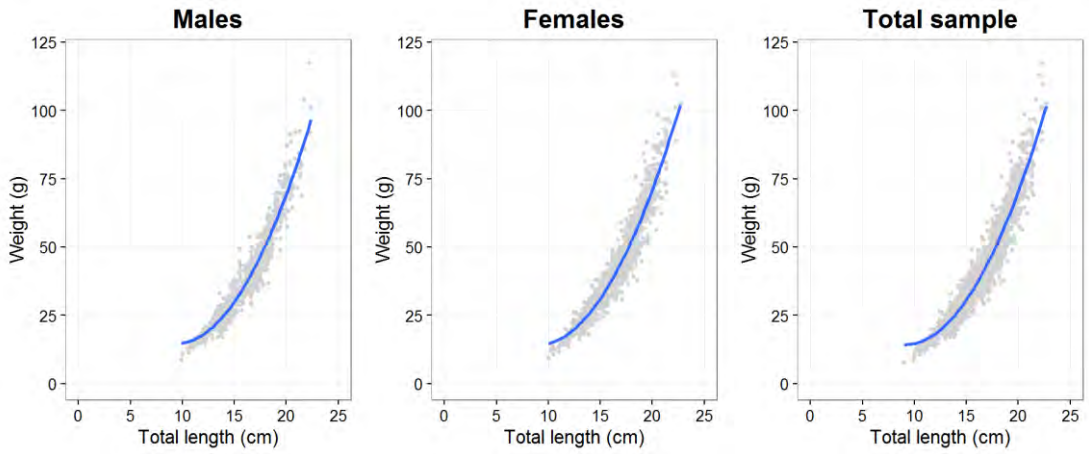


Figure 45. Length-weight relationship for males, females and for total sample

5.2.8. Blackbellied angler (*Lophius budegassa*)

During the entire sampling period (2008–2011, non-continuous), a total of 190 specimens of blackbellied angler were sampled. The average total length (TL) of the specimen was estimated at 29.1 ± 7.2 cm TL (min. 16.2 cm TL, max. 56.5 cm TL), while the average total weight (TW) was 413.0 ± 333.6 g TW (min. 57.1 g TW, max. 2200.0 g TW). Females ranged from 18.9 to 56.6 cm TL (average of 31.9 ± 8.6 cm TL), while males ranged from 16.2 to 48.4 cm TL (average of 27.8 ± 6.0 cm TL). Weight of females was in the 117.2–2200.0 g TW range (average of 537.1 ± 440.4 g TW), while the males were somewhat lighter (54.2–1792.0 g TW, average of 355.7 ± 252.7 g TW).

The underrepresentation of certain length categories in the length frequency distribution makes the determination of modes for blackbellied angler difficult, but a mode between 22 and 28 cm TL is readily apparent.

Blackbellied angler had the greatest abundance in landings in September in 2007/08 and 2009/10, and in March on the 2010/11 sampling period.

Length frequency distribution of the blackbellied angler is shown in Figure 46. Due to the small number of specimens collected during each of the trimesters of the entire three-year sampling period, all samples, after raising to the trimester, were pooled and are presented in a single chart.

Of the 190 specimens in the total sample, 60 (32%) were females, 113 (59%) were males, and 17 (9%) were unsexed. Sex ratio by sampling period is presented in Table 36.

Table 36. Blackbellied angler sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	38%	62%	0%
2009/10	26%	71%	3%
2010/11	27%	51%	22%

The males were consistently dominant in the sample, except between 40 and 42 cm TL, where females outnumber the males approximately 4:1 (Figure 47).

Almost 90% of the blackbellied angler specimens were in gonad maturity stage 2 (88% males, 87% females), with 12% males and females in stage 1. There were no individuals in the spawning stage (stage 3) sampled, and only a single female in the post-spawning stage (stage 4) (Table 37).

Length at first maturity ($L_{50\%}$) was estimated at 25.72 cm TL for the total sample, and at 24.14 cm TL for males (Figure 48). Due to the low number of individuals in the sample, it was not possible to estimate length of first maturity for females.

The gonadosomatic index of blackbellied angler females reached its highest value in December (1.647). Unfortunately, it was not possible to calculate GSI for males for December, so no comparison between the two can be made. Males reach their GSI peak in January (0.622) (Table 38).

The exponent b of the length-weight relationship was lower than 3 ($b_{TOT} = 2.8630$, $b_{♂} = 2.9262$, $b_{♀} = 2.7450$), indicating a negative allometric growth (Figure 49).

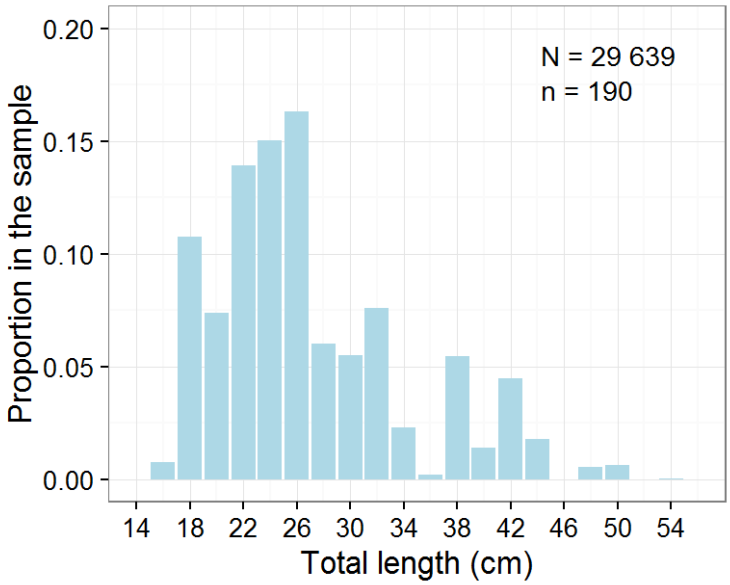


Figure 46. Length frequency distribution of the blackbellied angler for the entire sampling period (n – number of individuals in the sample, N – number of specimens raised to the total sampling period)

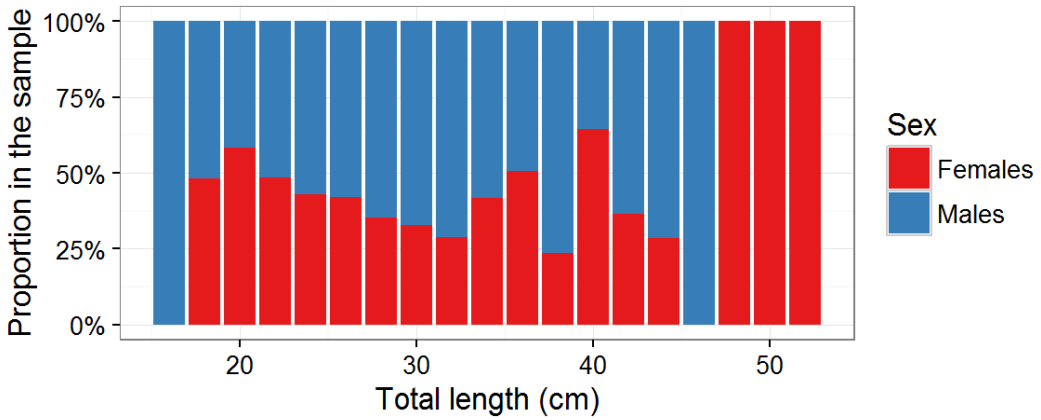


Figure 47. Sex ratio by length in the Montenegrin commercial catch of *L. budegassa*

Table 37. Blackbellied angler gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	13	12%	16.6	33.0	7	25%	18.9	37.4
2	98	88%	18.4	48.4	52	70%	21.0	56.5
3	0	0%	—	—	0	5%	—	—
4	0	0%	—	—	1	0%	55.0	55.0
Total	111	100%			60	100%		

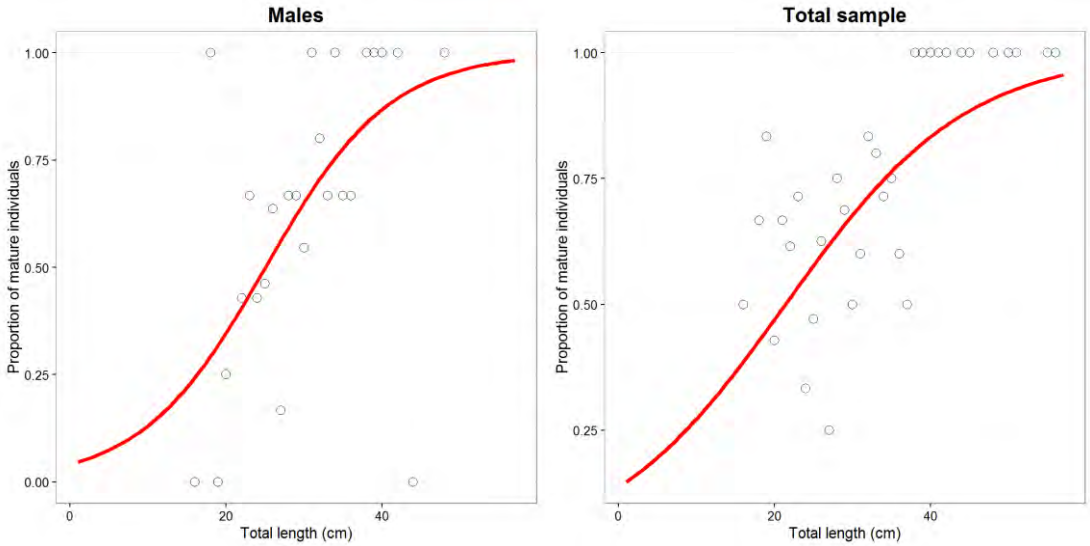


Figure 48. Maturity ogives for males and total sample of blackbellied angler

Table 38. Gonadosomatic index of blackbellied angler, by month and sex

Month	GSI	
	Females	Males
January	0.468	0.622
February	0.665	0.473
June	0.238	0.362
August	0.460	0.509
December	1.647	—

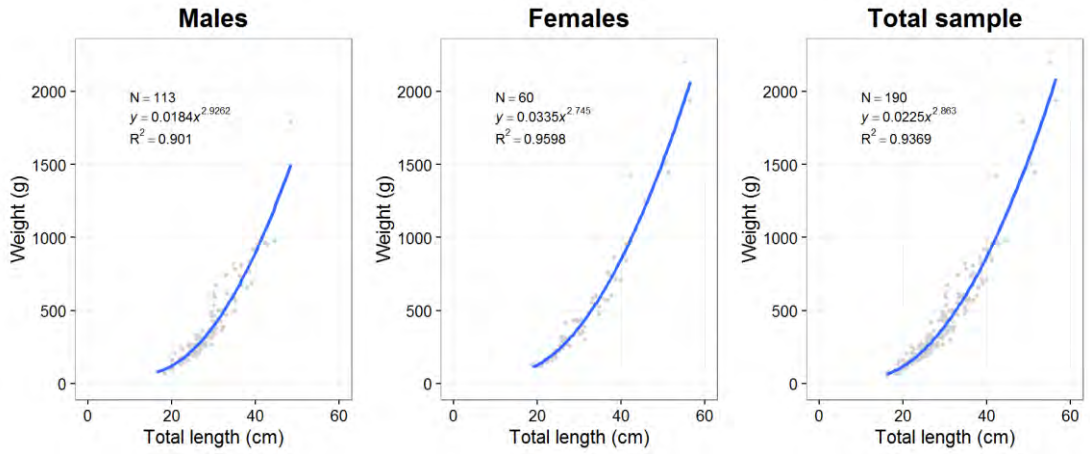


Figure 49. Length-weight relationship for blackbellied angler males, females, and total sample

5.2.9. Chub mackerel (*Scomber japonicus*)

During the two-year sampling period (2009–2011), a total of 303 specimens of chub mackerel were sampled. Chub mackerel had the greatest abundance in landings in March in the 2007/08 and 2010/11 sampling periods, and in September in 2009/10. The minimum total length (TL) recorded in the samples was 18.4 cm TL, while the maximum was 48.6 cm TL. Average length was calculated at 32.1 ± 6.0 cm TL. Minimum and maximum total weight (TW) were 38.3 g TW and 806.9 g TL, respectively, with an average of 336.3 ± 169.3$ g TW. Minimum and maximum length of females were identical to those of the total sample (18.4–48.6 cm TL), but the average was somewhat higher, 33.0 ± 6.1 cm TL. Minimum weight was 42.4 g TW, with maximum of 732.9 g TW, and an average of 364.8 ± 171.1 g TW. Male length ranged from 19.3 cm TL to 46.6 cm TL (average of 31.6 ± 5.7 cm TL), with weight from 47.1 g TW to 806.9 g TW (average of 322.2 ± 163.9).

Modes were between 19 and 21 cm TL, between 27 and 30 cm TL, and between 33 and 35 cm TL.

Due to the relatively small total sample of chub mackerel, and considering that the data on the fishing gear used is scarce and incomplete, no raising of the sample was performed. Length frequency distribution given on Figure 50 represent the entire sample.

Of the 303 specimens in the total sample, 119 (39%) were female, 181 (60%) were male, and only 3 (1%) were unsexed. Sex ratio by sampling period is given in Table 39.

Table 39. Chub mackerel sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2009/10	28%	72%	0%
2010/11	44%	54%	1%

Although males were more numerous in the sample overall, they are more dominant at lengths up to 33 cm TL. Females have significant presence at length over 33 cm TL (Figure 51).

The majority of males in the sample were in gonad maturity stage 3 (spawning stage; 55%), while the majority of females was in stage 2 (69%). No females of stage 1 were present in the sample (Table 40).

The length at first maturity ($L_{50\%}$) was estimated at 21.46 cm TL for the total sample, 21.81 cm TL for females, and at 21.70 cm TL for males (Figure 52).

The gonadosomatic index of both females and males peaked in July (Table 41), showing secondary peaks in March.

Length-weight relationship for the total sample, females and males showed a coefficient *b* higher than 3 (b_{TOT} = 3.5291, $b_{♂}$ = 3.5627, $b_{♀}$ = 3.4827) (Figure 53).

Table 40. Chub mackerel gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	5	19%	19.7	22.1	0	25%	—	—
2	59	76%	19.3	40.6	82	70%	18.4	48.6
3	99	5%	26.2	46.6	23	5%	29.0	41.0
4	18	0%	32.3	40.0	13	0%	28.4	39.0
Total	181	100%			118	100%		

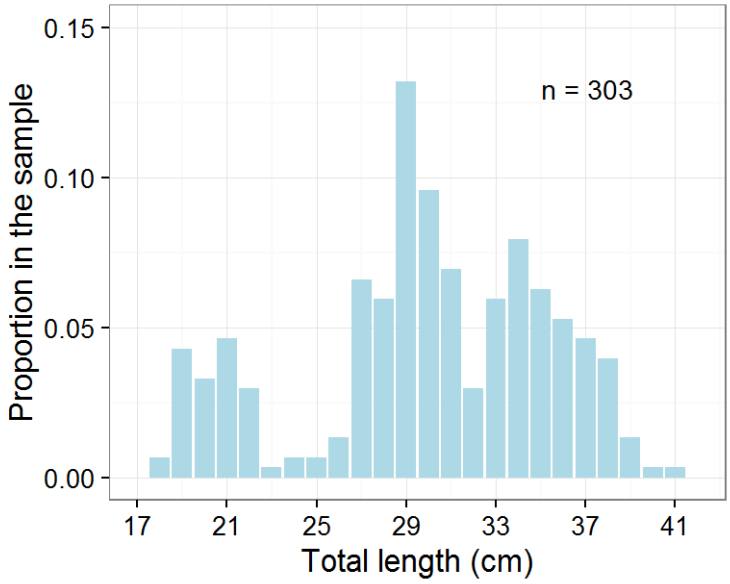


Figure 50. Length frequency distribution of chub mackerel for the entire sampling period (n – number of individuals in the sample)

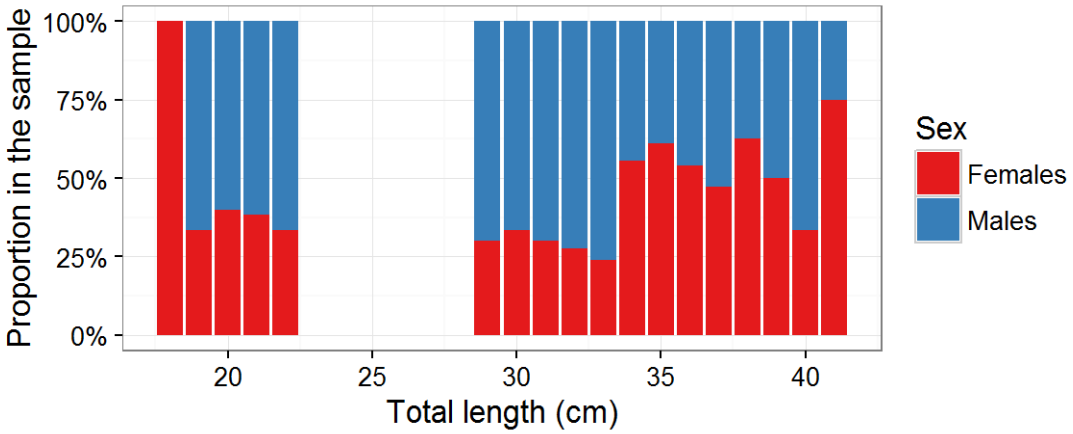


Figure 51. Sex ratio of chub mackerel in Montenegrin commercial catches, by length category and sex

Table 41. Gonadosomatic index of chub mackerel, by month and sex

Month	GSI	
	Females	Males
January	0.296	0.141
February	0.618	0.626
March	2.258	1.691
July	5.052	4.871
September	0.467	0.859
November	0.374	0.110

