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AcousMed

HARMONIZATION OF THE ACOUSTIC DATA IN THE MEDITERRANEAN 2002-2006

NEGOTIATED PROCEDURE No MARE/2009/09

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Final Report

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1 Objectives & background

The present study aims at the "Harmonization of the acoustic data in the Mediterranean 2002-2006". Acoustic surveys have been conducted by Member states of EU on a regular basis in several Mediterranean geographical subdivisions (GSAs) during the last decades. Specifically, in the western Mediterranean the Iberian coast has been regularly surveyed since 1990, the Gulf of Lions since 1995, the western part of the Adriatic Sea since 1976 and the Strait of Sicily since 1998. In the Eastern Mediterranean Sea acoustic surveys were held in northern Aegean Sea since 1995 but with temporal gaps. Regularly the area has been surveyed since 2003 in the framework of the Data Collection Regulation (DCR). All these acoustic surveys operated under a common target which was the estimation of the population abundance of small pelagic fish as well as their spatial distribution per respective surveyed area. Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) were the main target species for all surveys. However these surveys have not been internationally coordinated and data have been analyzed and presented in diversified ways. The acoustic surveys in the aforementioned areas are currently being part of the Pan Mediterranean Acoustic Survey (MEDIAS) from 2008 onward. In the 1st and 2nd MEDIAS meeting several issues have been raised that require the harmonization among the different surveys.

Therefore, the present study has specific targets aiming to assure the optimization of the design of these acoustic surveys held in the five different geographical areas (i.e. Spanish Mediterranean waters, Gulf of Lions, western Adriatic Sea, Strait of Sicily and North Aegean Sea), promote the compatibility of the acoustic estimations among these areas as well as the compatibility of old and new acoustic data within each area. The lack of harmonization among the different acoustic surveys comprises an impediment to the use and meta-analysis of the existing time-series of acoustic data at large spatial and temporal scales.

Specifically, one of the main tasks of the current study includes the revision of existing survey designs along with an estimation of the precision of each survey. Abundance data of historic acoustic surveys (2002-2006) concerning anchovy and sardine populations in each study area will be analyzed and geostatistical analysis will be applied in order to estimate survey accuracy (i.e. variance) and examine alternative survey designs.

In addition, within the scope of the present study is the harmonization and the optimization of the acoustic methodology used in each survey. This covers three major issues i.e. (a) the Target Strength equation used for the target species in each area, (b) the effect of the time of day on the acoustic and biological sampling as well as (c) the standardization of a common format for acoustic data and the estimated parameters that would allow a comparable presentation of the data for the requirement of the DCR as well as their integration for common analysis.

Project duration was 24 months starting March 2010 and the results are presented below.

2 Work achieved

Within the general co-ordination of the project and the first year of the study two meetings were carried out according to the proposed plan and one workshop on survey design organized jointly with the ICES WGACEGG.

One kick-off meeting was carried out at CNR-IAMC Capo Granitola (Sicily) 23-24 March 2010. During this kick off meeting we discussed on the availability of appropriate acoustic data from each partner and per task as well as on the work to follow for each task. One or two persons were set as responsible for each task from each partner/study area and a common protocol to analyze the available data for each task was defined and agreed in order to assure the harmonization of the work. In order to facilitate the collaboration between partners, the exchange of ideas and an easy access to common protocols a wiki page under the name of the AcousMed project was created for this purpose. The web address is http://acousmed.wikispaces.com/. All documents related to the project can be found in this site. The agenda of the kick off meeting, the minutes of the meeting and the list of participants are sited in Annex 1.

A second meeting took place at Palma de Mallorca 22-24 November 2010 hosted by IEO and Dr Magdalena Iglesias. This second meeting was carried out jointly with the ICES WGACEGG in order to encourage the collaboration between the Atlantic acoustic surveys targeting anchovy and sardine and the Mediterranean ones, the exchange of ideas on common problems of the acoustic surveys and possible solutions and promote the harmonization of data analysis. The agenda of this second meeting, the minutes of the meeting and the list of participants are sited in Annex 1.

Moreover, a joined AcousMed Project/ICES WGACEGG Workshop on Geostatistics (WKACUGEO) was held, supported by ICES SSCICOM and chaired by Dr P. Petitgas (IFREMER) and Dr. M. Giannoulaki (HCMR). The joined workshop took place at Palma de Mallorca (Spain) 20-21 November 2010 hosted by IEO and Dr Magdalena Iglesias. The workshop allowed gathering most of the European acoustic surveys on anchovy and sardine in ICES and Mediterranean waters. The objectives of the workshop were to standardize data analysis methods for the evaluation and optimization of survey design. Within the framework of this workshop basic geostatistics were applied to different case studies from the Mediterranean and the Atlantic in order to estimate the suitability of existing survey designs and also test alternative survey designs. Workshop report can be found online at http://groupnet.ices.dk/wkacugeo2010/default.aspx. Details of the analysis concerning the Mediterranean case studies are presented and discussed within the framework of WP2.

Concerning Task 3 which involves all issues related to the “Harmonization and optimization of acoustic surveys” considerable progress of work was achieved during the first year of the project. It should be clarified that although the project was focusing on the analysis of data from past acoustic surveys, gaps in data availability were identified and big effort was taken from all partners in order to collect additional data within on going surveys. In particular, targeted surveys for examining the effect of day-time or night-time sampling on acoustic and biological data were held in the Adriatic Sea and the Strait of Sicily during 2010. Moreover, within the framework of Task 3 the second meeting of the project (Palma de Mallorca 22-24 November 2010) was held jointly with the annual ICES WGACEGG meeting. This comprised an important step to bring together scientists involved in acoustic surveys in the Atlantic and the Mediterranean, promoting the collaboration, the exchange of expertise, the identification of common problems and solutions between ICES and Mediterranean surveys.

During the first year of the project a review of existing appropriate data for the estimation of *in situ* Target strength equations (sub task 3.1), day night comparisons in acoustic sampling (sub task 3.2), day night comparisons in biological sampling (sub task 3.3) and existing acoustic database formatting (sub task 3.4) was completed. Common protocols for the analysis were defined and agreed. Moreover, significant part of the work concerning the estimation of *in situ* Target strength equations (sub task 3.1), the day-night comparisons in acoustic and biological sampling based on past data was largely completed.

During the second year of the project two meetings were held. One in parallel with the Annual Steering Committee Meeting of the MEDIAS surveys, which mainly addressed the evaluation of survey design by means of the indicator approach. Update of the protocols based on initial data, partly re-analysis mainly concerning the TS equations along with the analysis of data collected during the time period for the purposes of sub tasks 3.2 and 3.3 was done during the second year of the project. The final project meeting took place in Iraklion (Crete) hosted by HCMR in December 2011 where final results were discussed and evaluated along with the synthesis of the final report of the project.

