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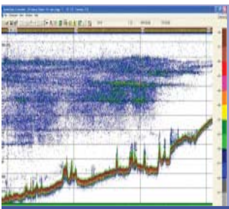

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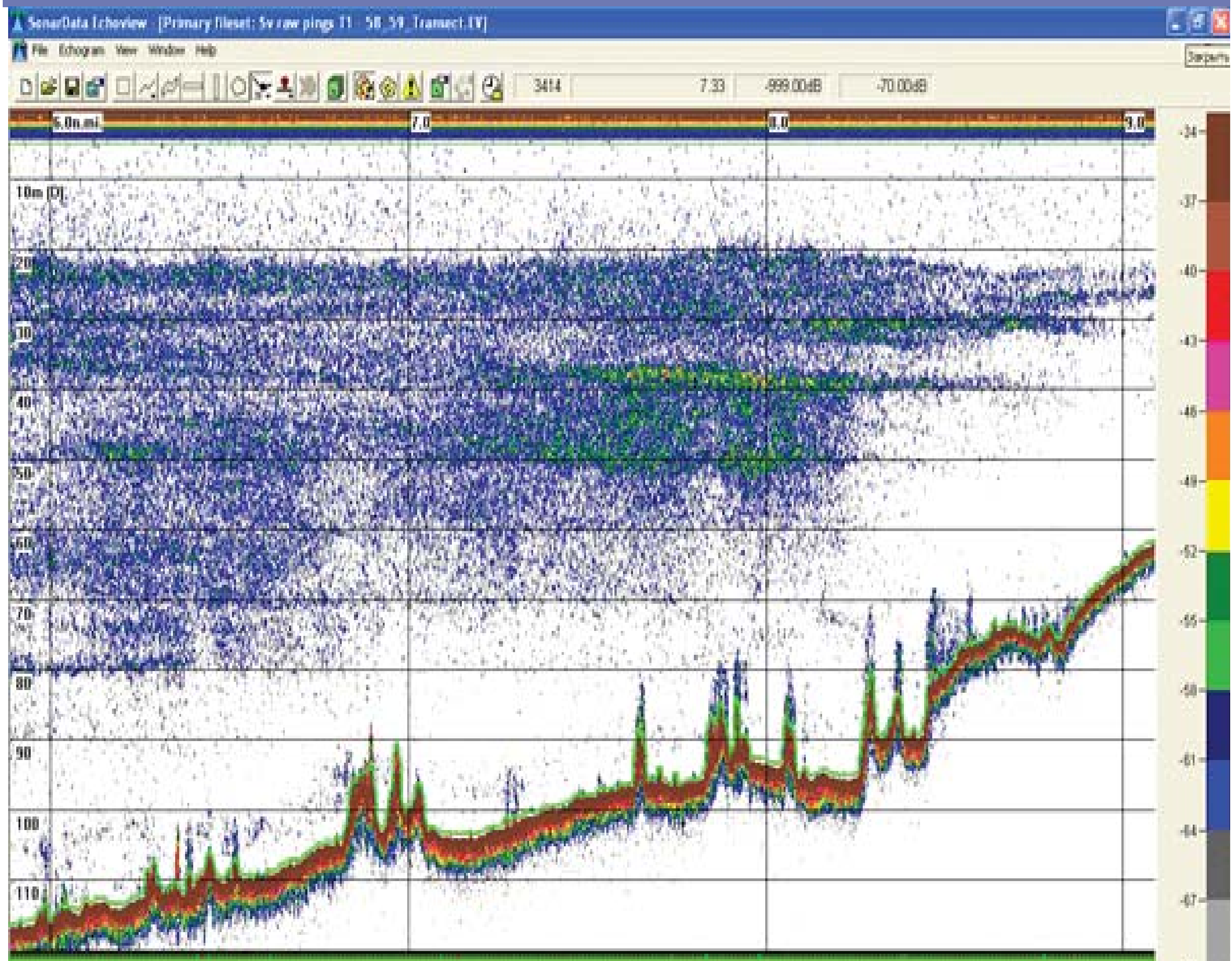
MEDSUDMED - TECHNICAL DOCUMENTS

Report of the MedSudMed Acoustic survey: Lybian continental shelf - South Central Mediterranean Sea (14 August - 06 September 2008)



REPORT OF THE MEDSUDMED ACOUSTIC SURVEY: LIBYAN CONTINENTAL SHELF – SOUTH-CENTRAL MEDITERRANEAN SEA

(14 AUGUST – 06 SEPTEMBER 2008)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome 2015

Preface

The Regional Project "Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily" (MedSudMed) is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Italian Ministry of Agriculture, Food and Forestry Policies (MiPAAF). The Directorate-General for Maritime Affairs and Fisheries of the European Commission (DG MARE) co-funded the project since October 2012. The Italian Regione Siciliana funded a project aimed at strengthening MedSudMed's effectiveness on issues related to demersal resources, namely crustaceans, for 18 months, starting from May 2011.

MedSudMed promotes scientific cooperation between research institutions of the four participating countries (Italy, Libya, Malta and Tunisia), for the continuous and dynamic assessment and monitoring of the status of the fisheries resources and the ecosystems in this area of the Mediterranean Sea.

Research activities and training are supported to increase and use knowledge on fisheries ecology and ecosystems, and to create a regional network of expertise. Particular attention is given to the technical coordination of the research activities between the countries, which should contribute to the implementation of the FAO Code of Conduct for Responsible Fisheries and the Ecosystem Approach to Fisheries. Consideration is also given to the development of an appropriate tool for the management and processing of data related to fisheries and their ecosystems.

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Publications

The MedSudMed Project publications are issued as series of Technical Documents (GCP/RER/010/ITA/MSM-TD-00) and Scientific Reports (GCP/RER/010/ITA/MSM/SR-00) related to meetings, missions and research organized by or conducted within the framework of the Project.

Comments on this document would be welcomed and should be sent to the Project headquarters:

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Preparation of this document

Acoustic surveys are probably the most important source of fisheries independent data to investigate the ecology, abundance and spatial distribution of small pelagic fish species, and to detect possible influence of environmental factors on their abundance and distribution. The experts of the countries participating in the FAO MedSudMed Project (Assessment and Monitoring of the fisheries Resources and the Ecosystems in the Straits of Sicily), during the "MedSudMed Expert Consultation on Small Pelagic Fishes: Stock Identification and Oceanographic Processes Influencing their Abundance and Distribution (Tunisia, October 2003)", deemed it necessary to expand the area covered by acoustic surveys and investigate areas where little or outdated information on fish biomass was available. As follow up, cooperative acoustic and oceanographic surveys at sea were planned and have been organised by the Project in the south-central Mediterranean Sea.

This document is the final version of the report of the MedSudMed Acoustic Survey carried out in Libyan waters from 14th August to 06th September 2008 on board of the R/V Dallaporta. The document presents also the results of the processing of the data collected during the survey. The survey was organised in the framework of the MedSudMed Project in cooperation with the Istituto per l'Ambiente Marino Costiero (IAMC-CNR) of Mazara del Vallo/Capo Granitola (Italy) and the Marine Biology Research Centre (MBRC) of Tajura (Libya). The Fishery Acoustic Laboratory of VNIRO, Moscow, Russia and the Fishing Technology Department of the Istituto di Scienze Marine (ISMAR-CNR) of Ancona, Italy, were also involved in the survey and/or in the data processing.

This report is one of resultss of the MedSudMed Project component on "Small Pelagic Fish: Stock Identification and Oceanographic Processes Influencing their abundance and distribution". This report is primarily for scientists of the south-central Mediterranean Sea; it can also be of interest for students and professional of fisheries research and management in the Mediterranean Sea region. It is believed to be a contribution to the improvement of knowledge on the distribution and abundance of small pelagic fish in the south-central Mediterranean Sea.

Acknowledgements

The Libyan Authorities, through the General Authority of Marine Wealth, are gratefully acknowledged for their support. Mr. Nurredin Essarbout (MBRC, Libya) and Mr. Salvatore Mazzola (IAMC-CNR, Italy) are warmly thanked for the effort made and the support provided in the organization of all activities and for making this work possible. The crew of the R/V is thanked for its work. The assistance of Ms Caroline Bennett is also widely acknowledged.

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MedSudMed Technical Documents No. 30. GCP/RER/ITA/MSM-TD-30, Rome, 2015: 54 pp.

ABSTRACT

This document is the final version of the report of the MedSudMed Acoustic Survey carried out in Libyan waters from 14 August to 06 September 2008 on board the R/V Dallaporta. The document also presents the results of the processing of the data collected during the survey. The survey was carried out under the cooperative framework promoted by the FAO Project MedSudMed (Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily). The main objective of the survey was to collect information on abundance and distribution of small pelagic fish and on some environmental factors along the Libyan continental shelf. To this end, acoustic measurements of small pelagic fish were carried out. Sampling of small pelagic fish using a pelagic trawler was carried out as well. Advantage was also taken during the survey to measure some physico-chemical parameters of the water column. The acoustic survey was the first survey for the assessment of small pelagic fish biomass since 1993-1994 in Libyan waters. An overall description of the sampling scheme, of the area explored and of the methods adopted is provided. The biomass, abundance, spatial distribution, length frequency distribution and length weight-relationship for the main small pelagic species found in Libyan waters is described: *Engraulis encrasicolus*, *Sardina philcardus*, *Sardinella aurita*, *Trachurus mediterraneus*, *Scomber japonicas*, *Boops boops*, *Spicara* spp. and *Etrumeus teres*. Sea water temperature, salinity and oxygen along the water column are also illustrated.

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1. Introduction

The cooperative MedSudMed oceanographic survey "MSM Libya 2008" was carried out in Libyan waters on board "R/V Dallaporta" from 14th August to 06th September 2008 and was the first survey for the assessment of small pelagic fish biomass since 1993-1994 in this area. The survey was executed in cooperation with scientists of the Istituo per l'Ambiente Marino Costiero-Consiglio Nazionale per le Ricerche (IAMC-CNR) of Mazara del Vallo (Italy), the Marine Biology Research Centre (MBRC) of Tajura (Tripoli, Libyan Arab Jamahiriya), the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) of Moscow (Russia) and the FAO MedSudMed Project (Assessment and Monitoring of the Fisheries Resources and the Ecosystem in the Straits of Sicily, GCP/RER/010/ITA). The Fishing Technology Department of the Istituto di Scienze Marine (ISMAR-CNR) of Ancona also participated in the survey.

The survey was carried out in the framework of the MedSudMed Component on "Small Pelagic Fish: Stock Identification and Oceanographic Processes Influencing their abundance and Distribution". The overall objective of the survey was to assess the biomass and the spatial distribution of small pelagic fish in the Libyan waters by means of acoustic methods. During the survey, CTD data were also collected to study the water-mass circulation and its possible effects on the spatial distribution of small pelagic fish. The area covered during the survey spans the whole Libyan coasts as shown in Figure 1.

The following activities were carried out during the survey:

1) Acoustic measurements of small pelagic fish stock using a scientific echo-sounder Simrad EK60 with three split beam transducers (ES38B, ES120-7C and ES200-7C) fixed on the hull and operating at frequencies 38, 120 and 200 kHz. The scientific echo-sounder was calibrated for the three frequencies at the end of the transects covered between Marsala and Siracusa during the "Ancheva 2008" survey. The calibration was made on 10th and 11th August in the bay of Siracusa using standard copper spheres with known target strength (TS, -33.6 dB for 38 kHz, -40.4 dB for 120 kHz and -44.8 dB for 200 kHz). During the acquisition phase, echogram signals were recorded on hard disk with the acquisition and post-processing software ER60.

2) Biological sampling of small pelagic fish using a pelagic trawl net equipped with a Simrad ITI, to control the trawl opening during the sampling. The trawl was a "Volante Monobarca" type, with the following characteristics: 78 m total length, 22 m sack with 18 mm mesh opening, 7 m vertical opening and 13 m horizontal opening, for a total mouth opening of 91 m^2. The trawl net had a total of 252 meshes (78 x 2 + 48 x 2) of 600 mm. Steel rope of 16 mm diameter and 50 m length warp were used. Boards were rectangular, 190 x 115 cm and 380 kg each.
   The sensors of the Simrad ITI were positioned on the upper part of the net mouth. The hydrophone used for the transduction of acoustic signals into electric signals was fixed on the same structure of the echo-sounder transducers. The speed of the vessel was 3.5-4 knots during the biological sampling. For each biological sample, EK60 records were monitored and saved to check the bottom and to be used during the acoustic data processing. Acoustic data can be used both to study the TS vs length relationship with *in situ* data and for species identification.

3) Measurement of physical-chemical parameters of the water column through a multiparametric probe SEABIRD mod. 9/11 plus. The probe was put into the water from the starboard side of the vessel, using a double drum and an 8 mm steel cable. The sensors that were connected to the CTD (Conductivity, Temperature, Depth) measured: pressure, temperature (double sensors), conductivity (double sensors), fluorescence, dissolved oxygen (double sensors), light transmission and PH. Data were acquired along the vessel track trying to collect at least 2 CTD profiles for each transect.

2. Participating Institutes

Scientists from the following Institutions participated in the organization and the execution of the survey:

1. Istituto per l'Ambiente Marino Costiero – Consiglio Nazionale per le Ricerche (IAMC – CNR), Mazara del Vallo, Italy;
2. Marine Biology Research Centre (MBRC), Tripoli, Libya;
3. FAO - MedSudMed Project
4. Fishery Acoustic Laboratory of VNIRO, Moscow, Russia

3. Staff on board

Eleven scientists participated in the first leg of the survey (14 – 26 August 2008) (Table 1). Ten scientists participated in the second leg of the survey (26 August – 06 September 2008) (Table 2). The work shifts (hours) allocation is reported in Table 3.

Table 1. List of scientists who participated in the 1st leg of the "MSM Libya 2008" survey on board the R/V Dallaporta.

Name	Sex	Nationality	Title	Role on board	Institution
1) Angelo Bonanno	M	Italian	CNR Researcher	Chief scientist	IAMC-CNR Mazara (TP)
2) Tarub Bahri	F	Algerian /French	FAO officer	Misc. measurements	FAO MedSudMed
3) Domenico Tegolo	M	Italian	Associated Prof.	Misc. measurements	University of Palermo
4) Sergey Goncharov	M	Italian	CNR Technician	Acoustics	VNIRO FAL
5) Salem Zgozi	M	Libyan	MBRC Researcher	Misc. measurements	MBRC Tripoli
6) Sergey Popov	M	Italian	CNR Researcher	Acoustics	VNIRO FAL
7) Mohamed Hamza	M	Libyan	MBRC Researcher	Misc. measurements	MBRC Tripoli
8) Mohamed Assughayer	M	Libyan	MBRC Researcher	Misc. measurements	MBRC Tripoli
9) Ahmed Nfate	M	Libyan	MBRC Researcher	Misc. measurements	MBRC Tripoli
10) Vito Palumbo	M	Italian	CNR Collaborating technician	Fishing operations	IAMC-CNR Mazara (TP)
11) Jamal Salem Rabha	M	Libyan	Coast Guard	Observer	Tripoli

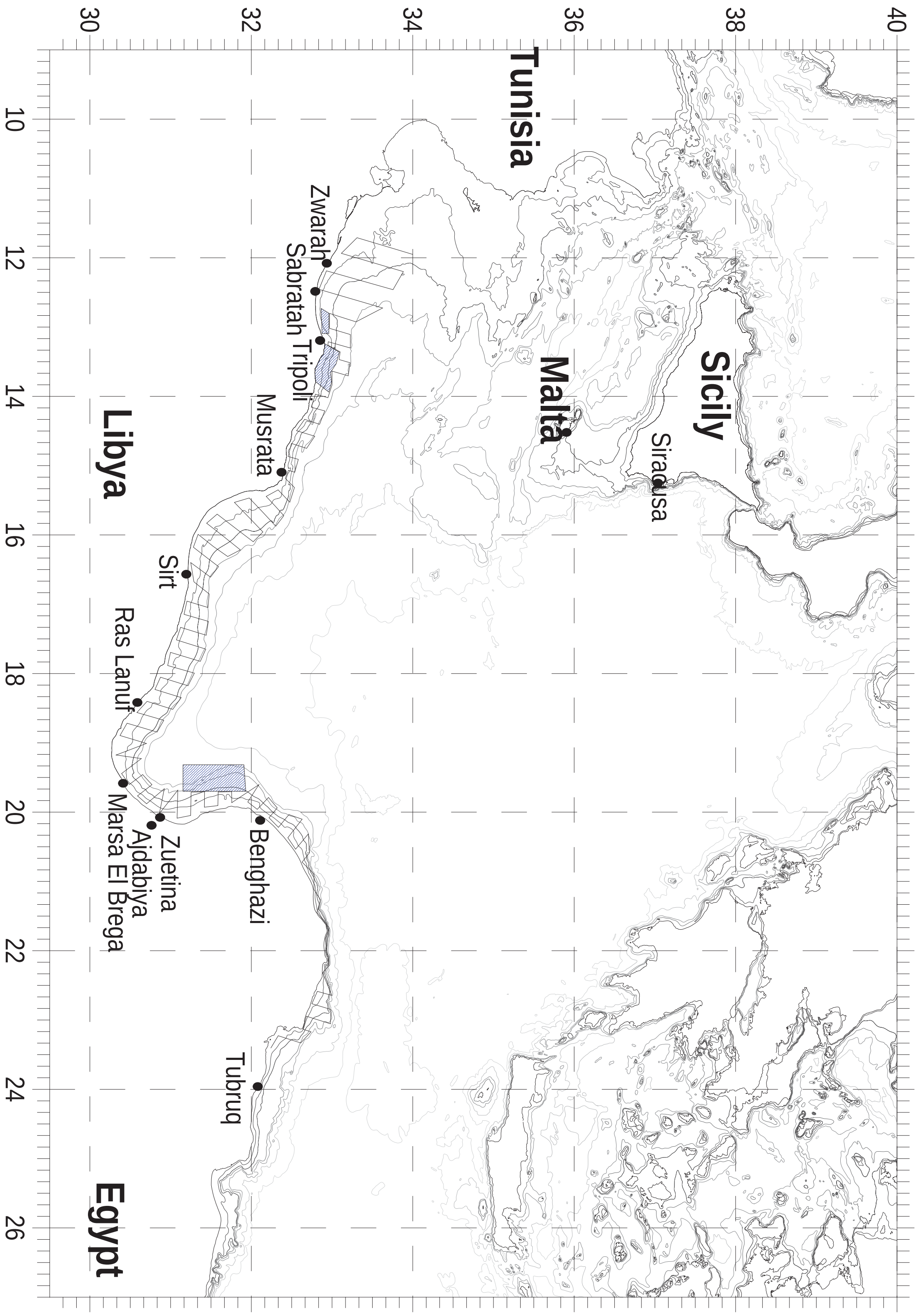


Figure 1. Acoustic transects covered during the survey “MSM Libya 2008”, R/V Dallaporta, 14 August – 7 September 2008.

Table 2. List of scientists who participated in the 2nd leg of the "MSM Libya 2008" survey on board the R/V Dallaporta.

Name	Sex	Nationality	Title	Role on board	Institution
1) Gualtiero Basilone	M	Italian	Researcher	Chief scientist	IAMC-CNR Mazara (TP)
2) Ignazio Fontana	M	Italian	Technician	Misc. measurements	
3) Giovanni Giacalone	M	Italian	Technician	Misc. measurements	
4) Luca Caruana	M	Italian	Technician	Fishing operations	
5) Sergey Popov	M	Russian	Researcher	Acoustics	VNIRO FAL
6) Salem Zgozi	M	Libyan	Researcher	Misc. measurements	MBRC Tripoli
7) Mohamed Hamza	M	Libyan	Researcher	Misc. measurements	
8) Mohamed Elsger	M	Libyan	Researcher	Misc. measurements	
9) Ahmed Nfate	M	Libyan	Researcher	Misc. measurements	
10) Jamal Salem Rabha	M	Libyan	Coast Guard	Observer	

Table 3. Working hours on board and scientific staff involved: A = first leg, 14 – 26 August 2008; b = second leg, 26 August – 7 September 2008.

A	Working period	Scientific staff
1st shift Acoustics and CTD	00 – 04 and 12 – 16	Domenico Tegolo Tarub Bahri
2nd shift Acoustics and CTD	04 – 08 and 16 – 20	Sergey Popov Mohamed Elsger
3rd shift Acoustics and CTD	08 – 12 and 20 – 24	Sergey Goncharov Salem Zgozi Angelo Bonanno
Biological sampling*	7.00 – 23.00 *	Vito Palumbo Ahmed Nfate Mohamed Hamza

B**	Working period	Scientific staff
1st shift Acoustics and CTD	00 – 04 and 12 – 16	Ignazio Fontana Giovanni Giacalone
2nd shift Acoustics and CTD	04 – 08 and 16 – 20	Sergey Popov Mohammed El-Sgear
3rd shift Acoustics and CTD	08 – 12 and 20 – 24	Salem Zgozi Gualtiero Basilone
Biological sampling*	7.00 – 23.00 *	Luca Caruana Hammed Nafathi Mohammed Hamza

**All scientific staff participated in the activities related to biological sampling carried out during the related work shift.*

***It was agreed to have two members more of the crew on deck during the night shifts in the CTD stations.*

4. Narrative of the survey

Day 1: 14 August (Thursday, Catania).
The morning was dedicated to the formalities of embarking of scientific crew. Work shifts were allocated (Table 3) also considering the Libyan scientists who will embark in Zwara (Libya). Departure time from Catania was set at 17:30. Weather conditions were good in the Ionian Sea. Bad weather was forecasted for the Strait of Sicily. A biological sample was collected in the evening (Haul 18), as well as a CTD cast.

Day 2: 15 August (Friday, Siracusa).
Weather conditions worsened south of Capo Passero, therefore the Captain decided to go back to Siracusa at 00:40 to wait for improvement. The ship remained in Siracusa harbor all day.

Day 3: 16 August (Saturday, Siracusa).
At 08:00, calibration operations started in the middle of the Bay of Siracusa (37º02.686´N; 15º17.367´E). This was the second calibration of the 200 kHz transducer, as the previous one had been done using a tungsten sphere used with the previous echo-sounder (Biosonics). The results of the calibration are reported in Annex 1. Calibration was achieved at 14:00 and the vessel went back to the harbor to wait for an improvement in the weather conditions.

Day 4: 17 August (Sunday, Siracusa).
The vessel remained at the harbor because of the bad weather conditions in the entire area.

Day 5: 18 August (Monday Siracusa – Malta).
Administrative formalities were completed with the Port Authority and the Police Station. The vessel left the harbor bound for Libyan waters. It was decided to record acoustic data during the trip along the transect M3-M4 (a) on the Maltese continental platform. CTD casts were also recorded (Stations MSM2008_102, MSM2008_103, MSM2008_104, MSM2008_105 e MSM2008_106 (Figure 3). Biological sampling (Haul 19) was also carried out with a pelagic trawl at a depth of 100 m. All activities were interrupted after station M3; the vessel left for Libyan waters.

Day 6: 19 August (Tuesday Malta - Zwara).
The trip from Maltese to Libyan waters took all night and part of the day. The vessel traveled towards Zwara to embark the scientists of the MBRC and the coast guard.

Day 7: 20 August (Wednesday, Zwara).
The vessel reached the anchor area at 01:30 and waited for notice from the Marine agency (Marine Agency Department – Tel. +218 91 21 25 685; Fax +218 21 33 51 608; E-mail agency@rashilal.com). Staff from the Marine Agency, local authorities and the staff to embark reached the vessel around 11:00 on a small vessel. After finalization of the administrative formalities, the activities started. CTD casts MSM2008_107, MSM2008_108, MSM2008_109, MSM2008_110, MSM2008_111, MSM2008_112, MSM2008_113 and MSM2008_114 were recorded and the hauls L1 and L2 were carried out (Figure 2). The weather conditions improved during the day.

Day 8: 21 August (Thursday, Zwara – Sabratah).
Good weather conditions. Collection of acoustic data and CTD casts was carried out regularly. Two biological samples were collected using the midwater pelagic net (Figure 2).

Day 9: 22 August (Friday, Sabratah – Al Khums).
Good weather conditions, except for the disturbance caused by a long wave that lasted all day.