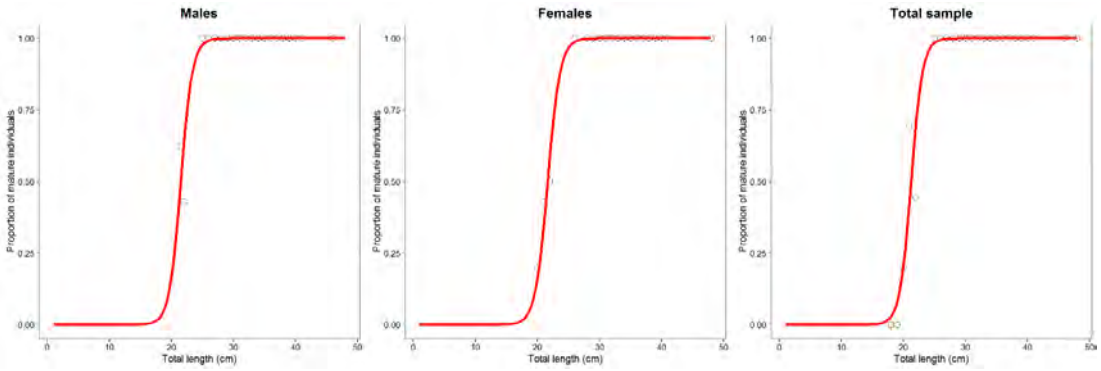


Figure 52. Maturity ogives for chub mackerel males, female sand total sample

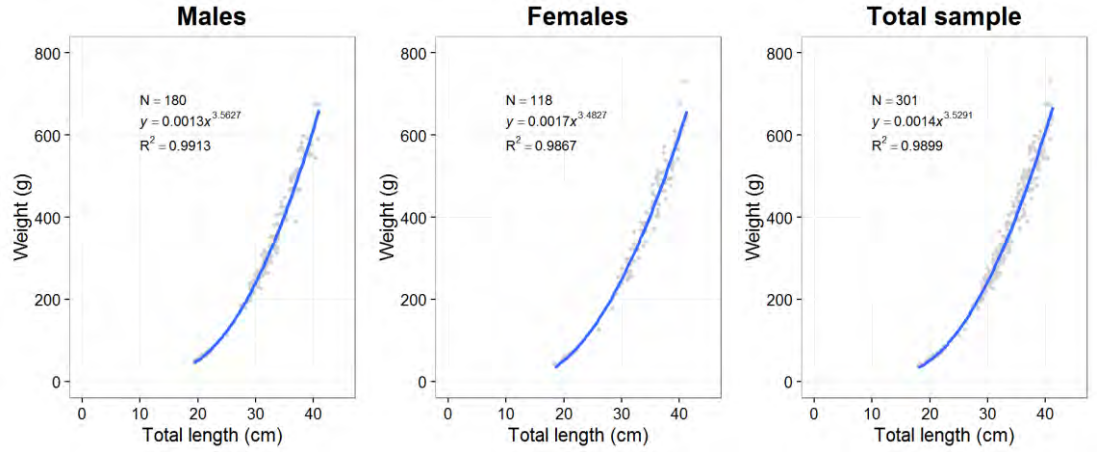


Figure 53. Length-weight relationship for chub mackerel males, females and total sample

5.2.10. Shortfin squid (*Illex coindetii*)

During the three-year sampling period (2008–2011, non-continuous), 768 individuals of shortfin squid were sampled. The greatest abundance of shortfin squid in the landings was recorded in September of 2007/08 and 2010/11, and in May in the 2009/10 sampling period. Sample length ranged from 39 mm DML (dorsal mantle length) to 207 mm DML, with an average value of 108.8 ± 29.1 mm DML. Weight ranged from 2.69 g total weight (TW) to 271.73 (average of 53.1 ± 39.5 g TW). Females ranged from 72 mm DML to 207 mm DML (average 118.6 ± 30.4 mm DML), while the length of males had somewhat lower values (62–202 mm DML, average 117.2 ± 21.5 mm DML). Average weight for females was 61.3 ± 3.0 g TW (min. 10.48 g TW, max. 271.7 g TW). Both the minimum recorded weight for males (11.2 g TW) and the average male weight (63.4 ± 31.5 g TW) were somewhat higher than the corresponding female values, but the maximum weight was considerably lower (184.35 g TW).

Figure 54 gives the length frequency distribution of shortfin squid according to trimester and sampling period. Second trimesters of both sampling periods 2009/10 and 2010/11 are missing either due to the lack of samples in that period, or due to a very small sample (3 specimens).

Of the 768 sampled individuals, 360 (47%) were male, 239 (31%) were female, and 169 (22%) were unsexed. The breakdown of sex ratio by sampling period is given in Table 42.

Table 42. Shortfin squid sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	38%	52%	9%
2009/10	23%	48%	29%
2010/11	31%	31%	38%

Generally, females are more dominant in the sample until about 100 mm DML, and again starting at about 140 mm DML (Figure 55).

The major part of the specimens in the sample were in maturity stage 2 (maturing/mature) (50% of males, 48% of females), followed by stage 1 (immature) (23% of males, 30% of females). Nevertheless, a significant amount of specimens was in the spawning stage (stage 3) (20% of males, 23% of females) (Table 43).

The length at first maturity ($L_{50\%}$) was estimated at 121.8 mm DML for both the total sample and for females, and at 120.8 mm DML for males (Figure 56).

Females had their gonadosomatic index peaking in July, while the GSI of males peaked a month earlier, in June (Table 44).

The *b* coefficient of the length-weight relationship was consistently lower than 3 for total sample ($b_{TOT} = 2.8194$), females ($b_{♀} = 2.8373$\$), and males ($b_{♀} = 2.8709$) (Figure 57).

Table 43. Shortfin squid gonad maturity stages by sex

Maturity stage	Males				Females			
	No.	%	ML		No.	%	ML	
			min	max			min	max
1	81	19%	62	134	70	25%	72	152
2	208	76%	8	182	113	70%	72	207
3	71	5%	105	202	54	5%	116	183
Total	360	100%			237	100%		

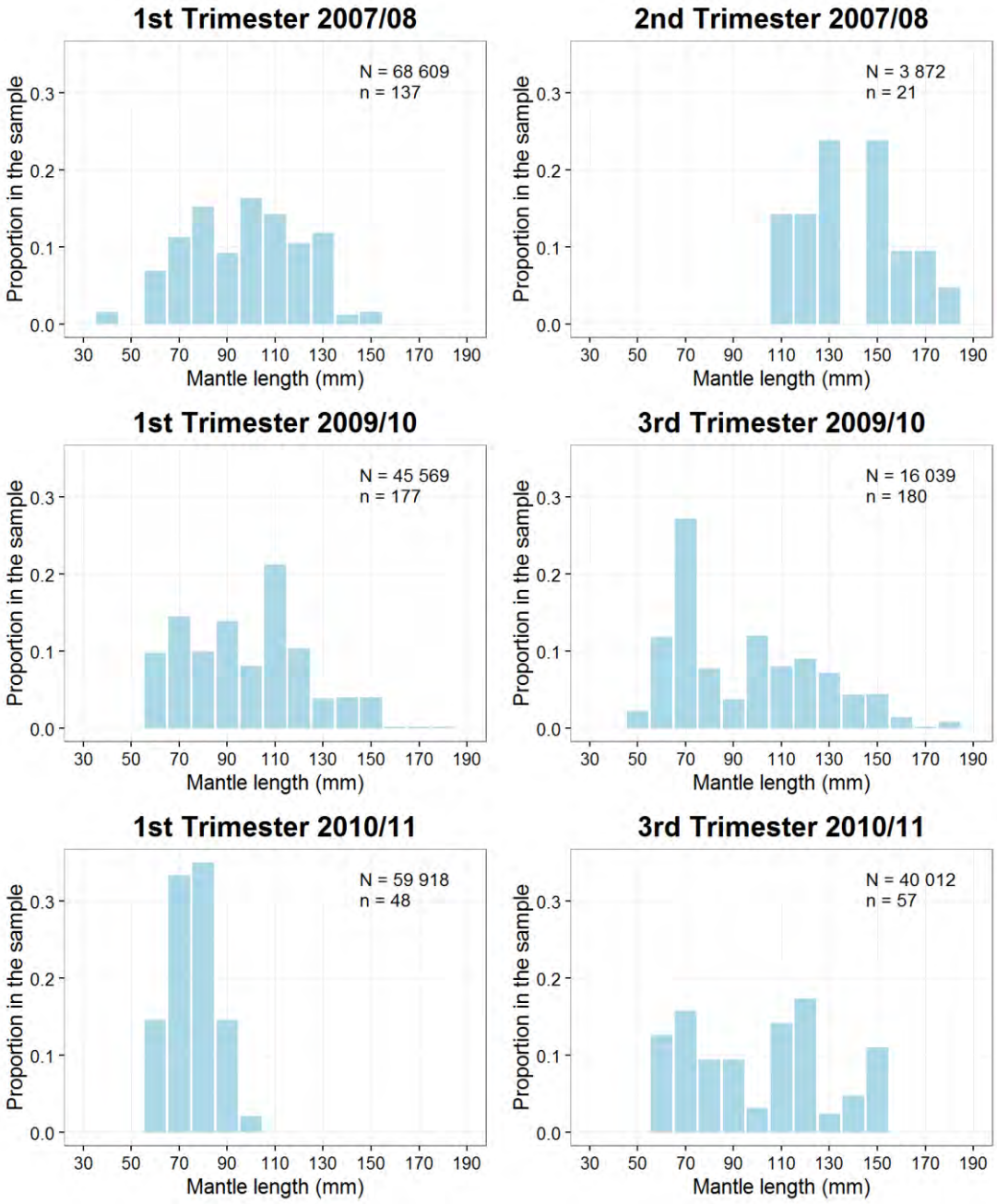


Figure 54. Length frequency distribution of shortfin squid, by trimester and sampling period (n – number of specimens in the sample, N – number of specimens raised to the trimester)

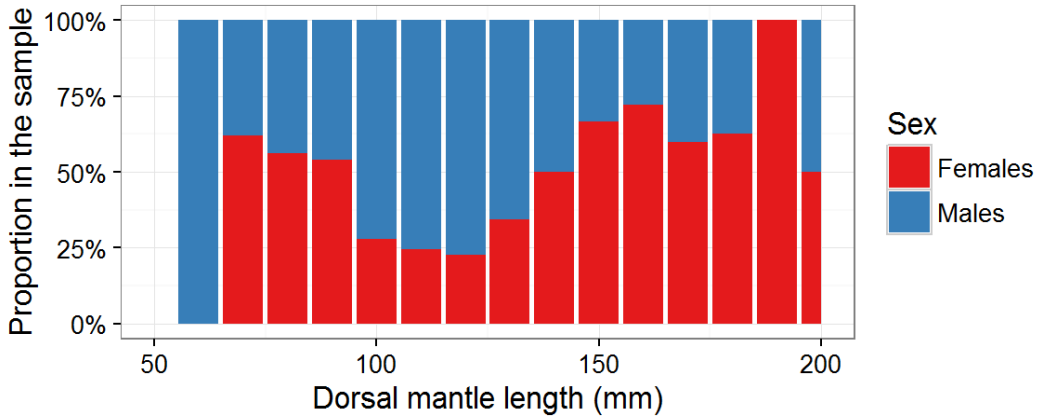


Figure 55. Sex ratio by length for the Montenegrin catch of *I. coindetii*

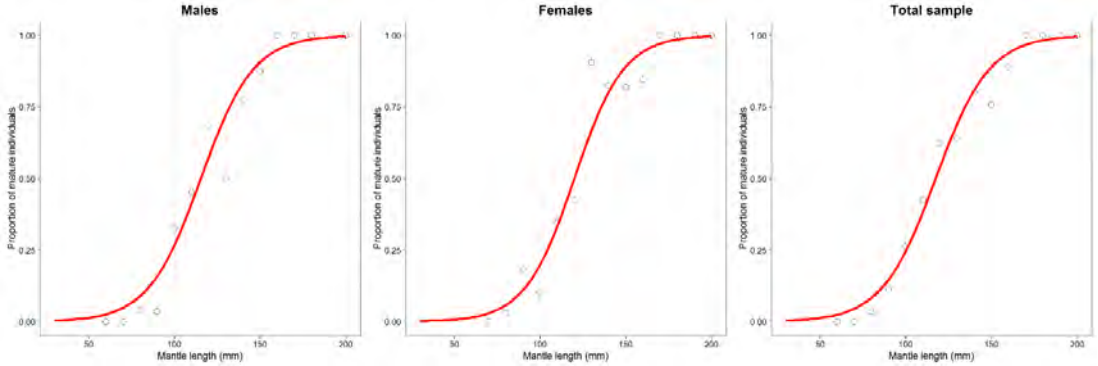


Figure 56. Maturity ogives for shortfin squid total males, females and total sample

Table 44. Gonadosmatic index of shortfin squid, by month and sex

Month	GSI	
	Females	Males
January	6.434	3.606
February	6.683	1.250
June	5.206	5.105
July	8.802	4.956
August	6.419	2.746
September	5.466	2.528
December	5.737	5.301

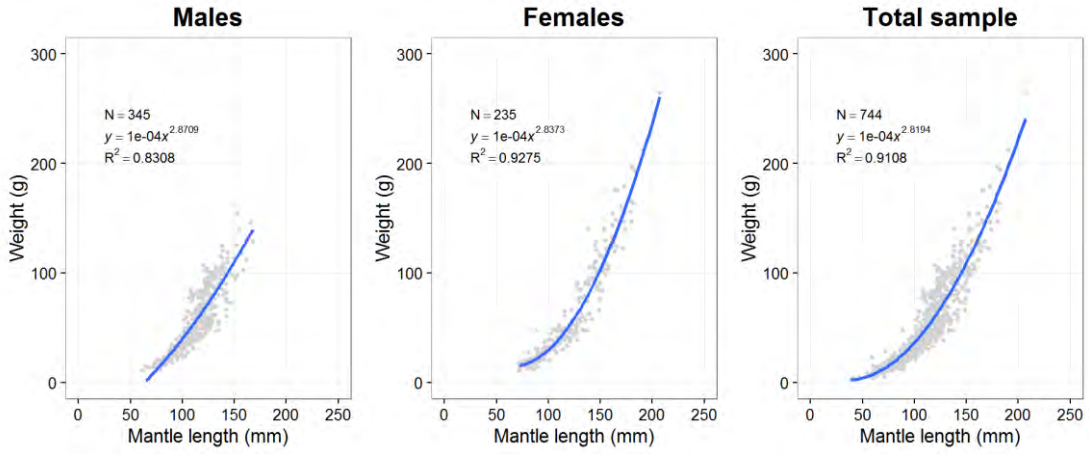


Figure 57. Length-weight relationship of shortfin squid males, females and total sample (N – number of individuals in the sample)

5.2.11. Atlantic bonito (*Sarda sarda*)

A total of 81 specimen of the Atlantic bonito were sampled in the three–year sampling period (2008–2011, non-continuous). The average length of the specimen in the sample was 46.5 ± 5.3$ cm total length (TL), while the length range was 40.0–63.9 cm TL. Weight ranged from 615.4–2913.3 g total weight (TW), with an average of 1049.3 ± 483.8 g TW. Male length was from 41.5–55.5 cm TL (average of 45.7 ± 5.0 cm TL), with weight ranging from 626.3–1848.5 g TW (average of 1001.7 ± 465.4$ g TW). Females were both longer (40.0–63.9 cm TL; average 46.7 ± 5.3 cm TL) and heavier (615.4–2913.3 g TW, average 1062.0 ± 491.4 g TW). One mode was identified, between 42 and 44 cm TL.

As there was a small number of individuals of Atlantic bonito, no raising was done. Instead, Figure 58 gives proportion by length category in the total sample.

Of the 81 specimens in the sample, 63 (78%) were female, 17 (21%) were male, and just 1 was of undetermined sex. Table 45 gives sex ratio by sampling period.

Females were generally more numerous in all length categories. Table 46 gives sex ratio for those length classes where males were present.

Individuals in gonad maturity stage 2 (maturing/mature) dominated the sample, both for males (88% of all males in the sample) and for females (84%). No individuals in stage 3 (spawning) or stage 4 (post-spawners) were present in the samples. Atlantic bonito maturity stages by sex are shown in Table 47.

Table 45. Atlantic bonito sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	92%	8%	0%
2009/10	72%	24%	4%
2010/11	71%	29%	0%

The gonadosomatic index (GSI) of both males and females was higher in January than in March (Table 48). However, since there is no data for the other months, no conclusions can be drawn from this information.

The *b* coefficients of both males (3.7158) and females (3.4249), as well as that of the total sample (3.4542) were higher than 3 (Figure 59). The validity of data for males is somewhat questionable.

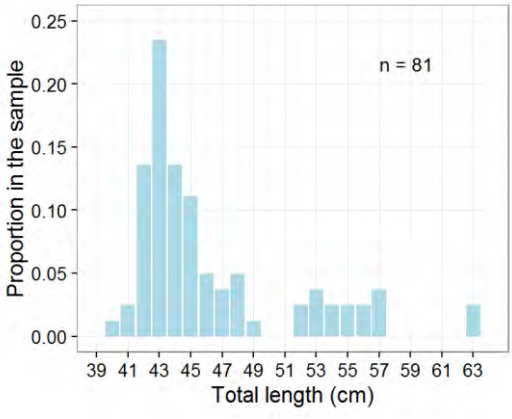


Figure 58. Length frequency distribution of Atlantic bonito total sample (n – number of specimens in the sample)

Table 46. Atlantic bonito sex ratio by length class

TL	Females	Males
42	82%	18%
43	63%	37%
44	82%	18%
53	67%	33%
55	50%	50%

Table 47. Atlantic bonito maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	2	12%	43.0	43.5	10	16%	42.0	48.5
2	15	88%	41.5	55.5	53	84%	40.0	63.9
Total	17	100%			63	100%		

Table 48. Gonadosomatic index of Atlantic bonito, by month and sex

Month	GSI	
	Females	Males
January	0.903	0.116
March	0.542	0.105

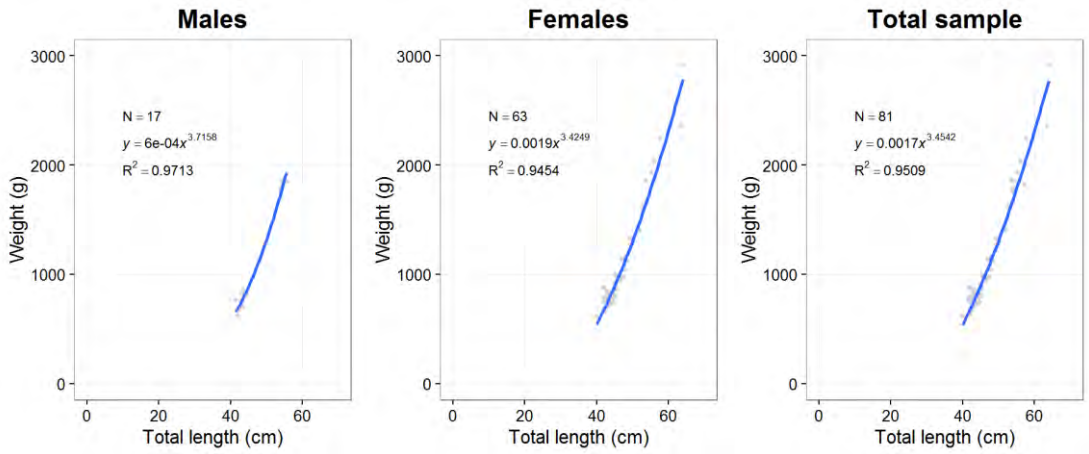


Figure 59. Length-weight relationship for Atlantic bonito males, females, and total sample (N – number of individuals in the sample)

5.2.12. Common pandora (*Pagellus erythrinus*)

A total of 258 individuals of common pandora were sampled during the two-year sampling period (2009–2011). The greatest abundance of common Pandora in the landings was recorded in November in 2007/08, September in 2009/10, and in March in 2010/11 sampling periods. Average length of the sampled individuals was 17.8 ± 3.0 cm total length (TL) (11.6–36.0 cm TL), while the average total weight (TW) was 73.7 ± 49.7 g TW (24.0–529.3 g TW). Length range of females was from 11.6 cm TL to 28.1 cm TL, with an average of 17.8 ± 2.5 cm TL, while males ranged from 11.8–36.0 cm TL, and had an average of 17.8 ± 3.9 cm TL. Average weight of females was 71.8 ± 33.8 g TW (24.0–270.1 g TW), while that of males was 77.7 ± 72.8 g TW (24.2–529.3 g TW). In 2009/10, two modes were identified, between 14 and 17 cm TL, and between 19 and 21 cm TL. In 2010/11, modes were between 14 and 16 cm TL, and again between 19 and 21 cm TL.