Summarizing the main findings of the AcousMed project:

- Concerning the evaluation and optimization of existing surveys design in the study areas a two approach based on geostatistics was followed: First in order to analyze the spatial structure of the target species in the study areas, we applied variogram modeling on raw data adapting in each study area the type of applied variogram to the peculiarities of the local populations. In a second step, enhanced spatial analysis was applied following the indicator function that allowed standardization of the analysis among the different areas. Moreover it impaired a geometric perspective to the analysis of survey design, estimating the probability to encounter patches of high values representing a given percentage of total biomass. Variography on raw data generally showed that existing survey designs seem well adapted to

- Concerning Task 3 and the harmonization and optimization of acoustic sampling a big step towards the re-evaluation of existing practices in terms of applied Target Strength equations, day - night acoustic and biological sampling and the standardization of a common database format for acoustic data was achieved.
- For sub - Task 3.1 and the Target Strength equations of anchovy and sardine we assessed the effect of different TS~length equations parameters on biomass acoustic estimates at the different study areas with results highlighting that even small differences in the b_{20} values can lead to a significant underestimation or overestimation of the fish stock biomass. Furthermore acoustic data from previous or recent years' acoustic surveys (2000-2011) derived from the Iberian coast, the western part of the Adriatic Sea, the Strait of Sicily and the Aegean Sea were analyzed towards the *in situ* TS estimation for anchovy and sardine. Different TS-TL equations were estimated per study area upon data adequacy based on single target estimations for both anchovy and sardine. However the large variation in the TS equations from the different areas impaired the need to integrate all available data towards the estimation of a global equation. Such an equation was not found significant when considering data from all areas. A significant relationship was found concerning the central and eastern Mediterranean for anchovy. These results clearly indicate that a re-evaluation for the currently applied b_{20} values especially for anchovy is required. Differences were less pronounced concerning sardine TS however this was based on a small number of hauls and further work is required. Moreover the series of problems encountered during the TS analysis that need to be overcome towards the adaption of a new TS equation for anchovy and sardine are suggested.
- For sub - Task 3.2 and day – night acoustic sampling data from past surveys as well as targeted minisurveys were analyzed and results indicated differences largely depending on area characteristics in terms of plankton and fish density. Generally, in most cases no large deviations between day-time and night-time estimations were observed especially when night-time data were analyzed at -70 dB threshold. In two out of three study regions, in the Strait of Sicily and the western Adriatic Sea higher NASC values were estimated on average during night-time compared to day-time, although these differences were not always found significant. Going further within the framework of this sub task an attempt to anticipate the error in acoustic estimates between day-time and night-time was made.
- For sub - Task 3.3 and day – night biological sampling data from past surveys as well as targeted minisurveys were analyzed and results indicated that fishing during night seems to be more random (less selective), less biased and more representative of the local populations at sea recognizing the fact that day-time sampling is essential and practically obligatory in

- Concerning Task 3.4 and the fields of a common database related to acoustics: existing databases from partners were revised, required fields and useful estimations necessary to facilitate DCF data requirements and abundance assessments were identified. Moreover, fields and input data associated to acoustic surveys but connecting their output to the ecosystem approach to fisheries were defined.

The analytical results of all Tasks are analytically presented in this final report. This report along with all meetings/workshops presentations can be found in AcousMed wiki page http://acousmed.wikispaces.com/.

3 Optimization of Survey design (Task 2)

(Involved participants: IFREMER, HCMR, IEO, CNR-ISMAR, CNR-IAMC)

Background/State of the art

Acoustic survey design is an important issue strongly related to the accuracy of the acoustic estimates (i.e. minimization of the variance, Petitgas, 2001; Rivoirard *et al.*, 2000) as well as the surveyed area characteristics (e.g. size of the area, topography, days at sea and research vessel availability). Existing survey designs include pre-planned, non-random sampling with parallel or triangular scheme and different inter transect distance per area. Within the framework of the present study a revision of existing survey designs will be made along with an estimation of the precision of each survey. The latter requires a model of spatial covariance (model-based variance) and the associated application of spatial modeling and geostatistical analysis (Petitgas, 2001; Rivoirard *et al.*, 2000; Giannoulaki *et al.*, 2006). Geostatistics provides a method for estimating the variance conditional on the sample locations, providing an ideal method for determining the relationship between the survey design, the location of the samples and the precision of the estimate (Rivoirard *et al.*, 2000). Geostatistics links the sample locations with the underlying population spatial correlation structure to compute the precision of the mean estimate (Matheron, 1971). Therefore geostatistics can be used whatever the survey design. In the fisheries context, geostatistics has been useful to evaluate / discuss survey design (Rivoirard *et al.*, 2000). How to design a homogeneous survey over an area can be thought of in geometrical terms. In particular for acoustic surveys of pelagic schooling fish a major question is how to calibrate the inter-transect distance to patches of high values. This can be answered by taking indicators of high values and characterizing their average patch dimension; or we can consider the underlying spatial correlation structure, which applies to all ranges of values. The inter-transect distance should be close to patch dimension or the correlation range for regularly spaced transects to encounter enough patches. For the examination of the appropriateness of existing survey design, we considered homogeneous survey designs (not adaptive sampling) and applied linear geostatistics (intrinsic case: Matheron, 1971). In this approach, the structural tool is the variogram. The variogram measures how on average in the area the variance between pairs of points increases with increasing vector distance between them. We considered evaluating survey precision using the precision of the mean survey estimate.

3.1 Review of survey design (SubTask 2.1)

Objectives

The objective of this sub task was the summarization of the existing survey design of each study area, an estimation of each survey precision along with the peculiarities of each area (e.g. size of the area, topography, required working time and research vessel availability). A review presenting the existing information on the spatial characteristics of small pelagic fish aggregations in the surveyed areas was also planned within this task.

In order to fulfill these objectives the survey characteristics (e.g. area covered, target species, acoustic methodology applied, existing survey design etc) of each Case Study are presented in a summary table followed by a respective map of the Mediterranean, indicating the existing survey design. A review presenting the existing information on the spatial characteristics of small pelagic fish aggregations in the surveyed areas will be presented in the final report based on the geostatistical analysis results that will be completed in Task 2.2.

Table 3.1.1. Summary table of studied areas in the Mediterranean Sea.

Survey Identity	**Greece - Aegean Sea**	**Italy - Adriatic Sea**	**Italy – Strait of Sicily**	**France - Gulf of Lions**	**Spain - Iberian Coast**
Geographic area	northern Aegean Sea	Western side (Italy)	Strait of Sicily	Gulf of Lions	Spanish Mediterranean Sea (continental shelf)
Size of Area covered (NM^2)	9 000 nm^2	About 15 000 nm^2	2 680 nm^2	3 300 nm^2	6 922 nm^2
Days at sea	40	41	10	26	31
Period of survey	June-July	July - September	July	July	November-December
Echo sounder	Biosonic DTX (Split beam)	Simrad EK60 (Split beam)	Simrad EK60 (Split beam)	Simrad ER60 since 2006 (Split beam)	Simrad EK60 (Split beam) since 2006
Threshold for assessment (dB)	-70	-70	-60	-60	-60
Survey design					
Transects design	Perpendicular to bathymetry, zigzag inside the gulfs	Parallel grid, perpendicular to the coastline/bathymetry	Parallel transects and perpendicular to bathymetry	Perpendicular to the coastline/bathymetry	Perpendicular to the coast
Inter-transect distance (nm)	10 nm	10 nm and 8 nm in narrow shelf areas	4-8 nm	12 nm	8 nm in wide continental shelf, 4 nm in narrow shelf
Time of day for acoustic sampling	Day-time	Day-time & night-time	Day-time & night-time	Day-time	Day-time
EDSU (nm)	1 nm	1 nm	1 nm	1 nm	1 nm
Min Bottom depth sampled(m)	10 m	10 m	10 m	10 m	30 m
Echo sounding depth (m) recording.	230	250	300	200	200-220
Vessel speed	7 kn	9-10 kn	9-10 kn	8 kn	10 kn
Abundance indices estimated	ν Total fish NASC per EDSU ν Anchovy,	Total pelagic biomass and biomass per species per area	ν Total fish NASC per EDSU Anchovy,	Pelagic biomass and biomass per species, Biomass per nautical mile	ν Total fish NASC per EDSU

Survey Identity	Greece - Aegean Sea	Italy - Adriatic Sea	Italy – Strait of Sicily	France - Gulf of Lions	Spain - Iberian Coast
	Sardine NASC per EDSU		Sardine NASC per EDSU		ν Anchovy, Sardine NASC per EDSU
Target species	Anchovy and Sardine	Anchovy, sardine	Anchovy and Sardine	Anchovy and Sardine	Sardine, anchovy
Other species	Horse mackerel Mackerel Gilt sardine	Sprat, atl. Mackerel, horse mackerel, chub mackerel, bogue, gilt sardine, pickerel	Mackerel, Sardinella, Horse mackerel	All pelagics	*Trachurus mediterraneus*, bogue, sardinella, *Scomber colias* & *Scomber scombrus*.