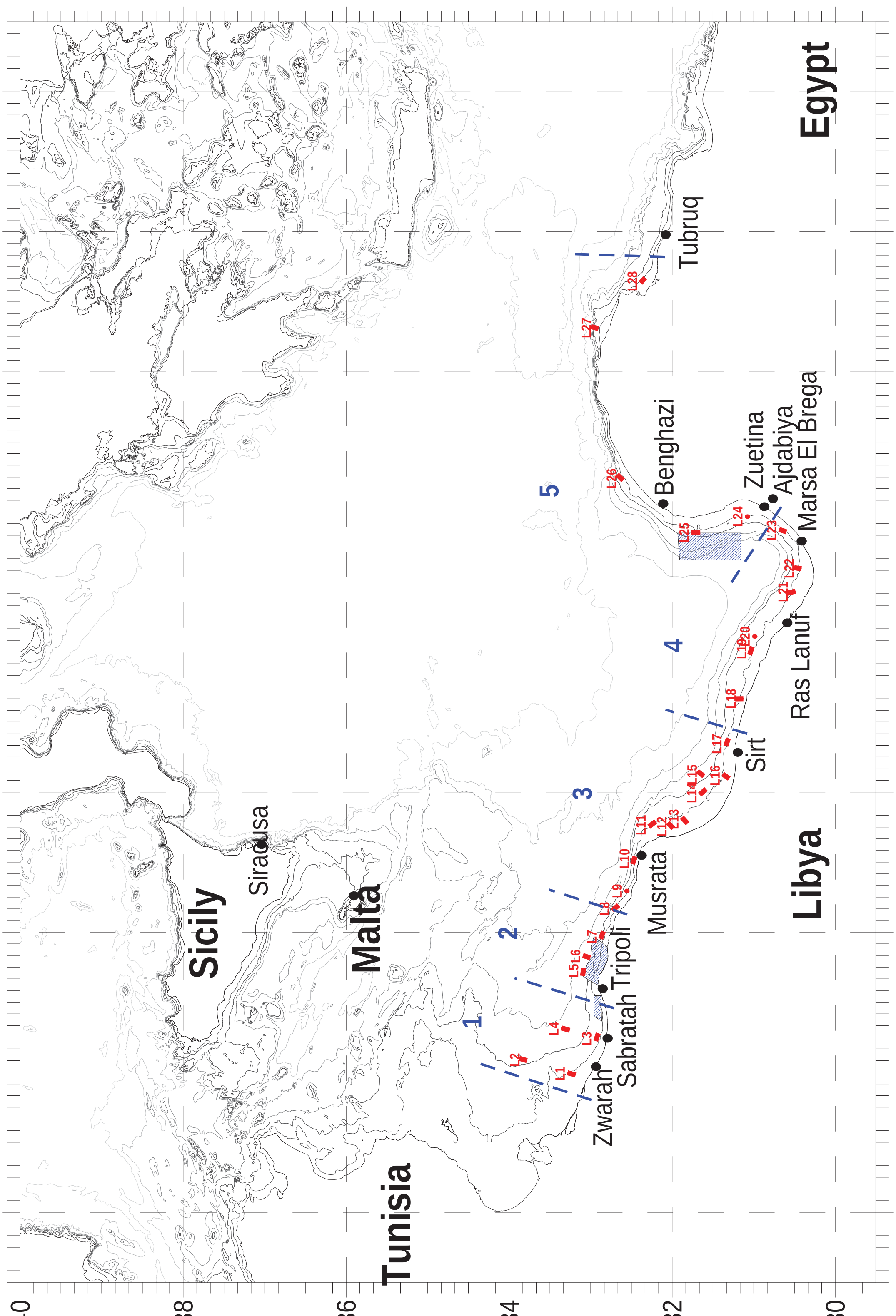


Figure 2. Position of the trawl hauls made and the acoustic transects covered during the survey "MSM Libya 2008", R/V Dallaporta, 14 August – 7 September 2008.

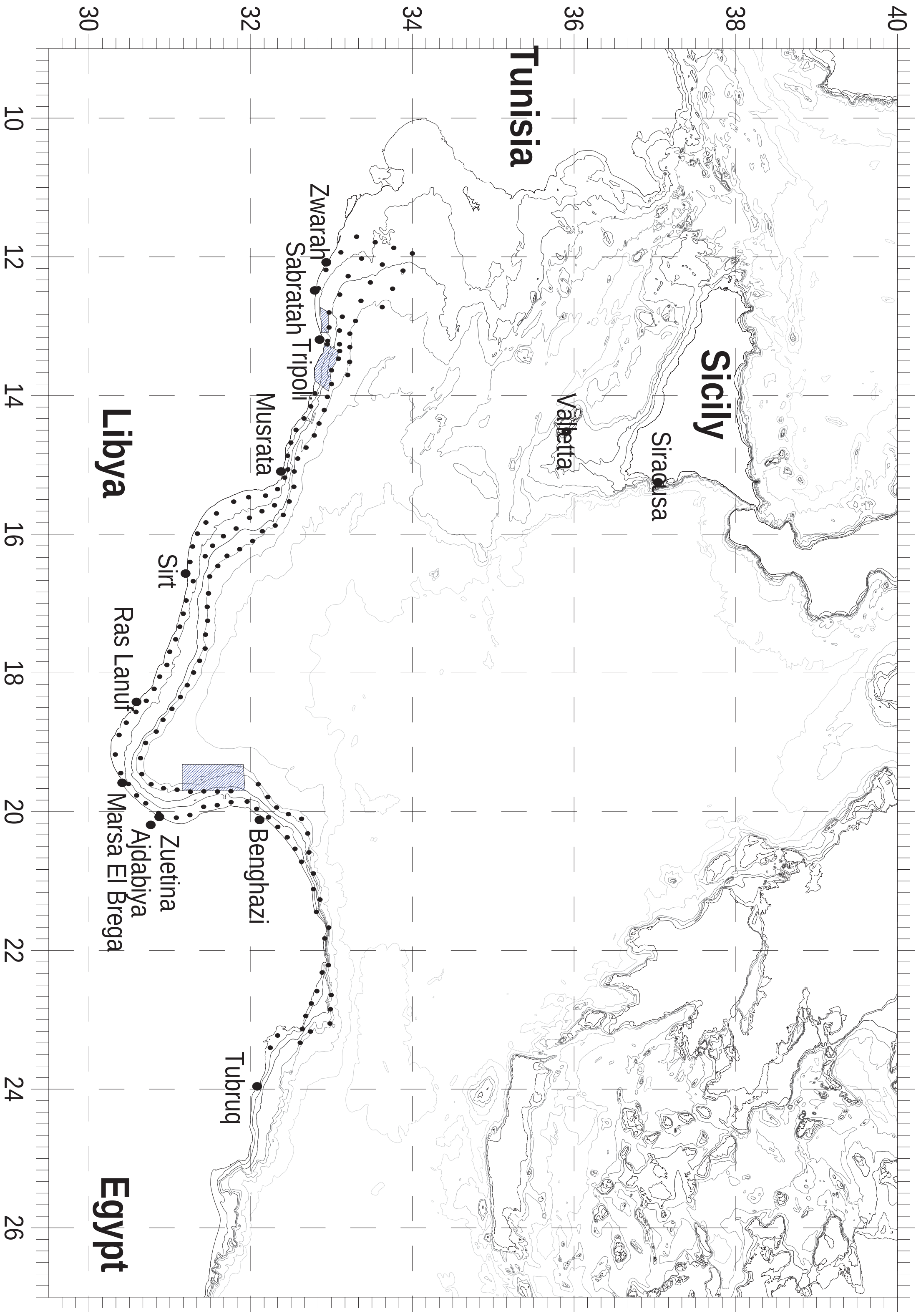


Figure 3. Position of CTD stations covered during the survey "MSM Libya 2008", R/V Dallaporta, 14 August – 7 September 2008.

Day 10: 23 August (Saturday, Al Khums – Misurata).
The whole day was dedicated to the collection of acoustic data and CTD casts. During haul L9, the trawl boards overlapped and so the crew had to take the necessary steps to remedy this and disentangle the net. Excellent weather conditions.

Day 11: 24 August (Sunday, Misurata – Gulf of Sirt).
Excellent weather conditions. Collection of acoustic data and CTD casts proceeded without significant change to the work plan. CTD stations from MSM2008_154 to MSM2008_163 (Figure 3) and 3 hauls were made (Figure 2). Notice was received from the IAMC-CNR of Mazara del Vallo that the replacement crew could not take the plane for Tripoli due to passport problems. It was therefore decided to delay the arrival in Sirt and the crew change by one day.

Day 12: 25 August (Monday, Misurata – Sirt).
Excellent weather conditions. Activities proceed as planed for the collection of acoustic, CTD and biological data. The replacement team informed those on board that administrative problems had been solved and that they could travel to Tripoli. The Marine Agency was in charge of the transfer of the researchers between Tripoli and Sirt where they planned to arrive the following day, early afternoon.

Day 13: 26 August (Tuesday, Sirt).
Acoustic and CTD data collection went on all night. Activities were interrupted at station CTD MSM08_181 to travel towards Sirt. The vessel reached the harbor around 13:00 to change scientific crew and load water, fuel and provisions. Angelo Bonanno, Tarub Bahri, Sergey Goncharov, Domenico Tegolo and Vito Palumbo disembarked; Gualtiero Basilone, Luca Caruana, Ignazio Fontana e Giovanni Giacalone embarked. Work shifts are shown in Table 3.
Supplying water was achieved with some difficulties due to the dimensions of the pipe which were different from that of the tank. Only 5 m^3 of water were filled in 3 hours. It was therefore decided to remain in the harbor to fill water overnight. The tank was filled at around 02:30.

Day 14: 27 August 2008 (Wednesday, departure from Sirt).
Departure from Sirt at 08:15 with calm sea. Acquisition of acoustic data started again after CTD station MSM08_181. A reconnaissance was carried out to check whether the bottom was suitable to carry out a haul. As the bottom was quite irregular, it was decided not to fish in the morning and to make an attempt in the afternoon, provided that the bottom shape allowed for this. The data acquisition was interrupted at 15:55 to look for an area in which to fish between the isobaths 60 and 70 m. However, the bottom remained very irregular and it was decided to go back to the transect to continue the collection of acoustic data. Another interruption occurred at 16:32 and after several attempts, it was decided to postpone the haul to the evening when the fishing can be done in a pelagic layer. Station MSM08_182 was covered. The bottom was explored in the coastal area and haul L18 was made in the layer 20-30 m (with a bottom depth between 40 and 60 m). Few fish were caught, mainly juveniles of round sardinella.

Day 15: 28 August 2008 (Thursday, Ra's Lanuf)
Transects were completed during the night as far as the vortex corresponding to the CTD station MSM08_192. At 08:00, the sea was calm and the weather conditions excellent. Areas where schools were detected by the echo-sounder show an extremely uneven bottom. At 09:45 the echogram shows a bottom shape apparently more even and it was decided to interrupt the data acquisition to fish. Although no trawlable bottom was found for more than 1 n.m. it was decided to fish anyway (Haul L19) without letting the trawl touch the bottom, because of the presence of numerous fish schools. Unfortunately the net remained empty and at 12:07 the transect was continued towards station MSM08_194. Depths were over 100m until 17:00 and no fish were detected. Subsequently the bottom seemed more even and some schools were recorded along the transect. It was decided to turn back on the transect and to carry out haul L20 (bottom depth around 60-70m). This time, the trawl was laid on the bottom, but the catch was null with mostly trash. The list of hauls carried out by the Libfish Project in 1994 was consulted and confirmed that this area had been classified as untrawlable. Collection of acoustic and CTD data continued. In the evening, the echogram showed a similar layer as the one corresponding to the catch of round sardinella juveniles. It was decided not to fish to save time. Weather conditions were still good, even though the wind increased during the evening.

Day 16: 29 August 2008 (Friday, SE Ra's Lanuf)
Time 8.00: calm sea. Transects were completed during the night until station MSM08_202 (Figure 3). At 10.15, after checking for the presence of fish on the echogram and the evenness of the bottom, it was decided to interrupt the survey to look for a suitable area for fishing. Haul L21 was started at 11.20 (Figure 2) and was the first good catch of the second leg (46 kg). The catch included 99% of round sardine, both juveniles and adults at an average depth of 57 m. The survey continued until 17.01, time at which another suitable fishing area was sought, without success. It was decided to continue collecting acoustic and CTD data. In the evening (21.38), haul L22 was collected in a pelagic layer (28-35 m); the catch was composed of juveniles of round sardine and another unidentified species of clupeoids. Samples were saved in formalin for accurate identification in the laboratory. A sample was also given to the MBRC staff. So far, it was noticed that there are areas in which to carry out hauls at depths of around 60-70 m; however without enough fish that could justify collection of biological samples (also considering the time left to complete the survey). On the contrary, fish seem to be abundant in shallow waters the where the bottom is not trawlable.

Day 17: 30 August 2008 (Saturday, Ra's Lanuf).
Good weather and sea conditions, calm sea and little wind. Transects were completed until station MSM08_212 during the night. The survey was interrupted at 08:45 to look for a suitable area to collect haul L23. The sample was collected at 09:30 in 70 meter-depth area; the trawl-eye sensor did not function (probably because of flat batteries) and therefore the position of the trawl could not be monitored. No pelagic fish were caught, only 1.5 kg of demersal species were caught. Collection of acoustic data was started again at 10.57. It was interrupted at 16.42 between stations MSM08_215 and MSM08_216 to look for a suitable area for fishing. The haul L24 was collected at 17.33 at 71 m depth. Despite quite an even bottom, the trawl was halted 10 minutes before the theoretetical duration of the haul, as it seemed not to react to changes in the vessel speed. Indeed, the trawl was full of algae that probably weighed it down and broke it. The catch was 6 kg of demersal fish. The survey started again at 19.57. Operations were

initiated to change the trawl and move the transducers on the new trawl and took longer than expected, preventing the team from making the evening haul.

Day 18: 31 August 2008 (Sunday, Qaminis)

Calm sea, little wind and veiled sky. Acoustic acquisition was interrupted at 09.00 to look for a suitable area for fishing. Haul L25 was made in a 66 m-depth area. The survey was interrupted at station MSM08_225 at 16:16 to try to make a haul. The echogram showed abundant fish, but the bottom was too uneven to make any attempt to fish. After one hour spent looking for a suitable area, the survey was started again. In the evening, the area prospected showed depths between 100 and 200 m. No fish was detected and it was decided to cancel the evening haul.

Day 19: 01 September 2008 (Monday, Tukrah).

Good weather and sea conditions. Some fish schools were recorded during the 04-08 work shift, with even bottom around 60-70 m. Haul L26 was made at 65 m depth; 5 kg of fish were caught, among which round sardinella, boops and spicara. The survey started again at 12.06. Several fish schools were detected in the afternoon around 65 m, but after having prospected the zone, it was decided not to make any hauls because of the unevenness of the bottom. CTD casts were collected up to the maximum depth of 450 m. Considering the shape of the echogram, the evening haul was also cancelled, as it was deemed that it would not provide useful information for the purposes of the survey. Because of the presence of a long wave (resulting from a storm in the Aegean Sea) the speed was reduced to 6 knots.

Day 20: 02 September 2008 (Tuesday, Darnah-Ra’S Al Hilal).

The long wave lasted all night. It was decided to complete the transect as far as station CTD MSM08_249 and then travel to Ra’S Al Hilal to load fuel (8000 l) and water (2500 l). The harbor was reached at 11.30. Loading started at 12.40 and finished at 18.30. The work started again with a haul: haul L27 was made on a layer close to the bottom at 55-60 m depth: the catch contained mainly crustacean larvae and bottom fish. Acoustic acquisition started again from station MSM08_250 at 23:12.

Day 21: 03 September 2008 (Wednesday, Ra’S At Tin).

07.30 am, moderately rough sea; the weather forecasts predicted wind from SE in the next hours. The speed was reduced to 7.7 knots during the night because of the weather and sea conditions. The following transects were inspected in order to detect the possible presence of fish aggregations and consequently to define the next sampling point. Neither fish aggregations nor appropriate grounds to carry out a sampling haul were detected. At 13:58, once the presence of some fish aggregations had been recorded and once an inspection of the bottom had been carried out, haul L28 (45 m depth and at a distance of 4 m from the bottom) was initiated. During the haul, the “trawl-eye” sensor did not work, which prevented the proper monitoring of the net. Approximately 24 kg of demersal fish and 2 balister fish were caught at the end of the haul, while no pelagic fish were found. Pelagic fish were not detected by the echo-sounder in this area either. Likewise, the few fishing vessels encountered in this area did not seem equipped to capture small pelagic fish but rather demersals and only occasionally migratory species, mostly having long lines, FAD and trammel nets. At the end of the haul the captain suggested that the crew update the working timetable considering both the distance from the port of Mazara del Vallo (650 n.m.) and the remaining vessel time. The working timetable foresaw continuation along the transect until Tubruq harbor (by covering other 80 n.m. by the following morning) and then entering the port in order to disembark the Libyan scientists. However, the Captain reminded the scientific crew that the weather forecasts indicated the arrival of a strong wind from SE in the Ionian Sea and in the Sicily Channel; he also stressed that completing the timetable would imply a delay in the departure from Tubruq until the improvment of the weather conditions. According to the captain, this could imply a 3-day forced stop. To avoid this risk the Captain suggested a temporary break-off from the survey, disembarking the Libyan scientists in Tubruq and leaving the port as soon as possible, perhaps during the night. Following this advice the Libyan colleagues disembarkation in Tubruq was quickly organised. At 15.45 the echo survey was definitively stopped and the direction to Tubruq was taken, arriving at 18.30 in Tubruq. The ship was anchored in the natural bay waiting for the Ship agency which was preparing the custom documents. Unfortunately during Ramadan it was not possible to enter the port (as already stated by Dr Salem Zgozi), but luckily the local Authorities gave permission and at 22.00 the ship approached the dock to carry out the customs operations. At midnight the vessel left the port and begun the journey back.

Days 22, 23 and 24: 04, 05 and 06 September2008 (Thursday, Friday, Saturday, transfer towards Mazara del Vallo)
Travel back to Mazara del Vallo in rather good weather and sea conditions. Mazara was reached on 06 September at 15.30 hours. Staff and equipment were disembarked and the vessel left for Ancona.

5. Materials and Methods

5.1 Acoustic data acquisition

The echosurvey covered the continental shelf with depths ranging from 0 to 200 m. Figure 1 shows the echosurvey design adopted in GSA 21 (Libyan waters). Since it was the first MedSudMed echosurvey in this area, the sampling scheme was designed according to the general protocol agreed and adopted by the experts participating in MedSudMed. The echosurvey was conducted along parallel transects perpendicular to the coastline. The mean distance between transects was 10 nautical miles (nm). Only on the largest continental shelf in the western part of the study area, due to the length of transects, the selected distance between them was 15 nm. Due to the reduction of the continental shelf extension along the Eastern Libyan coasts, a zig-zag survey design was adopted in this area (see Figure 1). In total, the distance covered along and between parallel transects was about 1958 nm.

Routine acoustic sampling was performed at a vessel speed of 8-9 knots, using a scientific echo-sounder Simrad EK60 with three split beam transducers (ES38B, ES120-7 and ES200-7C) fixed on the hull (3.5 m from the sea surface) and operating at frequencies 38, 120 and 200 kHz.

Due to the available vessel time it was decided to acquire acoustic data 24 hours a day (during both day and night time), even though the acoustic prospecting is recommended only during the day.

The scientific echo-sounder was calibrated for the three frequencies, according to the methodology described by Johannesson and Mitson (1983), at the end of the transects that were covered between Marsala and Siracusa during the “Ancheva 2008” survey. The calibration was carried out on 10th and 11th August in the bay of Siracusa using standard copper spheres with known target strength (TS, -33.6 dB for 38 kHz, -40.4 dB for 120 kHz and -44.8 dB for 200 kHz). During the acquisition phase, echogram signals were recorded on hard disk with the acquisition and post-processing software ER60. In Annex 1 the results of the calibration procedure are reported.

5.2 Analysis of the Echograms

The analysis of acoustic data (post-processing) was performed by means of the SonarData EchoView (V. 3.30) software package. Minimum resolution of the echo-integration interval was agreed to be 1 nm. After having set the calibration parameters, the values of the Nautical Area Scattering Coefficient (NASC; MacLennan et al., 2002) for each nautical mile of the survey (EDSU) were estimated. In particular, Total NASC, due to the total backscattering signal in the water column, and NASC Fish per EDSU were evaluated. Some examples of the echograms acquired during the echosurvey area shown in Annex 2.

5.3 Biological sampling

The acoustic evaluation of fish biomass foresees carrying out fish catches at the same time as the acoustic data recording (McLennan and Simmonds, 2005). The acquisition of acoustic data on board the vessel was then interrupted according to a precise protocol, in order to carry out the experimental control catches by a pelagic/mid-water trawl net. The boat speed during the trawling was 3-4 knots and the net was monitored continuously by using a netsonde, in order to control the opening of the mouth and the position respect to the bottom.

The structure of the equipment used for the biological sampling is the following:

- pelagic trawl net 78 m long, code end 22 m long with 18 mm mesh size, vertical and horizontal opening 7 m and 13 m respectively (area about 90 m^2), initial mesh size 182x800 mm and lateral mesh size 400 mm;
- 50 m steel cable with a diameter of 16 mm, doors 190 x 115 cm of 380 kg each;
- Kongsberg Simrad ITI monitoring trawl net system.

For using the Simrad ITI system, the sensors were installed on the upper part of the mouth of the net while the hydrophone was installed on a tow body that was only put into the sea during trawl hauls. The vessel speed was 3.5-4 knots and the Simrad EK60 echosounder acquired acoustic data useful for the next stage of data processing.

It was necessary to use the scientific echosounder in order to inspect the bottom structure before performing the catch with the net; this procedure was adopted to avoid dangerous structures on the bottom (rocks, wrecks, bottom unevenness, etc.) since the net was installed very close to the bottom due to the tendency for small pelagic species to use escape techniques. The trawls position is shown in Figure 2.

The samples caught were weighed and measured according to the following:

- all catch was sorted, except for unusually large catches for which a sub-sample of the catch was sorted;
- total length (TL) was measured using ½ cm size classes;
- total weight (TW) was also taken for each measured specime at 0.1 g.

5.4 Estimation of fish density

The next step was to divide the estimated values of NASC Fish in relation to the results of the control catches. Usually, this procedure depends on the fish species caught, the bottom features, water mass circulation, etc.
During the "MSM Libya 2008" acoustic survey, 28 trawl hauls were carried out. However, in some parts of the study area no successful trawls were performed because of the rough, heterogeneous bottom. The trawl results appeared very useful for biomass evaluation but showed a great deal of variability in species composition and size distribution even when performed in closer sites. To reduce variability and its effect on the biomass estimation per species, it was chosen to adopt post-stratification and to combine data from several trawls. To achieve this the study area was divided into 5 sub-areas as shown in Figure 2; each sub-area was selected on the basis of the homogeneity of bottom morphology and species composition.
For each sub-area and species the size and weight distributions were obtained by gathering information from all trawls (group of trawls) in the same sub-area. Consequently, NASC fish values for each integration point (EDSU) in the sub-area was attributed to different species and different size classes identified in the control catches.

The analysis of the biological sample allowed for an estimation of the number of species (n) and the number of specimens for each of the m size classes. The proportion of each species (ν_j; $j = 1, \dots , n$) in each trawl haul and the proportion for each length class k ($k = 1, \dots, m$) and for each species f_{jk}, are

$$\sum_{j=1}^{n} \nu_j = 1 \qquad \sum_{k=1}^{m} f_{jk} = 1$$

$$\text{where} \qquad \nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

and

n_j = total number of specimens of species j in the sample,
n_{jk} = total number of specimens of species j in the length class k in the sample,
N = total number of specimens in the sample.

For the species j and the length class k the back-scattering coefficient is

$$\text{NASC}_{ajk} = \rho_{ajk} * \sigma_{spjk}$$

where

ρ_{ajk} = fish surface density of and species *j* [n° of fishes/mn^2],

σ_{spjk} = back-scattering cross section of length class *k* and species *j* given by

$$\sigma_{spjk} = 4\pi * 10^{\frac{TS_{jk}}{10}} \qquad \text{and} \qquad TS_{jk} = a_j Log_{10}(L_k) + b_j$$

where L_k is the length of the size class *k* in cm. For each nautical mile the back-scattering coefficient for the species *j* is

$$\text{NASC}_{aj} = \sum_{k=1}^{m} \rho_{ajk} * \sigma_{spjk}$$

and the back-scattering coefficient for all the species is

$$\text{NASC}_{a} = \sum_{j=1}^{n} \sum_{k=1}^{m} \rho_{ajk} * \sigma_{spjk}$$

On the other hand, surface density of the size class *k* for the species *j* [n° of fishes/mn^2] is

$$\rho_{ajk} = \rho_a * \nu_j * f_{jk}$$

where ρ_a [n° of fishes/mn^2] is the density of pelagic fish species. From the above equations the back-scattering coefficient for all the species is given by

$$\text{NASC}_{a} = \rho_a \sum_{j=1}^{n} \sum_{k=1}^{m} \nu_j * f_{jk} * \sigma_{spjk}$$

For each EDSU the NASC$_a$ may also be given by

$$\text{NASC}_{a} = \frac{\rho_{ajk}}{\nu_j * f_{jk}} * \sum_{j=1}^{n} \sum_{k=1}^{m} \nu_j * f_{jk} * \sigma_{spjk}$$

and substituting ν_j and f_{jk}, the density for each species and each size class is

$$\rho_{ajk} = \frac{\text{NASC}_a * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{spjk}} \qquad \text{n° of fishes/mn}^2$$

or

$$\rho_{ajk} = \frac{NASC_a * n_{jk} * w_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{spjk}} \qquad \text{t/mn}^2$$

where w_{jk} is the mean weight (g) of the size class *k* for the species *j*.

In the last equation the term $n_{jk}*w_{jk}$ is the total weight of the size class *k* for the species *j* (W_{jk} in g). Consequently ρ_{ajk} may be

$$\rho_{ajk} = \frac{NASC_a * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{spjk}} \qquad \text{t/mn}^2$$

The surface density for the species *j* is

$$\rho_{aj} = \sum_{k=1}^{m} \rho_{ajk} = \frac{NASC_a * 10^{-6} * \sum_{k=1}^{m} W_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} = \frac{NASC_a * 10^{-6} * W_J}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{t/mn}^2$$

where W_j is the total weight of the fish species *j* in the sample.
The total fish surface density is

$$\rho_{a} = \sum_{j=1}^{n} \rho_{aj} = \frac{NASC_a * 10^{-6} * \sum_{j=1}^{n} W_{j}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} = \frac{NASC_a * 10^{-6} * W}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{t/mn}^2$$

where *W* is the total weight (g) of the sample.

The used target strength (TS)-Length equations and the Total Length-Total Weight (TL-TW) relationships, estimated for all the pelagic species on the collected biological data, are reported in the table below.

Species	*TS equation*	*References*	*L-W relationship (cm, g)*	*(r^2)*
Sardina pilchardus	TS = 20 log TL -70.51	Barange, et al. (1996)	$TW = 0.0639*TL^{2.1748}$	0.96
Engraulis encrasicolus	TS = 20 log TL -75.29	Barange, et al. (1996)	$TW =0.0141*TL^{2.7001}$	0.98
Sardinella aurita	TS = 20 log TL -72.6	Debnol et al. (1985)	$TW =0.0092*TL^{2.8792}$	0.96
Trachurus trachurus	TS = 20 log TL -68.7	Lillo et al. (1996) clupeoids	$TW =0.006*TL^{3.1257}$	0.97
Boops boops	TS = 20 log TL -71.2	Ona (1999) clupeoids	$TW =0.0083*TL^{3.0389}$	0.99
Scomber japonicus	TS = 20 log TL -73.8	Svellingen et al. (2008)	$TW =0.0097*TL^{2.9464}$	0.99
Spicara sp.	TS = 20 log TL -71.2	Ona (1999) clupeoids	$TW =0.0075*TL^{3.095}$	0.96
Etrumeus teres	TS = 20 log TL -71.2	Ona (1999) clupeoids	$TW =0.0089*TL^{2.9301}$	0.97

The estimated fish surface density per species and size class were used to obtain the spatial distribution pattern by means of the Kriging interpolation method. To this aim, the SURFER© (Ver. 8.0 – Golden Software) software package was used.