The number of individuals in the sample, as well as the sampling dynamic made raising of the sample to trimester or sampling period awkward. Therefore, length frequency distribution data are presented pooled by the sampling period (Figure 60).

Out of the total 258 individuals in the sample, 175 (68%) were female, 83 (32%) were male. There were no unsexed individuals in the samples. Table 49 shows sex ratio by sampling period.

Table 49. Common pandora sex ratio by sampling period

Sampling period	Females	Males
2009/10	57%	43%
2010/11	87%	13%

Females were more dominant at all length classes below 22 cm TL (Figure 43). At length of 22 cm TL and above, males were almost absolutely dominant, but this should not be considered indicative due to the small number of specimens of those length categories in the sample. They are therefore not represented in Figure 61.

Most of the specimens in the sample were in gonad maturity stage 2 (maturing/mature), 83% of females and 96% of males. No males in the post-spawning stage (stage 4) were present in the sample (Table 50).

Length at first maturity for common pandora total sample was estimated at 15.8 cm TL and for males at 18.7 cm TL (Figure 62). Due to the lack of data, it was not possible to estimate length at first maturity for females.

Table 51 shows that the highest values of the gonadosomatic index (GSI) for both sexes were reached in April.

The *b* coefficient of the length-weight relationship of common pandora was slightly below 3 (b_{TOT} = 2.9356, $b_{♀}$ = 2.9345, $b_{♂}$ = 2.9293) (Figure 63).

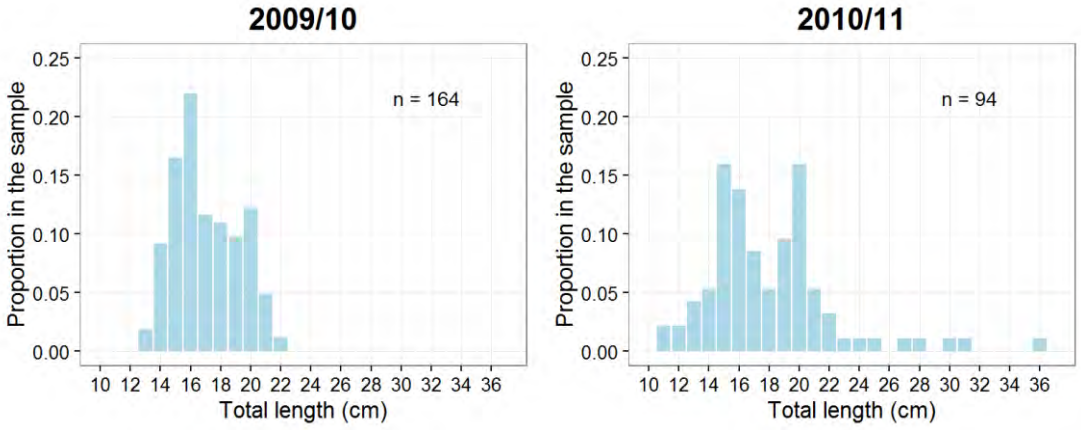


Figure 60. Length frequency distribution of the common pandora, by sampling period (n – number of specimens in the sample)

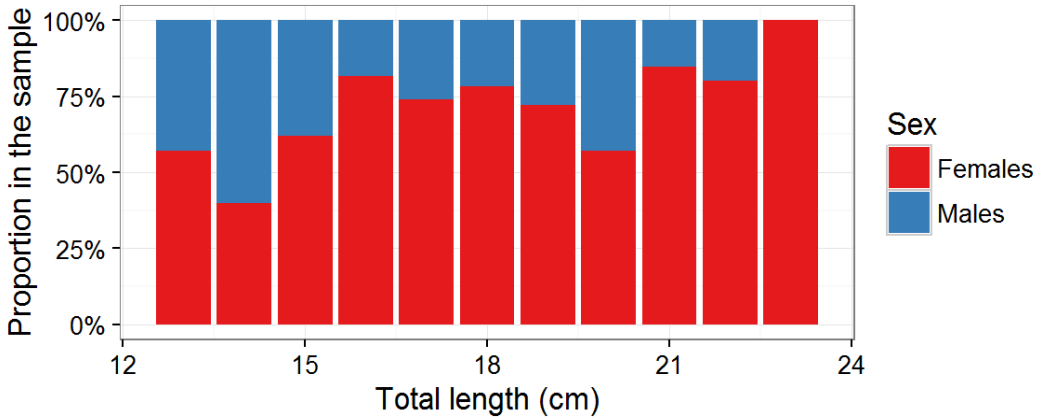


Figure 61. Sex ratio by length in the Montenegrin catch of *P. erythrinus*

Table 50. Common pandora maturity stages by sex

Maturity stage	Males				Females			
	No.	%	TL		No.	%	TL	
			min	max			min	max
1	1	1%	11.8	11.8	—	—	—	—
2	80	96%	12.9	36.0	145	83%	11.6	28.1
3	2	2%	18	18.4	25	14%	15.4	18.9
4	—	—	—	—	5	3%	14.2	17.6
Total	83	100%			175	100%		

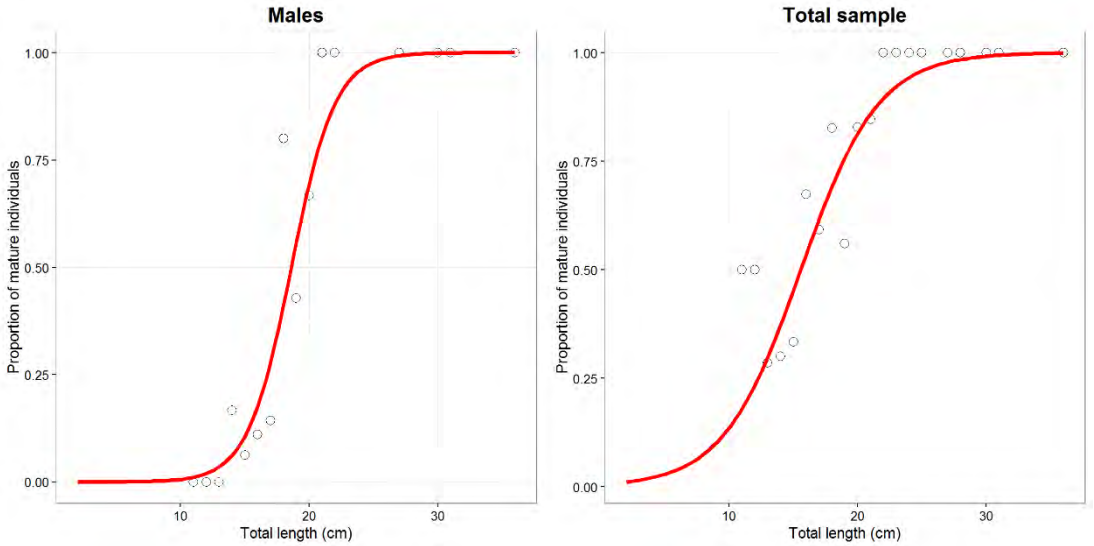


Figure 62. Maturity ogives for common pandora males and total sample

Table 51. Gonadosmatic index of common pandora, by month and sex

Month	GSI	
	Females	Males
January	0.737	—
February	0.547	0.506
March	0.778	0.340
April	2.037	0.953
October	0.192	0.154

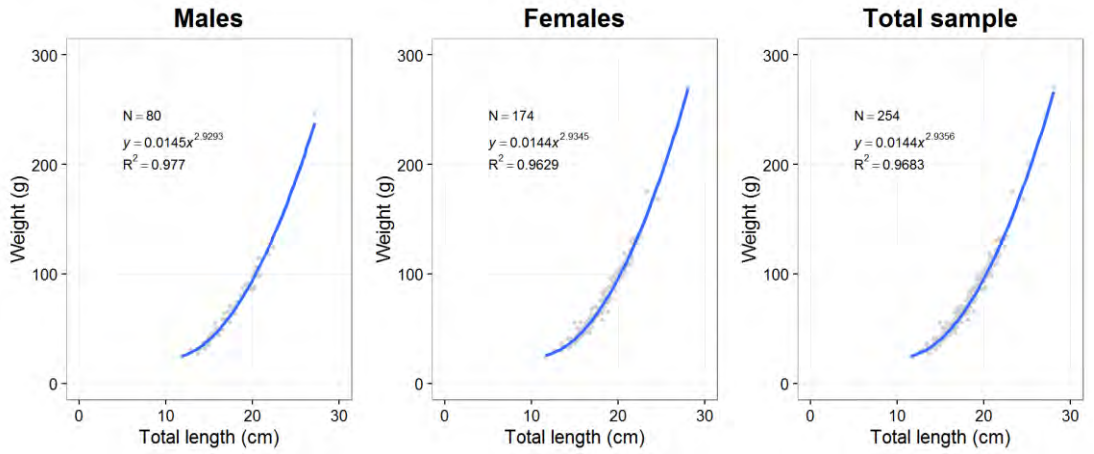


Figure 63. Length-weight relationship for common pandora males, females and total sample (N – number of individuals in the sample)

5.2.14. European squid (*Loligo vulgaris*)

A total of 472 specimens of European squid were sampled during the three-year sampling period (2008–2011, non-continuous). The greatest abundance of the European squid in landings was recorded in September in 2007/08 and 2009/10, and in October in 2010/11 sampling period. Length of the sampled specimens ranged from 30 mm dorsal mantle length (DML) to 191 mm DML, with an average of 92 ± 31 mm DML. Total weight (TW) of specimens in the sample was from 1.55 g TW to 260.00 g TW (average of 41.9 ± 38.8 g TW). Females were from 38 to 185 mm DML in length (avg. 103 ± 41 mm DML), and from 2.8 to 260.0 g TW in weight (average of 66.4 ± 62.6 g TW). Length of males had a minimum at 20 mm DML, and a maximum at 191 mm DML, with an average of 90 ± 29 mm DML. Weight ranged from 1.5 g TW to 240.0 g TW (average of 37.4 ± 30.6 g TW).

One mode was identified in 1st trimester 2007/08, between 80 and 110 mm DML. In 1st trimester 2009/10, the mode was between 80 and 100 mm DML, and in 2nd between 90 and 120 mm DML. In 2010/11, the mode was between 80 and 12 mm DML in 1st trimester, between 90 and 110 mm DML in 2nd trimester and between 80 and 100 mm DML in 3rd trimester.

Length frequency distribution of European squid by sampling period and trimester is shown in Figure 63.

Of the 472 specimens in the total sample, 266 (56%) were male, 74 (16%) were female, and 132 (28%) were unsexed. Sex ratio by sampling period is given in Table 53.

Table 53. European squid sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	24%	40%	36%
2009/10	10%	51%	39%
2010/11	11%	81%	8%

Males dominated in the entire sample, except at mantle lengths of 40 to 60 mm ML, where the male-to-female ratio was close to 1:1 (Figure 64).

The greatest number of European squid males in the sample was in gonad maturity stage 2 (53%), followed by maturity stage 1 (43%) and with only 5% in maturity stage 3, which is significantly different from females, who had the largest proportion of the sample in gonad maturity stage 1 (59%), followed by stage 3 (26%). Only 16% of the females were in gonad maturity stage 2 (Table 54).

Length at first maturity for females ($L_{♀50\%}$) was estimated at 129.9 mm DML (Figure 65). Due to some peculiarities in the sample, it was not possible to estimate the length at first maturity for males and, consequently, for the total sample.

The gonadosomatic index of European squid males and females reached its highest values in April, but temporal coverage is rather poor, as shown in Table 55.

The value of *b* coefficient of the length-weight relationship was below 3 for the total sample ($b_{TOT} = 2.7700$), females ($b_{♀} = 2.7738$) and males ($b_{♂} = 2.7387$) (Figure 66).

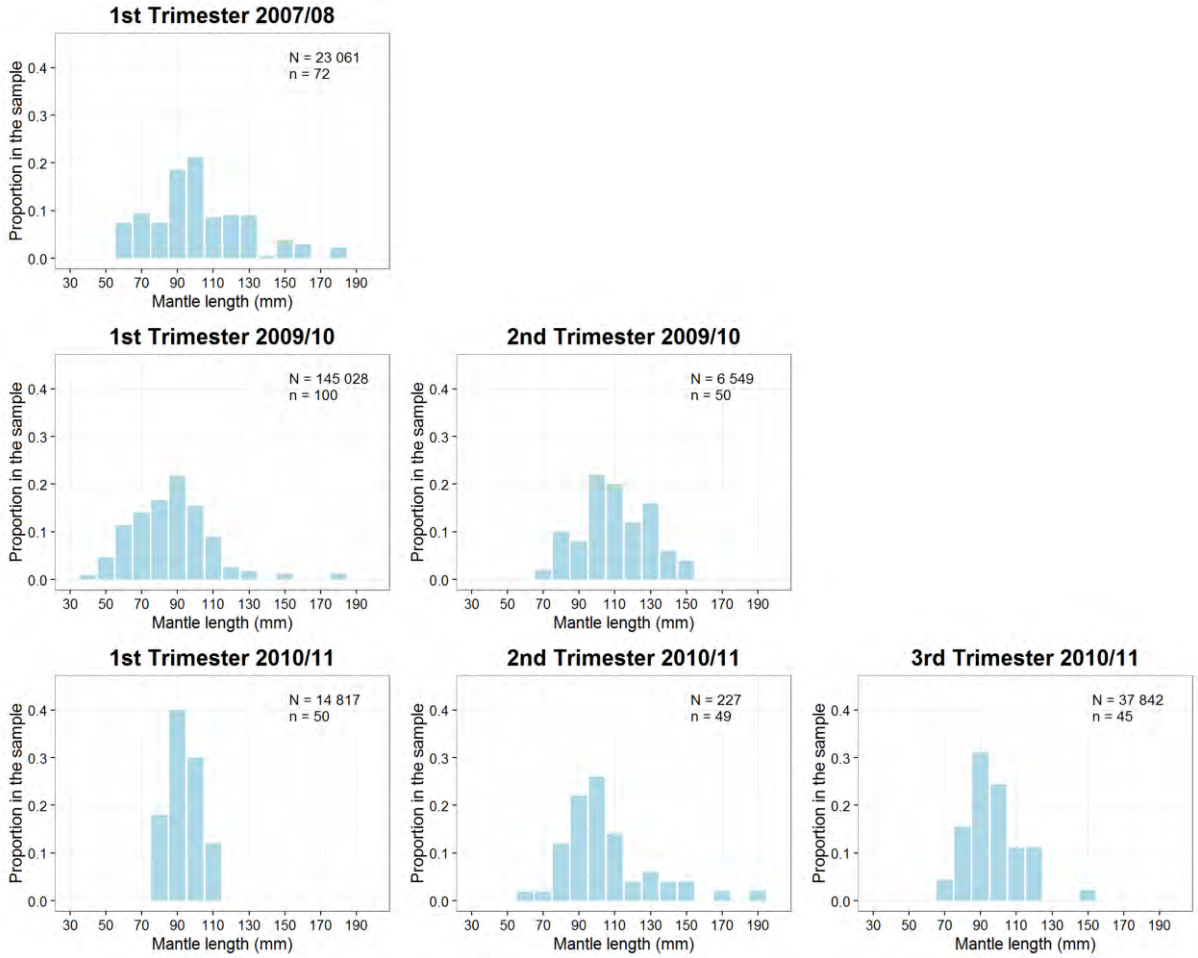


Figure 63. Length frequency distribution of European squid by trimester and sampling period (N – number of individuals raised to the trimester, n – number of individuals)

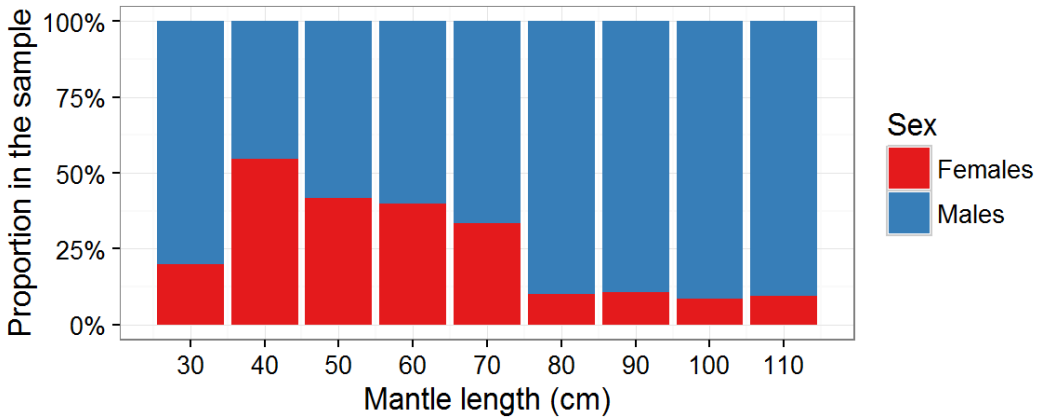


Figure 64. Sex ratio by length in the Montenegrin catch of *L. vulgaris*

Table 54. European squid maturity stages by sex

Maturity stage	Males				Females			
	No.	%	ML		No.	%	ML	
			min	max			min	max
1	108	43%	36	157	34	59%	38	132
2	134	53%	83	189	9	16%	87	154
3	12	5%	105	191	15	26%	119	185
Total	254	100%			58	100%		