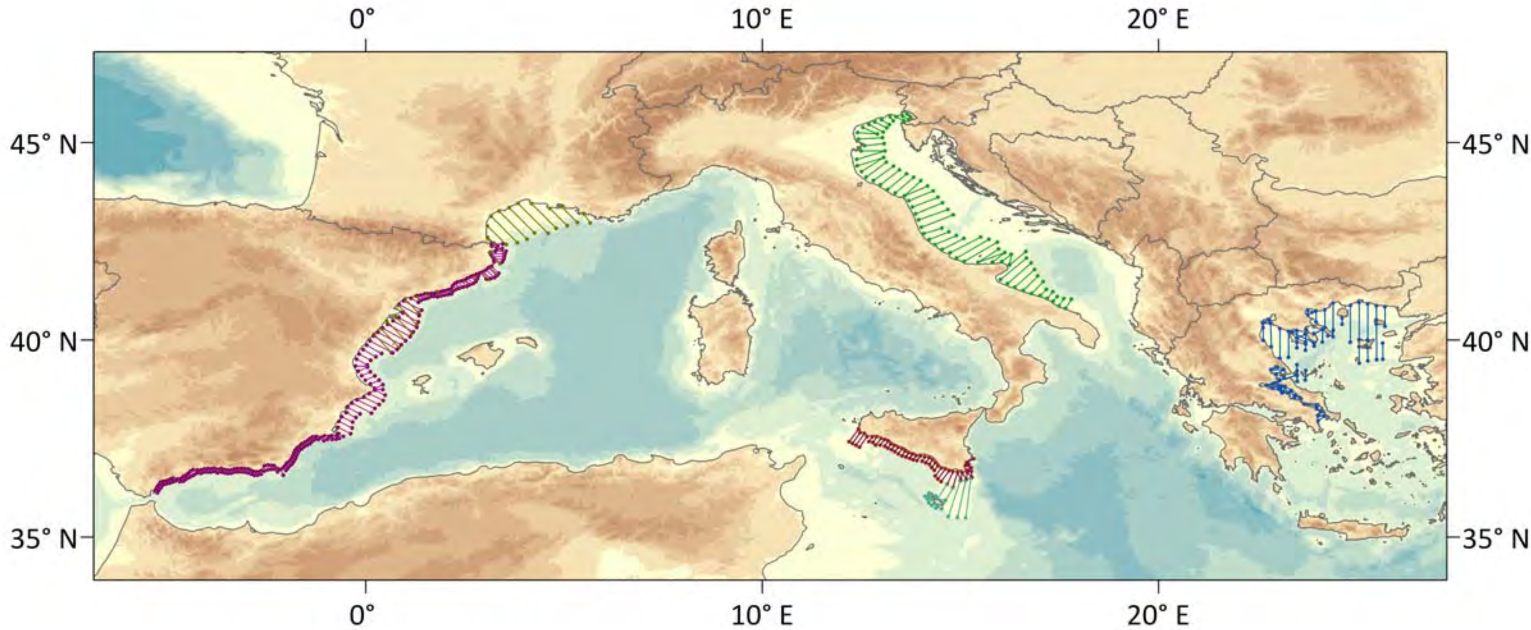


Figure 3.1.1. Survey design (acoustic transects) followed in different study areas.

3.2 Geostatistical analysis (Sub Task 2.2)

(Lead participant: IFREMER Involved participants: IFREMER, HCMR, IEO, CNR-ISMAR, CNR-IAMC)

Objectives

The aim of the sub task was to apply geostatistical analysis to past acoustic survey data from five different areas (i.e., Spanish Mediterranean waters, Gulf of Lions, western Adriatic, Strait of Sicily, Aegean Sea) in order to estimate the necessary geostatistical parameters that would facilitate the scientific advise on the optimization of the currently applied acoustic survey design. In addition, the precision of abundance estimates of each survey will be estimated. For this purpose, acoustic data from each respective area were analyzed concerning:

- small pelagic species total echo
- anchovy/and sardine echo abundance or biomass estimates depending on the historic data availability

Work achieved

According to the proposal, two workshops were held within the framework of this Task during the first year.

- The first workshop (1 day duration) took place following the kick off meeting of the project in the 31st of March 2010 in Capo Granitola hosted by CNR-IAMC. Within this workshop a revision of existing information was made, and the presentation of work that was done in the past in certain areas. Moreover, questions were raised on the applicability of different geostatistical methodologies. A common protocol for the application of geostatistical analysis was suggested and agreed under the scientific support of Dr. P. Petitgas (IFREMER). The agenda of this first workshop is sited in Annex 1.
- According to the proposed plan a second workshop (2 days duration) took place by the end of the 1st year under the scientific support of Dr P. Petitgas (IFREMER). Specifically, a joined AcousMed Project/ICES WGACEGG Workshop on Geostatistics (WKACUGEO) was held, chaired by Dr P. Petitgas (IFREMER) and Dr. M. Giannoulaki (HCMR). The joined workshop took place at Palma de Mallorca (Spain) 20-21 November 2010 hosted by IEO and Dr. Magdalena Iglesias. The workshop allowed gathering most of the European acoustic surveys on anchovy and sardine in ICES and Mediterranean waters. The objectives of the workshop were to standardize data analysis methods for the evaluation and optimization of survey design. Within the framework of this workshop,

In addition to the proposed workshops, two more workshops took place within the framework of this sub-task.

- A one day workshop took place in collaboration with the 4th annual MEDIAS (Pan Mediterranean Acoustic Survey) meeting on the 28th of March 2011 at Ancona (Italy) hosted by CNR-ISMAR. This workshop was held also under the scientific support of Dr P. Petitgas (IFREMER), it was held jointly with participants from non EU countries in the Mediterranean like Tunisia and Croatia aiming to promote collaboration among all acoustic surveys held in the Mediterranean basin and to initiate the evaluation of survey design by means of indicator variography. Details for this workshop report can be found in the 4th MEDIAS Steering Committee Meeting Report.
- A one day workshop also took place during the final AcousMed meeting that was held at Iraklion (Greece) from 13-16 December 2011. The workshop was also supported by Dr P. Petitgas (IFREMER). The aim of this workshop was the application of indicator variography to past acoustic surveys in the Mediterranean taking into account species abundance and the standardization of the work including the selection of a common threshold for all surveys.

Furthermore, for harmonization and standardization purposes a common R –script that was developed especially for the purposes of AcousMed by M. Barra (CNR-IAMC) was used along with EVA2 (Petitgas and Lafont, 1997) for the application of geostatistics. The R-script from M.Barra was based on functions of the geostatistical package RGeoS of Ecole des Mines de Paris (*Renard, Bez, Desassis and Laporte, 2010*: http://www.cg.ensmp.fr/rgeos/).

3.2.1 Methodological approach followed: Geostatistical analysis

To address the objectives of this subtask, the work was organized in the four workshops as explained below:

Standard linear geostatistics were used to characterize the underlying spatial autocorrelation in the data and compute the estimation variance of the mean estimate over the survey area. Briefs on acoustic survey errors and geostatistics methods were presented and a list of basic geostatistics references was provided during each meeting. Also, prior to the meeting a tutorial was provided to WK participants with software and R scripts and an example case study together with guide lines for preparing the data case study files. A common format was agreed for presenting case study key information relevant for the analyses.