5.5 Evaluation fish biomass

Since the echosurvey was the first one performed in the area, the biomass estimation was obtained by applying a post-sampling stratification, also with the aim of increasing the precision of estimates (Johannesson and Mitson, 1983).
The following density strata were defined

Stratum	Density range (t/nm^2)	Abundance description
1	0-5	very scattered
2	5-10	scattered
3	10-25	moderate
4	25-50	mean
5	50-100	dense
6	100-250	very dense

The total biomass W is evaluated by the formula

$$W = \sum_{i=1}^{n} W_i = \sum_{i=1}^{n} \rho_i * S_i$$

where in each i stratum W_i is the biomass (t), ρ_i is the biomass density (t/nm^2) and S_i is the area (nm^2). Variance of density values in the *i-th* stratum is espressed by

$$D_i^2 = \frac{\sum_{j=1}^{m_i} (\rho_{ij} - \overline{\rho}_i)^2}{m_i - 1} \qquad [t/nm^2]^2$$

where ρ_{ij} ($j = 1, \dots, m_i$) are density values in the *i-th* stratum, $\overline{\rho}_i$ is the mean density in the *i-th* stratum and mi is the number of density values in the *i-th* stratum. Biomass precision is estimated with

$$\omega_w = \sqrt{\sum_{i=1}^{n} \omega_i^2} = \sqrt{\sum_{i=1}^{n} \frac{D_i^2 \bullet S_i^2}{m_i}} \qquad [t]$$

where ω_i is the precision of the biomass estimate in the *i-th* stratum and n is the number of strata. The confidence intervals of the biomass estimate are

$$I = W \pm t(m) \bullet \omega_w \qquad [t]$$

where $m = \sum_{i=1}^{n} m_i$ is the total number of density values of the area and *t(m)* is the Student T-test with *m* degrees of freedom.

The cartographical projection formulas of Mercator equiangular cylindrical projection in cylindrical projection with metric coordinates according to reference-ellipsoid of Krasovsky were used for areas and positions estimation:

$$X = \frac{111134.86 \cdot \varphi - 16036.48 \cdot \sin\left(\frac{2 \cdot \pi \cdot \varphi}{180}\right) + 16.78 \cdot \sin\left(\frac{4 \cdot \pi \cdot \varphi}{180}\right)}{1852}$$

$$Y = \frac{\left[111508.36 - 187.15 \cdot \cos\left(\frac{2 \cdot \pi \cdot \varphi}{180}\right) + 0{,}19 \cdot \cos\left(\frac{4 \cdot \pi \cdot \varphi}{180}\right)\right] \cdot \cos\left(\frac{\pi \cdot \varphi}{180}\right) \cdot [\lambda - \lambda_0]}{1852}$$

where: X - meridian arc length (latitude) from equator up to the given parallels (nm);
Y - parallels arc length (longitude) up to the given meridian (nm);
φ - latitude (degrees);
λ - longitude (degrees).

5.6 Acquisition and processing of oceanographic data

The sampling plan of oceanographic data adopted during the “MSM Libya 2008” echosurvey was designed to ensure compatibility between the procedure for the estimation of pelagic biomass and the study of water masses characteristics in the Libyan waters. To achieve this aim, the sampling plan with CTD probe focused on the sea area over the continental shelf, up to a depth of 200 m (Figure 3).

Hydrological data were acquired at each station through the multiparametric CTD probe SBE 9plus (Underwater Unit) and the SBE 11plus V2 module (Deck Unit) of the SEA-BIRD ELECTRONICS, Inc. At each station, a hydraulic winch shifted the CTD probe from the surface to the bottom with a constant speed of 50 m/min.
The SEASAVE program (sampling frequency of 24 Hz) was used to collect and save data; raw data were saved in hexadecimal format in the HD linked to the SEA-BIRD system.

In each station three different files were saved:

- namefile.con (configuration file for the parameters of all the installed sensors)
- namefile.hex (raw data file in hexadecimal format)
- namefile.hdr (station info file)

The multiparametric probe was equipped with sensors to measure pressure, temperature, conductivity, fluorescence, light transmission, dissolved oxygen concentration and photosynthetically active radiation (PAR, 0.38 μm ÷ 0.71 m).
Data acquired only during downcast were submitted to an appropriate post-processing procedure using the software package "SEASOFT-Win32 (SBE Data Processing - CTD Data Processing and Plotting Software). Such procedure uses an *ad hoc* processing and includes the following steps:

datcnv.exe	it converts the acquired data (raw data) from hexadecimal format to a text file format (namefile.cnv);
alignctd.exe	it corrects the error due to the position of various sensors installed on the CTD frame;
wildedit.exe	it finds unusual values and deletes them if required;
celltm.exe	it use a recursive filter to remove the effects of thermal inertia of the water mass inside the measuring cell on the conductivity values;
filter.exe	it uses a low-pass recursive filter to eliminate unexpected changes from the physical point of view;
loopedit.exe	it finds the values along the profiles corresponding to a speed of down cast less than a pre-established one;
binavg.exe	it evaluates variable values along the profile for a chosen sampling step (depth in m or pressure in db);
derive.exe	it derives salinity, density and other oceanographic parameters;

The interpolation of processed data and the subsequent presentation of the different fields at different depths was performed by means of the Ocean Data View software package (Schlitzer, 2007).

6. Results

In this section the biomass estimation and the spatial distribution pattern are presented for Anchovy (*Engraulis encrasicolus*), Sardine (*Sardina philcardus*), Round sardinella (*Sardinella aurita*), Mediterranean horse mackerel (*Trachurus mediterraneus*), Chub mackerel (*Scomber Japonicus*), Bogue (*Boops boops*), *Spicara sp*. and Red-eye round herring (*Etrumeus teres*).

Anchovy (*Engraulis encrasicolus*)

The total Anchovy biomass in the whole survey area was 63511 t with its higher density in the density strata 25-50 (t/nm^2); Table 4 summarizes the estimated biomass in each density stratum.

Table 4. Biomass estimation for Anchovie in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	454	49	35	31	18	7
Area, NM2	5065	1052	1096	720	112	9
Mean surface density, t/NM2	1.02	7.12	16.26	33.29	66.98	172.01
Standard deviation, t/NM2	1.30	1.44	4.28	6.59	10.67	60.73
Biomass in the density intervals, t	5179.06	7490.93	17819.21	23971.72	7501.95	1548.11
Total area (NM2) =	17649	Anchovy biomass (t) =		**63510.99**	±	**2094.04**
						± 3.3 %

The spatial distribution of anchovy showed greater density (weight per nm^2) in the western part of the surveyed area (sub-areas 1 and 2), even though a small nucleus was also recorded near the shore in the Sirte Gulf (Figure 4).

Anchovies were found in the trawls n. 2, 3, 5, 7 e 14 (for trawl positions see Figure 2). Two well-distinct modes were found in the length frequency distribution: at around 3.5 cm TL (post-larvae) and at around 13 cm TL. Other minor modes (11 and 15 cm TL) are linked to different cohorts. The overall size range was between 3 and 16.5 cm TL (Figure 5). The post-larvae were collected only in the trawl n. 2. In trawl n. 3 almost all the specimens ranged between 9 and 11.5 cm TL. Trawl n. 5 presented two distinct modes and trawl n. 14 size distribution falls between 14 and 16 cm TL. The spatial segregation observed among size classes suggests that probably the stock is not fully mixed and different life stages probably inhabit different habitats and environmental conditions. Unfortunately no age data are available to support this hypothesis.

The different size classes recorded allowed for a representative length vs. weight relationship to be obtained for a wide size range (Figure 6). The length-weight relationship parameters are also shown in Figure 6.

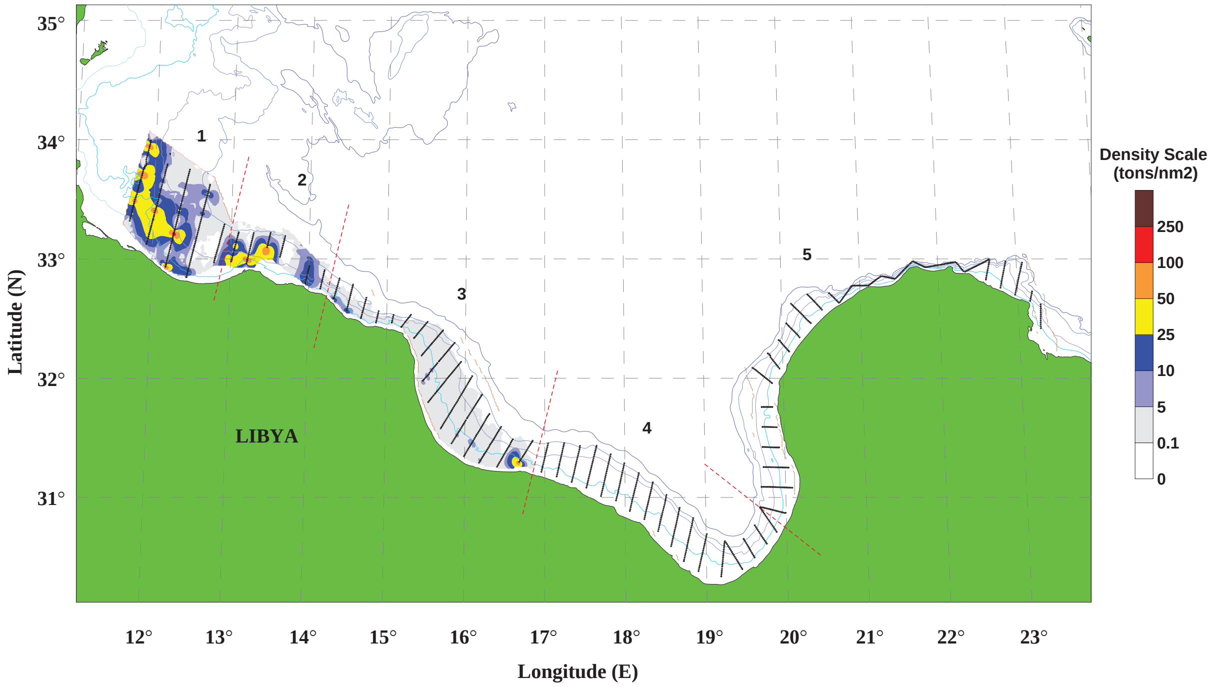


Figure 4. Anchovy spatial distribution pattern in the Libyan waters. Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

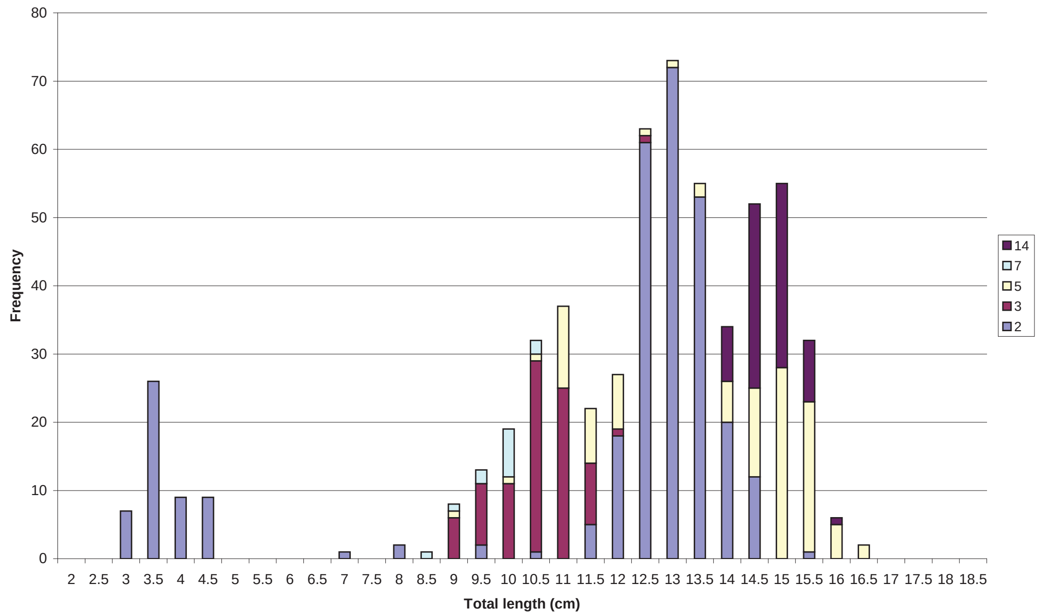


Figure 5. Size frequency distribution of Anchovy collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008. Trawl hauls are shown with different colors; identification number of hauls is provided in the legend.

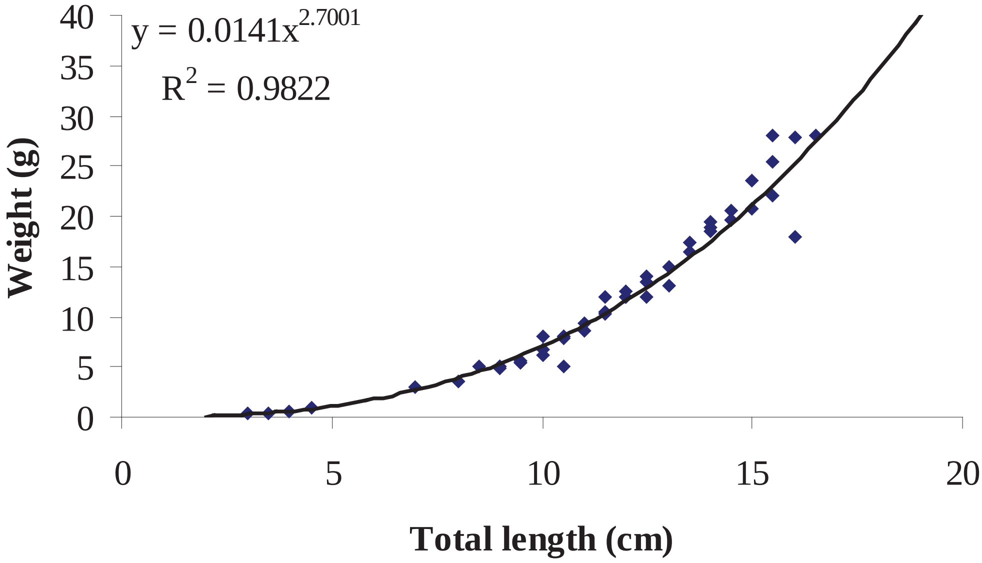


Figure 6. Length-weight relationship for Anchovy collected in Libyan waters during the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Sardine (*Sardina philcardus*)

The total Sardine biomass in the whole survey area was 13975 t with its higher density in the stratum 10-25; Table 5 summarizes the estimated biomass in each density stratum. Sardine was found only in the western area (sub-area 1, Figure 7). No other trace of sardine was observed in the surveyed area.

Table 5. Biomass estimation for Sardine in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	158	25	21	4	3	0
Area, NM2	2606	585	358	16	3	0
Mean surface density, t/NM2	1.04	7.52	17.16	33.43	65.91	0.00
Standard deviation, t/NM2	1.15	1.44	4.42	4.45	13.25	0.00
Biomass in the density intervals, t	2701.02	4397.98	6143.87	534.93	197.73	0.00
Total area (NM2) =	17649	Sardina biomass (t) =		**13975.52**	±	**746.98**
						± 5.3 %

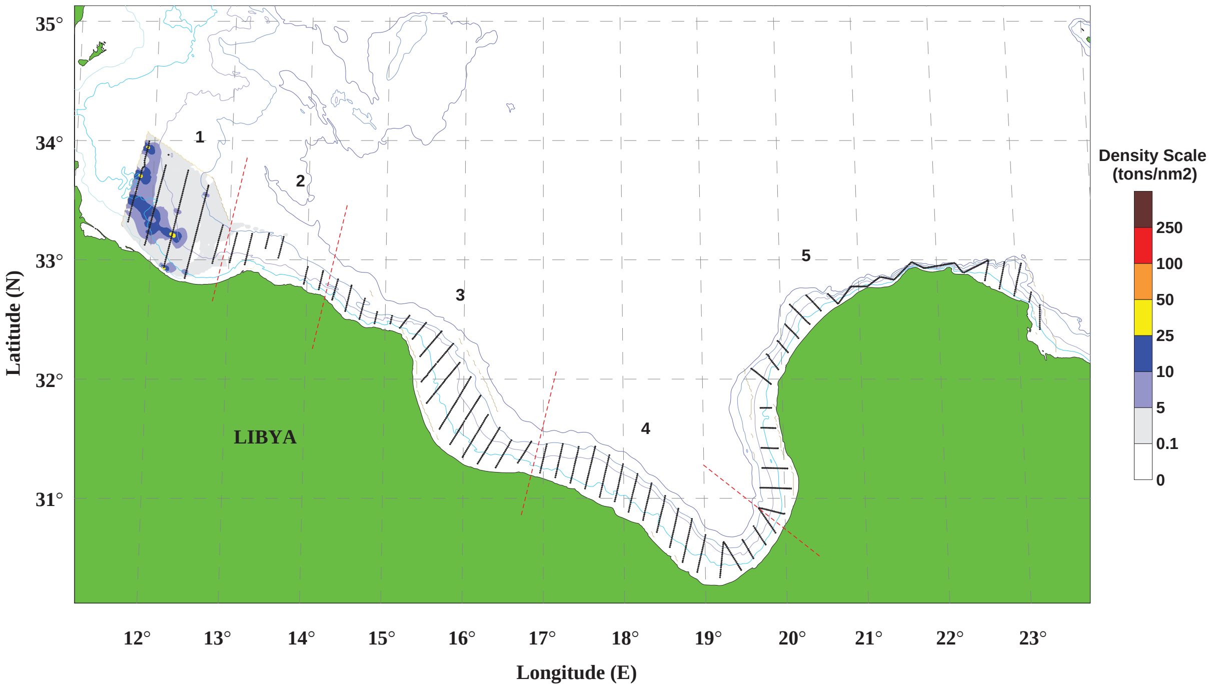


Figure 7. Sardine spatial distribution patterns in the Libyan waters. Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

The sardine was only found in trawl n. 2 and only one mode was observed in its length frequency distribution at around 15 cm TL (Figure 8). No juveniles were found in the catches probably because the survey was carried out before the recruitment size was reached for sardine, or because during postlarval and juvenile stages sardine are very close to the coast, or because the nursery ground for sardine are out of the surveyed area. Unfortunately the relationship between total length and weight for sardine was based only on one trawl and, consequently, the size range is very narrow, i.e. between 13.5 and 17.5 cm TL (Figure 9).

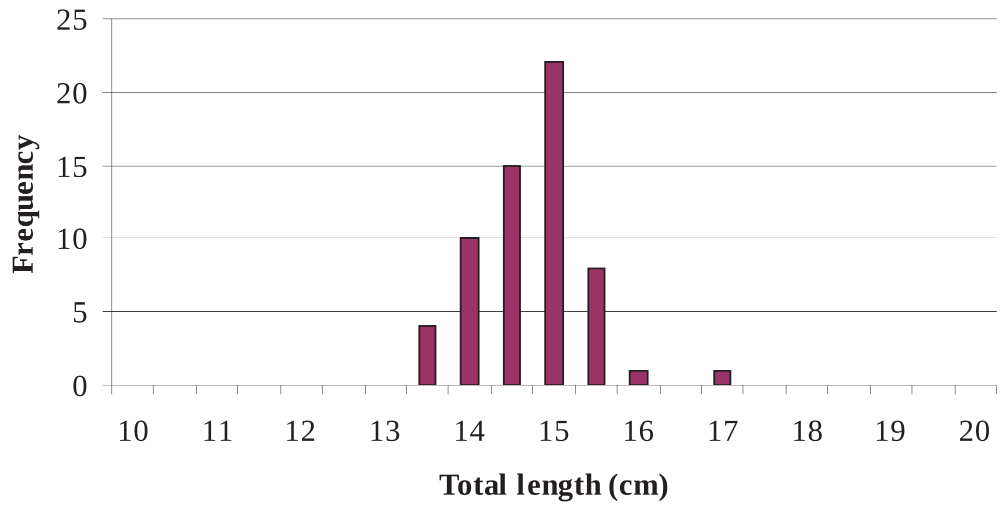


Figure 8. Size frequency distribution of Sardine collected in the Echosurvey “MSM Libya 2008”, 14 August – 06 September 2008.

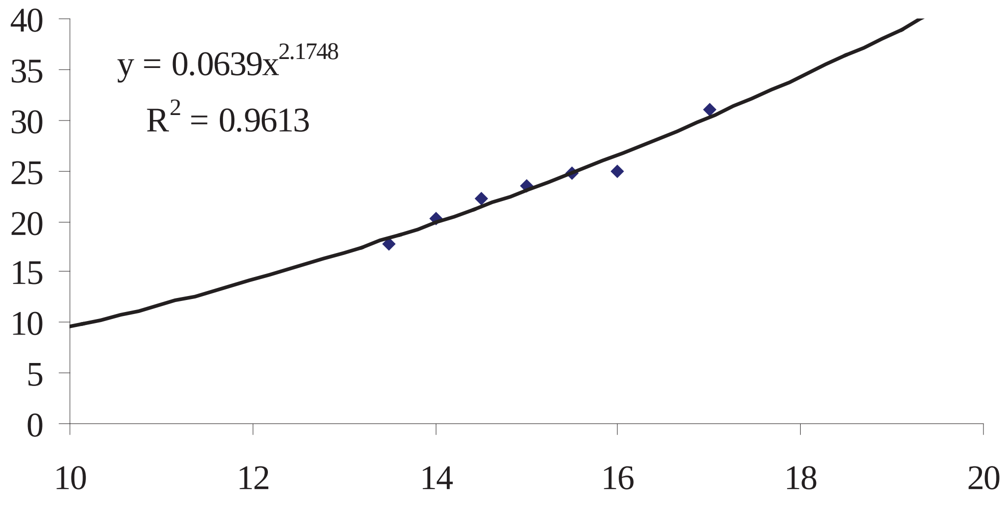


Figure 9. Length-weight relationship for Sardine collected in the Echosurvey “MSM Libya 2008”, 14 August – 06 September 2008.

Round sardinella (Sardinella aurita)

The total Round sardinella biomass in the whole survey area was 46136 t with its higher density in the stratum 10-25 (t/nm^2); Table 6 summarizes the estimated biomass in each density stratum per Round sardinella.

Round sardinella spatial distribution, shown in Figure 10, was more extended if compared to anchovy or sardine. The higher density was recorded in the sub-area 4 along the Sirte Gulf coast, even though lower densities were recorded also in sub-areas 1 and 3. It is worth noting that no Round sardinella specimens were collected in trawls located in sub-areas 2 and 5.

Table 6. Biomass estimation for Round sardinella in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	997	91	70	22	7	2
Area, NM2	11187	1860	931	129	38	8
Mean surface density, t/NM2	0.87	7.09	15.69	35.82	71.92	152.16
Standard deviation, t/NM2	1.21	1.36	3.78	6.80	15.18	50.43
Biomass in the density intervals, t	9766.47	13192.41	14606.39	4620.75	2732.86	1217.31
Total area (NM2) =	17649	Sardinella biomass (t) =		**46136.19**	±	**1267.51**
						± 2.7 %

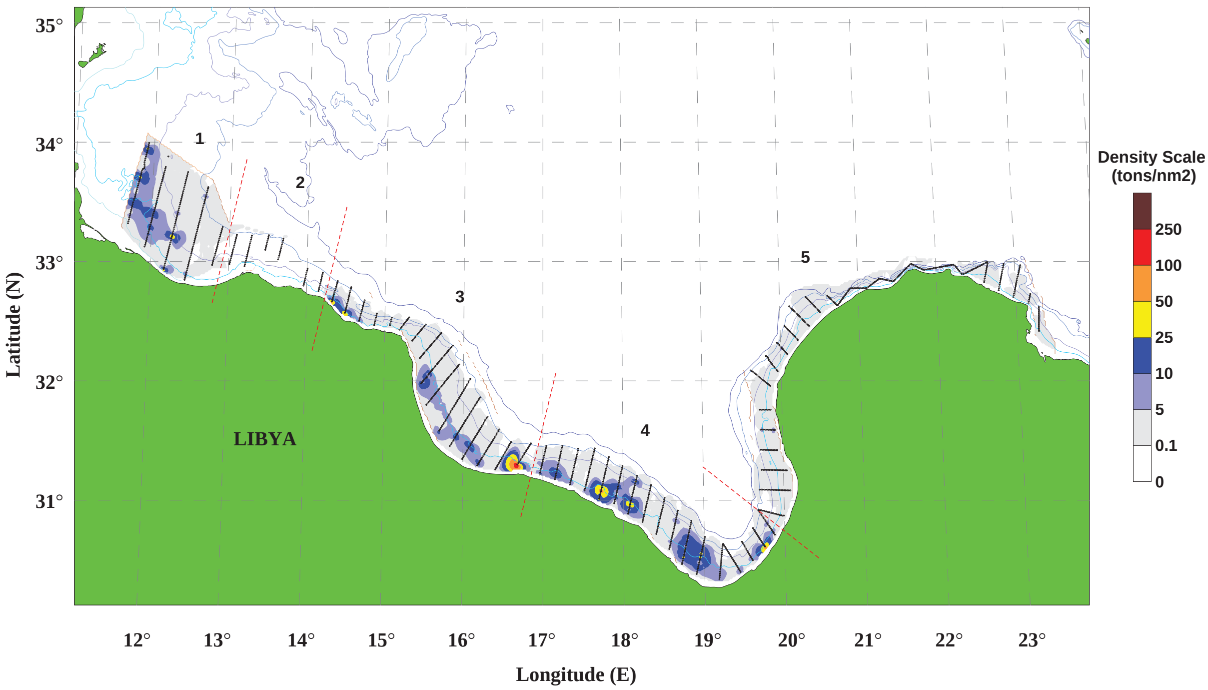


Figure 10. Round sardinella spatial distribution pattern in the Libyan waters. Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Round sardinella was found in the trawls n. 2, 3, 10, 11, 13, 14, 16, 18, 22, 26 (for trawl positions see Figure 2). Two well-distinct modes were found in the length frequency distribution of Round sardinella: around 9 cm TL (postlarvae) and around 15 cm TL. Other length frequency minor modes (7 and 17 cm TL) are linked to different cohorts (Figure 11). The full size range was between 2 and 18 cm TL. The post-larvae individuals were only collected in trawl n. 10, while in trawl n. 14 almost all the specimens were between 12 and 15 cm TL. Trawl n. 16 presented the widest size range with respect to the other trawls. The spatial segregation among size classes and trawls appear much less pronounced than for anchovy, suggesting that the stock is more mixed and different life stages, except postlarvae in trawl n. 10, probably inhabit the same habitat and environmental conditions. The different size classes collected permitted a representative length weight relationship to be obtained for a wide size range (Figure 12).