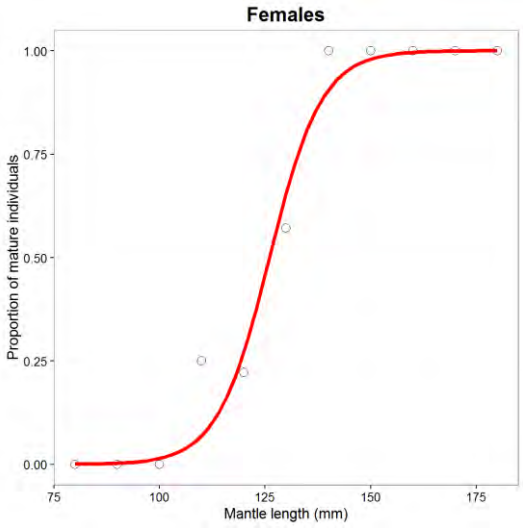


Figure 65. Maturity ogive for European squid females

Table 55. Gonadosomatic index of European squid, by month and sex

Month	GSI	
	Females	Males
February	7.331	4.752
April	9.427	5.930
August	—	0.957
September	—	—
October	—	2.523

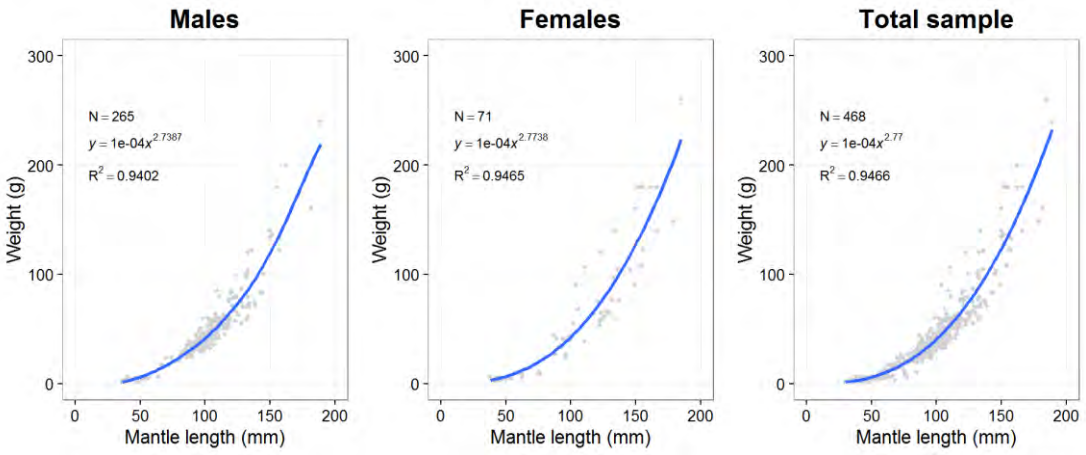


Figure 66. Length-weight relationship for European squid males, females, and total sample (N – number of individuals in the sample)

5.2.15. Musky octopus (*Eledone moschata*)

A total of 179 specimens of musky octopus were collected during the two-year sampling period (2009–2011). The greatest abundance of the musky octopus in landings was recorded in February in 2007/08 and 2010/11, and in March in 2009/10 sampling period. Minimum and maximum lateral mantle lengths (LML) were 43 and 112 mm DML, respectively, with an average at 69 ± 12$ mm LML. Average total weight (TW) was 144.6 ± 58.1 g TW (min. 33.6 g LML, max. 350.1 g LML). Female length was in the 53–112 mm LML range (average of 75 ± 12 mm LML). Female weight range was the same as for the total sample (33.6–350.1 g LML), but with a different average value, 177.1 ± 63.3$ g TW. Males were, on average, slightly smaller at 68 ± 10 mm LML (45–98 mm LML) and lighter (141 ± 48 g TW, min. 54.33 g, max. 271.96 g TW).

Modes were identified between 50 and 70 mm LML in 2009/10, and between 50 and 80 mm LML in 2010/11.

Length frequency distribution of musky octopus by sampling period is given in Figure 67. Due to small number of individuals sampled and the sampling dynamic, it was not possible to raise the sample to trimester while obtaining meaningful distributions.

Of the 179 specimens in the total sample, 51 (28%) were female, 167 (60%) were male, and 21 (12%) were unsexed. Sex ratio by sampling period is given in Table 56.

Table 56. Musky octopus sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2009/10	32%	54%	14%
2010/11	12%	85%	3%

Males were dominant at most sizes apart from the largest ones (100 mm LML and above). (Table 57).

Table 57. Musky octopus sex ratio by length class

LML	Females	Males
40	—	100%
50	19%	81%
60	24%	76%
70	40%	60%
80	50%	50%
90	33%	67%
100	100%	—
110	100%	—

A significant majority of males were reported in gonad maturity stage 2 (68%), while the females were almost equally divided between stages 2 and 3 (47% and 49%, respectively) (Table 58).

Length at first maturity was estimated for the total sample (L_{TOT}) at 71.13 mm LML (Figure 68). It was not possible to estimate lengths at first maturity for males and females separately.

The highest gonadosomatic inex (GSI) for females was recorded in September, while the males had their recorded in August. Unfortunately, there are no data for male GSI in September, and no data for females in August (Table 59).

Table 59. Gonadosomatic index of musky octopus, by month and sex

Month	GSI	
	Females	Males
February	—	1.925
April	3.743	1.854
June	1.980	5.765
August	6.989	—
September	—	9.630
October	—	4.307
December	6.866	—

The *b* coefficient for musky octopus was lower than 3, in all cases – total sample (b_{TOT} = 2.1971), females ($b_{♀}$ = 2.1271), males ($b_{♂}$ = 2.3182) (Figure 69).

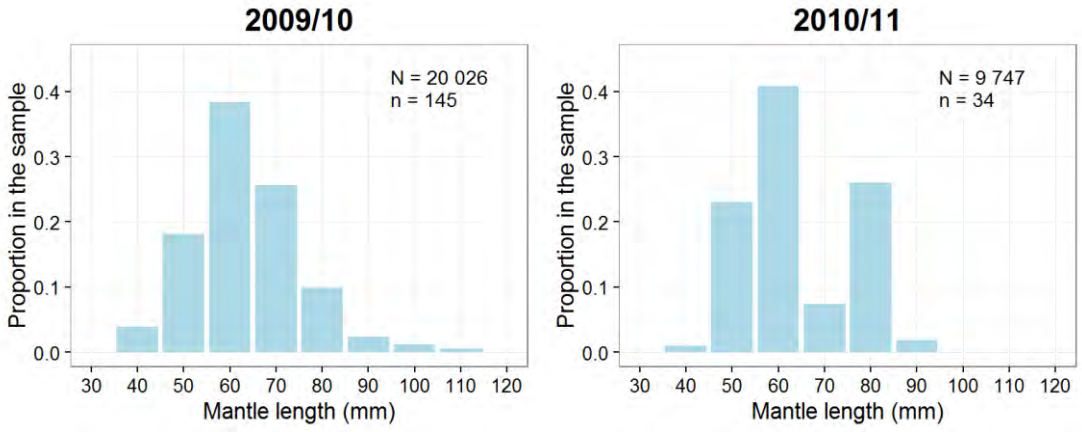


Figure 67. Length frequency distribution of musky octopus by sampling period (N – number of individuals raised to the sampling period, n – number of individuals in the sample)

Table 58. Musky octopus maturity stages by sex

Maturity stage	Males				Females			
	No.	%	ML		No.	%	ML	
			min	max			min	max
1	27	25%	53	72	2	4%	59	70
2	73	68%	45	98	24	47%	53	100
3	7	7%	60	76	76	49%	58	112
Total	107	100%			51	100%		

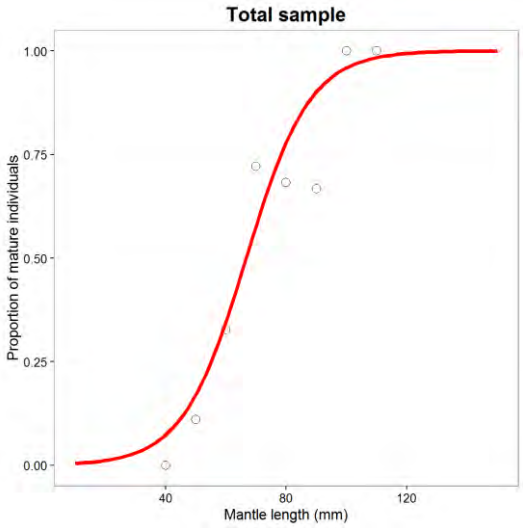


Figure 68. Maturity ogives for musky octopus total sample (n – number of individuals in the sample)

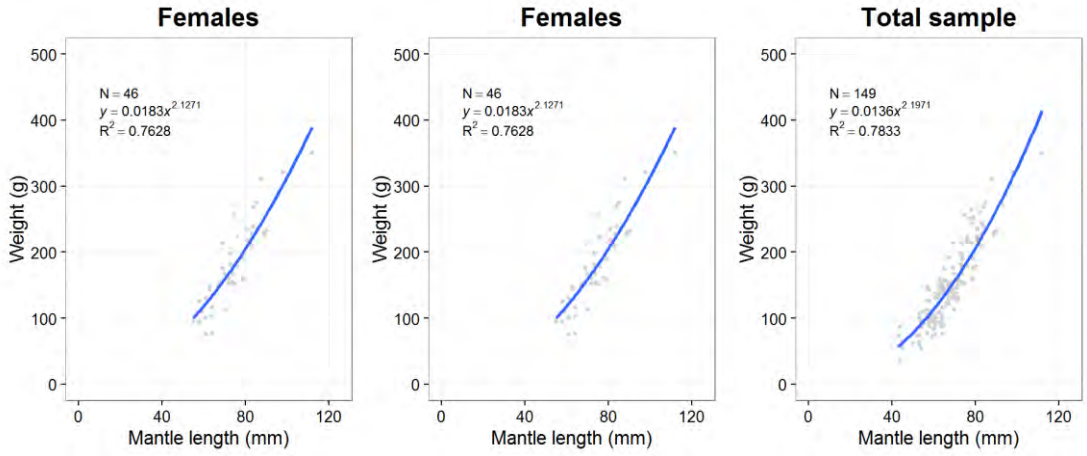


Figure 69. Length-weight relationship for musky octopus females, males and total sample (N – number of individuals in the sample)

5.2.16. Horned octopus (*Eledone cirrhosa*)

A total of 145 specimens of horned octopus were sampled during the three year sampling period (2008–2011, non-continuous). The greatest abundance of the horned octopus in landings was recorded in April in 2007/08, February in 2009/10, and in August in 2010/11. Lateral mantle length of the sampled individuals ranged from 29 to 114 mm LML, with an average of 63 ± 13 mm LML. Weight was in the range 14.4–360.0 g total weight (TW), with an average of 120.7 ± 58.6 mm TW. Both length and weight range of females were identical to those of the total sample, but average female length was 65 ± 13.1 mm LML, and average weight 131.7 ± 59.7 g TW. Males had lower lengths (min. 38 mm LML, max. 89 mm LML, average of 60 ± 12 mm LML) and weights (min. 18.1 g TW, max. 278.7 g TW, average of 103.8 ± 53.1 g TW).

Mode was estimated at between 50 and 70 mm LML in 2007/08, and between 50 and 70 mm LML in 2009/10.

Figure 70 gives the length frequency distribution of horned octopus by sampling period. The number of individuals in the 2010/11 sample was too low (19) to be representative.

Of the 145 specimens in the total sample, 88 (61%) were female, 54 (37%) were male, and 3 (2%) were unsexed. Sex ratio by sampling period is shown in Table 59.

Table 59. Horned octopus sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	73%	27%	0%
2009/10	57%	43%	0%
2010/11	5%	79%	16%

Females were dominant at almost every size, except at 50 mm LML, and only at 80 mm LML were both sexes equally represented (Table 60).

Table 60. Horned octopus sex ratio by sampling period

LML	Females	Males
20	100%	—
30	100%	—
40	60%	40%
50	42%	58%
60	62%	38%
70	85%	15%
80	50%	50%
90	100%	—
100	—	—
110	100%	—

Gonad maturity stage 2 was the most dominant stage for both males (60%) and females (58%). Immature females (stage 1) were barely present in the sample (Table 61).

In the length-weight relationship, b was consistently lower than 3 ($b_{TOT} = 2.5332$, $b_{♀} = 2.4524$; $b_{♂} = 2.5850$) (Figure 71).

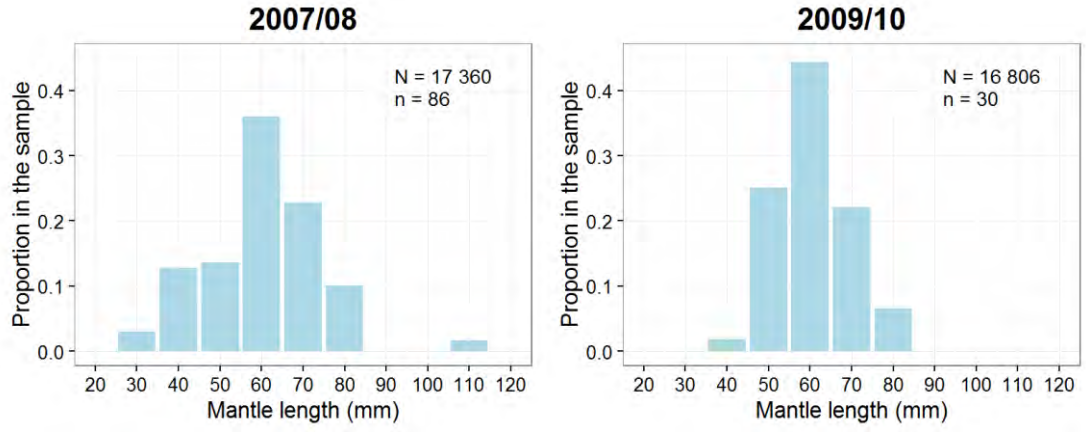


Figure 70. Length frequency distribution of horned octopus by sampling period (N – number of individuals raised to the sampling period, n – number of individuals in the sample)

Table 61. Horned octopus maturity stages by sex

Maturity stage	Males				Females			
	No.	%	ML		No.	%	ML	
			min	max			min	max
1	11	21%	48	70	1	1%	29	29
2	31	60%	41	83	51	58%	34	79
3	10	19%	51	89	36	41%	59	114
Total	52	100%			88	100%		

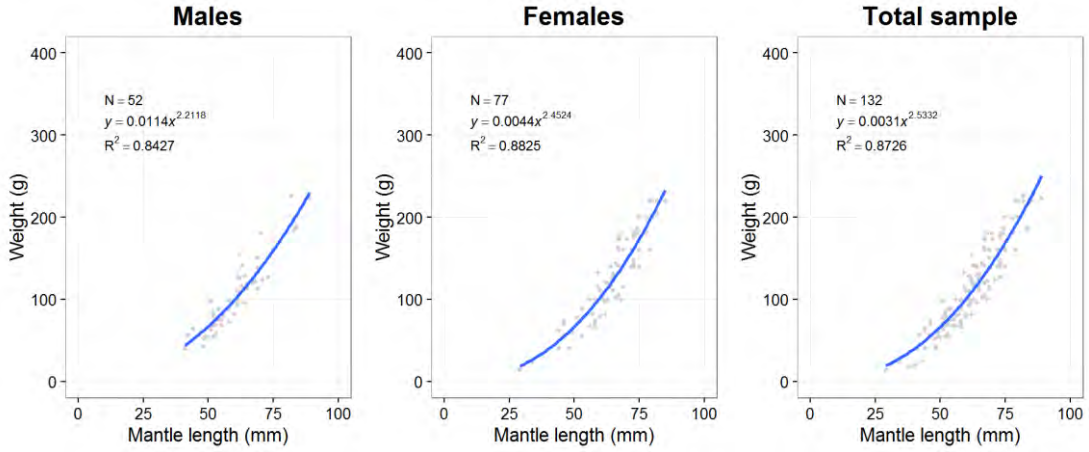


Figure 71. Length-weight relationship for horned octopus males, females and total sample (N – number of individuals in the sample)

5.2.17. Common cuttlefish (*Sepia officinalis*)

A total of 395 individuals of common cuttlefish were taken during the three-year sampling period (2008–2011; non-continuous). The greatest abundance of common cuttlefish in landings was recorded in January in 2007/08, September in 2009/10, and in November in 2010/11 sampling period. Minimum and maximum dorsal mantle lengths (DML) for the total sample were 36 and 142 mm DML, respectively (average of 74 ± 22 mm DML). Total weight (TW) ranged from 2.8 g TW to 377.4 g TW, with an average of 390.0 ± 54.5 g TW. Female mantle lengths ranged from 36 mm DML to 142 mm DML, and averaged at 74 ± 19 mm DML, with weights from 9.3 g TW to 377.4 g TW (average 63.7 ± 54.1). Length of males was within the 37--131 mm DML range, with an average at 79 ± 23 mm DML, with male average weight being 76 ± 54 g TW (min. 10.2 g TW, max. 223.2 g TW).

The mode could be estimated at between 50 and 70 mm DML in 2007/08, and between 80 and 100 mm DML in 2009/10.

Figure 72 gives length frequency distribution for the common cuttlefish according to the sampling period. Due to the small number of individuals in the sample and to the sampling dynamic, the sample was raised to the sampling period. There were only a few individuals in 2010/11 sampling period (9), and these are not shown on the charts.

Of the total number of individuals in the sample (395), 195 (49%) were female, 159 (40%) were male, and 41 (10%) were unsexed. Sex ratio by sampling period is shown in Table 62.

Table 62. Common cuttlefish sex ratio by sampling period

Sampling period	Females	Males	Unsexed
2007/08	56%	32%	12%
2009/10	30%	64%	6%
2010/11	44%	56%	0%

According to length frequencies, females dominated the mid-range (50–80 mm DML), while males dominated other sizes (Figure 73).

The majority of specimens in the sample were in gonad maturity stage 2 (maturing/mature), 61% of females and 59% of males (Table 63).