Subsequently, a twofold approach was followed concerning the application of geostatistical analysis.

Firstly, in order to analyze the spatial structure of the target species in the study areas, we applied variogram modeling on raw data. In each study area the type of applied variogram was adapted to the peculiarities of the local populations.

In a second step, enhanced spatial analysis was applied. Additionally to variogram modeling, we used the indicator function. Indicator functions are formed using the following scheme:

$$\begin{aligned} i(x) &= 1 \quad Z(x) >= T \\ &= 0 \quad Z(x) < T) \end{aligned} \tag{1}$$

where T is a threshold value chosen arbitrarily and Z is the original random function. An indicator variogram is simply a variogram computed using i rather than Z. Thus, we worked on transformed data, selecting an appropriate threshold to modify data into binary and apply indicator variograms. Depending on the threshold an indicator variogram can be less sensitive to skewed distributions. The objectives of this approach were to standardize data analysis methods among the different areas for the evaluation and optimization of survey design, and in particular answer how the current survey design is adapted to the spatial distribution of the patches of high or medium values. This makes the analysis of survey design a geometric one, estimating the probability to encounter patches of high values representing a given percentage of total biomass.

3.2.1.1 Raw data variography

Materials and Methods

Software and data files

Prior to the meeting, documentation on geostatistics was posted on SharePoint with a reference list (Annex 4). A software and an R script were posted on SharePoint with an example case study for the participants to get acquainted prior to the meeting with the technicalities of geostatistical computations that allowed to address the ToRs. The R script was designed to serve as tutorial for the analyses to be carried out during the workshop. The software EVA (Petitgas and Lafont, 1997) allows estimating the variogram from survey data, model it and compute the estimation variance for a variety of designs, including regular designs (approximation formulae), zigzag transects, scattered individual sampling points.

The softwares used were EVA (Petitgas and Lafont, 1997) and the R script used the R library RGeoS (Renard *et al.*, 2010).

Data files were prepared prior to the meeting following the instructions below.

Data file: text format with separators '\t' or ';' (the decimal symbol is '.')

Col.1=year or survey code

Col.2=longitude (decimal degrees)

Col.3=latitude (decimal degrees)

Col.4=variable to be analyzed (s_A value or biomass of target species)

Col.5,…n = any other variable (for another species or environment)

Polygon file: text format with separators '\t' or ';' (the decimal symbol is '.')

Col.1=longitude (decimal degrees)

Col.2=latitude (decimal degrees)

Columns contain the coordinates along long and lat of the polygon vertices. The polygon is closed : first and last lines are the same.

Polygon for selecting the data to be analyzed may differ from that for mapping.

Grid file: text format with separators '\t' or ';' (the decimal symbol is '.')

Line.1 : x0,y0 : coordinates (decimal degrees) of the lower left corner

Line.2 : dx,dy : mesh size (decimal degrees) along x and y

Line.3 : nx, ny : number of grid cells along x and y

The file contains 2 columns and 3 lines.

Survey design file: EVA2 format. See section 4.3.1 in document ICES CM 1997/Y:21. An empty formatted file can be created using EVA2 (file/create Eva data file).

Line.1 : comments or nothing

Line.2 : comments or nothing

Line.3 : header

Line.4,…n : data

In the EVA2 format, you only need to fill Cols.1,2 (x,y : 2D analysis for regular parallel transects) or Col.4 (lg tr. : 1D analysis for regular parallel transects : transect lengths) or Cols.15,16 (rtex,rtey : zigzag survey) depending on which case you are in. Also you may fill Cols. 5-6, …, 13-14 (px1 py1, … px5, py5 : closed polygon vertices) if you are considering polygons. If problems with EVA in selecting survey points inside polygon, add a dummy variable in Col.3.

This survey design file (data locations only) will serve to estimate the precision of the survey mean estimate, given a variogram model. Different survey designs (i.e., files) can be constructed and their precision compared.

Transformation of coordinates: In order to compute distances longitude need be transformed so that the same unit along x and y correspond to the same distance. A simple projection is to multiply the longitudes by the cosine of the survey area mid-latitude.

Variables, survey design and time series of surveys

Geostatistical analysis was applied to all case studies, which encompassed a diversity of situations. In each case study i.e. Spanish Mediterranean waters, Gulf of Lions, western part of the Adriatic Sea, Strait of Sicily and the North Aegean Sea, data concerning at least one species for one year were analyzed. If different years were considered, an average variogram can be used. The target variable to analyze was left at the appreciation of each case study leader. The precision of the global mean estimate for that variable was estimated to characterize survey precision.

For the North Aegean Sea and the Strait of Sicily case studies, the target variable analyzed was the NASC attributed to a species (anchovy or sardine) per EDSU (elementary sampling unit) along the acoustic transect lines. The survey precision for that variable then highlights the ability of the survey to effectively estimate the mean NASC of the species. The data values in this case are likely to contain other sources of error in addition to spatial error like the additional error of echogram scrutiny. If the total fish NASC is split into species based on acoustic proportions of species as observed in the trawl hauls (Simmonds and MacLennan, 2005, chap. 9) the additional error will be a mix of errors on the species TS, spatial distribution of species and mean length of species. In the case of the Adriatic survey, we used the total fish NASC value that was not partitioned into species. The survey design was then tested for its ability to sample echo traces irrespective of species. In other case studies species abundance was used. The abundance variable incorporated all survey errors in addition to spatial variability. In the Gulf of Lions case study (Pelmed surveys) and in the Strait of Sicily (2005 and 2006) the abundance was expressed in tons per nm^2, while in the Catalan sea case study (Ecomed surveys) it was expressed in numbers of individual fish.

In certain cases the total survey area has been divided into sub-areas and the geostatistical analysis was performed by sub-area. The survey design in each sub-area was adapted to the complexity of the geographical setting (coast line orientation, islands, bays, shelf width) by modifying the orientation of transects or using zigzag transects. In case studies where the shelf width was small, the design was either zigzag or parallel transects. In the Adriatic Sea, both parallel and zigzag designs had been performed and were compared. In the North Evoikos gulf, the survey design was a combination between zigzag and parallel transects. In the strait of Sicily case study, the part of the survey analyzed was the one where parallel transects were held. In the Catalan Sea, the shelf width is small. The inference of the spatial structure along transects with an EDSU length of 1 nm is therefore uneasy. In that case, the data were summed along each transect and a 1d-geostatistical analysis performed on transect sums. This approach was compared to the 2d one. In all case studies the EDSU was fixed, being 1 nm.

Because surveys are undertaken yearly, each case study contained a time series of surveys. In most case studies, the analysis was performed year by year. A small number of years were selected in each case study. The selection criterion was either that the year was a typical situation or it presented low or high abundance. In addition, in the North Aegean Sea case study, the average per year variogram was computed over the entire series of surveys.

Structural tools and methods used

In most case studies, the variogram was estimated on the raw NASC values using the classical estimator, which is the average square difference between pairs of values at vector distance h apart. In some situations though, this estimator is unable to extract the structure in the data, due to the high differences between pairs of values at short distance. In that case, log transforming the data was helpful (e.g. Ecomed). In certain cases like the Strait of Sicily case study, the largest values were omitted when computing the variogram to extract the underlying structure. In the North Aegean Sea case study, the variograms showed high nugget value and short autocorrelation range. Therefore, in order to obtain a better visualization of the geometry and the size of fish patches along transect, we applied omnidirectional indicator variograms at different percentiles (25%, 50% and 75%) of the data. In this case, the survey was tested for its ability to encounter particular patches and estimate the occurrence probability of these patches. In all cases except one, we considered the 2d-data with coordinates in latitude and longitude. In the Ecomed case study though, acoustic transects were very short in length and contained a few high values thus the approach used was to sum the values along transects and perform the estimation in 1d on the transect sums with the 1d-transitive method. In this approach, the structural tool was not the variogram but the transitive covariogram. Results were similar using a 2d or a 1d-transitive approach (Petitgas, 1993; Tugores *et al.*, 2010).