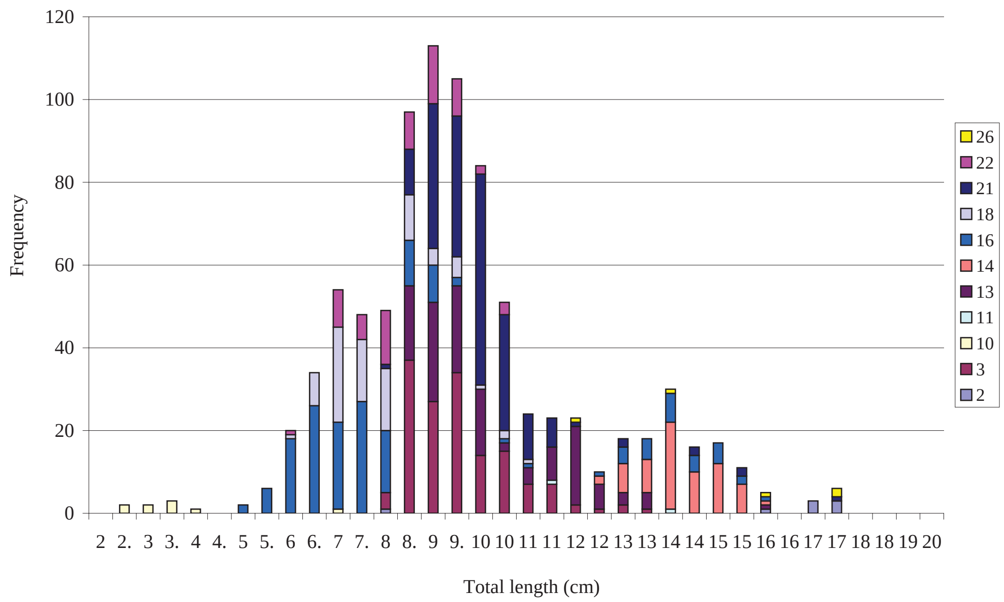


Figure 11. Size frequency distribution of Round sardinella collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008. Trawl hauls are shown with different colours; identification number of hauls is provided in the legend.

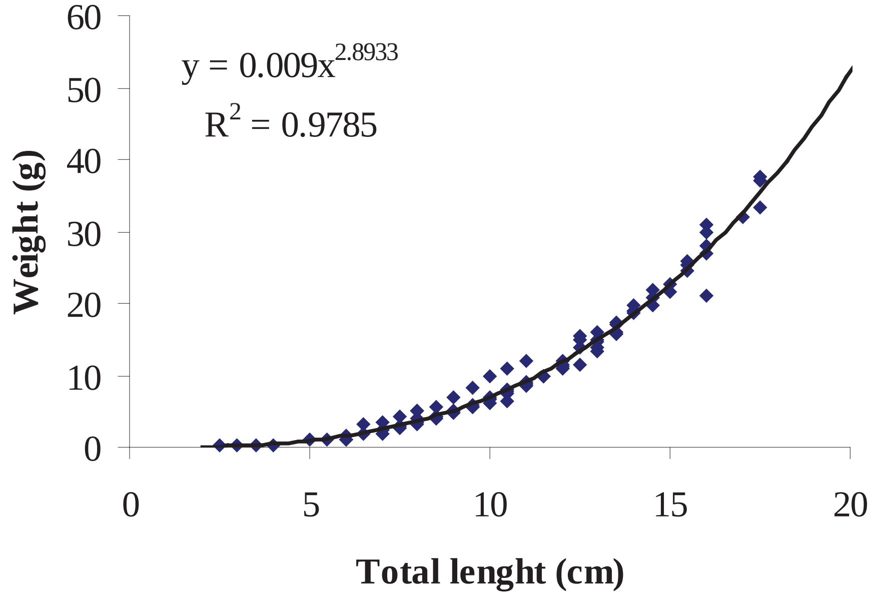


Figure 12. Length-weight relationship for Round sardinella collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Mediterranean horse mackerel (*Trachurus mediterraneus*)

The total Mediterranean horse mackerel biomass in the whole survey area was 15875 t with its higher values in the acoustic density stratum 10-25; Table 7 summarizes the estimated biomass in each stratum. Mediterranean horse mackerel spatial distribution singles out a greater density (espressed as biomass per nm^2) in the sub-area 1, even though a very small nucleus nearshore in the Sirte Gulf was also recorded (Figure 13). The spatial distribution observed for Mediterranean horse mackerel is similar to that observed for anchovy, suggesting a possible association between the two species.

Table 7. Biomass estimation for Mediterranean horse mackerel in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	533	31	22	5	3	0
Area, NM2	6912	669	360	16	3	0
Mean surface density, t/NM2	0.58	7.46	17.16	31.80	65.18	0.00
Standard deviation, t/NM2	0.92	1.39	4.36	4.74	13.11	0.00
Biomass in the density intervals, t	4002.72	4991.09	6176.94	508.80	195.53	0.00
Total area (NM2) =	17649	Trachurus biomass (t) =		**15875.09**	±	**767.45**
						± 4.8 %

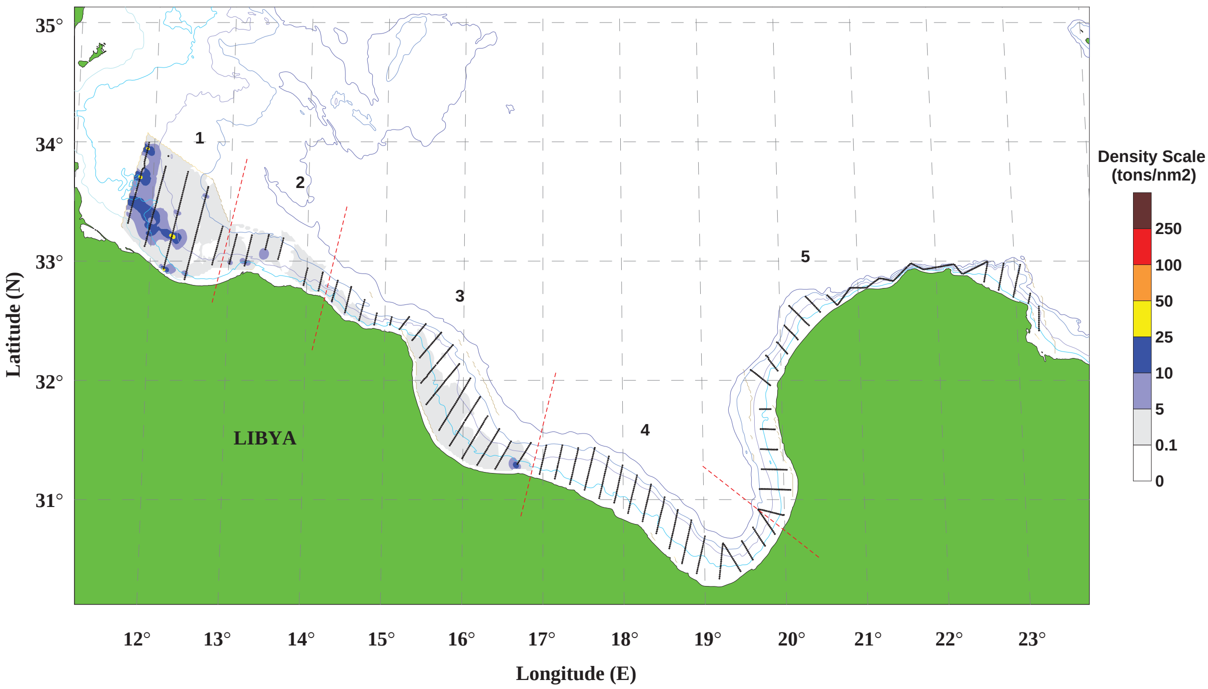


Figure 13. Mediterranean horse mackerel spatial distribution pattern in the Libyan waters. Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Mediterranean horse mackerel was found in several trawls: n. 1, 2, 5, 6, 7, 12, 13 and 16 (for trawl positions see Figure 2). Despite its wider distribution among trawls, a relative small number of specimens were found in the samples. Two well-distinct modes were present in the frequency distribution (Figure 14): around 11.5 cm TL (juveniles) and the around 17 cm TL. Other length frequency minor modes could have been occurred in the population but the low number of specimens does not allow their identification. The full size range for Mediterranean horse mackerel was between 10.5 and 25 cm TL. The juveniles were collected mainly in trawls 5 and 1, which also presented the widest size range among trawls. The spatial segregation among length classes and trawls appear much less pronounced than for anchovy, suggesting that Mediterranean horse mackerel stock is mixed even if different life stages inhabit different habitats and environmental conditions. The length weight relationship for the length range 10-25 cm TLwas estimated and shown in Figure 15.

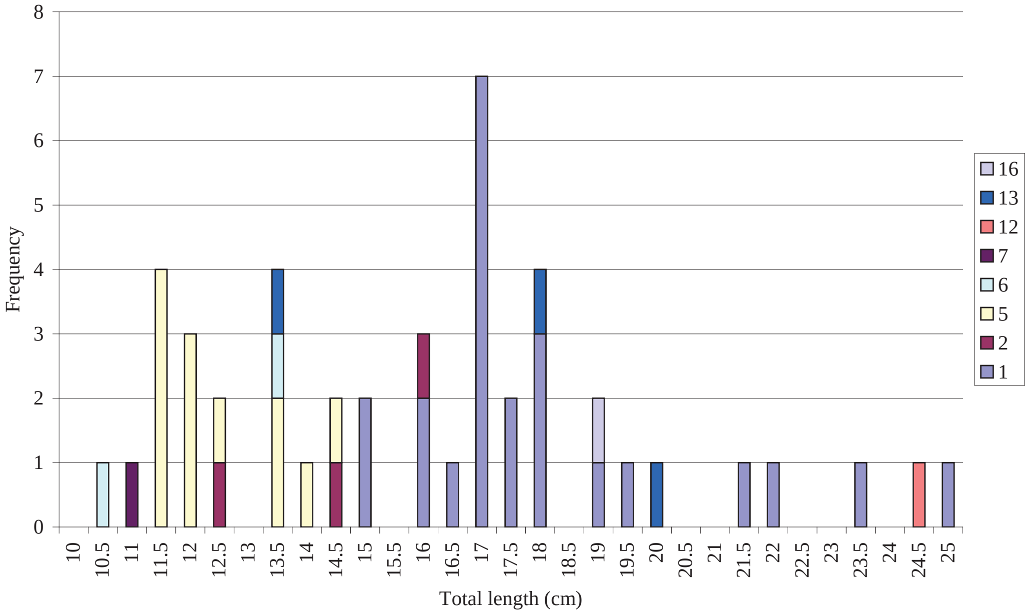


Figure 14. Size frequency distribution of Mediterranean horse mackerel collected in the Echosurvey “MSM Libya 2008”, 14 August – 06 September 2008. Trawl hauls are shown with different colours; identification number of hauls is provided in the legend.

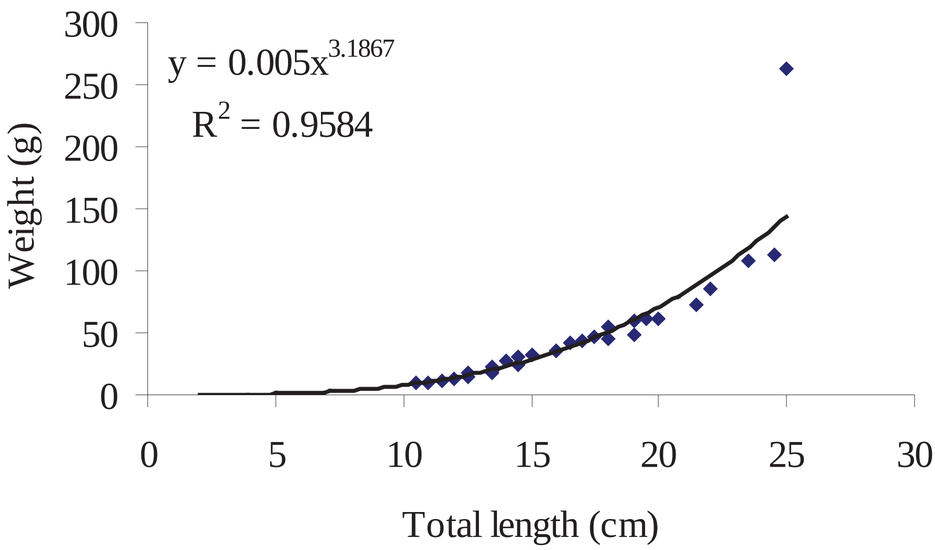


Figure 15. Length-weight relationship for Mediterranean horse mackerel collected in the Echosurvey “MSM Libya 2008”, 14 August – 06 September 2008.

Chub mackerel (*Scomber japonicus*)

The total Chub mackerel biomass in the whole survey area was 31334 t with its higher density in the stratum 5-10 (t/nm^2); Table 8 summarizes the estimated biomass in each density stratum. Chub mackerel spatial distribution extends mainly over the western part of the Libyan continental shelf (Figure 16). The highest density of Chub mackerel was recorded in sub-area 2 while lower densities were found in sub-areas 1 and 3. It is noticeable that no Chub mackerel were collected in the trawl hauls performed in the sub-areas 4 and 5.

Table 8. Biomass estimation for Chub mackerel in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	817	55	32	15	5	2
Area, NM2	9506	1160	475	205	37	2
Mean surface density, t/NM2	0.71	7.02	14.63	33.85	59.63	168.52
Standard deviation, t/NM2	1.03	1.53	3.57	8.50	11.78	75.56
Biomass in the density intervals, t	6751.49	8148.16	6951.48	6940.04	2206.41	337.05
Total area (NM2) =	17649	Scomber J. biomass (t) =	**31334.63**	±	**1182.08**
						± 3.8 %

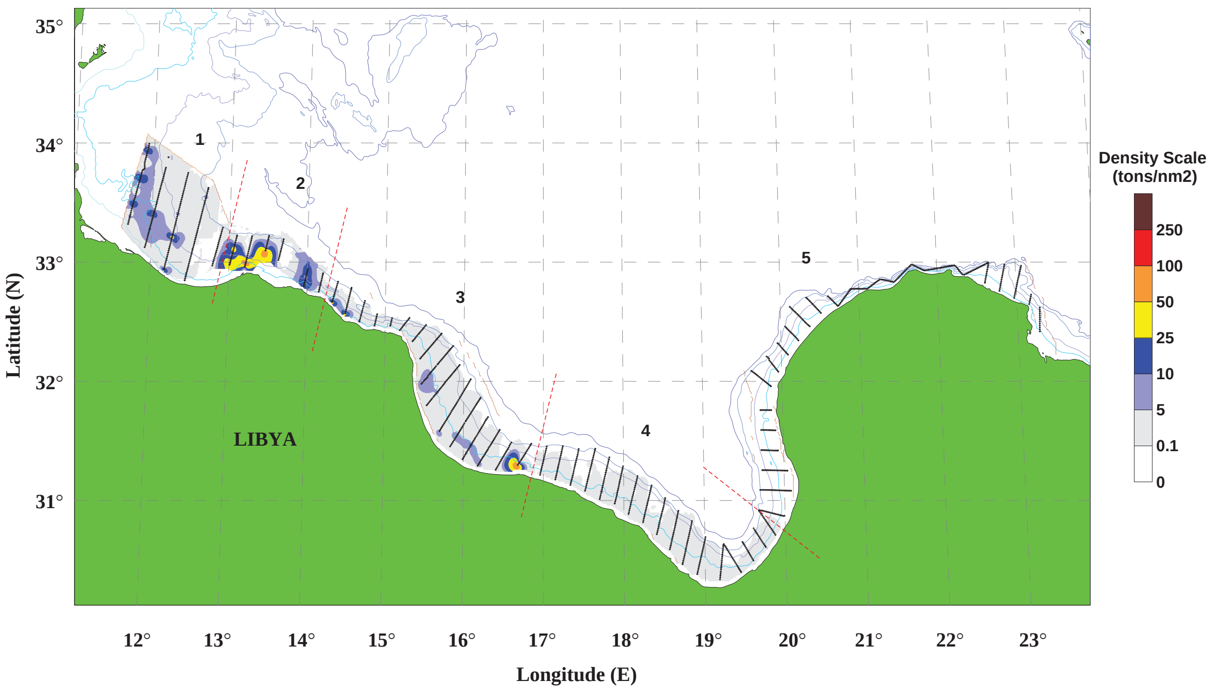


Figure 16. Chub mackerel spatial distribution pattern in the Libyan waters. Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

The Chub mackerel species was found in the trawls n. 2, 3, 5, 6, 13, 14, 16 and 22 (for trawl positions see Figure 2). Two well-distinct modes were present in the frequency distribution: around 13 cm TL (juveniles) and around 18 cm (Figure 17). Other length frequency minor modes at 16.5 and 22.5 cc TL could belong to different cohorts. The full size range for Chub mackerel was between 11 and 27 cm TL. Smaller specimens were mainly collected in the trawl n. 3 while in the trawl n. 6 almost all the specimens were between 17 and 19 cm TL. Trawl n. 13 presented the widest length range among trawls with two distinct modes. The spatial segregation among size classes and trawls suggests that the stock is not fully mixed and different life stages probably inhabit different habitat and environmental condition. The length weight relationship for the size range 11-28 cm TL is shown in Figure 18.

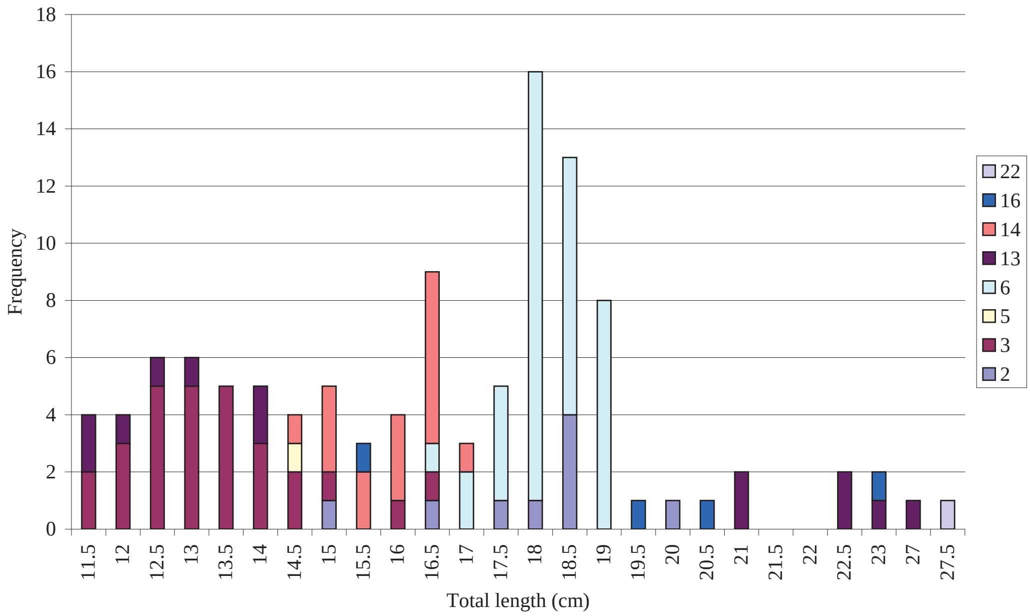


Figure 17. Size frequency distribution of Chub mackerel collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008. Trawl hauls are shown with different colors; identification number of hauls is provided in the legend.

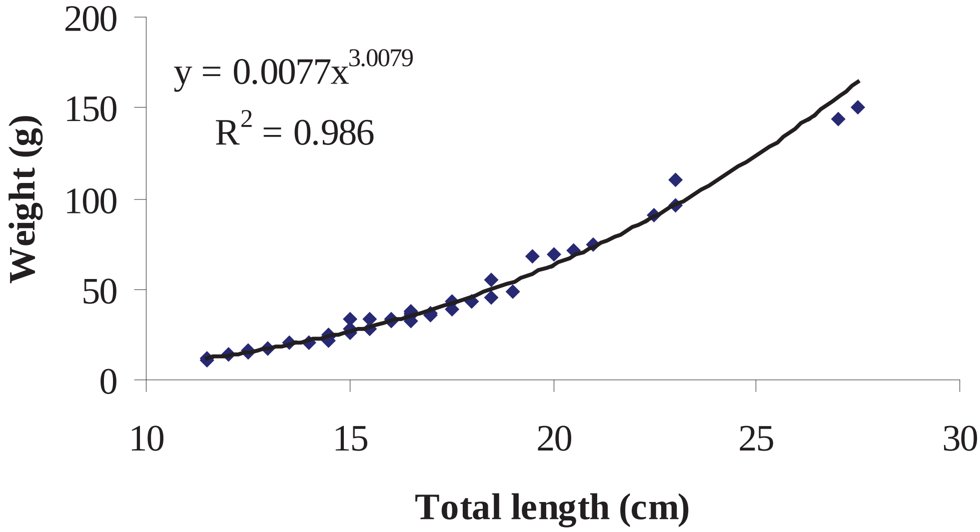


Figure 18. Length-weight relationship for Chub mackerel collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Bogue (*Boops boops*)

The total Bogue biomass in the whole survey area was 42286 t with its highest density in the stratum 10-25 (t/nm^2); the following table summarises the estimated biomass in each density stratum.

Table 9. Biomass estimation for Bogue in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	758	79	66	20	7	3
Area, NM2	9740	1502	843	173	36	10
Mean surface density, t/NM2	0.86	7.25	15.18	36.08	63.86	164.67
Standard deviation, t/NM2	1.19	1.55	4.16	5.84	11.63	30.39
Biomass in the density intervals, t	8417.46	10886.03	12796.34	6241.17	2299.13	1646.74
Total area (NM2) =	17649	Boops b. biomass (t) =		42286.87	±	1200.92
						± 2.8 %

Bogue spatial distribution, shown in Figure 19, is mainly concentrated in the eastern area (sub-area 5); high densities are also present in the western part of Sirte Gulf (sub-area 3). A very small nucleus was also recorded in the sub-area 1. It is noticeable that this distribution is complementary to other pelagic species presented before in this report.

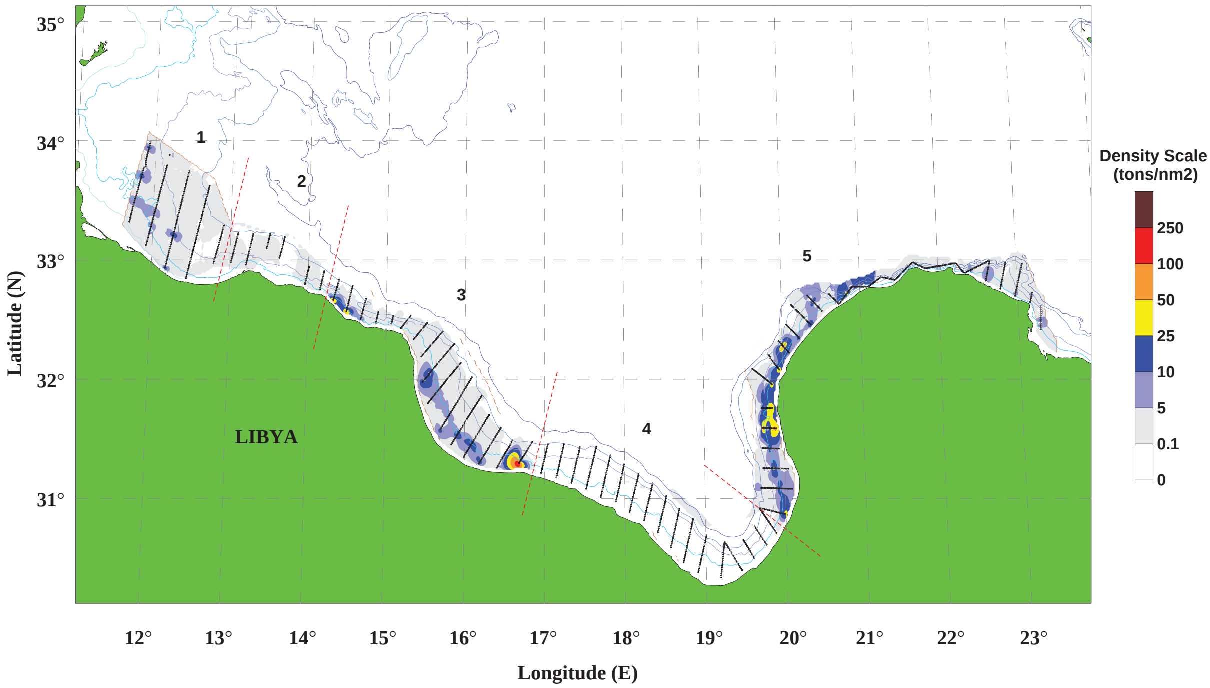


Figure 19. Bogue spatial distribution pattern in the Libyan waters. Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Boops boops was found in several trawls (n. 1, 5, 10, 11, 12, 14, 16, 25 and 26; for trawl positions see Figure 2). Two well-distinct modes were present in the frequency distribution (Figure 20): the post-larvae around 7.5 cm TL and the other around 14 cm TL. Other size frequency minor modes around 13 and 16.5 cm TL could belong to different cohorts. The full size range for Bogue was between 5 and 20 cm TL. The postlarvae were collected only in trawl n. 16 and present the most part of specimens in the range between 5 and 9 cm TL. In the trawl n. 10 almost all the specimens were between 7 and 15 cm TL. Trawl n. 16 presents the widest size range among the other trawls. The spatial segregation among length classes and trawls appears relevant suggesting that the stock is not fully mixed and different life stages probably inhabit different habitat and environmental condition (i.e trawl 10 and 11). The length weight relationship for the size range 5-20 cm TL is shown in Figure 21.