The highest gonadosomatic index (GSI) for both females and males was recorded in October (Table 64).

Similarly to other sampled cephalopod species, exponent *b* of the length-weight relationship was consistently lower than 3 for total sample (2.8821), females (2.4722), and males (2.5461) (Figure 74).

Table 63. Common cuttlefish maturity stages by sex

Maturity stage	Males				Females			
	No.	%	ML		No.	%	ML	
			min	max			min	max
1	52	34%	37	106	51	25%	36	105
2	95	61%	45	131	114	70%	45	141
3	8	5%	79	127	29	5%	53	142
Total	155	100%			194	100%		

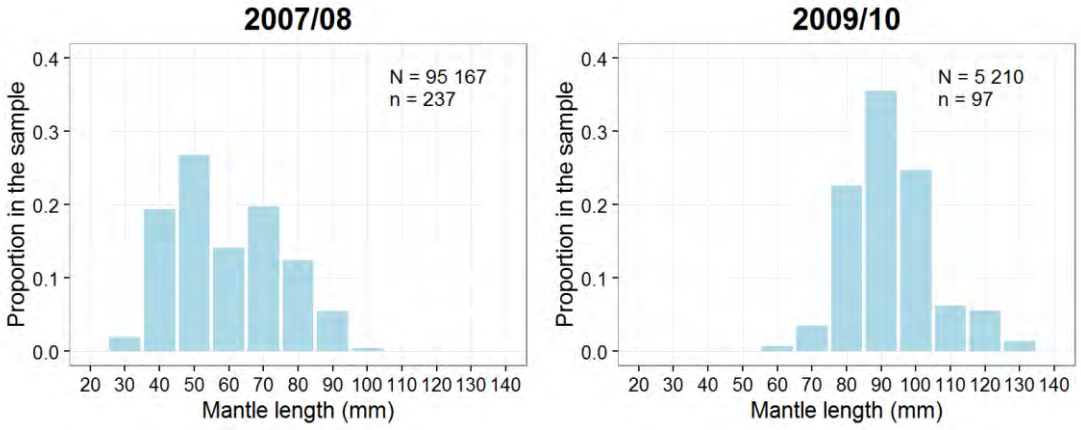


Figure 72. Length frequency distribution of common cuttlefish by sampling period (N – number of individuals raised to the sampling period, n – number of individuals in the sample)

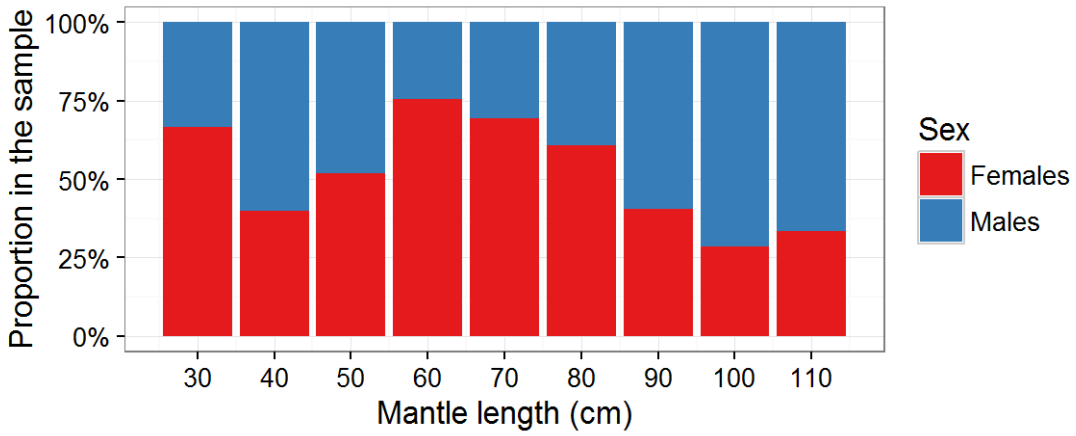


Figure 73. Sex ratio of *S. officinalis* by length in the Montenegrin catch

Table 64. Gonadosomatic index of common cuttlefish, by month and sex

Month	GSI	
	Females	Males
January	1.196	2.094
February	3.447	0.832
October	4.008	4.658

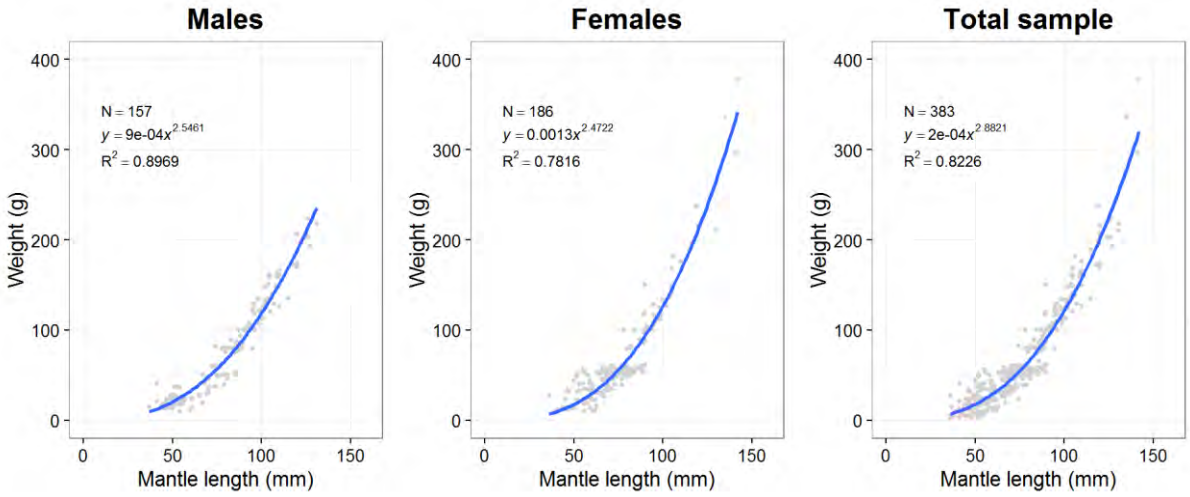


Figure 74. Length-weight relationship for common cuttlefish males, females, and total sample (N – number of individuals in the sample)

5.2.18. Mullets (Mugilidae)

A total of 834 specimens of the Mugilidae family were sampled during the three-year sampling period (2008–2011, non-continuously). The greatest abundance of mullets in landings was recorded in December in 2007/08, April in 2009/10 (with two extraordinarily large landings in June and July, weighted at 2520 kg and 2000 kg, respectively), and in November in 2010/11 sampling period. Table 65 gives the summary of minimum and maximum lengths and weights, as well as their average values with standard deviation, for the total sample, females, and males.

The modes in 1st trimester 2007/08 were determined at 20--24 cm TL and 30--34 cm TL, between 20 and 24 cm TL and 28--32 cm TL in 2nd trimester, and between 22 and 26 cm TL in 3rd trimester. In 2009/10, the mode was between 32 and 36 cm TL in 1st trimester, between 28 and 32 and 38 and 42 cm TL in 2nd trimester, and between 28 and 32 cm TL in 3rd. In 2010/11, the mode was at 26--30 cm TL in 1st trimester, 42--46 cm TL in 2nd, and between 26 and 30 cm TL in 3rd.

Figure 74 gives an overview of the length frequency distribution of mullets in the sample according to the sampling period and trimester.

Table 65. Summary of minimum, maximum, and average length and weight of mullets in the sample (TL – total length, TW – total weight)

	Total sample		Females		Males	
	TL (cm)	TW (g)	TL (cm)	TW (g)	TL (cm)	TW (g)
Min	12.4	70.20	12.4	70.20	19.6	79.00
Max	55.6	1167.00	50.9	1148.70	55.6	1167.00
Avg	31.0 ± 5.8	288.90 ± 188.10	31.7 ± 6.3	313.70 ± 212.30	30.2 ± 5.2	263.80 ± 153.90

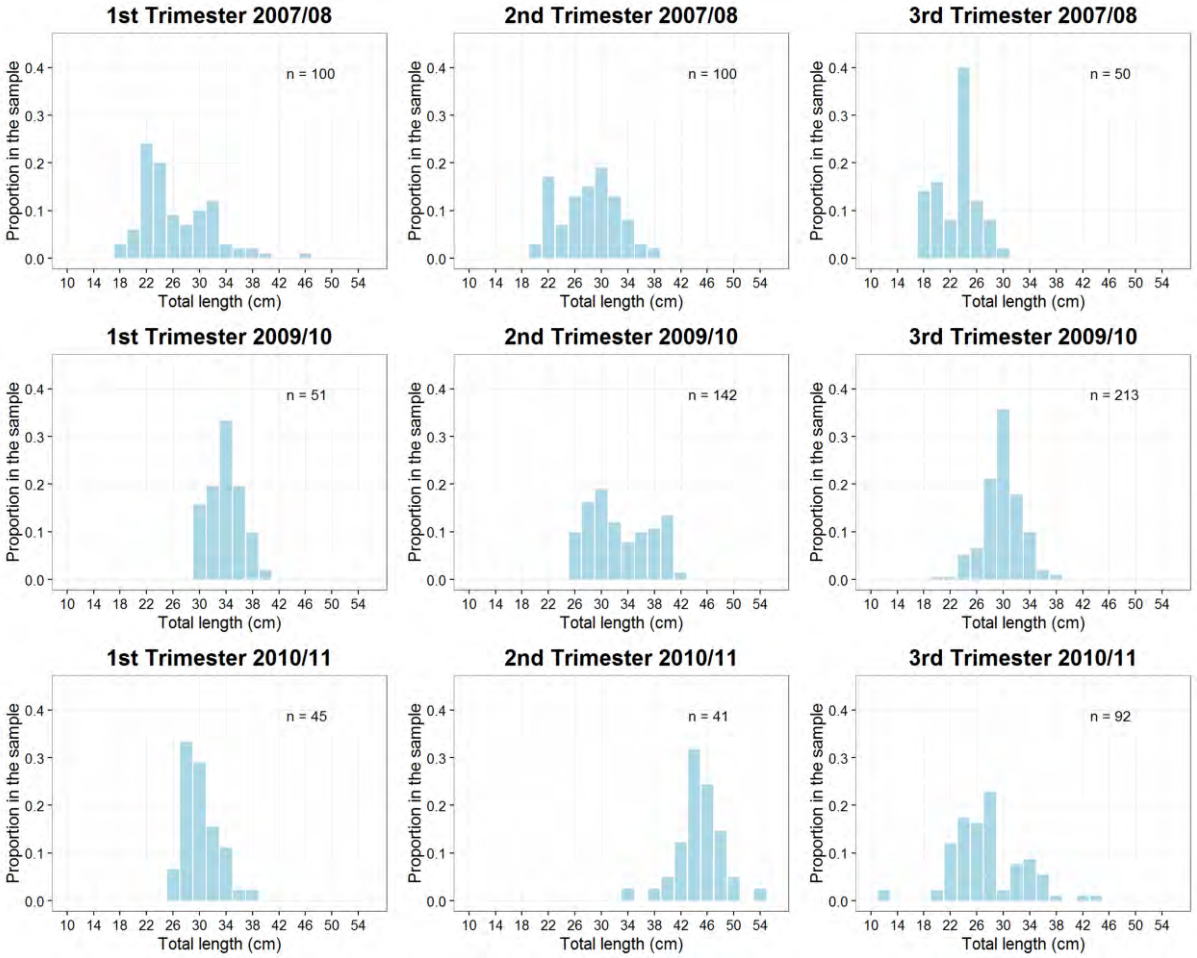


Figure 74. Length frequency distribution of mullet, by sampling period and trimester (n – number of individuals in the sample)

5.2.19. Picarel (*Spicara* spp.)

A total of 1318 specimens of picarel were collected during the three-year sampling period (2008–2011, non-continuous). The greatest abundance of picarels in landings was recorded in June in 2009/10 and in March in 2010/11 sampling period. Table 66 gives the summary of minimum and maximum lengths and weights, as well as their average values with standard deviation, for the total sample, females, and males.

The mode was determined at between 10 and 12 cm TL in 1st trimester 2007/08, and between 11 and 13 cm TL and 15 and 18 cm TL in 2nd. In 2009/10, it was between 10 and 12 cm TL in 1st trimester, between 14 and 16 cm TL in 2nd, and between 13 and 15 cm TL in 3rd. In the 2nd trimester 2010/11, the mode was between 12 and 14 cm TL, and between 11 and 14 cm TL in 3rd.

Figure 75 gives an overview of the length frequency distribution of picarel in the sample according to the sampling period and trimester.

Table 66. Summary of minimum, maximum, and average length and weight of picarel in the sample (TL – total length, TW – total weight)

	Total sample		Females		Males	
	TL (cm)	TW (g)	TL (cm)	TW (g)	TL (cm)	TW (g)
Min	9.0	7.24	9.0	7.34	9.1	7.2
Max	20.0	87.26	19.0	66.96	20.0	87.3
Avg	13.2 ± 2.4	24.20 ± 13.10	12.3 ± 1.9	19.30 ± 8.30	14.8 ± 2.2	33.20 ± 15.20

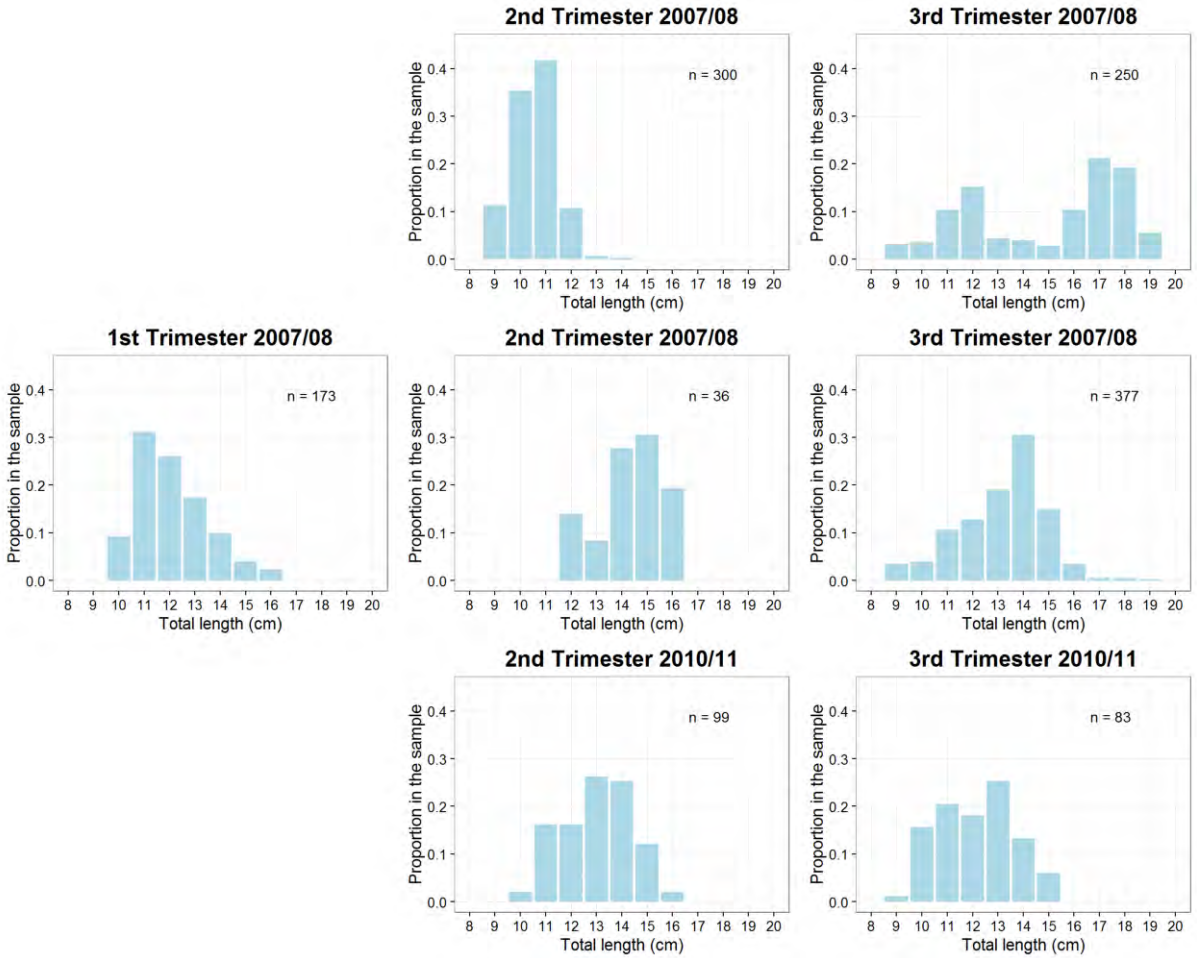


Figure 75. Length frequency distribution of picarel, by sampling period and trimester (n – number of individuals in the sample)

5.2.20. Horse mackerel (*Trachurus* spp.)

A total of 1050 specimens of horse mackerel were collected during the three-year sampling period (2008–2011, non-continuous). The greatest abundance of horse mackerel in landings was recorded in November in 2007/08, in October in 2009/10 and in February in 2010/11 sampling period. Table 67 gives the summary of minimum and maximum lengths and weights, as well as their average values with standard deviation, for the total sample, females, and males.

In 2007/08, the mode was estimated at between 15 and 17 cm TL in 1st trimester, between 16 and 18 cm TL in 2nd trimester, and between 17 and 19 cm TL in 3rd. In 2009/10, the mode was between 14 and 16 cm TL in 1st trimester, between 17 and 22 cm TL in 2nd, and between 17 and 20 cm TL in 3rd. In 1st trimester 2010/11, the modes were between 12 and 14 cm TL and 17 and 19 cm TL in 1st trimester, between 23 and 25 and between 41 and 43 cm TL in 2nd, and between 16 and 18 cm TL in 3rd trimester.

Figure 76 gives an overview of the length frequency distribution of picarel in the sample according to the sampling period and trimester.