Evaluation of the precision of abundance estimates using geostatistics

In each case study, for the variable and year chosen, the variogram was estimated and modeled. The precision of estimating the mean over the survey area applying the data arithmetic mean was computed for the survey design currently in use. Results are summarized in Table 3.2.1. The different approaches allowed dealing with particular data characteristics and inferring the underlying spatial structure from the data. In all cases the inter-transect distance was of the same order of magnitude than the correlation range of the underlying distribution. The survey precision as characterized by the coefficient of variation of the mean estimate (CVgeo) lied between 0.05 and 0.27 across all case studies and was thus satisfactory. In the North Aegean study, the indicator variable chosen represented the positive area of the fish spatial distribution. It can therefore be concluded that these surveys estimated the area of fish presence with high precision.

It should be noted that spatial variation and time variability during the survey were confounded in the data and analysis performed. In particular, the across-transect spatial structure may not always be accessible due to time variability during the survey (ICES, 1997; Rivoirard *et al.*, 2000). It was unclear how time variability could have affected the inference of the correlation range.

Results per case study are compiled below. The contribution of the nugget (pure random spatial component) to the survey precision increased with increasing sampling effort as the structural component gets more and more resolved by the survey spatial coverage. Survey precision was often not a linear function of inter-transect distance. Therefore, decreasing survey effort had a large negative impact on survey precision, while increasing it had a moderate positive impact.

Table 3.2.1. Summary table documenting for each case study: the variable used, its spatial correlation structure, the survey design and the precision of the mean estimate.

Survey series	Area	Survey design	Variable analyzed	Correlation Range 1	Correlation Range 2	Ratio nugget/sill	Inter-transect distance	CV geo	Method used
ECOMED	Catalan Sea (autumn)	Parallel transects	Nb.Fish Transect sums Anchovy 2003	88 nm	120 nm	0.09	8 nm	0.12	EVA software plan A 1D-transitive
			Nb.Fish Transect sums Anchovy 2004	72 nm	120 nm	0.01	8 nm	0.07	EVA software plan A 1D-transitive
PELMED	Gulf of Lions (summer)	Parallel transects	Biomass Anchovy 2003 (tons/nm^2)	10 nm		0.29	12 nm	0.12	EVA software plan A 2D-intrinsic
			Biomass Sardine 2003 (tons/nm^2)	10 nm		0.57	12 nm	0.19	EVA software plan A 2D-intrinsic

Table 3.2.1 (continued)

Survey series	Area	Survey design	Variable analyzed	Correlation Range 1	Correlation Range 2	Ratio nugget/sill	Inter-transect distance	CV geo	Method used
Strait of Sicily	Sicily South Western coast (summer)	Parallel transects	NASC Anchovy 2002	35 nm		0.40	5 nm	0.09	EVA software plan A 2D-intrinsic
	Sicily South Western coast (summer)		NASC Anchovy 2003	17 nm		0.94	5 nm	0.13	
	Sicily South Western coast (summer)		NASC Anchovy 2004	16 nm		0.72	5 nm	0.11	
	Sicily South Western coast (summer)		(tons/nm^2)Anchovy 2005	8 nm		0.84	5 nm	0.27	
	Sicily South Western coast (summer)		(tons/nm^2)Anchovy 2006	8 nm		0.95	5 nm	0.14	
	Sicily South Western coast (summer)		NASC Sardine 2002	35 nm		0.16	5 nm	0.064	
	Sicily South Western coast (summer)		NASC Sardine 2003	32 nm		0.27	5 nm	0.02	
	Sicily South Western coast		NASC Sardine 2004	38 nm		0.74	5 nm	0.16	

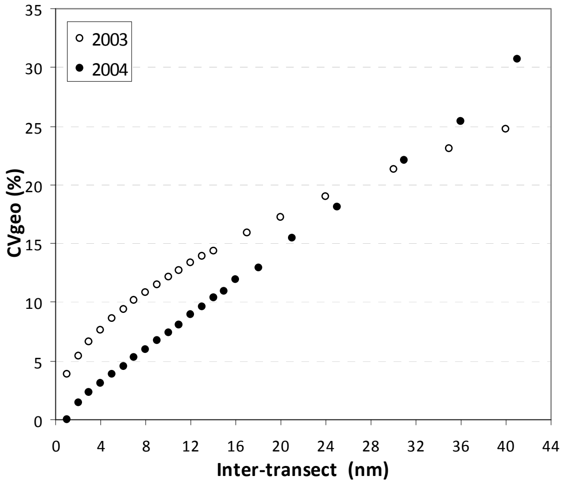
Survey series	Area	Survey design	Variable analyzed	Correlation Range 1	Correlation Range 2	Ratio nugget/sill	Inter-transect distance	CV geo	Method used
	(summer)								
	Sicily South Western coast (summer)		(tons/nm^2)Sardine 2005	8 nm		0.94	5 nm	0.18	
	Sicily South Western coast (summer)		(tons/nm^2) Sardine 2006	13 nm		0.82	5 nm	0.16	
Adriatic Sea	Italian part of Adriatic Sea (summer)	Zigzag transects	NASC Total fish 2005	18 nm		0.31	10 nm	0.05	EVA software plan D 2D-intrinsic
North Aegean Sea	Thermaïkos gulf (summer)	Parallel transects	NASC Anchovy Indicator of 0.25 percentile	9.5 nm (multiyear variogram)		0.68 (multiyear variogram)	10 nm	0.01	EVA software plan A 2D-intrinsic
	Thracian Sea (summer)	Parallel transects	NASC Anchovy Indicator of 0.25 percentile	10 nm (multiyear variogram)		0.68 (multiyear variogram)	10 nm	0.01	EVA software plan A 2D-intrinsic
	North Evoïkos gulf (summer)	Zigzag + parallel transects	NASC Anchovy Indicator of 0.25 percentile	14 nm (multiyear variogram		0.15 (multiyear variogram)	Zigzag + parallel transects	0.01	EVA software plan D

Survey series	Area	Survey design	Variable analyzed	Correlation Range 1	Correlation Range 2	Ratio nugget/sill	Inter-transect distance	CV geo	Method used
									2D-intrinsic

Summary graphs per case study

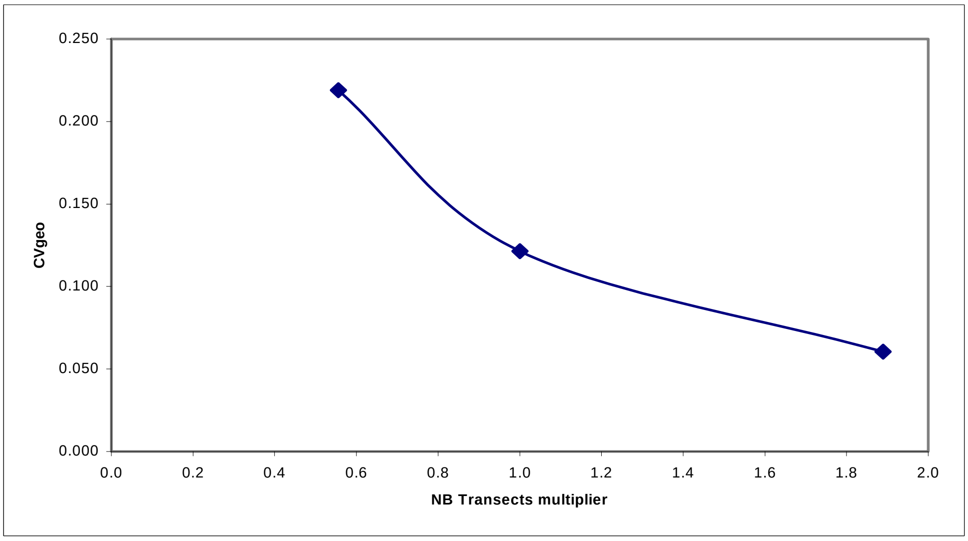
ECOMED surveys, Catalan Sea

Current design: Parallel transects regularly spaced. Inter-transect = 4 nm
Design tested: Inter-transect from 1 to 40 nm
Variable: anchovy, 2003, 2004, transect sums of number of fish
CVgeo as a function of designs tested:



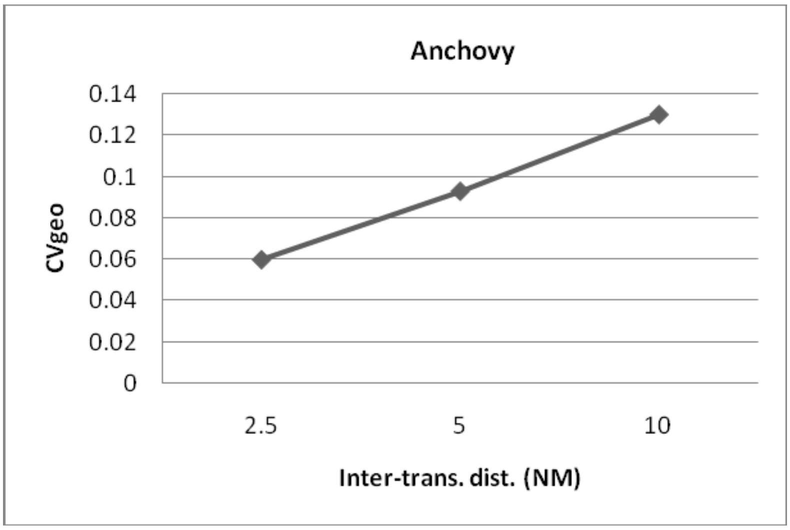
PELMED surveys, Gulf of Lions

Current design: Parallel transects regularly spaced. Inter-transect = 12 nm
Design tested: doubling / halving the number of transects and Inter-transect distance
Variable: anchovy biomass (tons/nm^2), 2003
CVgeo as a function of designs tested:

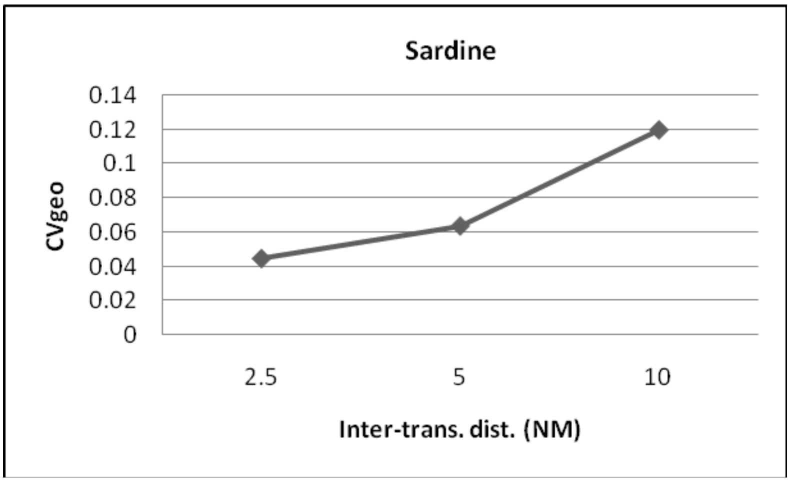


Strait of Sicily

Current design: Parallel transects regularly spaced. Inter-transect = 5 nm
Designs tested: doubling / halving the number of transect and Inter-transect distance
Variable: NASC anchovy, 2002
CVgeo as a function of designs tested:



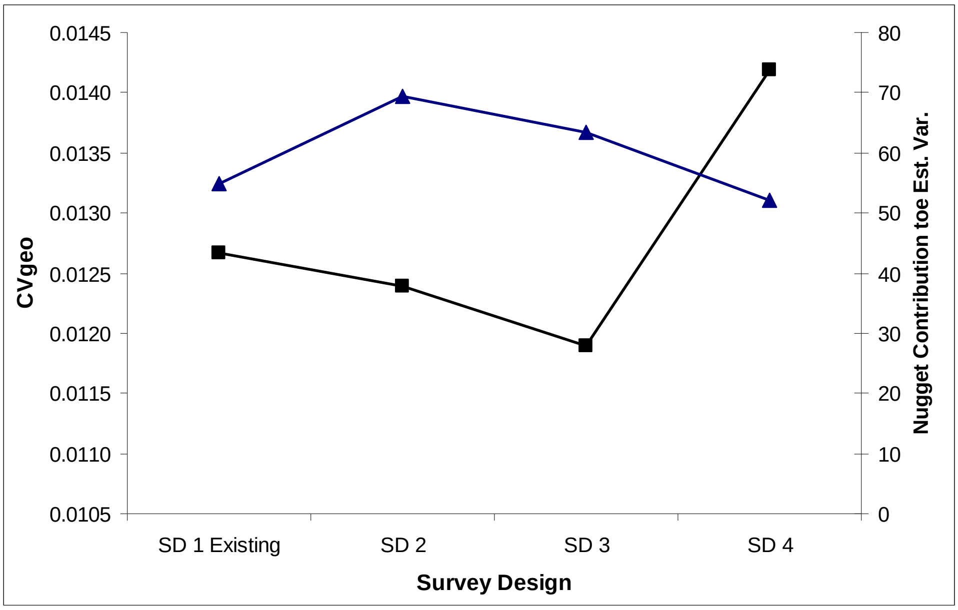
Current design: Parallel transects regularly spaced. inter-transect = 5 nm
Designs tested: doubling / halving the number of transects and inter-transect distance
Variable: NASC sardine, 2002
CVgeo as a function of designs tested:



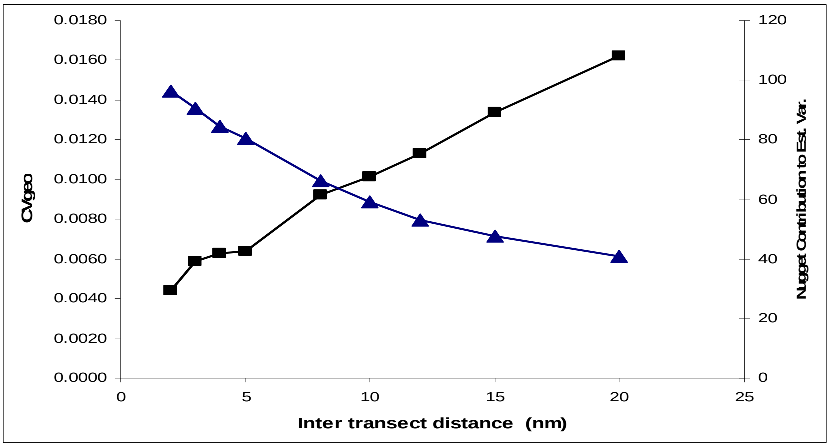
WESTERN ADRIATIC SEA

Design of reference (2005) : zigzag transects
Designs tested (2008): Parallel transects regularly spaced. Inter-transect distance = 10 nm
Variable: NASC total fish
CVgeo as a function of designs tested:
CVgeo (zigzag)= 0.048
CVgeo (parallel)= 0.036