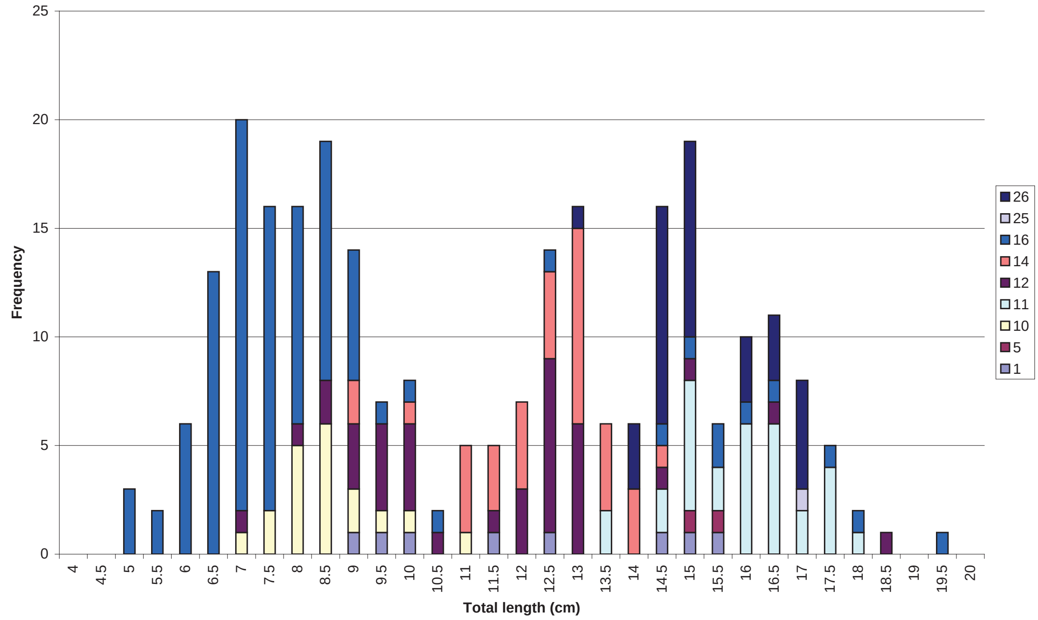


Figure 20. Size frequency distribution of Bogue collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008. Trawl hauls are shown with different colors; identification number of hauls is provided in the legend.

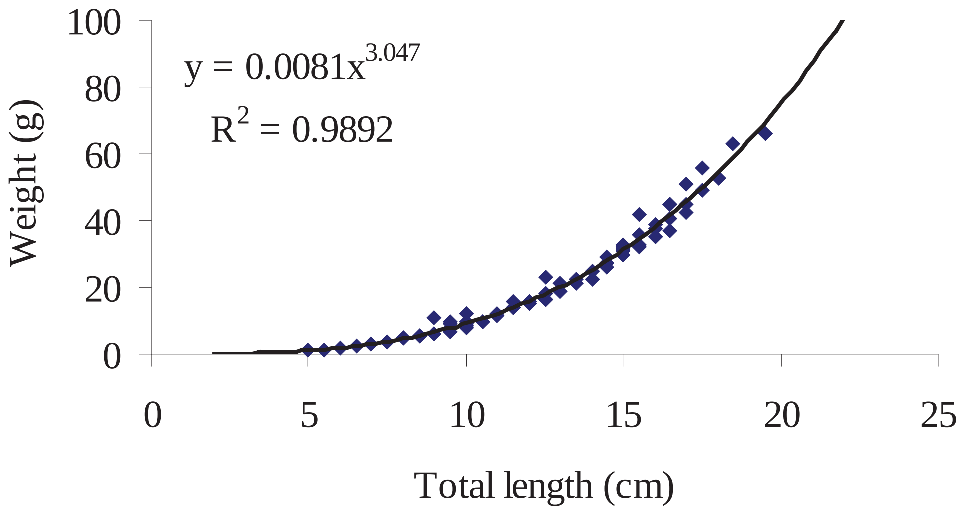


Figure 21. Length-weight relationship for Bogue collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Picarel (*Spicara* spp.)

The total *Spicara* spp. biomass in the whole survey area was 41126 t with its highest density in the stratum 10-25 (t/nm^2); Table 10 summarizes the estimated biomass in each density stratum. The biomass estimation was obtained for *Spicara* sp. even though three different species were collected in the trawl hauls: *Spicara flexuosa*, *Spicara smaris* and *Spicara maena*. This choice was made on the basis of the length-weight relationships for each species (Figures 24, 26 and 28) which do not appear to be significantly different. On the other hand, no specific TS-Total Length relationship is defined for the three species. *Spicara* sp. biomass was only distributed in the sub-areas 3 and 5 (Figure 22). Despite the acoustic biomass and spatial distribution evaluation was accomplished joining three different species of Spicara, the biological data, as size distribution along the trawls and length-weigth relationships, were estimated and presented here in separately.

Table 10. Biomass estimation for *Spicara* spp. in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	1072	87	69	26	6	5
Area, NM2	1221	1359	1108	171	49	29
Mean surface density, t/NM2	0.69	7.04	15.35	34.17	58.89	171.63
Standard deviation, t/NM2	1.07	1.28	3.99	6.17	5.41	88.03
Biomass in the density intervals, t	840.04	9568.87	17012.11	5842.28	2885.69	4977.32
Total area (NM2) =	17649	Spicara sp. biomass (t) =		**41126.32**	±	**1022.47**
						± 2.5 %

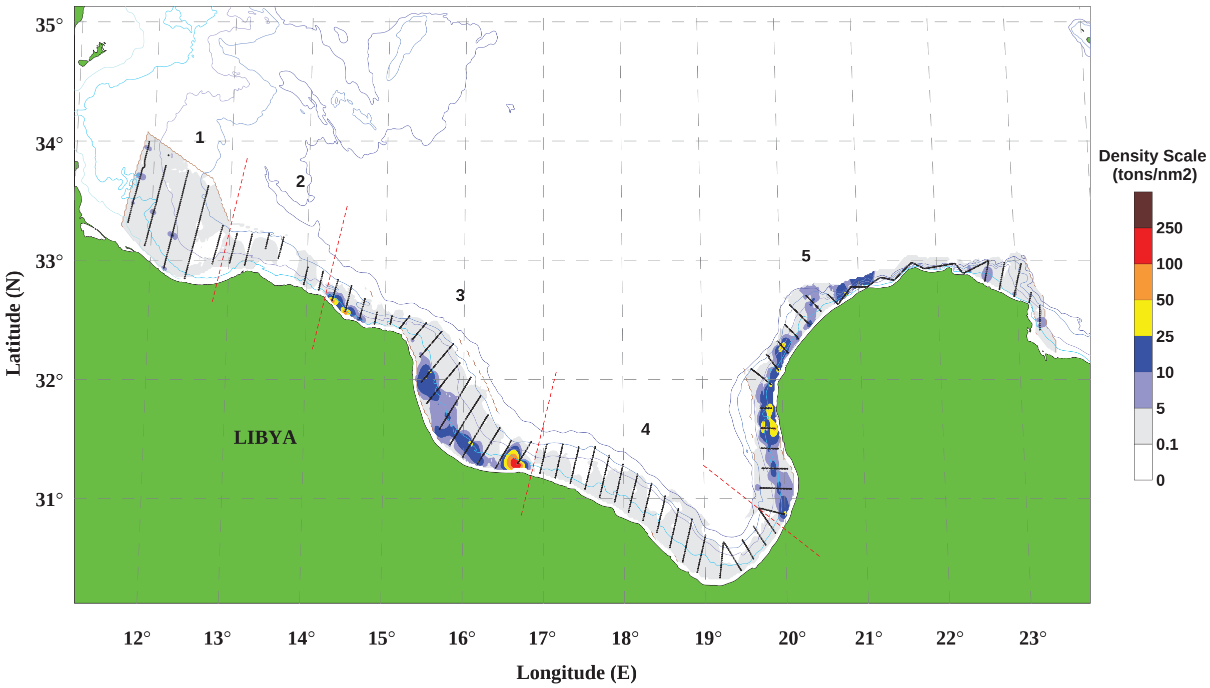


Figure 22. *Spicara* spp. spatial distribution pattern in the Libyan waters. Echosurvey “MSM Libya 2008”, 14 August – 06 September 2008.

Picarel (*Spicara flexuosa*)

The size range of *S. flexuosa* was between 8.5 and 15 cm TL. The size distribution among trawls appears to overlap suggesting a certain grade of mixing among different areas (trawls). The length weight relationship for the size range 8-17 cm TL is shown in Figure 24.

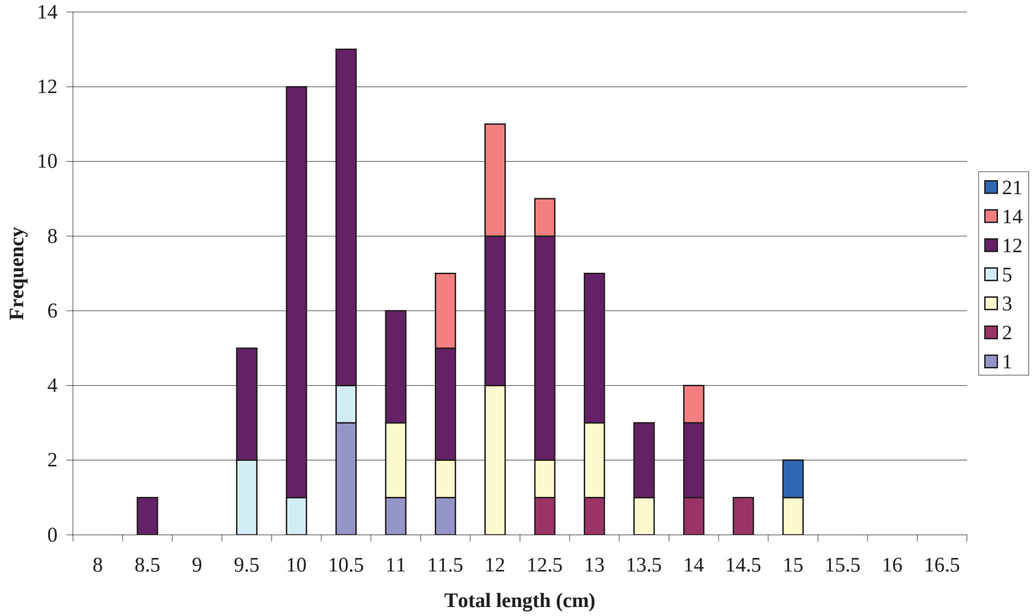


Figure 23. Size frequency distribution of *S. flexuosa* collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008. Trawl hauls are shown with different colors; identification number of hauls is provided in the legend.

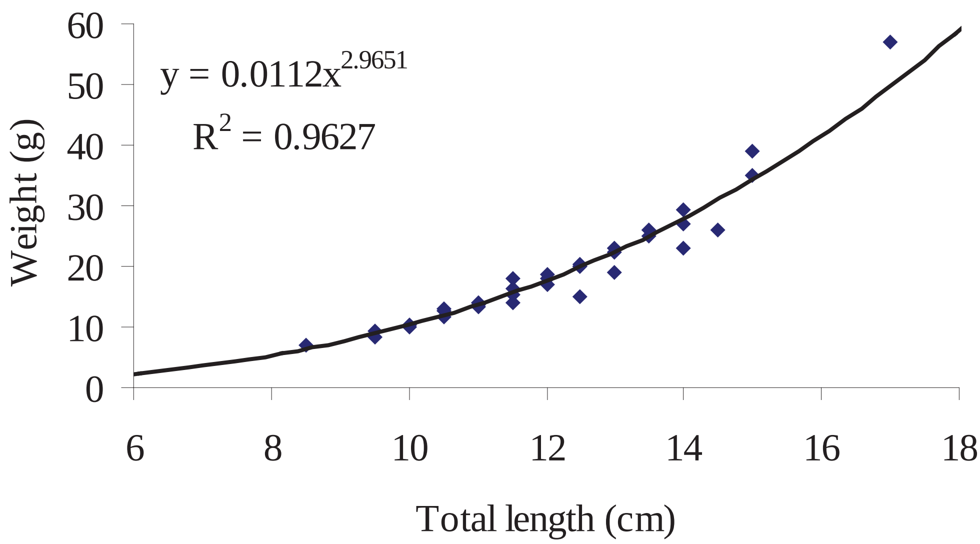


Figure 24. Length-weight relationship for *S. flexuosa* collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Picarel (*Spicara smaris*)

The recorded size range for *Spicara smaris* was between 5 and 17 cm TL (Figure 25), wider than for *S. flexuosa*. The size distribution among trawls appears partially overlapping; even bigger and smaller specimens were collected in two different trawls (11 and 16). Also for of *S. smaris* the spatial distribution among sizes suggests a certain degree of mixing among different areas. The length-weight relationship for the size range 5-18 cm TL is shown in Figure 26. The length-weight relationship for the size range 5-18 cm TL is shown in Figure28.

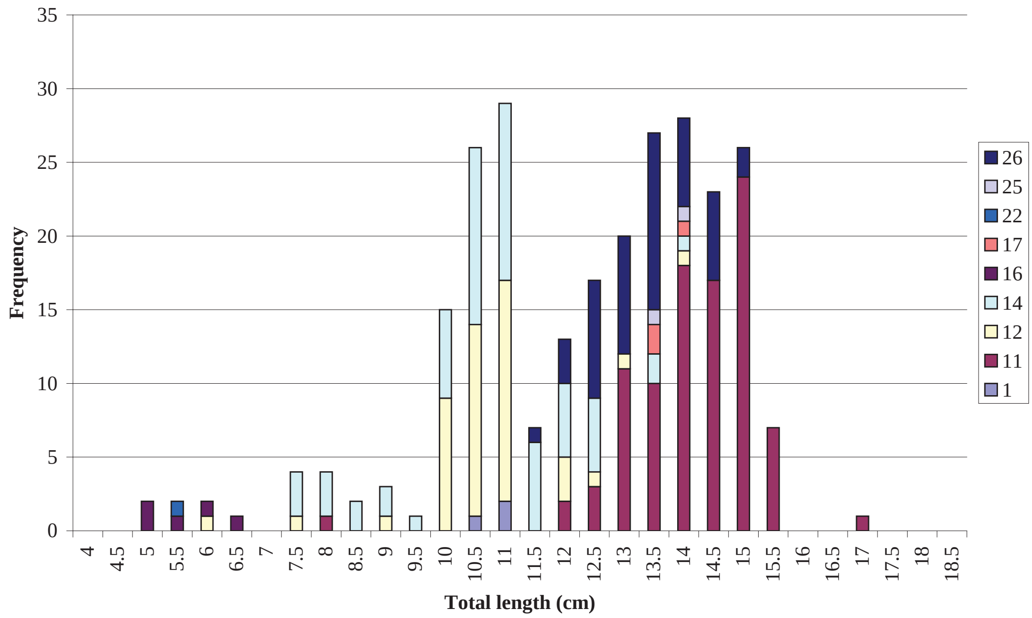


Figure 25. Size frequency distribution of *S. smaris* collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008. Trawl hauls are shown with different colors; identification number of hauls is provided in the legend.

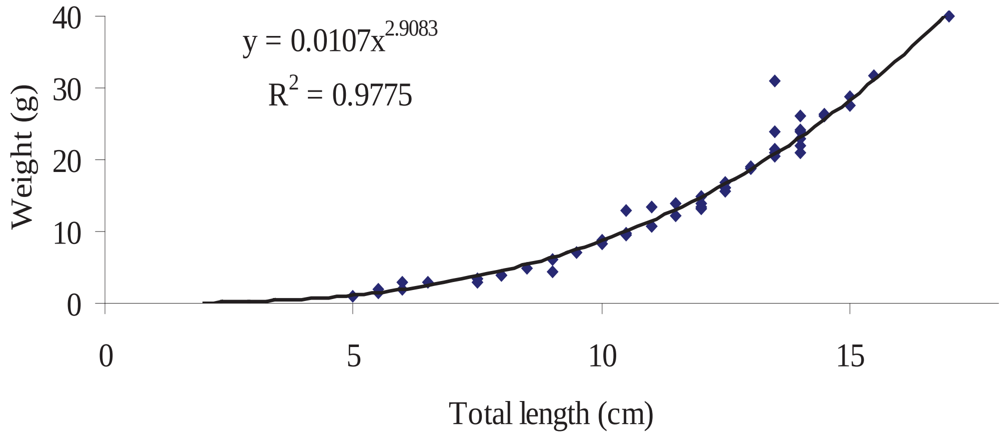


Figure 26. Length-weight relationship for *S. smaris* collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Blotched picarel (*Spicara maena*)

Only few specimens of *Spicara maena* were recorded in two trawls (n. 2 and n. 17). Based on these low numbers no significant results could be outlined on the size distribution between areas.

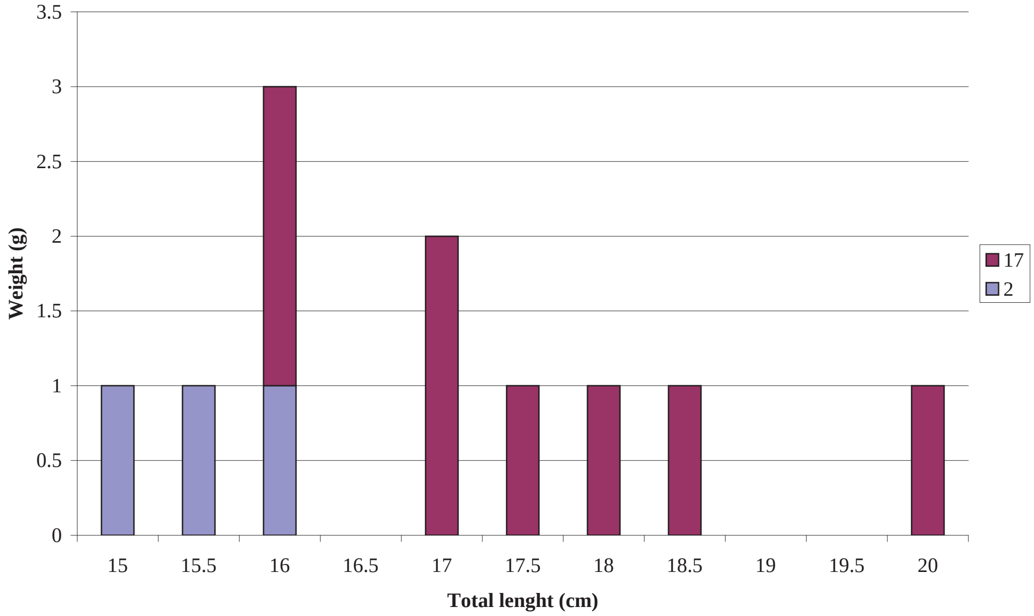


Figure 27. Size frequency distribution of *S. maena* collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008. Trawl hauls are shown with different colors; identification of the number of hauls is provided in the legend.

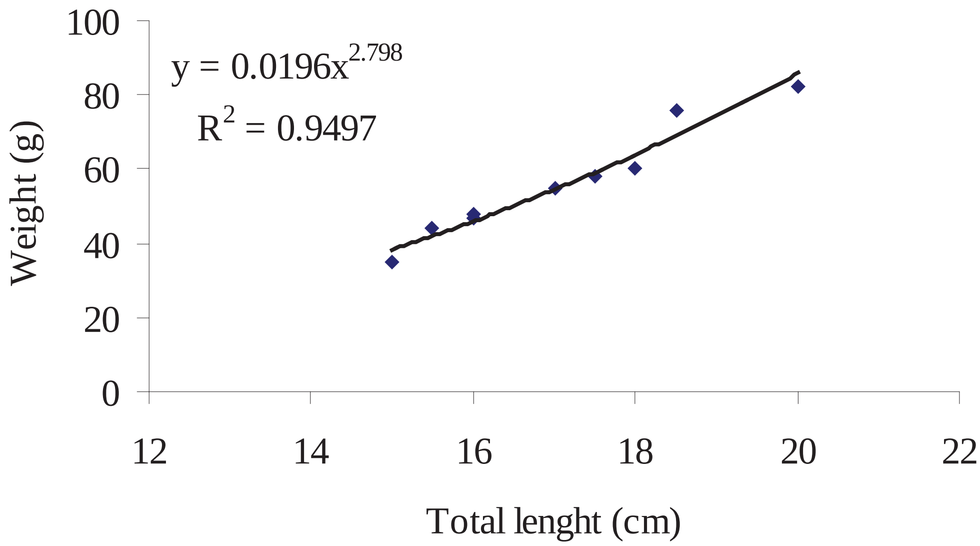


Figure 28. Length-weight relationship for *S. maena* collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Red-eye round herring (*Etrumeus teres*)

Red-eye round herring (*Etrumeus teres*) is an important species for fisheries around the world. In the Mediterranean its presence, probably due to the passage through the Suez Channel, had not been recorded before this survey. The biomass was evaluated in 2068 tons; Table 11 summarizes the estimated biomass in each density stratum.

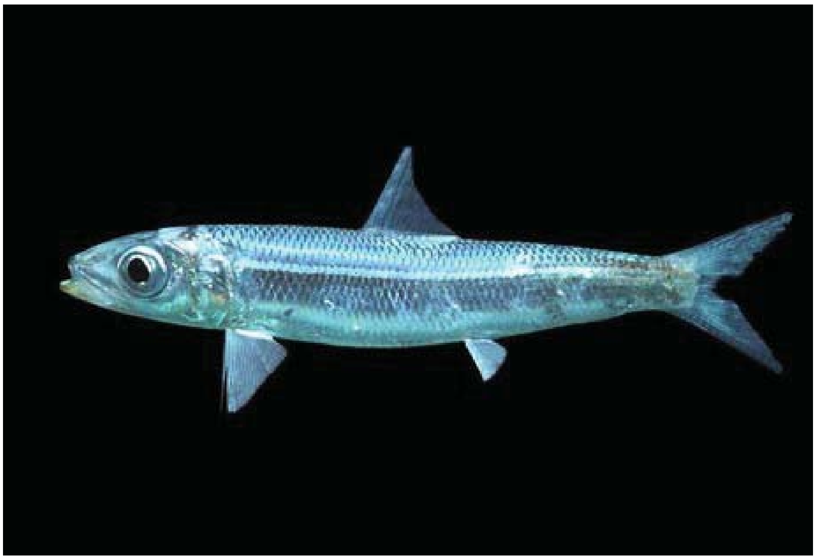


Table 10. Biomass estimation for Red-eye round herring in Libyan waters per density stratum.

Density strata, t/NM2	0-5	5-10	10-25	25-50	50-100	100-250
Sample dimension, num	323	7	2	0	0	0
Area, NM2	3787	18	1	0	0	0
Mean surface density, t/NM2	0.51	6.22	13.04	0.00	0.00	0.00
Standard deviation, t/NM2	0.86	1.47	1.48	0.00	0.00	0.00
Biomass in the density intervals, t	1943.25	111.95	13.04	0.00	0.00	0.00
Total area (NM2) =	17649	Etrumeus biomass (t) =		**2068.24**	±	**299.75**
						± 14.5 %

The only trawl in which this species was caught was n. 22 in the central part of the Libyan coast (Sirte Gulf waters, sub-area 4).

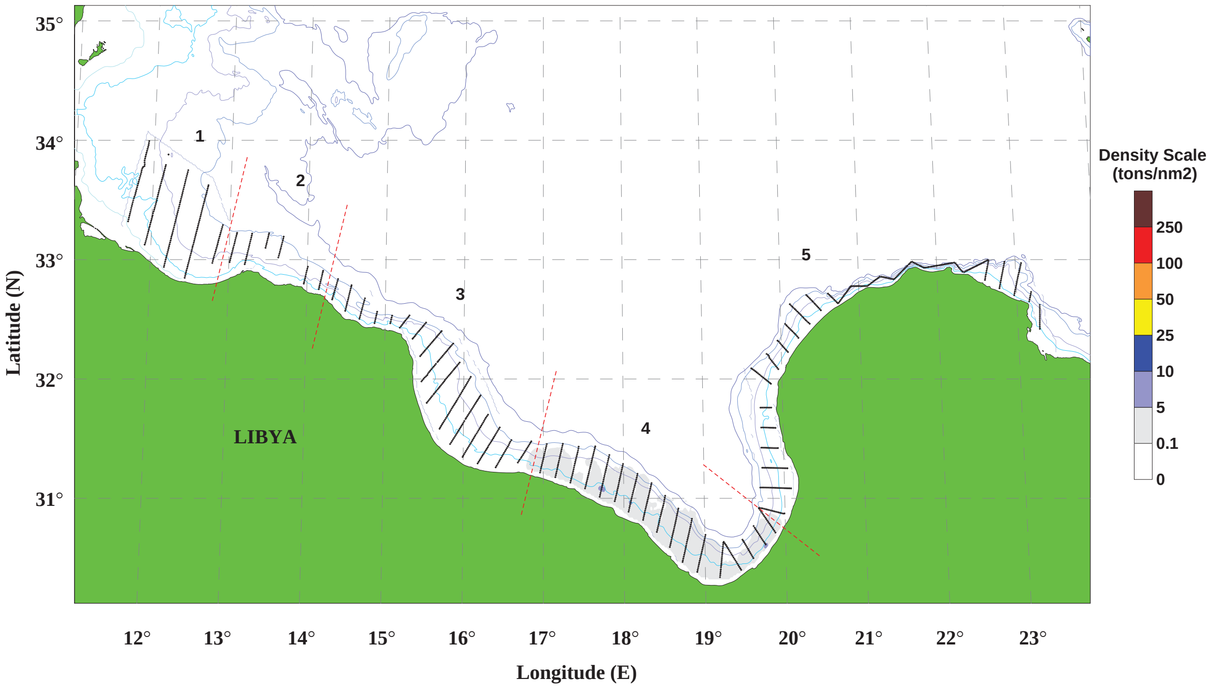


Figure 29. Red-eye round herring spatial distribution pattern in the Libyan waters. Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

The size distribution compared to the maximum length recorded in literature (30 cm TL) showed that the collected specimens were all juveniles in the size range 7.5-10 cm TL (Figure 30).