Table 67. Summary of minimum, maximum, and average length and weight of horse maskerel in the sample (TL – total length, TW – total weight)

	Total sample		Females		Males	
	TL (cm)	TW (g)	TL (cm)	TW (g)	TL (cm)	TW (g)
Min	7.7	3.13	11.0	11.22	7.7	3.10
Max	45.4	552.40	45.4	552.44	43.7	508.7
Avg	18.6 ± 4.6	59.80 ± 62.30	19.0 ± 4.4	63.0 ± 64.0	18.8 ± 4.6	61.20 ± 62.80

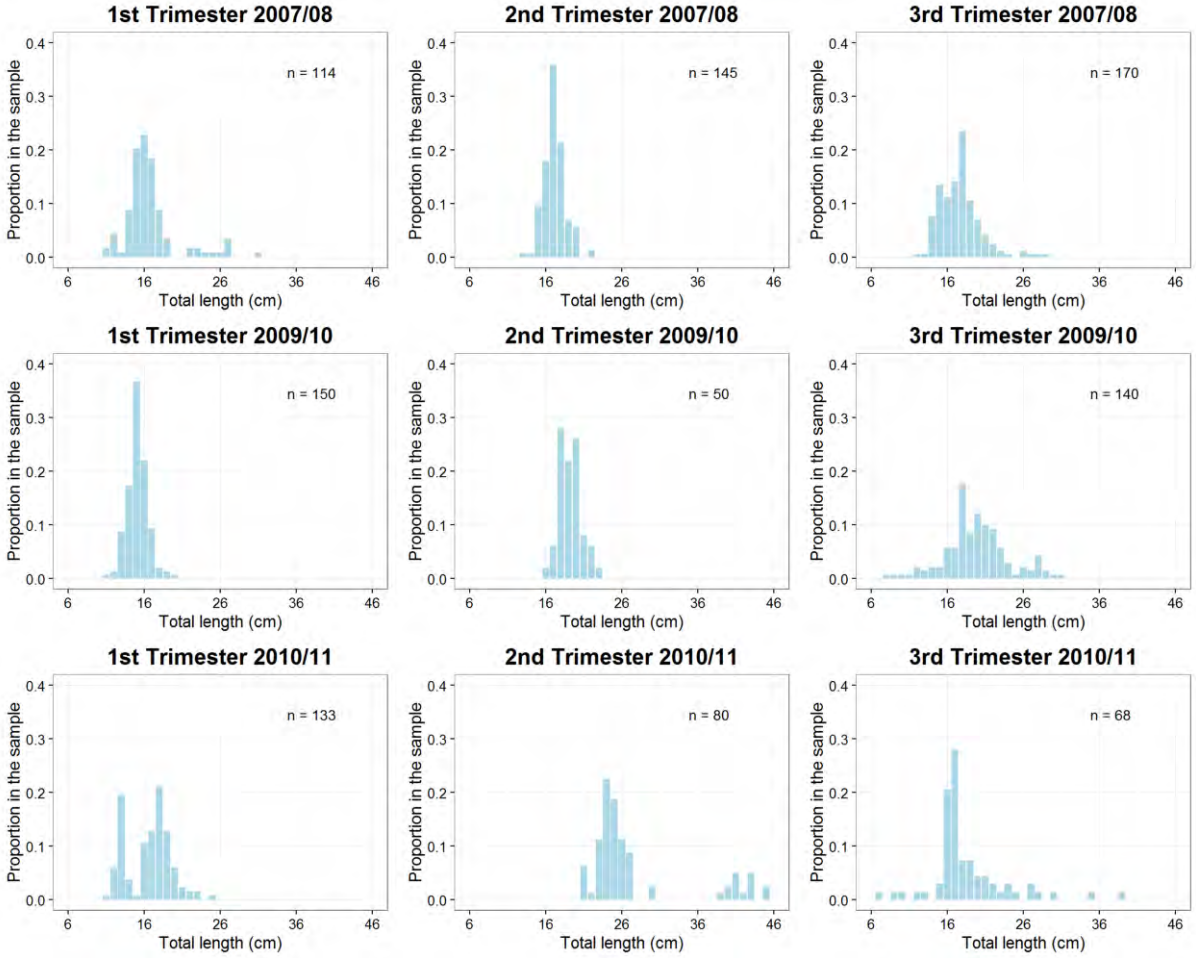


Figure 76. Length frequency distribution of horse mackerel, by sampling period and trimester (n – number of individuals in the sample)

5.3. Comparison of presented data with the existing data from the Adriatic area

Hake is the most common species in bottom trawl catches along the Montenegrin coast. Analysis of length frequency distribution shows that a significant part of the catch is composed of juveniles, sexually immature individuals whose total body length is lower than the minimum allowed catch size, which, according to the Order on prohibition of catch and trade in fish juveniles, undersized fish and other marine organisms (Official Gazette of Montenegro, 65/2015), is given as 20 cm. The situation is similar in central Adriatic, which is only to be expected, as that area represents the most important spawning and nursery area in the Adriatic (Krstulović Šifner *et al.*, 2009). Average length of hake calculated for the entire sampling period was 21.3 cm TL, and is significantly higher than the values reported in other parts of the Adriatic. Vrgoč *et al.* (2013) report a reduction in average length of hake from 19.29 to 13.02 cm TL, based on the comparison of length frequency data for demersal species in the south Adriatic during the Hvar (1948–1949) and MEDITS (2008–2011) expeditions. During the COAST project, which described the fishery resources and gave recommendations for sustainable demersal fisheries in the open waters of central Adriatic, the mean measured length of hake was 17 cm (Krstulović Šifner *et al*., 2009). The increase in exploitation intensity causes changes in population structure that manifest as reduction in mean length of individuals in the catch, as the larger individuals are selectively removed from the population through fisheries (Vrgoč *et al*., 2004). Such state in population is described as the overfishing of adult individuals, or *growth overfishing* (Vrgoč *et al*., 2013). If length at first maturity for the total sample, estimated at 24.62 cm TL, is taken into consideration along with the minimum catch size (20 cm TL), then the analysis of length frequency distribution shows that the symptoms of overfishing of individuals that have not yet reached sexual maturity have been confirmed in the present study. One of the possible explanations could be the low selectivity of the bottom trawl. Hake spawns through the entire year with different intensity (Vrgoč *et al*., 2004). Spawning peak occurs in summer (June for females, September for males) and winter (December), which corresponds to the results reported by Županović & Jardas (1986) and Jukić & Piccinetti (1981).

Red mullet is also a species important in bottom trawl fisheries along the Montenegrin coastline. The catch is dominated by females, which are, on average, longer than males, most likely due to different growth rates. Females are dominant in length classes larger than 15 cm, which is confirmed by Vrgoč (2000). Length at first maturity for females is estimated at 13.8 cm TL, and 13.4 cm TL for males, which is higher than the lengths reported by Vrgoč *et al*. (2004, 2005). Considering that the length at first maturity for both sexes combined is estimated at 13.5 cm TL in this study, and the minimum catch size is set at 11 cm TL, analysis of length frequency distributions indicates that only a small number of juveniles is present in the catches. According to Vrgoč *et al.* (2004), females spawn from April to May, which was confirmed in this study.

Among the crustaceans, **deep-water pink shrimp** is the one species of commercial importance. Average carapace length is 25 mm, similar to data from the COAST project

in 2009, which reports average carapace length of 24 mm in the open central Adriatic. Females were more numerous than males, and, on average, had higher length and body mass. At 28 mm CL and above, they are absolutely dominant in the catch (100%). Length at first maturity for females was estimated at 22.6 mm CL, while the reported length in the open central Adriatic was 22 mm CL (Krstulović Šifner *et al*., 2009).

Among the small pelagic fish, **European Anchovy** and **European Pilchard** take a special place, both in the Montenegrin fleet catches and in the catches in the entire Adriatic and the Mediterranean Seas. These two species together make for about 41% of the total marine fisheries catch in the Adriatic (1970–2005; FishStat, 2017). Pilchard and anchovy represent 34.62% of small pelagic catch in Italy (1970–2005), 65.22% of the total catch in Croatia (1992–2005) and 21.46% in Albania (1983–2005) (AdriaMed TD 24, 2008). In the catches of the eastern Adriatic, pilchard is much more represented, while on the western side the ratio between anchovy and pilchard varied, but the anchovy is far more abundant in the catch. Catches of these two species in Montenegro are mostly from beach seine nets in the Boka Kotorska Bay area, and, to a much lesser degree, from purse seines operating in the entrance to the Boka Kotorska Bay.

Total length of **anchovy** ranged from 5.0 to 14.4 cm (average of 10.0 ± 1.4 cm TL), females ranged from 6.5 to 14.4 cm TL, and averaged at 10.2 ± 1.3 cm TL, while males ranged from 7.5 to 13.2 cm TL, and averaged at 10.1 ± 1.2 cm TL. Đurović (2012) reported length distribution for area of the Boka Kotorska Bay from od 5.2 to 12.7 cm TL, averaged at 8.32 ± 1.11 cm for period 2004–2005. For period 2006–2007 length distribution ranged from 5.3 to 13.2 cm TL and averaged at 8.99 ± 1.21 cm. Sinovčić (1998) provides similar anchovy lengths in the Novigrad Sea Bay, from 4.4 to 12.5 cm TL, and Sinovčić & Zorica (2006) analysed length range of 4.5 to 14.5 cm TL. Females strongly outnumbered the males (females 59%, males 32%), and females were more numerous at each length class. Đurović (2012) reported ratio of females at 52.19%, and males at 47.81%, and females more numerous at all length classes above 11 cm. Obtained results on length at first maturity at 9.4 cm TL for anchovy females and 9.1 cm TL for males are in accordance with results of Mandić *et al*. (2015), where length at which 50% of anchovy were mature (L_{50}) was calculated as 9.28 for females and 9.02 for males, as well as with the results obtained from the Novigrad Sea Bay (the eastern central Adriatic), where Sinovčić (1998) found that 50% of anchovy reached maturity at 9.0 cm total length, and at 9.74 cm the whole population was sexually mature. The gonadosomatic index of both sexes peaked in May (4.74 for females, 4.97 for males), with a secondary peak in August (4.62 for females, 3.99 for males). According to Đurović (2012), in 2006 the GSI peaked in July–August period, and in 2007 in May–Jun period for both sexes in the Boka Kotorska Bay. Parameter *b* of length-weight relationship was 3.2980, very similar to the result for the 2004–2005 period, when it was calculated at *b* = 3,167, and in 2006–007 period when the *b* was 3.106 (Đurović, 2012).

Average length of analysed **pilchard** samples was 13.0 ± 2.1 cm TL (6.4–23.0 cm TL). Males ranged in length from 7.3 to 16.8 cm TL with an average of 13.1 ± 1.8, while the length range for females was from 7.1 to 23.0 cm, with an average of 13.4 ± 2.0 cm TL. Previous studies in the same area for 2006–2007 give similar length distributions, from 8.7 cm to 14.7 cm TL, with an average of

11.3 ± 1.32 cm (Pešić *et al.*, 2010). Similar values were reported for other coastal and channel areas of the Adriatic: Sinovčić *et al.* (2003, 2008) gives length distribution for pilchard in the Krka River estuary (Croatia, eastern Adriatic) at 7 to 12 cm TL and 4.9 to 12.5 cm TL; Mužinić (1964) analysed individuals in the Bay of Kaštela (Croatia, eastern Adriatic) with lengths in range from 10.1 to 17.0 cm TL. Lengths in the central Adriatic range from 8.9 to 20.3 cm (Sinočić, 1986), 7.5 to 18.4 cm (Sinovčić *et al.,* 2004), and from 13.0 to 19.0 cm (Mustać & Sinovčić, 2007). Females were more abundant at all length frequencies, except at 9.0, 10.0, 13.0 and 14.0 cm TL, where the males were more numerous, which corresponds to the results from 2006–2007, when females were dominant at all length categories above 10.5 cm TL (Pešić *et al*., 2010). This is also confirmed in Dalmatia (Croatia), where females were more numerous in all length categories above 10 cm TL (Sinovčić *et al*., 2008). Length at first maturity (in the October–April period) was estimated at 9.8 cm TL, while Sinovčić *et al*. (2003) reported that sardine reaches first maturity at length of 7.1 cm, while 50% of population is mature at 8 cm. Two peaks of GSI values were observed for sardine, for females in November and January (4.76 and 4.6.4), while for males they were reversed, in January and November (4.17 and 3.96). During the previous studies it was found that the mean GSI started to increase from September and October and reached its highest values of 5.22 for females and 6.58 for males in February (Pešić *et al.*, 2010). Sardine GSI values in the Adriatic reach the maximum (slightly higher than 4) in October, and retains a similar value until April (Nejedli *et al*., 2004). The coefficient *b* of the length-weight relationship for the total sample was estimated at 3.0528, which is in accordance with the earlier data from this area for 2004–2005 ($b = 3.1962$) (Pešić, 2011) and for 2006–2007 ($b = 3.0891$) (Pešić *et al.*, 2010).

Bogue is a species found in the entire Adriatic. Total length of bogues from bottom trawl catches ranged from 10 to 22 cm TL, which is a narrower range than that reported in the MEDITS programme in the Adriatic (1996–2010) by Piccinetti *et al*. (2012), 9 to 28 cm TL. Bogue length from gillnet catches was from 9.7 to 16.7 cm TL, which represents a greater range than reported by Dulčić & Glamuzina (2006) in the central Adriatic, which is likely due to diverse ecological factors. At higher length frequencies, females were more numerous, which agrees with Alegria-Hernández (1990) in his study on biological aspects of bogue populations in channel areas of the central Adriatic. The same author reports spawning period during spring, with a maximum in May. However, the data in present study indicate winter spawning, from January to March, with a peak in February. Consequently, the estimated length at first maturity for females and males (14.5 and 13.2 cm TL, respectively) in central Adriatic differs from the results presented in this study (14.9 cm TL for females and 14.3 cm TL for males). Values of the parameter *b* (slope) of the length-weight relationship were below 3 for females, males and both sexes combined, which agrees with the results given by Dulčić & Glamuzina (2006).

Although it has considerable economic importance, there is relatively little data on the biology of **black angler**. This species is caught during the entire year, and is counted as one of demersal resources of economic importance. Analysis of length frequency distribution shows that the total length ranged from 16.2 to 56.6 cm TL, while Piccineti *et al*. (2012) report wider range, i.e. from 6 cm TL

to 66 cm TL. Jardas (1987) studied the length-weight relationship of this species, and reports the inflexion point at lengths of 33 to 34 cm, which he assumed might correspond to the length at which 50% of the population is sexually mature. During the COAST project length at first maturity was estimated at 31 cm TL for males and 40 cm TL for females. The results of this study indicate a much lower length at first maturity, 25.72 cm for sexes combined, although this estimation should be taken with caution due to the small number of individuals in the total sample. According to Vrgoč *et al.* (2004), black angler spawns at the end of spring and beginning of summer, which is in agreement with the results of the COAST project (2009). The data presented here, however, report the highest gonadosomatic index values of females in December, and in January for males.

Commercially important species of cephalopods include common cuttlefish, European squid, shortfin squid, musky octopus and horned octopus. **Common cuttlefish** is a species with a short biological cycle but significant migration pattern, seasonal spatial distribution and abundance (Piccinetti *et al.*, 2012). It is much more abundant in the northern and central Adriatic compared to its southern part (Krstulović Šifner *et al.*, 2013). Mantle length ranged from 36 mm to 142 mm, although Piccinetti *et al.* (2012) report much smaller individuals during the MEDITS expedition (1996-2010), from 15 mm DML. Vrgoč *et al*. (2004) report spawning period from February to September in the south Adriatic, with a peak in period from April to June. This is not confirmed by this study, which indicates highest GSI values for both sexes during October.

Shortfin squid is a pelagic, semi-demersal species with pronounced daily vertical migration pattern: during the day it is found mostly near the seabed, and rises in the water column during the night (Krstulović Šifner *et al.*, 2009). Average mantle length of shortfin squid in the open central Adriatic is 84.7 mm DML, while the data presented here indicate significantly larger individuals, at 108.8 mm DML. This is also true for sexes separate, with 118.6 mm DML for females and 117.2 mm DML for males, compared to 105.3 mm DML for females and 96.1 mm DML for males in the open central Adriatic. Along the Montenegrin coast, shortfin squid spawns in July, and the estimated length at first maturity for both sexes combined is 121.8 mm DML. Estimated length at first maturity for females is identical to that of both sexes combined, and is estimated at 120.8 mm DML for males. Petrić (2011) gives length at first maturity at 162 mm DML in the eastern Adriatic, and Krstulović Šifner *et al*. (2009) reports 137 mm DML for males and 146 mm DML for females in the south Adriatic.

European squid can be found in the entire Adriatic. Males are larger than females, grow faster and dominate in the total catch, expect at 40 to 60 mm DML. Krstulović Šifner (2000) reports similar situation, and suggests mass mortality of females after spawning as an explanation, and also different sampling methods and behaviour modes between males and females. Although European squid spawns through the entire year, the spawning is most intense in the winter-spring period (Soro & Piccinetti Manfrin, 1989; Krstulović Šifner, 2000), which was confirmed in this study, as the GSI was highest in April. Length at first maturity was estimated at 129.9 mm DML, but Soro & Piccinetti Manfrin (1989) and Krstulović Šifner (2000) report larger sizes for other areas in the Adriatic.

Horned octopus is caught almost exclusively by bottom trawl in the open central and south Adriatic, and is much rarer

in the north part (Krstulović Šifner *et al*., 2009). According to the same source, the average mantle length of individuals caught in the open central Adriatic is 68.9 mm, but averages to 63 mm LML in Montenegrin waters. Females are, on average, significantly larger than males, with average mantle length of 65 mm, while males average at 60 mm ML. These values are lower than those reported in the central Adriatic, 87.5 mm for females and 64.3 for males (Krstulović Šifner *et al.*, 2009). There is no minimum catch length prescribed in Montenegro, but the minimum catch weight is set to 0.3 kg. Although it was not possible to determine length at first maturity for horned octopus in the current study due to small sample size, Ikica (2013) provides estimations for Montenegrin waters, 82 mm ML for females and 60 mm ML for males. This is significantly lower than the estimations presented by Krstulović Šifner *et al.* (2009) — 95 mm for females and 80 mm for males.

Unlike the horned octopus, **musky octopus** is more widespread in north-eastern Adriatic (Casali *et al*., 1998). This species spawns from winter to spring in central and north Adriatic (Vrgoč *et al*., 2004), with the highest abundance of sexually mature individuals recorded in January and February (Casali *et al*., 1998). Soro & Piccinetti Manfrin (1989) report length at first maturity for females at 90 mm LML, while the data in this study indicate 71.13 mm LML for both sexes combined, with the highest GSI recorded in September.