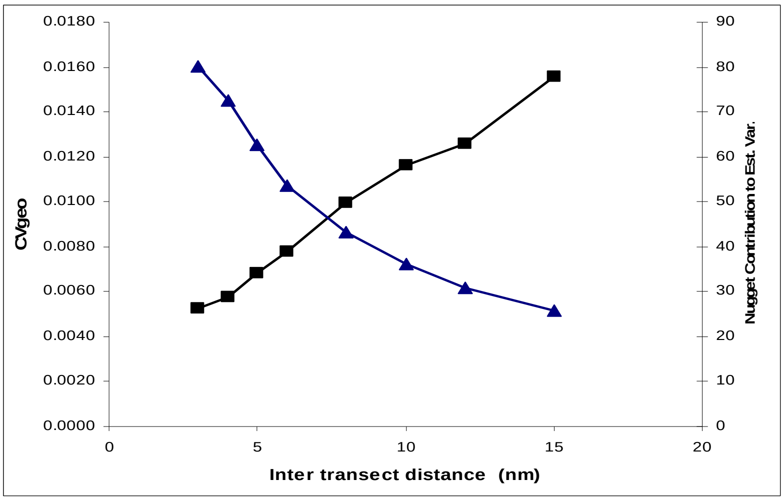
NORTH EVOIKOS GULF (NORTH AEGEAN SEA)
Current design: SD1, zigzag and parallel transects mixed
Designs tested: various combinations of zigzag and parallel transects to accommodate coastline: SD 2, 3 and 4
Variable: NASC anchovy, indicator of 0.25 percentile
CVgeo as a function of designs tested:
CVgeo(SD1)=0.0126; CVgeo(SD2)=0.0124; CVgeo(SD3)=0.0119; CVgeo(SD4)=0.0142;



THERMAIKOS GULF (NORTH AEGEAN SEA)
Current design: Parallel transects regularly spaced. Inter-transect = 10 nm
Designs tested: number of transect and inter-transect distance varied from 2 to 20 nm
Variable: NASC anchovy, indicator of 0.25 percentile
CVgeo as a function of designs tested: (black squares: CVgeo; blue triangles: nugget contribution (%))



THRACIAN SEA (NORTH AEGEAN SEA).
Current design: Parallel transects regularly spaced. inter-transect = 10 nm
Designs tested: number of transect and inter-transect distance varied from 3 to 15 nm
Variable: NASC anchovy, indicator of 0.25 percentile
CVgeo as a function of designs tested: (black squares: CVgeo; bleu triangles: nugget contribution (%))



0.0180
0.0160
0.0140
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
CVgeo
90
80
70
60
50
40
30
20
10
0
Nugget Contribution to Est. Var.
0
5
10
15
20
Inter transect distance (nm)

3.2.1.2 Transformed data: Indicator variograms

Material and Methods

The objectives of this approach were to standardize data analysis methods among the different areas for the evaluation and optimization of survey design and answer how the current survey design is adapted to the spatial distribution of the patches of high or medium values. To fulfill these objectives, we estimated the spatial error of a survey when estimating the area (geometry of patches) containing values larger than a given threshold. This would make the analysis of survey design a geometric one, estimating the probability to encounter patches of high values representing a given percentage of total biomass. To serve this purpose, indicator variograms were applied where variables are binary or represent classes of values.

Software and data files

The framework of linear geostatistics and indicator variograms was considered as flexible and robust enough to allow analysis of all case studies, extract the underlying spatial correlation structure, estimate survey precision for the current survey design and evaluate other designs. A common protocol was proposed that is described below in order to standardize the analysis of data.

Files were prepared according to a common format presented below:

Data : text format with separators '\t' or ';' (the decimal symbol is '.')
Col.1=year or survey code
Col.2=longitude (decimal degrees)
Col.3=latitude (decimal degrees)
Col.4=variable to be analyzed (s_A value or biomass of target species)
Col.5,…n = any other variable (for another species or environment)

Polygon : text format with separators '\t' or ';' (the decimal symbol is '.')
Col.1=longitude (decimal degrees)
Col.2=latitude (decimal degrees)
Columns contain the coordinates along long and lat of the polygon vertices. The polygon is closed : first and last lines are the same.
Polygon for selecting the data to be analyzed may differ from that for mapping.

Survey design : EVA2 format. See section 4.3.1 in document ICES CM 1997/Y:21 (eva2_doc.zip). An empty formatted file can be created using EVA2 (file/create Eva data file).
Line.1 : comments or nothing
Line.2 : comments or nothing
Line.3 : header
Line.4,…n : data

In the EVA format, you only need to fill Cols.1,2 (x,y : 2D analysis for regular parallel transects) or Col.4 (lg tr. : 1D analysis for regular parallel transects : transect lengths) or Cols.15,16 (rtex,rtey : zigzag survey) depending on which case you are in. Also you may fill Cols. 5-6, …, 13-14 (px1 py1, … px5, py5 : closed polygon vertices) if you are considering polygons. If problems with EVA in selecting survey points inside polygon, add a dummy variable in Col.3.

This survey design file (data locations only) will serve to estimate the precision of the survey mean estimate, given a variogram model. Different survey designs (i.e., files) can be constructed and their precision compared. The file eva_survey_1.txt is one of such files.
The file ‘eva_survey_data.txt’ is a test data file in eva. The file ‘eva_survey_1.txt’ is a file for an alternative survey design to be tested with EVA2.

Common software was used for analysis. Specifically, RGeoS library of R statistical language was used for this purpose and a common script called “geostatfun” written by Marco Barra (CNR-IAMC) for the purposes of AcousMed was used to calculate indicator variograms. The precision of the estimate of the area of patches and comparison of the precision for different survey designs were estimated both by EVA2 (Petitgas and Lafont, 1997) as well as by “geostatfun” R-script.

Data analysis

For each case study, 3 years of data presenting minimum, maximum and average abundance were analyzed in order to examine the precision of different survey designs at different levels of abundance. In each case study, target variables were: Anchovy and Sardine NASC values. Seven case studies were analyzed for the purposes of the current project: Thracian Sea (North Aegean Sea, Eastern Mediterranean), Thermaikos Gulf (North Aegean Sea, Eastern Mediterranean), Western part of the Adriatic Sea (Central Mediterranean), Sicily Strait (Central Mediterranean), the Gulf of Lions (Western Mediterranean), the northern subarea of the Spanish Mediterranean waters (Western Mediterranean) and the southern subarea of the Spanish Mediterranean waters (Western Mediterranean).

For the selection of the threshold, the percentage of biomass/echo abundance was plotted as a function of threshold: curve P(z); and the threshold z was chosen depending on the percent biomass carried by the values above the threshold:

```
o2<-order(Z,decreasing=T); Z2<-Z[o2]; P<-cunsum(Z2)/sum(Z)
```
(2)

In order to further standardize the approach followed to specify a common threshold, geostatistical aggregation curves were used. These curves relate to the spatial selectivity index and the spreading index. The curve QT of Matheron (1981) (geostatistical ‘‘selectivity’’ curve) relates the abundance Q(z) to the area T(z) occupied by densities greater than the threshold z. These curves are called geostatistical aggregation or concentration curves because Q(z) measures the maximum abundance that can be on any area T(z) in the survey area (Petitgas, 1998).

Spreading area, which quantifies the of the aggregations of high values was computed using a common R script written by Pierre Petitgas, based on spatial indices functions (Woillez *et al.*, 2009). Aggregation curves were also obtained using the same script. Based on the inspection of the aggregation curves in all case studies a common threshold that included about 80% of the total echo abundance was selected as appropriate as it corresponded to just before the curvature in the geostatistical aggregation curve

QT, representing the outer limit of patches of concentrated biomass. This threshold was applied to all case studies. Results are presented below by case study.