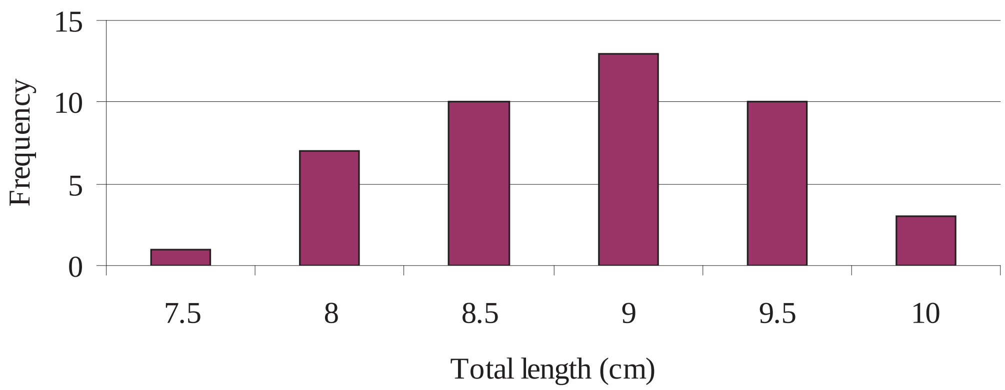


Figure 30. Size frequency distribution of Red-eye round herring collected in the Echosurvey "MSM Libya 2008", 14 August – 06 September 2008.

Within the observed size range the length-weight relationship is shown in figure 31. The two parameters were 0.008 and 2.9.

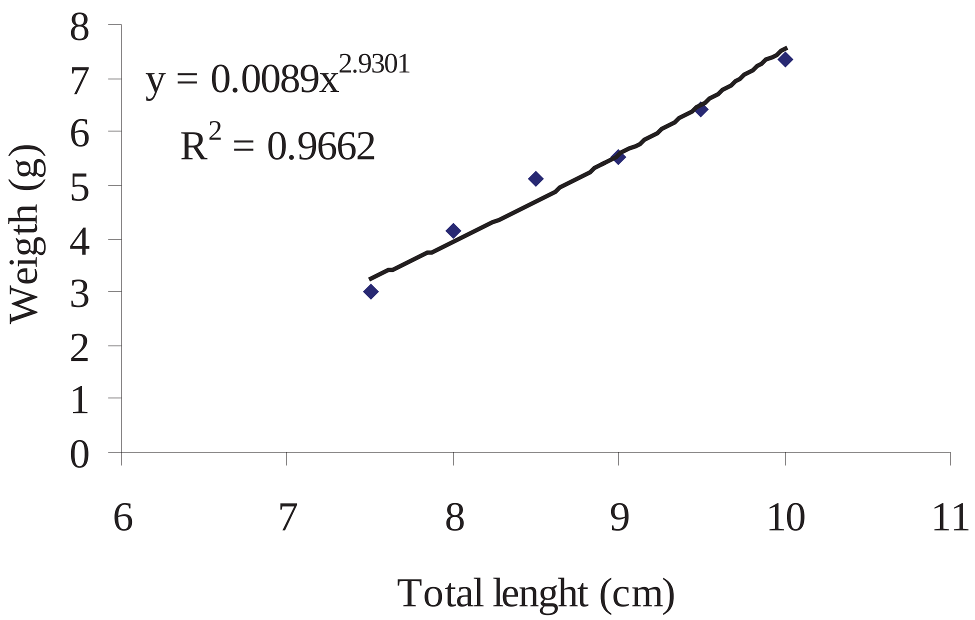
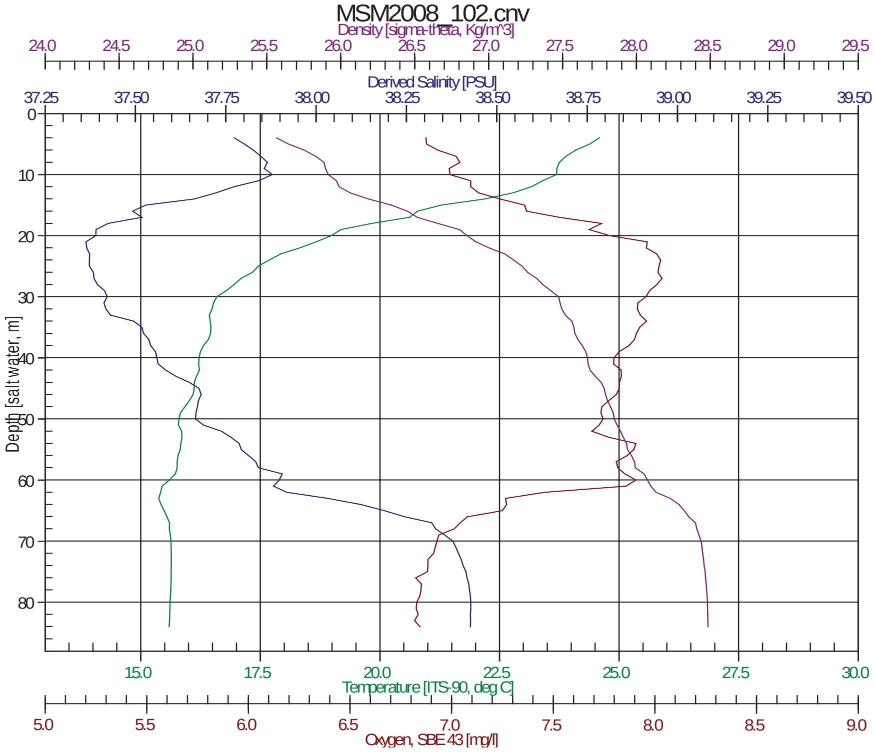
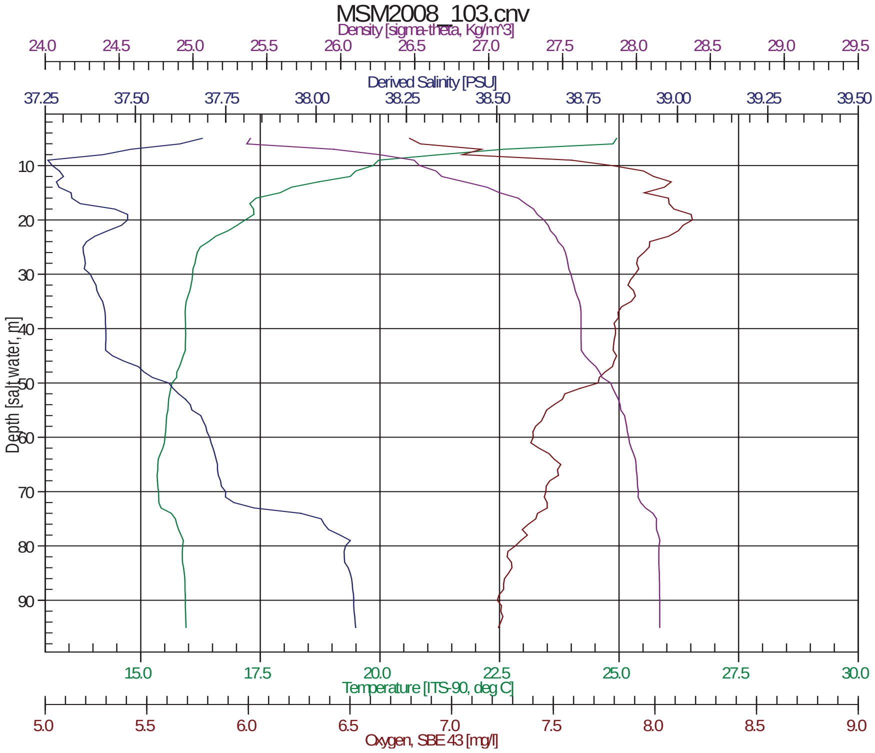


Figure 31. Length-weight relationship for Red-eye round herring collected in the Echosurvey “MSM Libya 2008”, 14 August – 06 September 2008.

Water masses characteristics

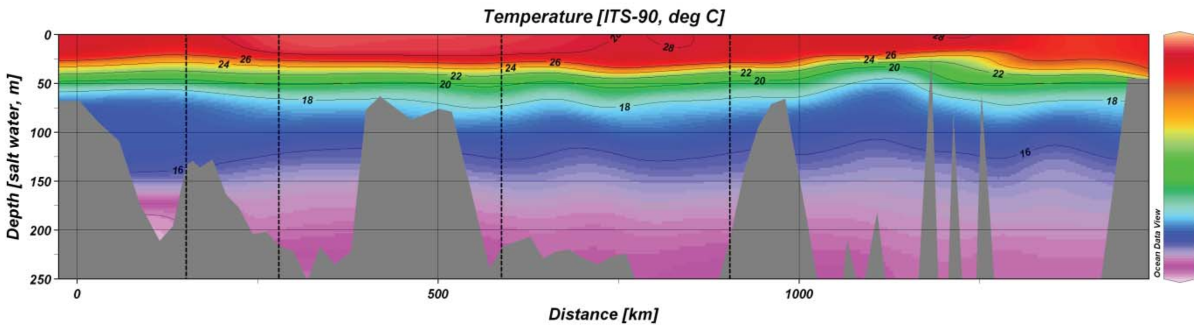
Among the recorded oceanographic parameters (Temperature, salinity oxygen, fluorescence, ph, water transparency, etc.) in this section only temperature, salinity and oxygen were selected and discussed as the most representative to characterize the water masses along the Libyan coast during the echosurvey. Some CTD casts profiles recorded in the 156 stations are reported below.



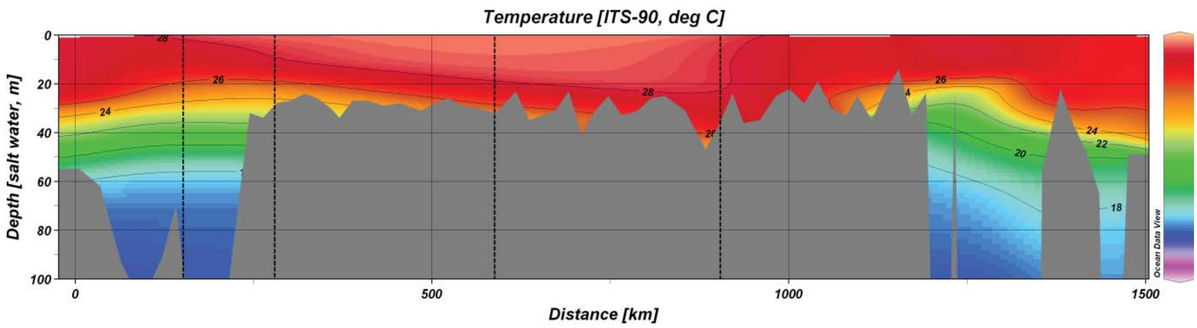


Vertical sections of the whole area

In the following the temperature pattern (Figure 32) is shown along an offshore (a) and an inshore (b) coastal section. Both sections present a well-stratified environment where the upper mixed layer is about 20 m depth and the thermocline is between 20 and 50 m depth. The vertical dotted black lines delimitates the 5 different sub-areas, showed from 1 to 5 in the eastward direction. These vertical sections do not allow differences between the sub-areas to be described in terms of the temperature regimes.



(a)

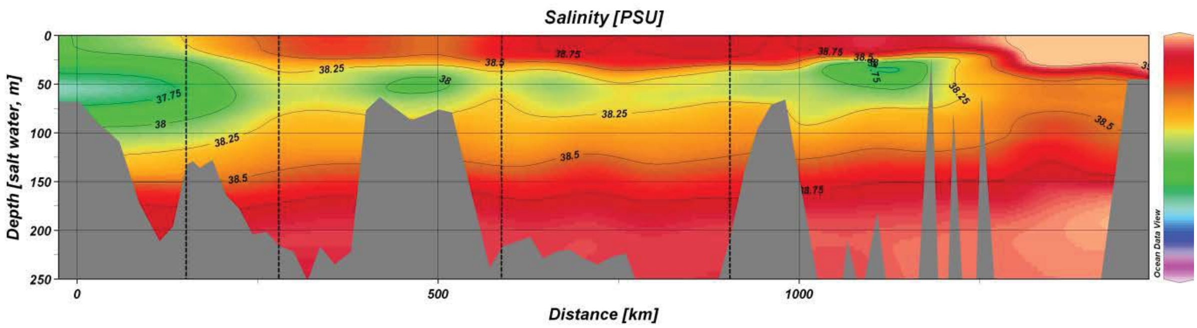


(b)

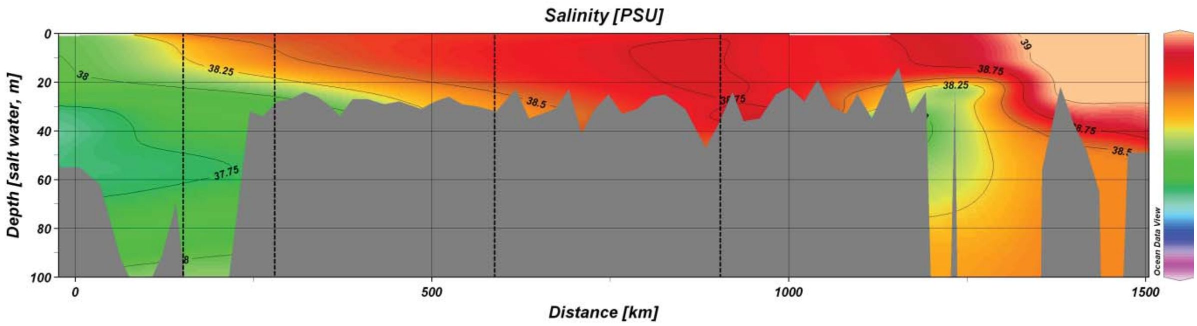
Figure 32. Temperature pattern over the whole study area in the offshore (a) and inshore (b) sections. Black dotted line separates the section in the sub-areas from 1 to 5 in westward directions.

The salinity sections (Figure 33) present significant differences among sub-areas, especially between sub-area 1 and the others, both in the offshore (a) and in the inshore (b) sections.

A clear low salinity area (37.7 ‰) in the western part of the Libyan waters characterizes the upper water masses, while in the eastern higher salinity values were recorded (39 ‰).

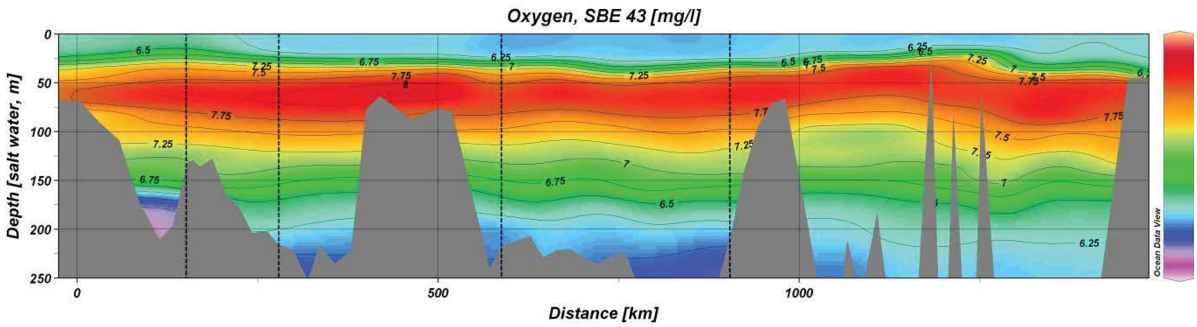


(a)

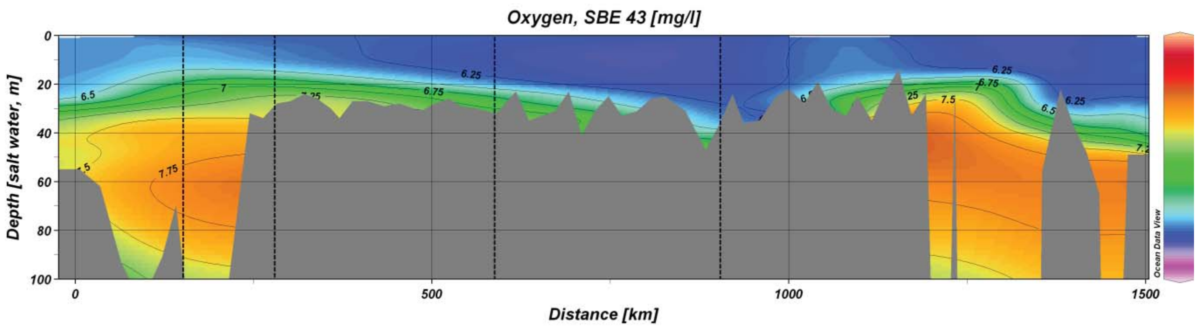


(b)

Figure 33. Salinity patterns over the whole study area in the offshore (a) and inshore (b) sections. Black dotted lines separate the section in the subareas from 1 to 5 westward direction.



(a)



(b)

Figure 34. Oxygen pattern over the whole study area in the offshore (a) and inshore (b) sections. Black dotted lines separate the section in the sub areas from 1 to 5 westward direction.

The oxygen pattern shows a clear low density in the upper mixed layer except for the sub-area 1 where a certain degree of mixing with lower layers exists, with an increase of the value from 6 to 6.5 mg/l. This mixing effect could probably be driven by the branch of the ATC (Atlantic Tunisian Current) which meanders near the coast in that area.

Surface plots of the whole area

Both the temperature surface plot (5 and 40 depth m – Figure 35) showed a certain degree of dissimilarity among the sub-area 1 and the others, while sub areas 2, 3 and 4 appear quite similar. Salinity surface plots (Figure 36) discriminate among sub-areas much better than temperature plots, both in the 5 and 40 m depth.

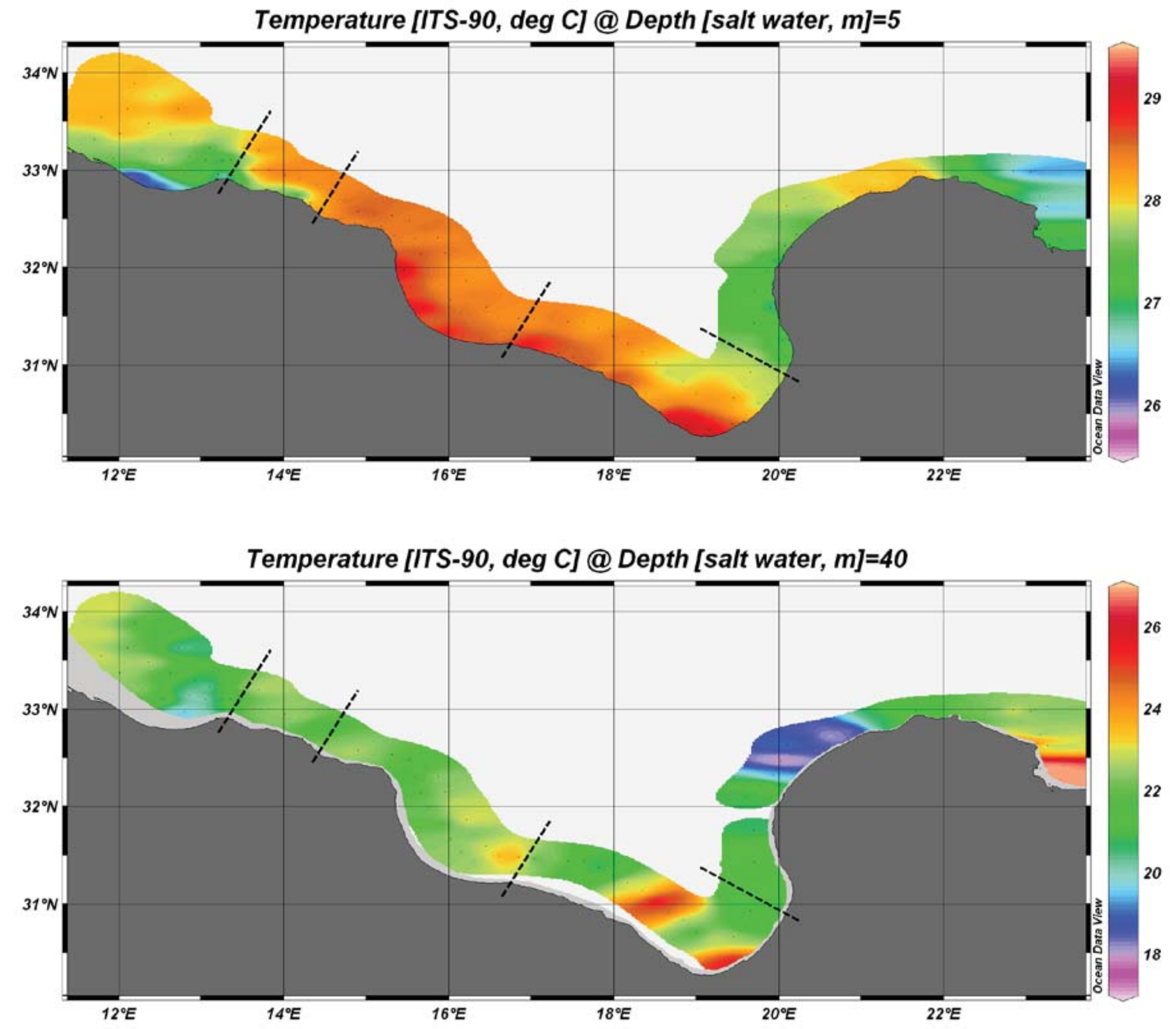


Figure 35. Surface temperature patterns over the whole study area at 5 m depth (a) and at 40 m depth (b). Black dotted lines separate the section in the sub areas from 1 to 5 westward directions.

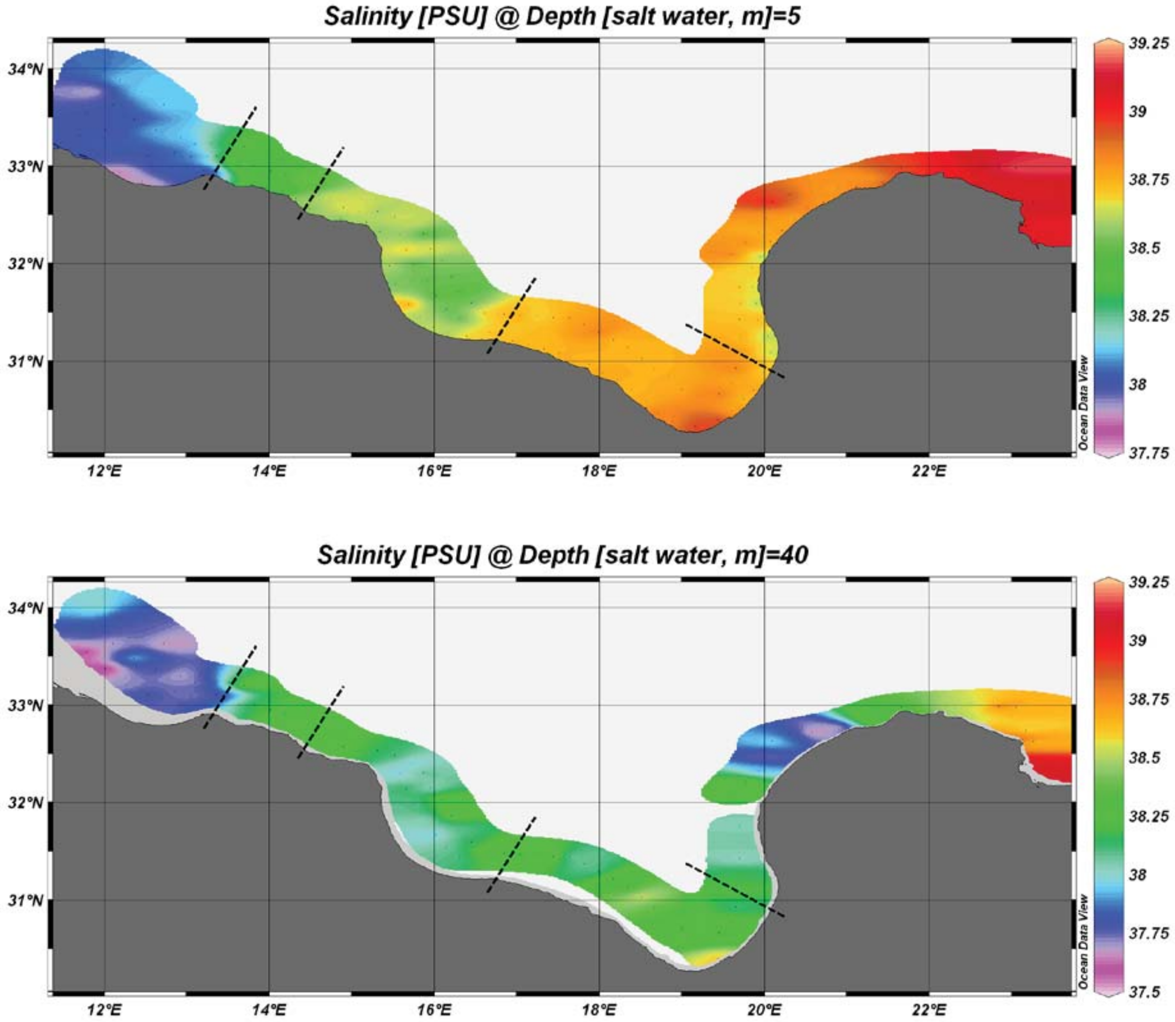
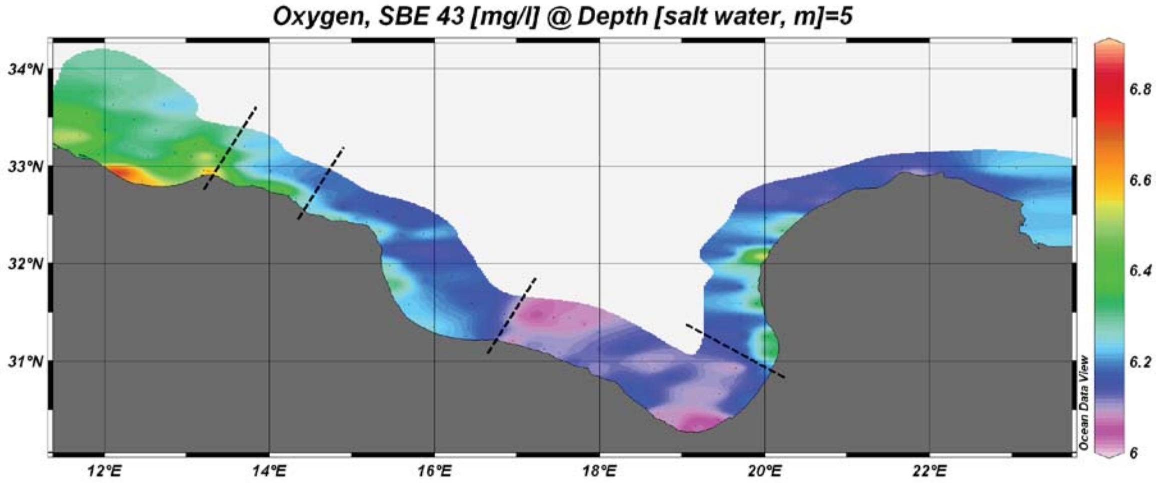


Figure 36. Surface salinity pattern over the whole study area at 5 m depth (a) and at 40 m depth (b). Black dotted lines separate the section in the sub areas from 1 to 5, westward directions.