Chub mackerel is a coastal pelagic species of commercial importance. Average length was 32.1 cm TL, which is higher than the central Adriatic, 23.8 cm TL (Čikeš Keč & Zorica, 2011a). The result presented in this study should be taken with caution, however, as the total sample was relatively small and the species was sampled only during the two-year period (2009–2011). Males were more abundant during the sampling, and dominated the larger length classes, from 33 cm on, which is similar to reports from central Adriatic (Čikeš Keč & Zorica, 2011b). Chub mackerel spawns from March to September, with a peak in July for both sexes, which agrees with the results from Čikeš Keč & Zorica (2011b), who report spawning period from May to August, with a peak in June. Estimated length at which 50% of population is sexually mature is 21.45 cm TL, which is higher than 18.3 cm TL reported for the central Adriatic (Čikeš Keč & Zorica, 2011b).

Atlantic bonito is found in the entire Adriatic, especially is southern part. Length ranged from 40 to 63.9 cm TL, with an average of 46.5 cm TL. Franičević *et al*. (2005) reports greater length range in central Adriatic, 33 cm to 67 cm TL, with an average of 42.2 cm TL. The authors also report that growth follows positive allometry, i.e. values of the slope parameter (*b*) of the length-weight relationship are higher than 3, which concurs with the results presented in this study.

Common pandora is found in the entire Adriatic Sea, but is more common in channels than in the open water (Jardas, 1996). It is a typical circalittoral zone species (Vrgoč *et al*., 2004). Length range reported in the central Adriatic (9.2 cm to 26.1 cm TL) is smaller than the range presented in this study, 11.6 cm to 36 cm TL. Average value of total length of all samples individuals is 17.8 cm TL. Females were more abundant at lower length classes, until 22 cm TL, which concurs with Rijavec & Županović (1965) results for the central Adriatic. This is not surprising, as the species is a protogynous hermaphrodite. In the Adriatic, common pandora spawns in spring or at the beginning of summer (Vrgoč *et al.*, 2004). Length at first maturity was estimated at 15.8 cm TL, and agrees with the data given

by Rijavec & Županović (1965) and Županović & Rijavec (1980) for the central Adriatic, as well as with Vrgoč (2000) for northern and central Adriatic.

5.4. Operational units in Montenegro (Pilot Study)

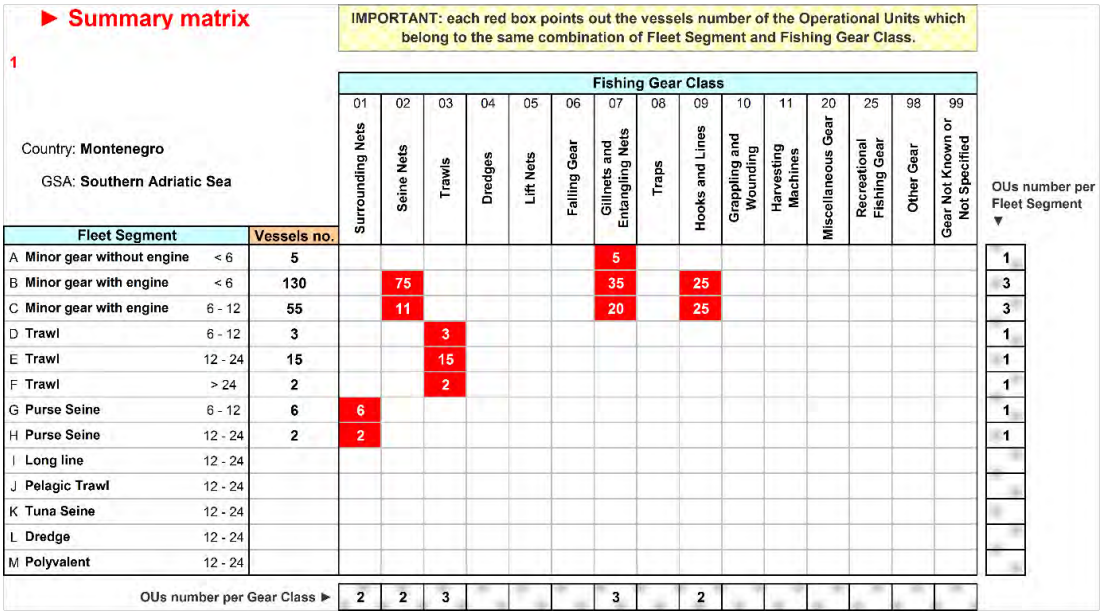
The conceptual framework for identifying OUs was developed according to three main criteria: geographical (the GFCM Geographical sub-Areas division), characteristics of the fisheries (fleet segments identified by fishing gear and capacity), type of resources targeted (group of target/accessory species). According to these criteria, and to the data collected in the country in 2008, a total of 12 OUs were identified in Montenegro, comprising 8 different fleet segments, 5 types of fishing gears and targeting three main groups of target species.

Fleet segments and fishing gears considered are those developed in the framework of the GFCM and included: small vessels (minor gear < 6m LOA and minor gear 6-12 m LOA) with and without engine using as fishing gears gill nets/entangling nets, seine nets and hooks and lines (7 OUs); trawlers divided in three segments 6-12, 12-24 and > 24 m LOA (3 OUs); and purse seines with two segments, 6-12 and 12-24 m LOA (2 OUs). All these group of vessels operated in Montenegrin territorial waters (South Adriatic, GSA 18) and target mainly inshore and offshore demersal species and small gregarious pelagic species.

The results of the first OUs identification and listing based on the data collected during the Pilot Study, as well as the tables summarising their characteristics according to the GFCM Task 1 Matrix are described in Figures 68–71.

In 2009, a new Law on marine fisheries and mariculture (Official Gazette of Montenegro 56/09) was established in Montenegro, followed by the related Rulebooks. With the new law, the situation in fishing fleet has been changed as artisanal fishery is no longer recognized as a separate type of fisheries, and as a result the number of vessels for small-scale fisheries was reduced. Also the structure of bottom trawlers fleet was changed because one vessel with LOA over 24 operating outside the 8 NM limit was introduced into the fleet.

The current state of the Montenegrin fishing fleet and OUs is in the preparation withinin the frame of the Fishery Information System (FIS), which is being developed by the Fishery Unit in the Ministry of agriculture and rural development (MARD). FIS is developed in the frame of IPA 2010/12 Project "Sustainable Management of Marine Fishery", and is composed of different sub-systems: Sub-System Fleet Register; Sub-System Logbook, over 10 m LOA; Sub-System Monthly report, up to 10 m LOA; Sub-System Licenses; Sub-System Common alarm; Sub-System Common user management; Sub-System Reporting GFCM Task 1; Application VMS; Application Sampling data and Biological data; Application Electronic logbook; Application Sale notes. Sub-System Reporting GFCM Task 1 contains all the information that is required by the GFCM Task 1 and the system is organized to automatically transfer data using SQL linked server. Creation of the FIS is in the final phase, and by the end of 2013 updated information on the Montenegrin fishery fleet and OUs for 2012 will be submitted to GFCM.



► Summary matrix

IMPORTANT: each red box points out the vessels number of the Operational Units which belong to the same combination of Fleet Segment and Fishing Gear Class.

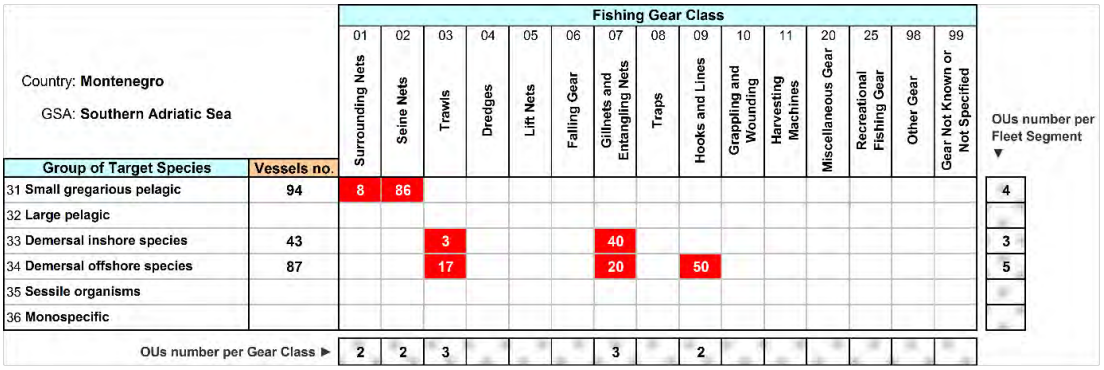
1

Country: Montenegro

GSA: Southern Adriatic Sea

Fleet Segment		Vessels no.	Fishing Gear Class: 01 Surrounding Nets	02 Seine Nets	03 Trawls	04 Dredges	05 Lift Nets	06 Falling Gear	07 Gillnets and Entangling Nets	08 Traps	09 Hooks and Lines	10 Grappling and Wounding	11 Harvesting Machines	20 Miscellaneous Gear	25 Recreational Fishing Gear	98 Other Gear	99 Gear Not Known or Not Specified	OUs number per Fleet Segment ▼
A Minor gear without engine	< 6	5							5									1
B Minor gear with engine	< 6	130		75					35		25							3
C Minor gear with engine	6 - 12	55		11					20		25							3
D Trawl	6 - 12	3			3													1
E Trawl	12 - 24	15			15													1
F Trawl	> 24	2			2													1
G Purse Seine	6 - 12	6	6															1
H Purse Seine	12 - 24	2	2															1
I Long line	12 - 24																	
J Pelagic Trawl	12 - 24																	
K Tuna Seine	12 - 24																	
L Dredge	12 - 24																	
M Polyvalent	12 - 24																	
OUs number per Gear Class ►			2	2	3				3		2							

Figure 61. Summary matrix of Operational Units in Montenegro for 2008, according to fleet segmentation and fishing gear classes



Country: Montenegro

GSA: Southern Adriatic Sea

Group of Target Species	Vessels no.	Fishing Gear Class: 01 Surrounding Nets	02 Seine Nets	03 Trawls	04 Dredges	05 Lift Nets	06 Falling Gear	07 Gillnets and Entangling Nets	08 Traps	09 Hooks and Lines	10 Grappling and Wounding	11 Harvesting Machines	20 Miscellaneous Gear	25 Recreational Fishing Gear	98 Other Gear	99 Gear Not Known or Not Specified	OUs number per Fleet Segment ▼
31 Small gregarious pelagic	94	8	86														4
32 Large pelagic																	
33 Demersal inshore species	43			3				40									3
34 Demersal offshore species	87			17				20		50							5
35 Sessile organisms																	
36 Monospecific																	
OUs number per Gear Class ►		2	2	3				3		2							

Figure 62. Summary matrix of Operational Units in Montenegro for 2008, according to group of target species and fishing gear classes

Country: **Montenegro**

GSA: **Southern Adriatic Sea**

Fleet Segment		Vessels no.	Group of Target Species 31 Small gregarious pelagic	32 Large pelagic	33 Demersal inshore species	34 Demersal offshore species	35 Sessile organisms	36 Monospecific	OUs number per Fleet Segment ▼
A Minor gear without engine	< 6	5			5				1
B Minor gear with engine	< 6	130	75		35	25			3
C Minor gear with engine	6 - 12	55	11			45			3
D Trawl	6 - 12	3			3				1
E Trawl	12 - 24	15				15			1
F Trawl	> 24	2				2			1
G Purse Seine	6 - 12	6	6						1
H Purse Seine	12 - 24	2	2						1
I Long line	12 - 24								
J Pelagic Trawl	12 - 24								
K Tuna Seine	12 - 24								
L Dredge	12 - 24								
M Polyvalent	12 - 24								
OUs number per Group of Target Species ►			4		3	5			

Figure 63. Summary Matrix of Operational Units in Montenegro for 2008 according to fleet segmentation and group of target species

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GFCM Task 1 - Operational Units

Country:	**Montenegro**
GSA:	**Southern Adriatic Sea**
Number of Vessels:	**218**
Number of Operational Units:	**12**
Number of Fleet Segment:	**8**
Number of Fishing Gear Class:	**5**

Figure 64. Summary of Operational units in Montenegro for 2008

6. General remarks

- At the beginning of the sampling for the Pilot Study there were difficulties in communicating with the fishermen and mostly due to a general lack of trust in the use of information gathered during the interview (catch, number of fishing days, number of fishing hours, net characteristics). However, during the Project these communication problems were almost completely overcame. To this extent, the purchasing of samples was very helpful, as such practise was not custom in Montenegro till now and in previous national projects samples for scientific studies were taken without payment (predicted by Law).
- Considering the biological sampling and the total number of samples by species to be taken, the biggest problem was the complete lack in the catch of some species that were included in the sampling scheme, i.e. *Mullus surmuletus, Euthynnus alletteratus,* Atherinidae. In spite to the official capture production statistics of previous years, these species were not landed in the sampling sites and for this reason the forecasted sampling scheme could not be completely followed. Moreover, adverse weather condition, difficulties in the sampling (e.g. previous agreement between fishers and traditional customers for selling fish), relatively low quantity of landing for "target species" prevented to gather the total number of samples forecasted. Therefore, the samples of *Mullus surmuletus, Euthynnus alletteratus,* Atherinidae included in the Pilot Study were drastically reduced or removed completely from the sampling scheme in the following years. Common pandora (*Pagellus erythrinus*) was included in 2010–2011 sampling.
- A relatively low number of fishing days per month was recorded for most of the fleet segments and it was related to bad condition of the vessels, which seriously limits their activity, especially during the winter season when weather conditions are not optimal. This, combined with the low demand for fishery products in Montenegro in general (where total consumption of fish is about 4.5 kg per capita) is mostly why there was neither fishing nor sampling activity during winter, especially in the January–February period.

7. Summary and conclusions

The AdriaMed biological and economic data collection and monitoring system in Montenegro (2007–2011), carried out by the Institute for Marine Biology (IMB) of Kotor in cooperation with the Ministry of Agriculture and Rural Development, enabled for the first time the collection of data on effort and catch of all different fishing fleet segments (according to vessel type and fishing gear) in the three most important fishing ports along the Montenegrin coast (i.e. Bar, Budva and Herceg Novi).

During the monitoring activities samples of the most important (for quantity landed and economic values) fisheries target species were collected for the investigation of their main biological characteristics in the Montenegrin waters and of their occurrence in the catch. Samples of 12 fisheries target species were gathered and for most of them the period of highest occurrence in the catch (over time and by fishing gear), the average size and size frequency distribution, as well as the sex ratio, the occurrence of sexual maturity stages in the commercial landings, the size at first maturity and the length-weight relationship parameters were estimated for the first time.

The data collected on the fisheries in Montenegro also allowed to complete the necessary information for the first identification and listing of Operational Units (OUs) in 2008 and enabled the country to comply with the requirements of the FAO General fisheries Commission for the Mediterranean (GFCM).

This biological monitoring is at present the only national monitoring system covering catch and effort statistics at landing sites, which support the Ministry for Agriculture and Rural Development in the adoption of responsible fisheries management strategies based on an ecosystem approach. Such monitoring system would also enable Montenegro to comply with the requirements of the regional and sub-regional bodies in terms of fisheries resources assessment, management and conservation. In this context the data gathered from the biological monitoring were used by the "EC funded IPA Project on the sustainable development of the fisheries sector of Montenegro" that will use the data collected to elaborate a draft proposal for a fisheries management plan for Montenegro.

The sampling scheme and the some aspects of the data collection should be and could be improved, however, taking into consideration the achievements related to the implementation of this monitoring activity, its pursuing over time, is considered of utmost importance for the country.

8. References

Alegria-Hernández, V. (1990): Some aspects of reproductive biology of bogue (*Boops boops* L., Pisces Sparidae) from the mid-Adriatic Channels. Acta Adriat. 31 (1/2): 301-313.

Casali, P., G. Manfrin Piccinetti & S. Soro (1998): Distribuzione di cefalopodi in Alto e Medio Adriatico. Biol. Mar. Medit., 5 (2): 307-318.

Čikeš Keč, V. & B. Zorica (2011): Biometry markers of chub mackerel, *Scomber japonicus* Houttuyn, 1782, in the Adriatic Sea. Acta Adriat. 52 (2): 215-222.

Čikeš Keč, V. & B. Zorica (2011): The reproductive traits of *Scomber japonicus* (Houttuyn, 1782) in the Eastern Adriatic Sea. J.Appl. Ichtiol., doi: 10.1111/j.1439-0426.2011.01893.x

Dulčič, J. & B. Glamuzina (2006): Length–weight relationships for selected fish species from three eastern Adriatic estuarine systems (Croatia). Journal of Applied Ichthyology, 22 (4): 254–256.

Đurović, M. (2012): Ecological study of the juvenile anchovy, *Engraulis encrasicolus* (Linnaeus, 1758), in the Bay of Kotor. PhD Thesis, University of Belgrade, Faculty of Biology

Fisheries and aquaculture software. FishStat Plus – Universal software for fishery statistical time series. 14 September 2017. http://www.fao.org/fishery

Franičević, M., G. Sinovčić, V. Čikeš Keč & B. Zorica (2005): Biometry analysis of the Atlantic bonito in the Adriatic Sea. Acta Adriat. 46 (2): 213-222.

Higginbottom, I., Woon, S., Schneider, P. (2008): Hydracoustic data processing for standard stock assessment using Echoview: technical manual (CC/10/info 4). AdriaMed Technical Documents No. 24. 138 pp.

Ikica, Z. & O. Kasalica (2011): Some biological parameters of shortfin squid, *Illex coindetii* (Vérany, 1839), in trawl fisheries on the Montenegrin coast. 5th international conference "Aquaculture & Fishery", Belgrade, 1–3 June, 2011. Conference proceedings: 518–523.

Ikica, Z. (2013): Dinamika populacije muzgavaca (*Eledone cirrhosa* (Lamarck, 1798) i *Eledone moschata* (Lamarck, 1798)) na području južnog Jadrana. Doctoral thesis. University Centre for Marine Studies, University of Split. 223 pp.

Ikica, Z. O. Kasalica (2011): Some biological parameters of shortfin squid, *Illex coindetii* (Vérany, 1839), in trawl fisheries on the Montenegrin coast. 5th International Conference "Aquaculture & Fishery", Belgrade, 1–3 June 2011. Conference Proceedings: 518–523.

Ikica, Z. O. Kasalica, A. Joksimović, M. Đurović (2010): Preliminarna istraživnaja učešća Cephalopoda u kočarskom ribolovu na Crnogorskom primorju. 39th Annual Conference of the Serbian Water Pollution Society "Water 2010", Divčibare (Serbia), 8–10 June 2010. Conference Proceedings: 221–226.

Ikica, Z. S. krstulović Šifner, A. Joksimović (2011): Some preliminary data on biological aspects of the musky octopus, *eledone moschata* (Lamarck, 1798) (Cephalopoda: Octopodidae) in Montenegrin waters. Studia Marina, 25(1): 21–35.

Ikica, Z., O. Kasalica, M. Mandić, M. Đurović (2011): Dužinsko-težinski odnos najzasupljenijih vrsta cephalopoda u kočarskom ribolovu na Crnogorskom primorju. 40th Annual Conference of the Serbian Water Pollution Society "Water 2011", Zlatibor (Serbia), 7–9 June 2011. Conference Proceedings: 283–286.

Jardas, I. (1987): On the biology and ecology of *Lophius* species (Teleostei, Lophiidae) in the Adriatic Sea. Proc. V Congr. europ. Ichthyol., Stockholm 1985, 181-185.

Jardas, I. (1996): Jadranska ihtiofauna. Školska knjiga, Zagreb, 536 pp

Joksimović, A. (1999): Length-weight relationship of pandora, *Pagellus erythrinus* (Linnaeus, 1758), from the Montenegrin shelf. *Acta Biologica Iuogoslavia- Ichthyologia*, 31(1): 9-21.

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 Sciences, University of Kragujevac: 73p.

Joksimović, A. (2000): Biomass estimate and maximum sustainable yield of Pandora *Pagellus erythrinus* (Linnaeus, 1758) in trawling fisheries at Montenegrin shelf. *Acta Biologica Iugoslavica: Ichthyologia,* 32(1): 17-29.

Joksimović, A. (2001): Growth of Pandora, *Pagellus erythrinus* (Linnaeus, 1758) from the Montenegrin shelf (South Adriatic). Rapp. Com. int. Mer Medit. 36: 278.

Joksimović, A. (2005): Population Dynamic of Red mullet *Mullus barbatus*, Linnaeus, 1758 in the Montenegrin shelf. Doctoral dissertation. Faculty of Biology, University of Belgrade: 93p.

Joksimović, A., M. Đurović, O. Kasalica & A. (2006): Sustainable Utilisation of Marine Fishery Resources of the Montenegrin Coastal area. J. Sci. Agric. Research 67, 238 (2006/2), 83-89.

Joksimović, A., S. Regner & Z. Gačić (2009): Mortality of Red Mullet (*Mullus barbatus* Linnaeus, 1758) on the Montenegrin shelf (South Adriatic). Arch. Biol. Sci., Belgrade. 61 (3), 493-499.

Joksimović, A., S. Regner, O. Kasalica, M. Đurović, A. Pešić, M. Mandić, (2008): Growth of the Red Mullet, *Mullus barbatus*, Linneaus, 1758 on the Montenegrin shelf (South Adriatic). Electronic Journal of Ichthyology (EJI) 4(1): 1-7.

Jukić, S. & C. Piccinetti (1981): Quantitative and qualitative characteristics of demersal resources in the Adriatic sea with some population dynamic estimates. FAO, Fish. Rep., 253: 73-91.

Kapiris, K., O. Kasalica, D. Klaoudatos, M. Djurovic (2011): A comparative study on fishery and biology of *Parapenaeus longirostris* in E. Ionian and S.Adriatic Seas. 5th international conference "Aquaculture & Fishery", Belgrade, 1–3 June, 2011. Conference proceedings: 530-532.

Kasalica, O. 2005. Population dynamics of deep-water pink shrimp *Parapenaeus longirostris* (Lucas, 1846) on the shelf of Montenegrin coast. M. A. thesis. Belgrade, 2005. 75 pp.

Kasalica, O., S. Regner & M. Đurović (2011): Some aspects of the biology of the bogue *Boops boops* (Linnaeus, 1758) in Montenegrin waters (south Adriatic Sea). Studia marina, 25(1): 59-72.

Kasalica, O., S. Regner, Z. Ikica (2011): Some aspects of the biology of the Mediterranean horse mackerel, *Trachurus mediterraneus* (Steindacher, 1868) in Montenegrin waters (south Adriatic Sea). 5th International Conference "Aquaculture & Fishery", Belgrade, 1–3 June 2011. Conference Proceedings: 533–539.

Kasalica, O., S., Regner, B. Petrov & A. Joksimović (2011): Some aspects of the reproductive biology of deep-water pink shrimp *Parapenaeus longirostris* (Lucas, 1846) (Decapoda, Penaeidae) on the Montenegrin shelf. Crustaceana 84 (14): 1683-1696

Krstulović Šifner, S. (2000): Prilog poznavanju biologije i ekologije lignje, *Loligo vulgaris* (Lamarck, 1798) u Jadranu. Master Thesis. Sveučilište u Zagrebu. 98 pp.

Krstulović Šifner, S., E. Lefkaditou, N. Ungaro, L. Ceriola, S. Kavadas, N. Vrgoč (2005): Composition and distribution of the cephalopod fauna in the eastern Adriatic and eastern Ionian Sea. Israel Journal of Zoology. Vol. 51, 315-330.

Krstulović Šifner, S., M. Peharda Uljević, V. Dadić, I. Isajlović, D. Ezgeta, I. Marušić, V. Vlahović & D. Bašković (2009): Opis ribolovnih resursa i preporuke za održivi pridneni ribolov u otvorenom srednjem Jadranu. Program Ujedinjenih naroda za razvoj i Institut za oceanografiju i ribarstvo, Split, Hrvatska, 98 pp.

Krstulović Šifner, S., Z. Ikica, M. Đurović, N. Vrgoč, I. Isajlović & A. Joksimović (2013): Distribution, abundance and population structure of the common cuttlefish, *Sepia officinalis* Linnaeus, 1758, in the Adriatic Sea. VI International conference "WATER & FISH", 12-14 June, 2013, Zemun, Serbia. Conference proceedings: 380-385.

Mandić, M. & S. Regner (2010): Distribution of anchovy eggs in Boka Kotorska bay. Rapp. Comm. int. Mer Médit., 39. 579.

Mandić, M. (2010): Distribution and ichthyoplankton assemblage in Boka Kotorska Bay. The 39 annual Conference of Yugoslav Water Pollution Control Society »WATER 2010«. June 8-10, 2010. Divčibare, Serbia. Conference proceedings: 227-230.

Mandić, M. (2011): Seasonal aspects of ichthyoplankton diversity in the Boka Kotorska Bay. PhD Theses. University of Belgrade. 169

Mandić, M., A. Pešić, & S. Regner (2011): Estimate of anchovy (*Engraulis encrasicolus*, L.) biomass in the southern Adriatic Sea by DEP (Daily Egg Production) Method (2005-2010). . V International Conference "Fishery", February, 1-3 June, 2011, Zemun, Belgrade. Conference proceedings: 554-558.

Mandić, M., A. Pešić, A. Joksimović & M. Đurović (2007): Species composition of juvenile fish in Boka Kotorska Bay. III International Conference "Fishery", February, 1-3, 2007, Zemun, Belgrade. Conference proceedings: 347-352.

Mandić, M., A. Pešić, A. Joksimović & M. Đurović (2008): Main characteristic of population dinamic of hake (*Merluccius merluccius*, Linnaeus 1758) in the open sea of the Montenegrin coastal waters. Natura Montenegrina 7(3): 529-536.

Mandić, M., A. Pešić, A. Joksimović, M. Đurović (2008**):** Main characteristic of Population Dynamic of Hake (*Merluccius merluccius*, Linnaeus 1758) in the open sea of the Montenegrin coastal waters. Natura Montenegrina 7(3): 529-536.

Mandić, M., A. Pešić, M. Đurović, A. Joksimović, O. Kasalica & Z. Ikica (2011): Biological and fisheries characteristics of red mullet (*Mullus barbatus*, L.) from the Montenegrin shelf. The 40 annual Conference of Yugoslav Water Pollution Control Society »WATER 2011«. June 7-9, 2010. Zlatibor, Serbia. Conference proceedings: 277-281.

Mandić, M., A. Pešić, M. Đurović, A. Joksimović, O. Kasalica, Z. Ikica (2011): Ribarstveno-biološke karakteristike barbuna (*Mullus barbatus*, L.) na šelfu Crogorskog primorja. 40th Annual Conference of the Serbian Water Pollution Society "Water 2011", Zlatibor (Serbia), 7–9 June 2011. Conference Proceedings: 277–282.

Mandić, M., M. Đurović & S. Regner (2011): Spawning habitat and biomass estimation of anchovy (*Engraulis encrasicolus* L.) in Bokakotorska bay. Studia Marina, Vol 25. No1: 83-100.

Mandić, M., S. Regner, A. Joksimović & A. Pešić (2013): Spawning of sardine, Sardina pilchardus (Walb.) in Boka Kotorska Bay (South Adriatic Sea). 5th International Symposium of ecologist of Montenegro. ISEM 5. Tivat, Montenegro, 2-5 October. The Book of Abstracts and Programme. 134.

Mandić, M., S. Regner, J. Krpo-Ćetković & A. Joksimović (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

Mandić, M., S. Regner, M. Đurović, A. Joksimović, A. Pešić, & J. Krpo-Ćetković (2015): Distribution and abundance of eggs and estimation of spawning stock biomass of anchovy, *Engraulis encrasicolus* (Linnaeus, 1758), in the South-eastern Adriatic Sea. Journal of the Marine Biological Association of the United Kingdom, 1-9.

Manfrin Piccinetti, G. & M. Rizzoli (1984): Données recueilles au cours des expéditions Pipeta sur la biologie de *Eledone moschata* (Lam.) en Adriatique. FAO, Fish. Rep., 290: 139-141.

Mustać, B. & G. Sinovčić (2007): Morphometric and meristic characteristics of the sardine, *Sardina pilchardus* (Walb., 1792), in the middle eastern Adriatic Sea. Rapp. Co.. int. Mer Médit., 38, 549p.

Mužinić, R. (1964): Mortality of sardine (*Sardina pilchardus* Walb.) under experimental conditions. Archives of Biological Sciences, 16, No. 1-2, 83-95.

Nejedli, S., Z. Petrinec, S. Kužir, & E. Srebočan (2004): Annual oscillation of ovarian morphology in European pilchard (*Sardina pilchardus* Walbaum) in the northern Adriatic Sea. Vet. Arhiv 74 (2), 97-106.

Pešić, A. (2011): Fisheries and biological researches of juvenile sardine (*Sardina pilchardus* Walbaum 1792) in Kotor Bay. PhD Thesis, University of Belgrade, Faculty of Biology

Pešić, A., A. Joksimović, M. Mandić, M. Đurović, O. Marković, Z. Ikica (2012). Biological characteristics of Mediterranean horse mackerel (*trachurus mediterraneus*, Steindachner 1868) from the Montenegrin shelf (south Adriatic). Water Research and Management, 2(3): 29–33.

Pešić, A., A. Joksimović, S. Regner, & B. Mićković (2011): Some biological parameters of red mullet, *Mullus barbatus* (Linnaeus, 1758), in Montenegrin waters. Stud. Mar. 25 (1), 121-136.

Pešić, A., M. Đurović, A. Joksimović, S. Regner, P. Simonović, & B. Glamuzina (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.

Pešić, A., M. Mandić, O. Kasalica, M. Đurović, Z. Ikica, A. Joksimović (2011): Marine fisheries in Montenegro in the last decade (2000–2010). Agriculture & Forestry, 51(05)(1–4): 51–59.

Petrić, M. (2011): Dinamika populacije vrste *Illex coindetii* (Vérany, 1839) (Cephalopoda: Ommastrephidae) na području istočnog Jadrana. Doktorska disertacija. Sveučilište u Splitu i Sveučilište u Dubrovniku. 190 pp.

Piccinetti, C., N. Vrgoč, B. Marčeta, C. Manfredi (2012): Recent state of demersal resources in the Adriatic Sea. Intitute of Oceanography and Fisheries, Split, Croatia, 220 pp.

Regner, S. & A. Joksimoić (2002): Estimate of demersal biomass of the Montenegrin shelf (South Adriatic). Stud. Mar., 23(1): 33-40.

Regner, S. & A. Joksimović (2001): Length-weight relationship of Hake, *Merluccius merluccius* (Linnaeus, 1758), from the Montenegrin shelf (South Adriatic). Acta Biologica Iugoslavica: Ichthyologia, 33(1): 39-47.

Rijavec, L. & Š. Županović (1965): A contribution to the knowledge of biology of *Pagellus erythrinus* L. in the middle Adriatic. Rapp. P.-v. Reun. Comm. int. Explor. scient. Mer Medit., 18 (2): 195-200.

Šantić, M., A. Paladin & B. Rađa (2011): Feeding habits of common pandora *Pagellus erythrinus* (Sparidae) from eastern central Adriatic Sea. Cybium, 35 (2): 83-90.

Sinovčić, G. & B. Zorica. (2006): Reproductive cycle and minimal length at sexual maturity of *Engraulis encrasicolus* (L.) in the Zrmanja River estuary (Adriatic Sea, Croatia). Est. Coast. Shelf Sci. 69: 439-448.

Sinovčić, G. (1986): Estimation of growth, mortality, production and stock size of sardine, *Sardina pilchardus* (Walb.), from the Middle Adriatic. Acta Adriat. 27 (1/2), 67-74.

Sinovčić, G. (1998): The Population Dynamics of the Juvenile Anchovy, *Engraulis encrasicolus* (L.) under the Estuarine Conditions (Novigrad Sea-Central Adriatic). Cah. Options Mediterr. 35: 273-282.

Sinovčić, G., Čikeš-Keč, V. & Zorica, B. (2008): Population structure, size at maturity and condition of sardine, *Sardina pilchardus* (Walb., 1792), in the nursery ground of the eastern Adriatic Sea (Krka River Estuary, Croatia). Est. Coast. Shelf Sci., 76, 739-744.

Sinovčić, G., Franičević, M., Zorica, B. & Čikeš-Keč, V. (2004): Length–weight and length–length relationship for 10 pelagic fish species fro the Adriatic Sea (Croatia). J. Appl. Ichthyol. 20, 156-158.

Sinovčić, G., Zorica, B., Franičević, M. & Čikeš-Keč, V. (2003): First sexual maturity of sardine, *Sardina pilchardus* (Walb.) in the Eastern Adriatic Sea. Periodicum Biologorum 105 (4), 401-404.

Soro, S. & G. Piccinetti Manfrin (1989): Biologia e pesca di Cefalopodi in Adriatico. Nova Thalassia, 10 (1): 493-498.

Ungaro, N., A. Joksimovic, R. Kapidani, L. Ceriola & Milone, N. (2008): Comparability of two different methods for the stock assessment of hake (*Merluccisus merluccius* L.) in the Mediterranean Geographical Sub-Area 18 (Southern Adriatic Sea). GCP/RER/010/ITA/OP-30. AdriaMed Occasional Papers, 30: 13 pp.

Vrgoč N., M. Peharda Uljević & S. Krstulović Šifner (2005): Assessment of demersal fish and shellfish stocks commercially exploited in Croatia. Final Output of the European Union's PHARE 2005 Project: EuropeAid/123624/D/SER/HR program. Report, Institute of Oceanography and Fisheries, Split, Croatia, 163 pp

Vrgoč, N. (2000): Struktura i dinamika pridnenih zajednica riba Jadranskog mora. Disertacija. Sveučilište u Zagrebu. 198 pp

Vrgoč, N., E. Arneri, S. Jukić-Peladić, S. Krstulović-Šifner, P. Mannini, B. Marčeta, K. Osmani, C. Piccineti & N. Ungaro (2004): Review of current knowledge on shared demersal stocks of the Adriatic Sea. FAO-MiPAF Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea.GCP/RER/010/ITA/TD-12. AdriaMed Technical Documents, 12, 91 pp.

Vrgoč, N., I. Isajlović, S. Krstulović Šifner, M. Đurović, O. Kasalica & A. Joksimović (2013): Usporedba dužinskih frekvencija pridnenih vrsta riba u južnom Jadranu tijekom ekspedicija „Hvar" (1948./1949.) i MEDITS (2008.-2011.). 48th Croatian & 8th International Symposium on Agriculture, Dubrovnik, Croatia. Proceedings: 574-578.

Županović, Š. & I. Jardas (1986): A contribution to the study of biology and population dynamics of the Adriatic hake, *Merluccius merluccius* (L). Acta Adriat. 27(1/2): 97-146.

Županović, Š. & I. Jardas (1989): Fauna i flora Jadrana. Logos Split. 526 pp.

Županović, Š. & L. Rijavec (1980): Biology and population dynamics of *Pagellus erythrinus* (L) in the insular zone of the middle Adriatic. Acta Adriat. 21 (2): 203-226.

Ikica, Z., M. Đurović, A. Joksimović, M. Mandić, O. Marković, A. Pešić, E. Arneri, L. Ceriola, N. Milone

Monitoring ribarskog sektora u Crnoj Gori: BIOLOŠKO UZORKOVANJE (septembar 2007 – avgust 2011)

Sažetak

U ovom dokumentu predstavljeni su rezultati monitoringa ribarskog sektora u Crnoj Gori kroz sakupljanje podataka zavisnih o ribarstvu, a koji je sproveden u okviru FAO projekta AdriaMed. Dati su rezultati sakupljanja podataka, primijenjenih metoda i opis najvažnijih bioloških karakteristika uzorkovanih vrsta. Uzorkovanje je rađeno u tri ribolovne luke (iskrcajna mjesta) na Crnogorskom primorju (Geografska pod-regija/*Geographic Sub-Region* 18): Herceg Novi, Budva i Bar. U lukama su uzimani podaci o ulovu i ribolovnom naporu za sve aktivne segmente flote kroz intervjue sa ribarima na kraju ribolovnih putovanja. Sakupljanje podataka započelo je u septembru 2007. godine uzimanjem mjesečnih uzoraka (svaki mjesec iz druge luke). Za vrijeme monitoringa sakupljani su uzorci najvažnijih vrsta u ribolovu (odabranih prema zastupljenosti u ulovu i ekonomskoj važnosti) kako bi se procijenile njihove najvažnije biološke karakteristike i zastupljenost u ulovu, npr. prosječna dužina i distribucija dužinskih frekvencija, odnos polova, zastupljenost stadijuma polne zrelosti u komercijalnom ulovu. Procijenjeni su i dužina prve polne zrelosti i dužinsko-težinski odnos. U vrijeme pisanja monografije, biološki monitoring bio je jedini nacionalni sistem monitoringa koji je pokrivao ulov i ribolovni napor na iskrcajnim mjestima, što može poslužiti ribarskoj administraciji u usvajanju strategija za upravljanje odgovornim ribarstvom zasnovanim na ekosistemskom pristupu ribarstvu.

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