The oxygen surface plots (Figure 37) reflect the salinity distribution much more with different average values in the several sub-areas. Namely, areas 1 and 4 recorded respectively the highest and lowest oxygen values. These features are more evident in the 5 m depth surface plot in Figure 37 (a).



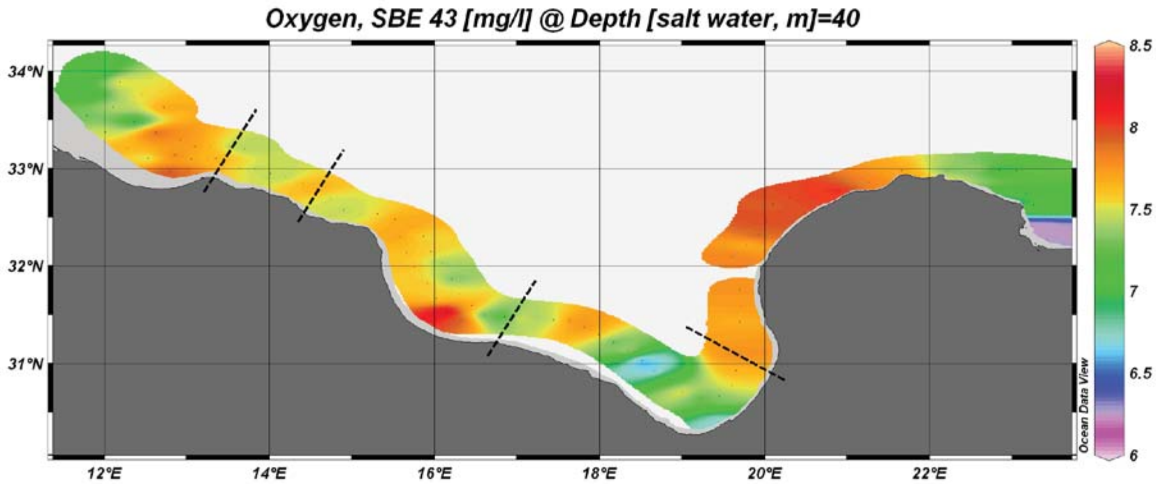


Figure 37. Surface oxygen pattern over the whole study area at 5 m depth (a) and at 40 m depth (b). Black dotted lines separate the section in the sub areas from 1 to 5 westward directions.

The TS scatter-plot for all the CTD stations, shown in figure 38, was obtained by superimposing stations of different sub-areas with different colours. It is well known that TS plot allows differences in the water mass characteristics to be singled out. Such differences are evident for the upper layer and for LIW (Levantine Intermediate Water).

Moving from west to east, a significant difference is evident in the MAW (upper water layer), specially for the sub areas 1 and 5. Moreover, the LIW, located at depths lower than 180 m, shows decreasing salinity values westward.

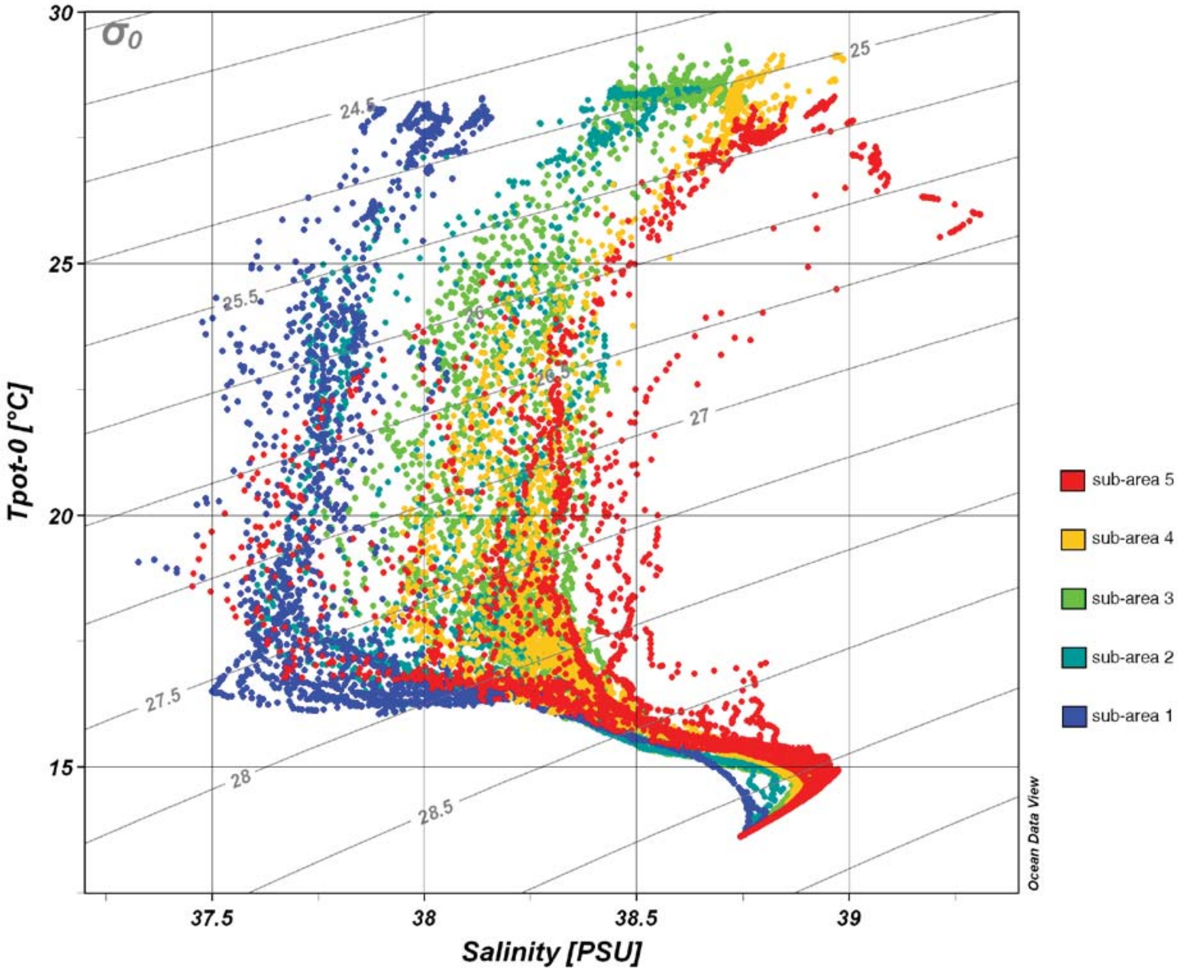


Figure 38. TS scatter-plot for all the CTD stations for each sub-area.

7. Discussions

The oceanographic conditions in the whole area showed a clear distribution pattern, which support the chosen stratification of the survey area. In particular, the oceanographic data collected singled out, also by means the TS scatter-plot, two completely different physical environment in the western and in the eastern parts of the surveyed area; sub-areas 2, 3 and 4 can be seen as transition areas between 1 and 5. As it was mentioned in Chapter 5, these sub-areas were selected on the basis of bottom morphology and species association. After the analysis of oceanographic data it was clear how these sub-areas correspond to different habitats (oceanographic conditions). The latter could also explain why fish species associations are different between the sub areas. One of the most relevant features that could be singled out is related to the differences between sub area 1 and the rest of the survey area. Moreover, as it was presented in the results chapter, the pelagic fish association in sub area 1 is completely different compared to the rest of the area. It is noticeable sub area 1 presents exclusive association of small pelagic species such as *Engraulis encrasicolus* and *Sardina pilcardus*, which were not met in the others sub-areas (see results sections on these two species). Similar consideration could be outlined for the other fish associations and oceanographic conditions.

Nevertheless, it would be desirable to see these preliminary observations confirmed by further statistical analysis and further observations.

The most relevant information, on the basis of the acoustic data collected and biological samples (trawls), is that the pelagic species constitute a relevant fishing resource. Eight commercially important fish species were estimated in the Libyan waters. *Sardina pilchardus* was found only in one trawl in the western part of the Libyan waters. Its biomass was really limited. *Engraulis encrasicolus* showed a higher presence, compared to sardine, and its presence was recorded in several trawls mainly located in the western area. Its biomass is relevant for fisheries activity. The most abundant pelagic species was the *Sardinella aurita* which was also widely distributed along the Libyan coasts. Among the species mentioned only *Sardinella aurita* represents a target species for Libyan fishery. The chub mackerel also constitutes an important target species for Libyan fishery and the acoustic evaluation supported the presence of a biomass above 30000 t with specimens also present in larger size classes (>20 cm). Other species, like *Boops boops* and *Spicara sp.*, are economically less important but their role in the ecosystem is relevant, based mainly on their distribution and abundance which suggest a relevant role in the pelagic food web. More detailed studies would be necessary to apply the ecosystem approach to the fishery and to reconstruct the linkage among all these components. Currently the Libyan ecosystem seems to represent the most well-preserved Mediterranean habitat, which permits comparative studies with other areas that are much more exploited. This opportunity should be kept by Libyan scientists to increase the scientific knowledge on ecosystem dynamics.
Another important aspect is related to the opportunity for the rational exploitation of pelagic species that are not yet fished.

8. Notes, recommendations and acknowledgments

Taking into account the results of biomass evaluation, the very high fish density estimated in some area requires much more detailed information on species composition and size distribution. To achieve this aim a longer survey time is needed for additional trawls together with a more detailed description of species composition in the area. Otherwise a possible mistake could arise in overestimating one species and underestimating other species.
Furthermore in some areas, due to the roughness of the bottom that is exploited by fish schools as shelter sites, it was not possible to perform any successfully trawls, despite the large amount of fish detected by the echosounder. In order to achieve more precise results on species composition and their size distribution, in the next echosurveys it would be necessary to have an additional fishing vessel equipped with a purse seine net (*Lampara* vessel) that is much more efficient than the pelagic trawls used routinely in acoustic surveys to catch fish samples in rough-bottomed areas.

The relevant amount of fish biomass estimated suggests the necessity to manage the pelagic resources, to monitor the standing stock each year by means of echosurvey and by collecting information on commercial fishery by means of a detailed landing survey. In this way it would be possible to obtain data on the total amount of pelagic species landed throughout the year and to take biological samples to study the fundamental parameters of population dynamics and the population structure (age composition, length at first maturity, etc.).

Results of the *Sardinella aurita* biomass distribution showed its presence very near the coast, but unfortunately, due to forbidden access to the area close to the coastline (3 nm from the shoreline) there was evidence that its total biomass was underestimated during this survey; so it is strongly recommended for the next survey that permission should be obtained for navigation closer to the coast, as far as a depth of 10 m.

The total echosurvey track along the Libyan coasts was not completed in the western area due to bad weather conditions and limited vessel time.

The timing of the survey was affected by the bad weather which delayed the beginning of the work and by the relative small size of the vessel and its limited autonomy. Moreover, the second part of the survey was carried out in an area known for its uneven bottom where trawling is rather difficult. However, the work-plan was almost fully covered and the data collected allowed updating information on the status of small pelagic fish stocks along the Libyan coast.

The Libyan Authorities are gratefully acknowledged for having authorized the survey. The Marine Agency Ras Hilal provided valuable assistance for the logistics and all formalities. Thanks are also expressed to all scientific staff and crew members for their work during the whole period.

9. References

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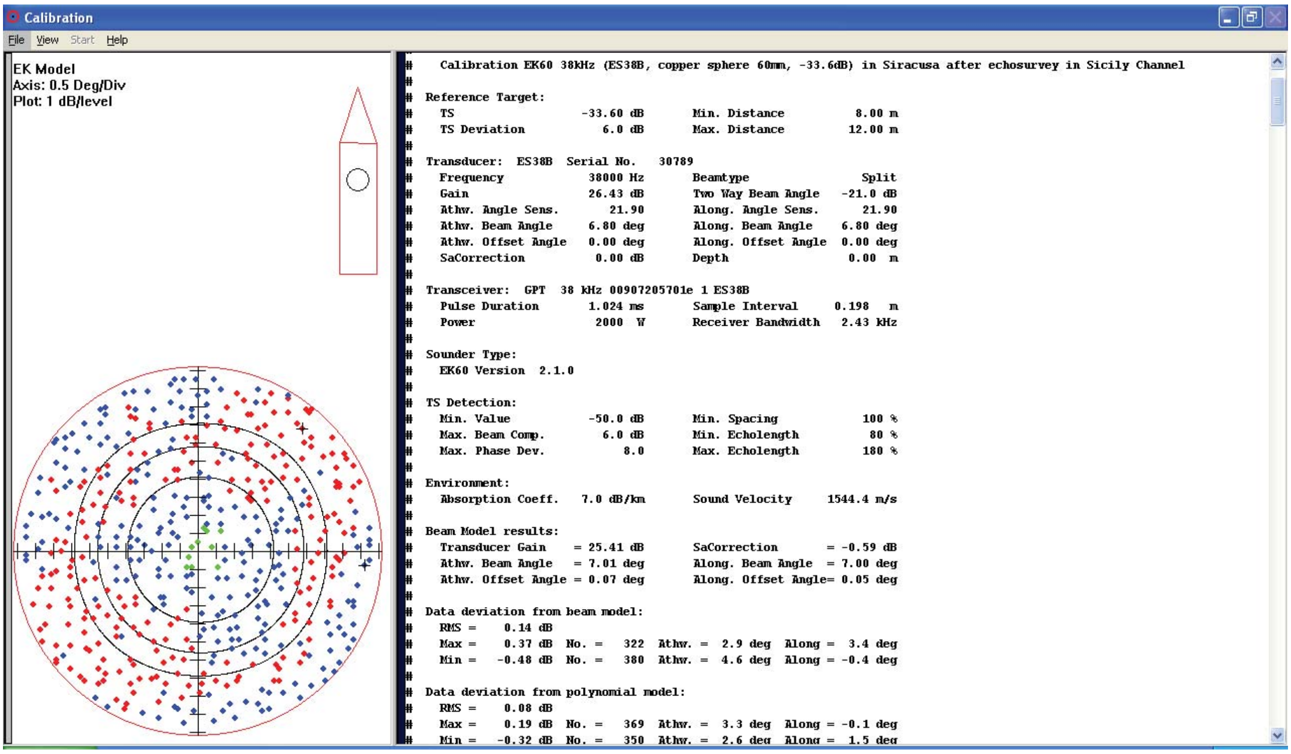
Annex 1

Calibration reports

GPT38kHz, ES38B (s/n 30789): 1024mks, 2000W **Date 10/08/2008**

Calibration EK60 in Siracusa waters (37º02.642´N; 15º17.540´E)
Depth = 13.6m; Sphere depth = 10.2m



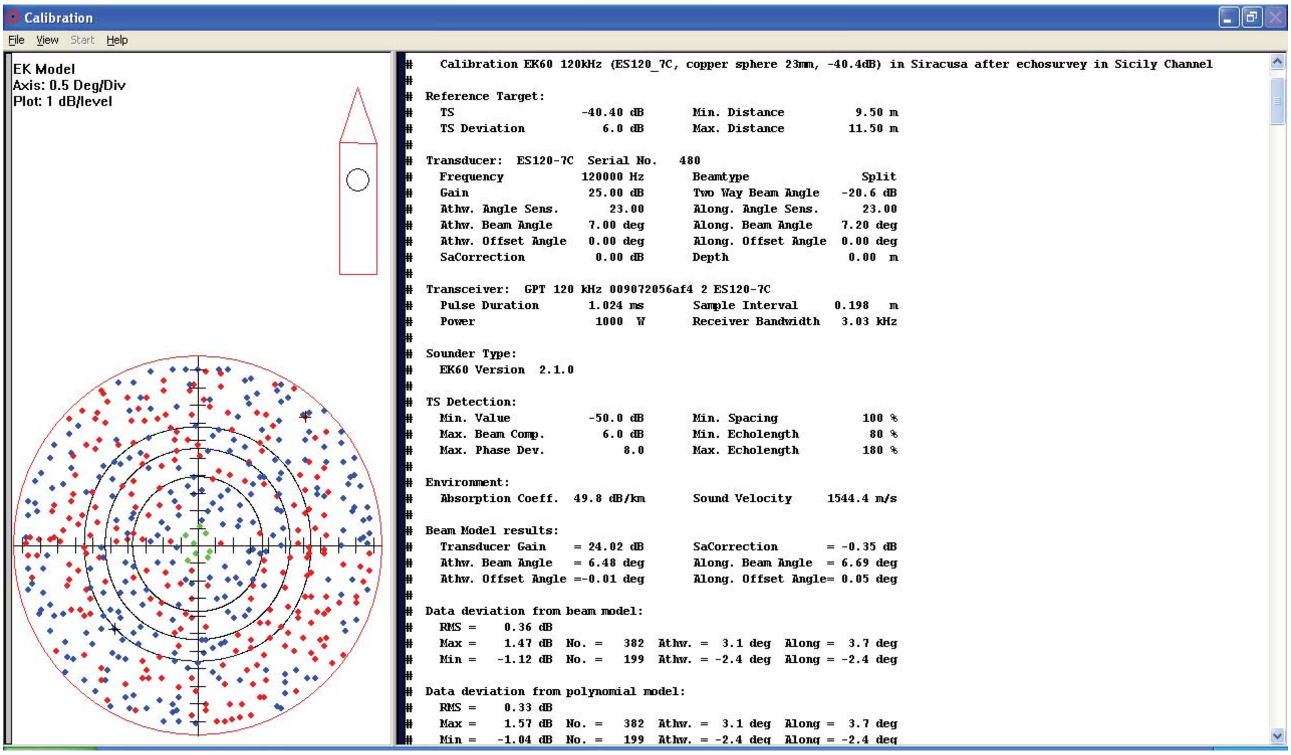
	DEFAULT	RESULT
Water temp. =	25.0ºC	26.0 ºC
Salinity =	37.9º%	38.38 º%
Absorption coef. =	7.122dB/km	6.988dB/km
Sound speed =	1541.5m/s	1544.4m/s
GAIN =	26.43dB	25.41dB
Sa Correction =	0.00dB	-0.59dB
Athw. Beam Angle =	6.8deg	7,0deg
Alog. Beam Angle =	6.8deg	7.01deg
Athw. Offset Angle =	0.0deg	0.05deg
Along. Offset Angle =	0.0deg	0.07deg

FILE:

D20080810-T101653.raw - record of copper sphere after inst. parameters of calibration

GPT120kHz, ES120_7C (s/n 480): 1024mks, 1000W **Date 11/08/2008**

Calibration EK60 in Siracusa waters (37º02.683´N; 15º17.536´E)
Depth = 13.7m; Sphere depth = 10.5m



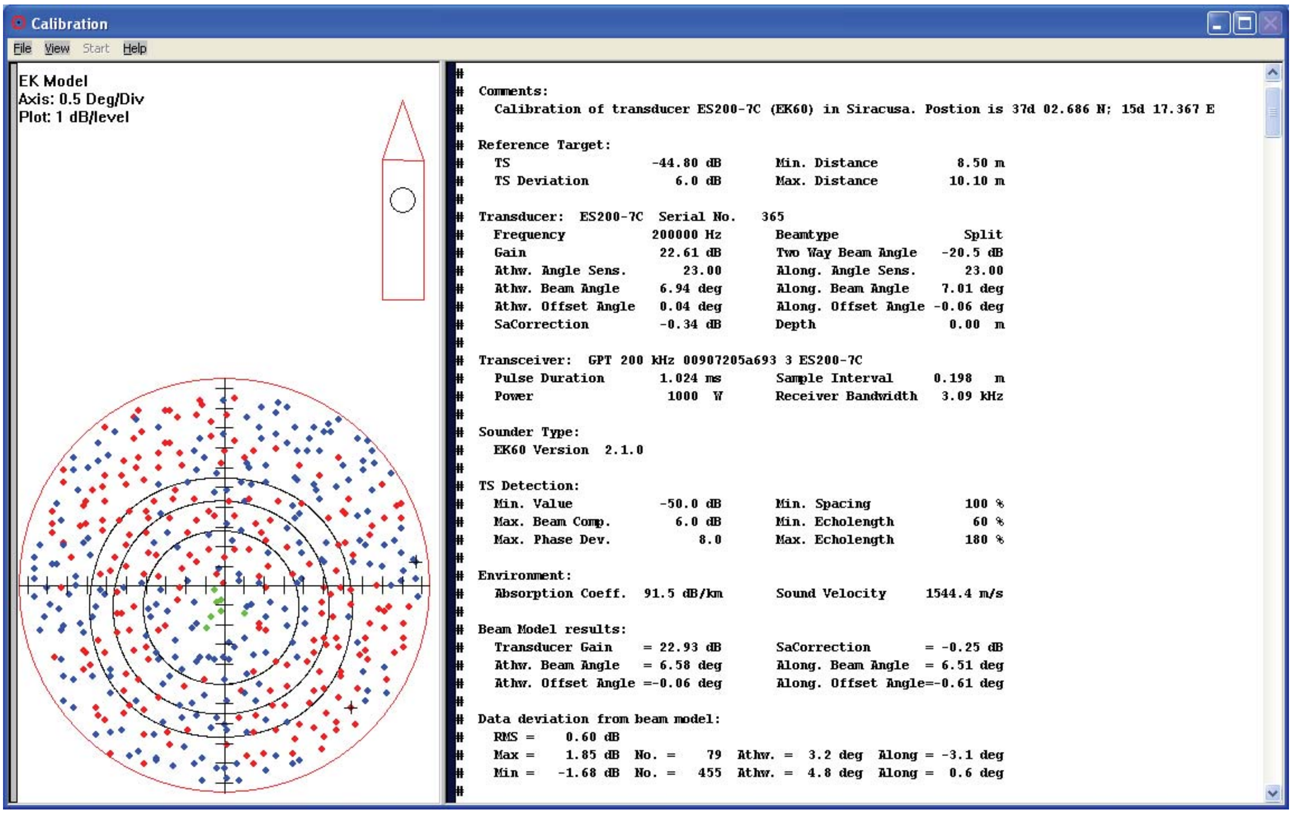
	DEFAULT	RESULT
Water temp. =		26.0 ºC
Salinity =		38.38 º%
Absorption coef. =		49.766dB/km
Sound speed =		1544.4m/s
GAIN =	27.0 (25.0) dB	24.02dB
Sa Correction =	0.00dB	-0.35dB
Athw. Beam Angle =	7.20deg	6,48deg
Alog. Beam Angle =	7.00deg	6.70deg
Athw. Offset Angle =	0.0deg	-0.01deg
Along. Offset Angle =	0.0deg	0.05deg

FILE:

D20080811-T115231.raw – record (120kHz) of copper sphere after inst. parameters. of calibration (TS = -40.4dB)
D20080811-T120239.raw – record (38kHz) of copper sphere 23mm (TS = - 50.0dB)

GPT200kHz, ES200_7C (s/n 365): 1024mks, 1000W **Date 18/08/2008**

Calibration of EK60 in Siracusa waters (37º02.686´N; 15º17.367´E)
Depth = 12.8m; Sphere depth = 9.0m



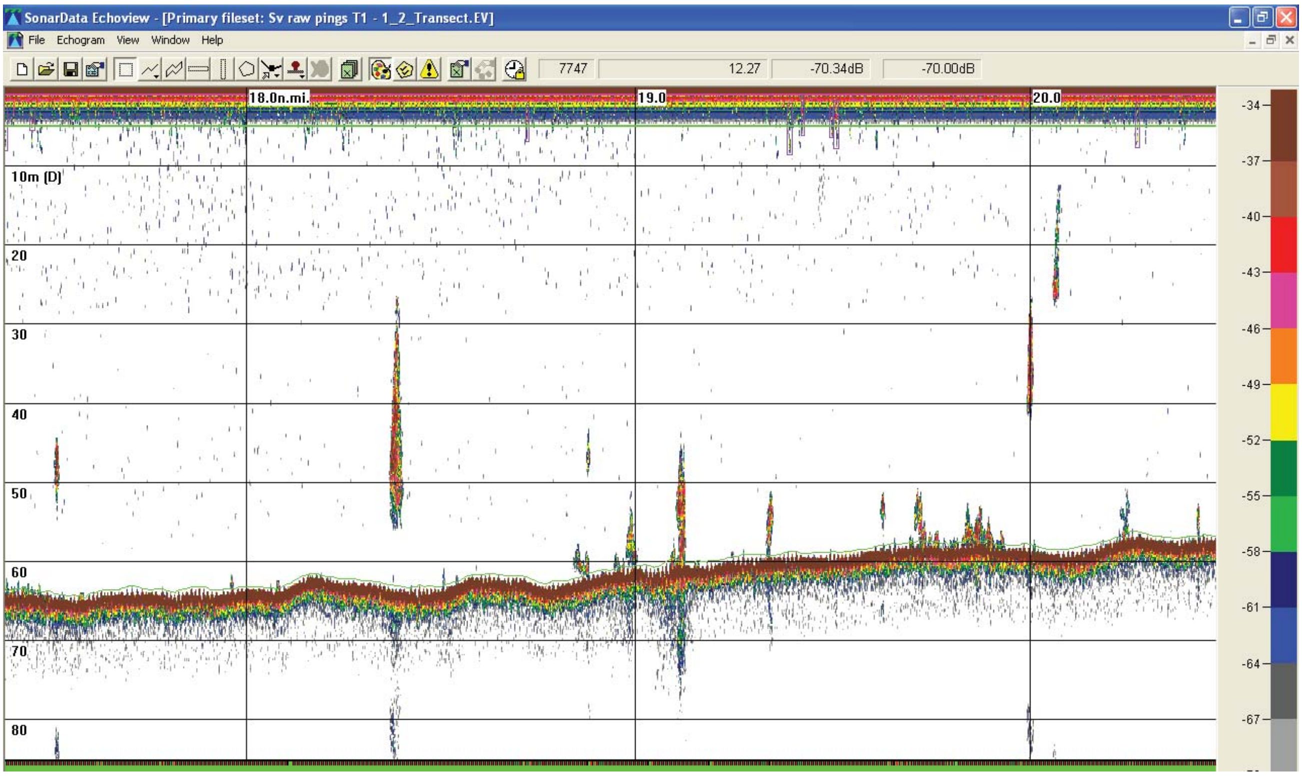
	DEFAULT	RESULT
Water temp.		26.0 ºC
Salinity		38.38 º%
Absorption coef.		91.5dB/km
Sound speed		1544.4m/s
GAIN	22.61dB	22.93dB
Sa Correction	-0.34dB	-0.25dB
Athw. Beam Angle	6.94deg	6,58deg
Alog. Beam Angle	7.01deg	6.51deg
Athw. Offset Angle	0.04deg	-0.06deg
Along. Offset Angle	-0.06deg	-0.61deg

FILE:

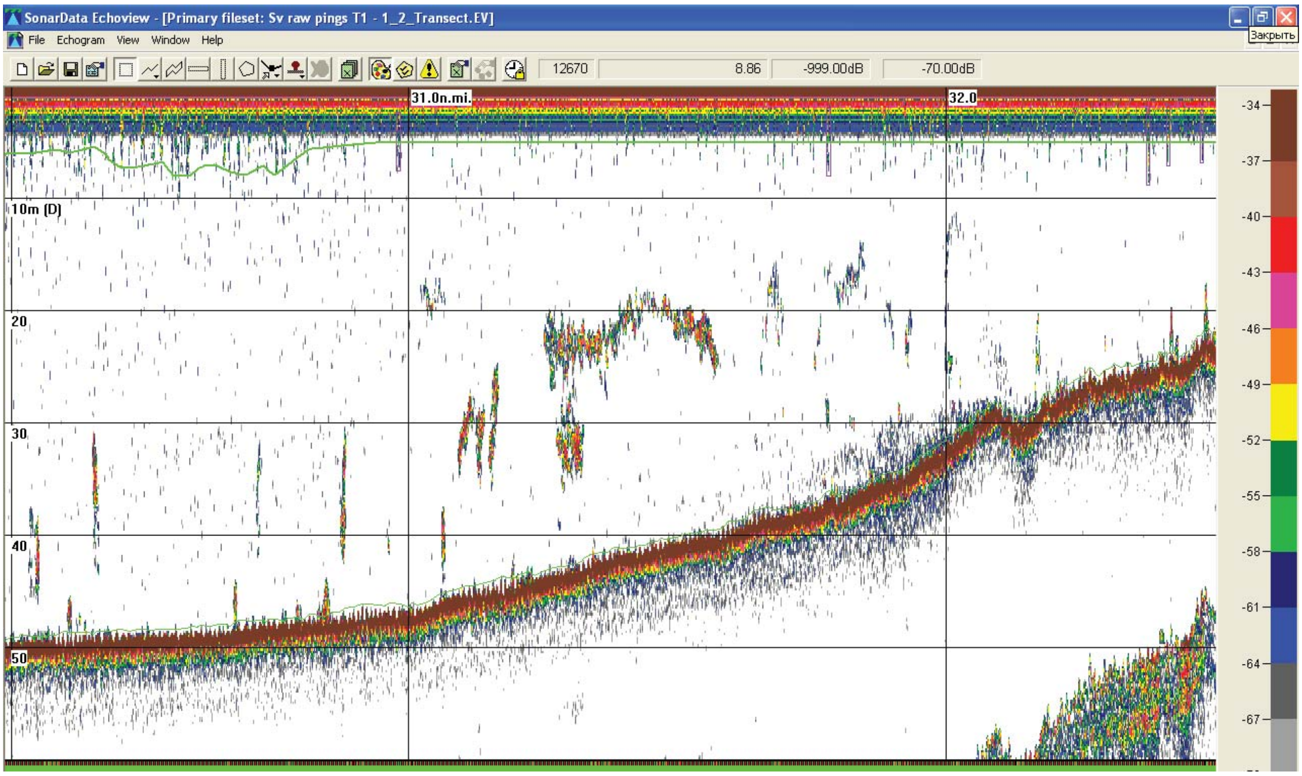
D20080816-T114214.raw – record (200kHz) of copper sphere 13.7mm after installation param. of calibration
D20080816-T120754.raw – record (38kHz) of copper sphere 13.7mm (TS = - 52.3dB)
D20080816-T121947.raw – record (120kHz) of copper sphere 13.7mm (TS = - 46.5dB)

Examples of echograms showing some schools sheltered by rough bottom

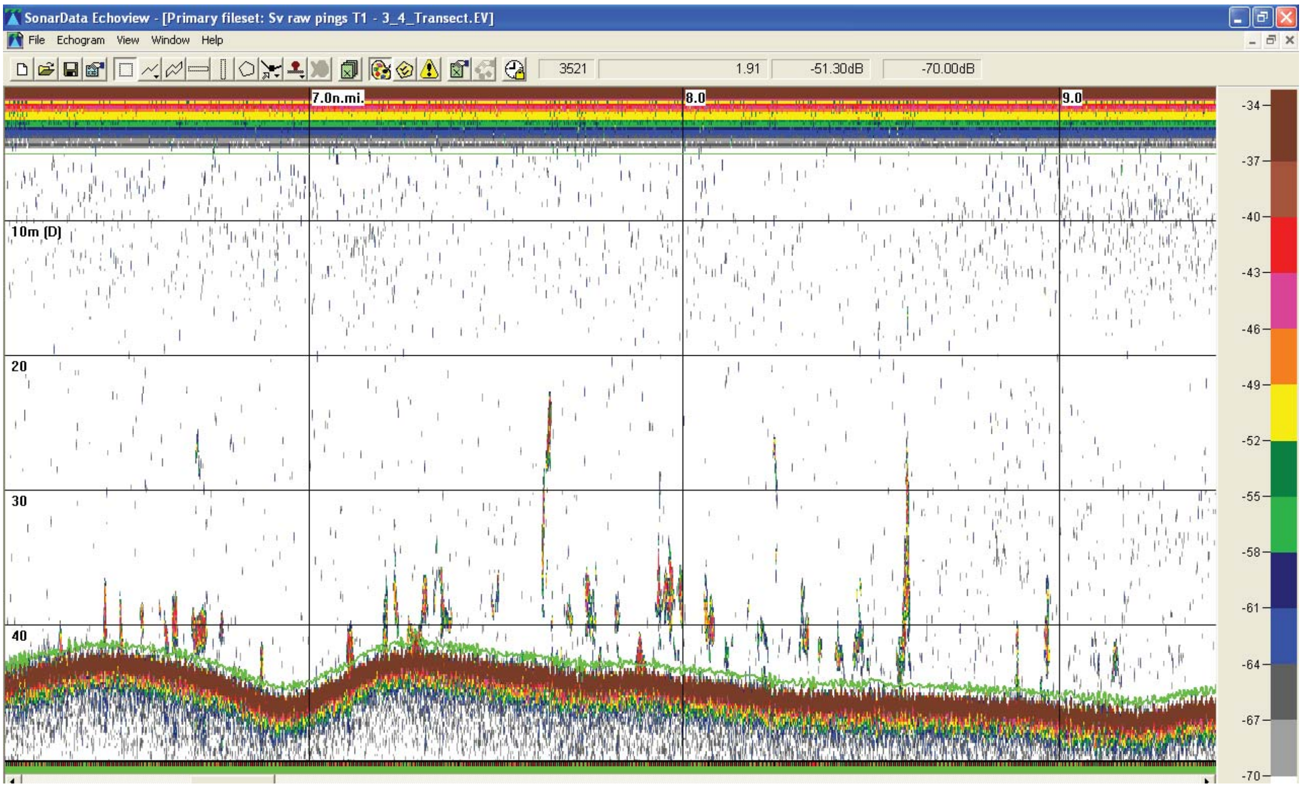
Transect #1-2



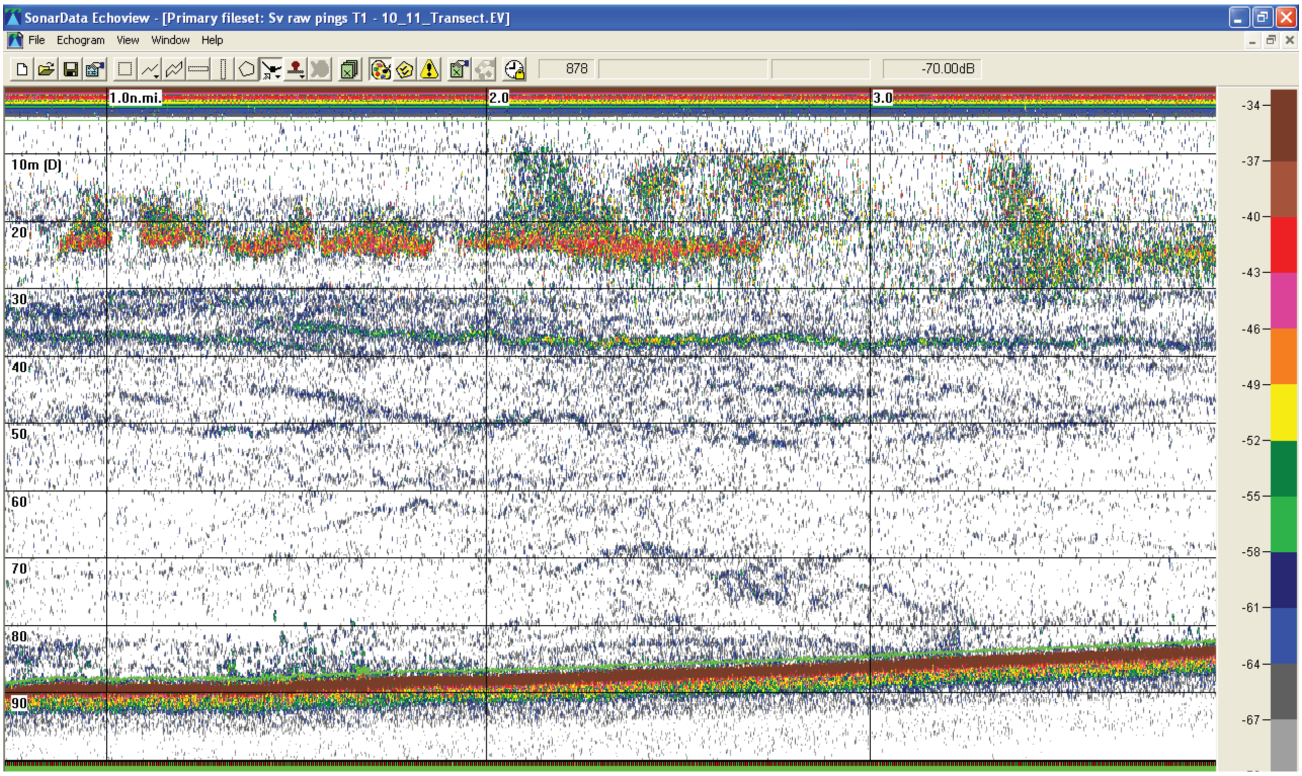
Transect #1-2



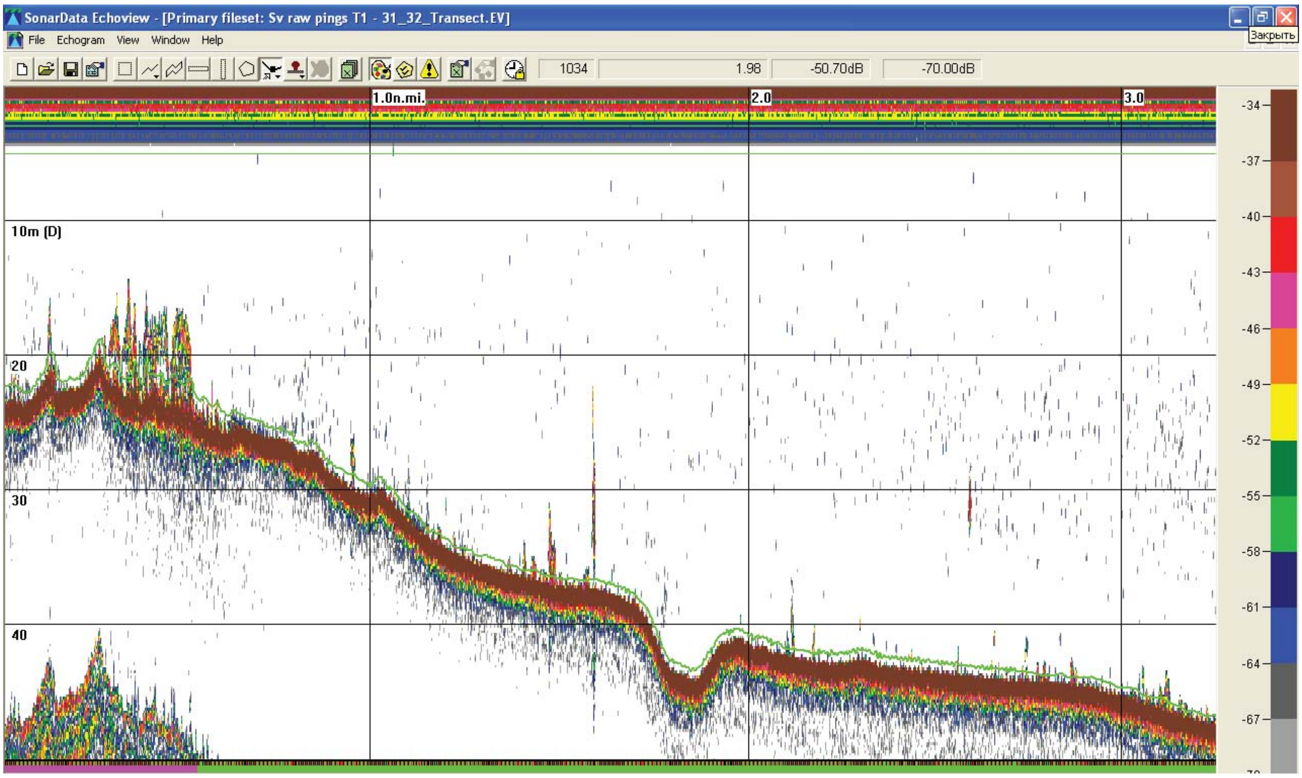
Transect #3-4



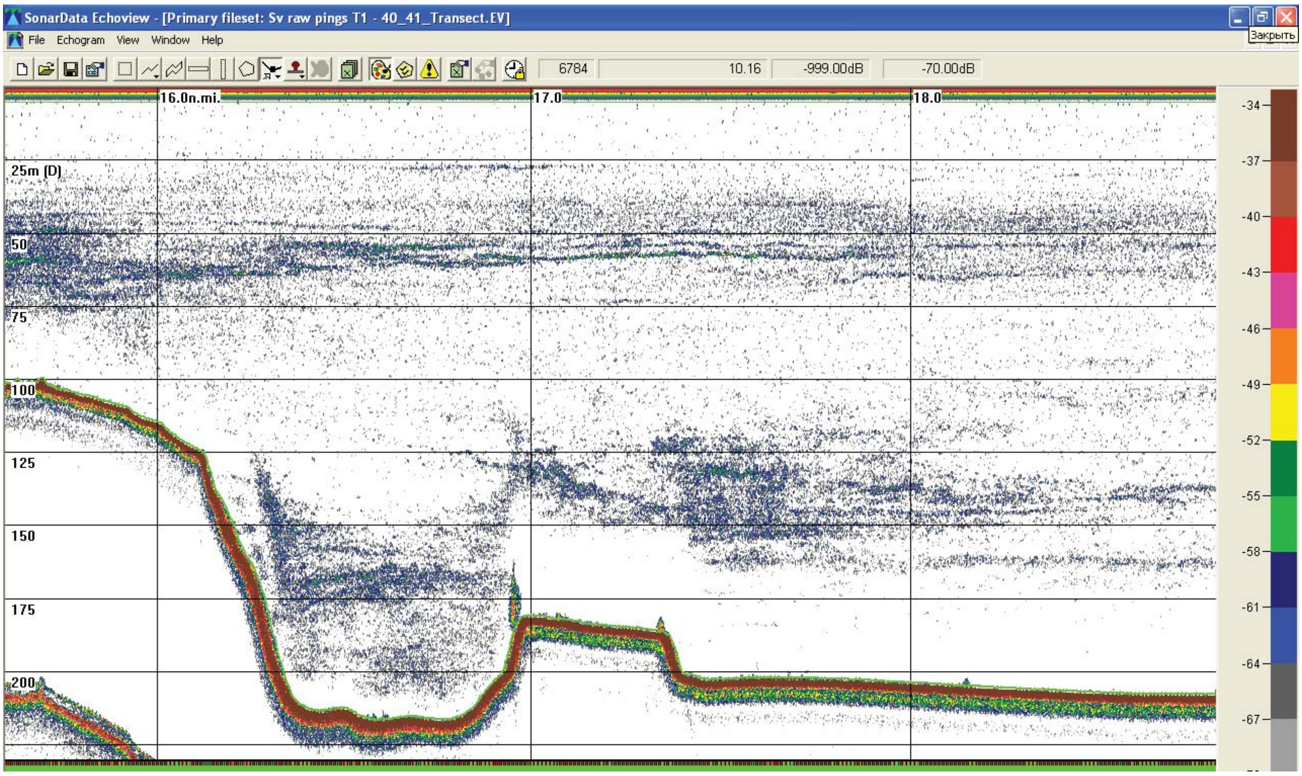
Transect #8-9



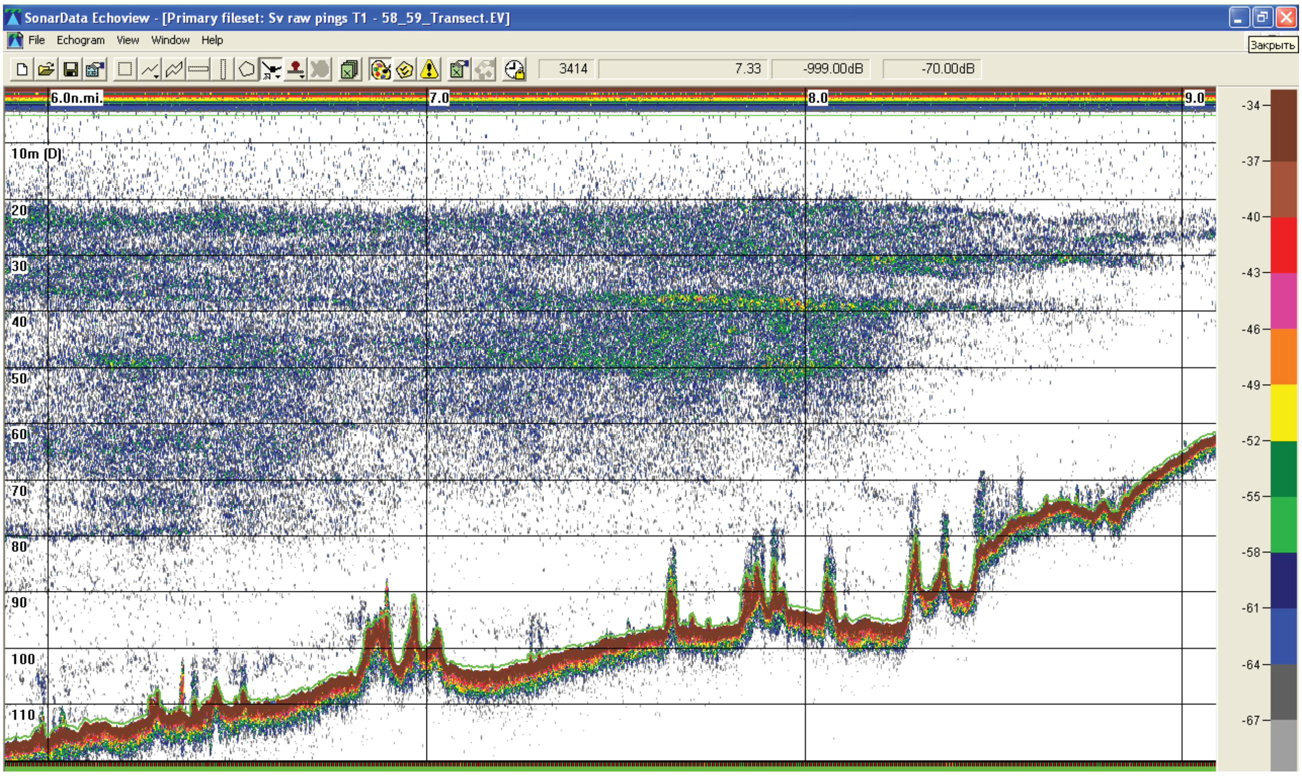
Transect #31-32



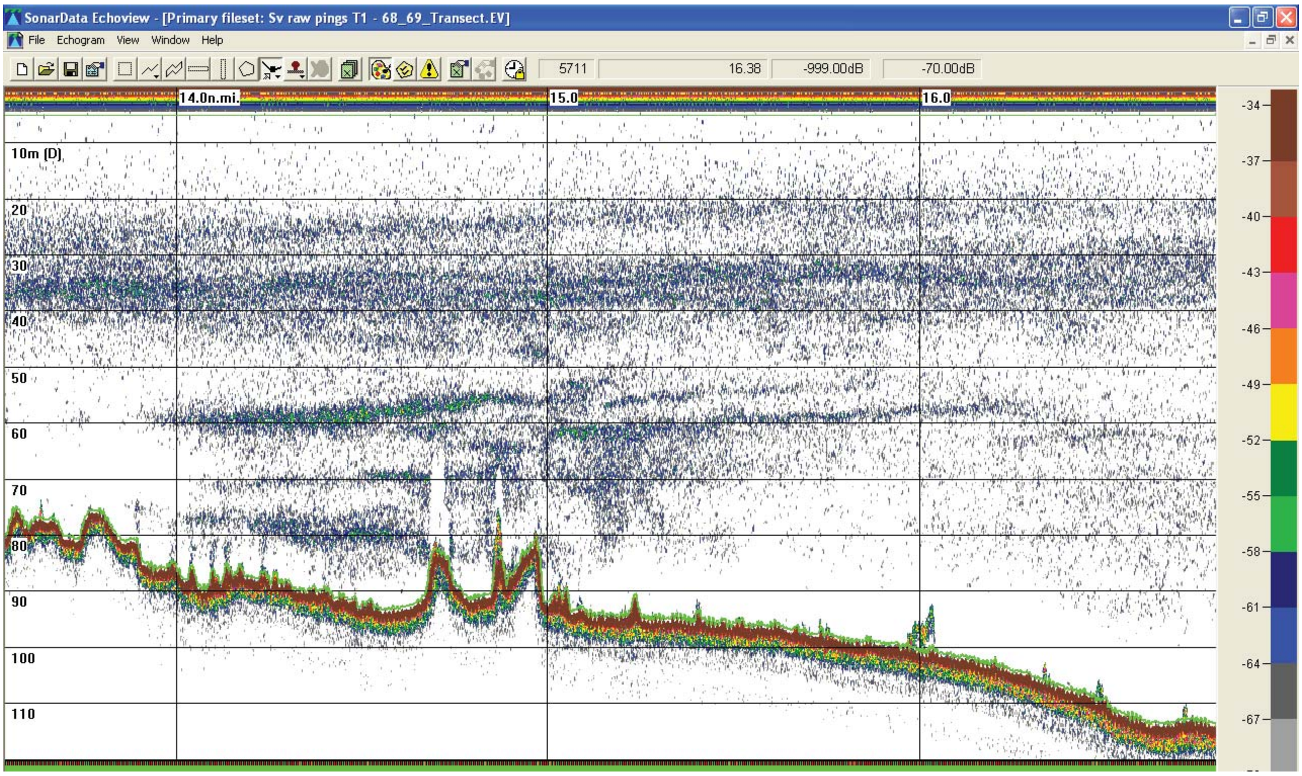
Transect #40-41



Transect #58-59



Transect #68-69



NOTES

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