Spanish Mediterranean waters

Area description

Anchovy and sardine s_A (m^2/nm^2) data, obtained from stock assessment acoustic surveys in Spanish Mediterranean waters in late autumn. Three years, one of high, low and average abundance for each of the species was analyzed. Inter-transect distance varied according to the continental shelf width. It was 4 nm between Cape Cerbère and Cape Salou (Northern subarea, NS) and 8 nm between Cape Salou and Albufera de Valencia (Southern subarea, SS).

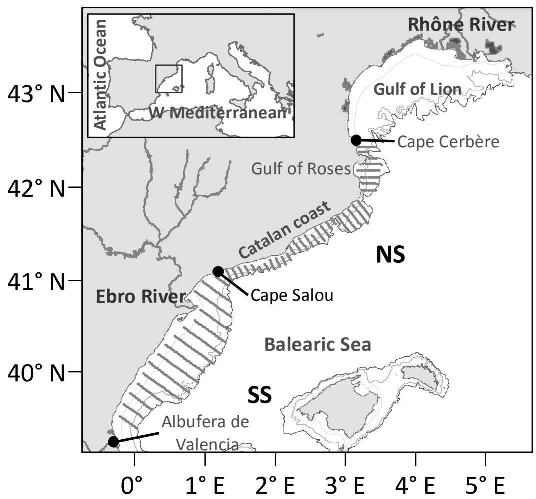


Figure 3.2.1. *Spanish Mediterranean waters:* Study area, subareas established for data analysis and sampling design. NS: Northern subarea, SS: Southern subarea.

Data Analysis

For anchovy, selected lag width was one half the inter-transect in each of the analyzed areas (2 nm in the NS, 4 nm in the SS), while for sardine it was one half the inter-transect in the SS but it was a bit bigger.

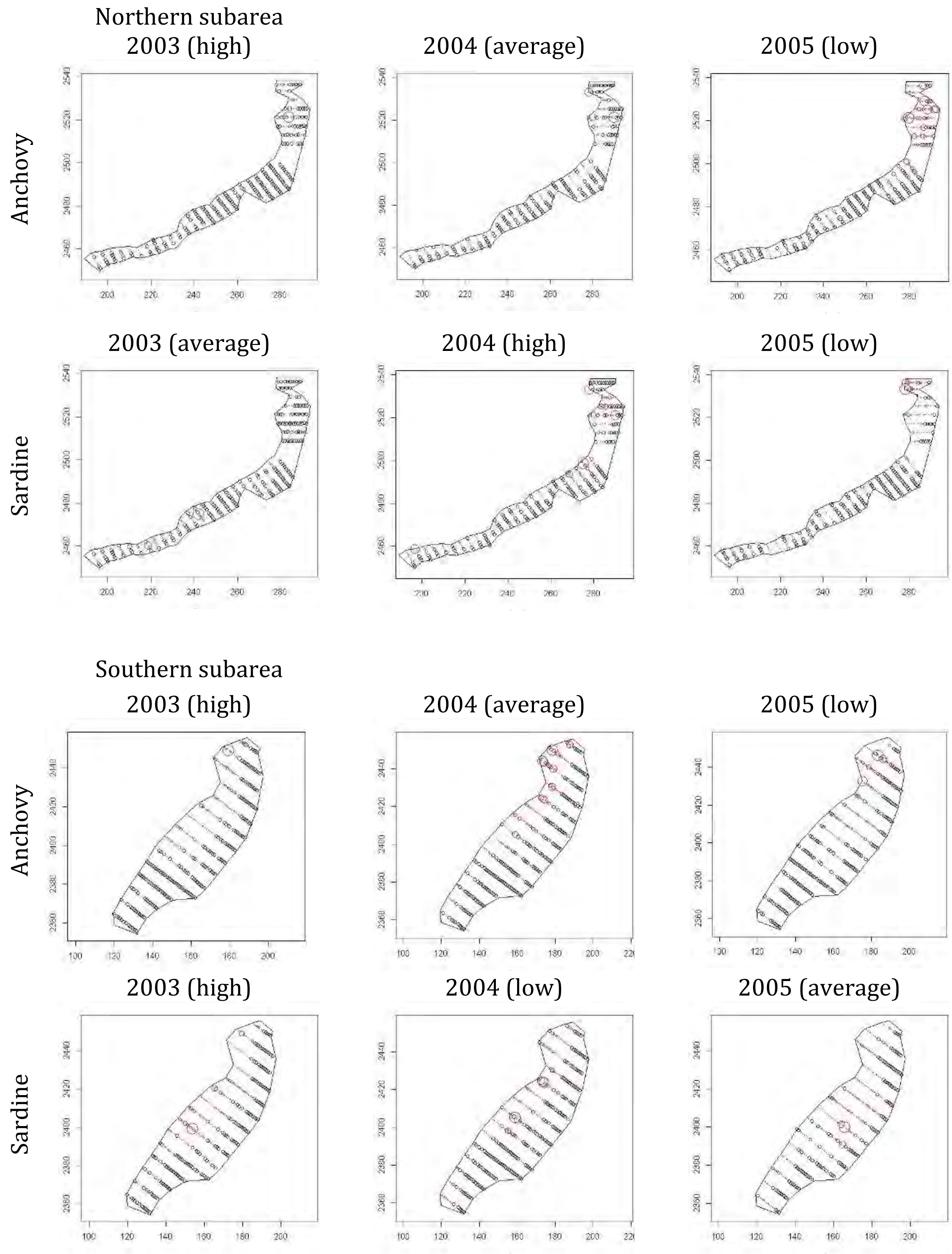


Figure 3.2.2. Distribution of anchovy and sardine a high, a low and an average abundance year in the two analyzed subareas. Distance units: nm.

Results and Discussion

A small amount of values represent a high proportion of abundance. This is more pronounced in the Northern subarea (NS) than the Southern subarea (SS) (Figure 3.2.2). A big percentage of abundance (or the really high values) occupies a really small area (Figure 3.2.4). Thus, the probability of encountering the high abundance values is quite low, especially in the Northern subarea (Table 3.2.2). No relationship seems to exist between mean sA and spreading area or between mean s_A and biomass (Table 3.2.2).

Evident spatial structure was observed for the two species in the SS showing well-structured indicator experimental variograms (Figure 3.2.5). Contrarily, in the NS the spatial structure was not so clear, experimental variograms showing great variability and no proper sill with the exception of anchovy in 2005 (Figure 3.2.5).

Spatial models fitted revealed longer ranges of correlation for sardine than for anchovy in the NS, but the reverse is observed in the SS, with anchovy displaying spatial autocorrelation at further distances compared to sardine (Table 3.2.4). The nugget explained a high percentage of the variance, always higher than 85% in the NS and higher than 75% in the SS (Tables 3.2.5 & 3.2.6). Focusing on the estimations obtained with EVA2, the geostatistically estimated coefficient of variation (CVgeo) which is indicative of the precision in the determination of the area containing the high values, was generally higher in the NS than in the SS (Tables 3.2.5 & 3.2.6); indicating that more homogeneous spatial distribution is far less homogeneous in the NS than in the SS. In the NS, the precision was higher (lower CVgeo) for sardine than for anchovy with the exception of the year with low abundance (Table 4), while in the SS the precision was quite similar for both species (Table 3.2.6).

Despite the scarcity of anchovy and sardine and their spatial distribution, the results obtained with EVA2 referring to the CVgeo, suggest that the sampling design is fairly well adapted to the determination of the area of the high values in the NS. However, semivariograms obtained did not really display a good shape, thus the spatial analysis derived may not to be highly trustful. In the SS, the semivariograms show more clear shapes, with lower CVgeo, indicating that the sampling design is better adapted to the population of anchovy and sardine in this subarea.

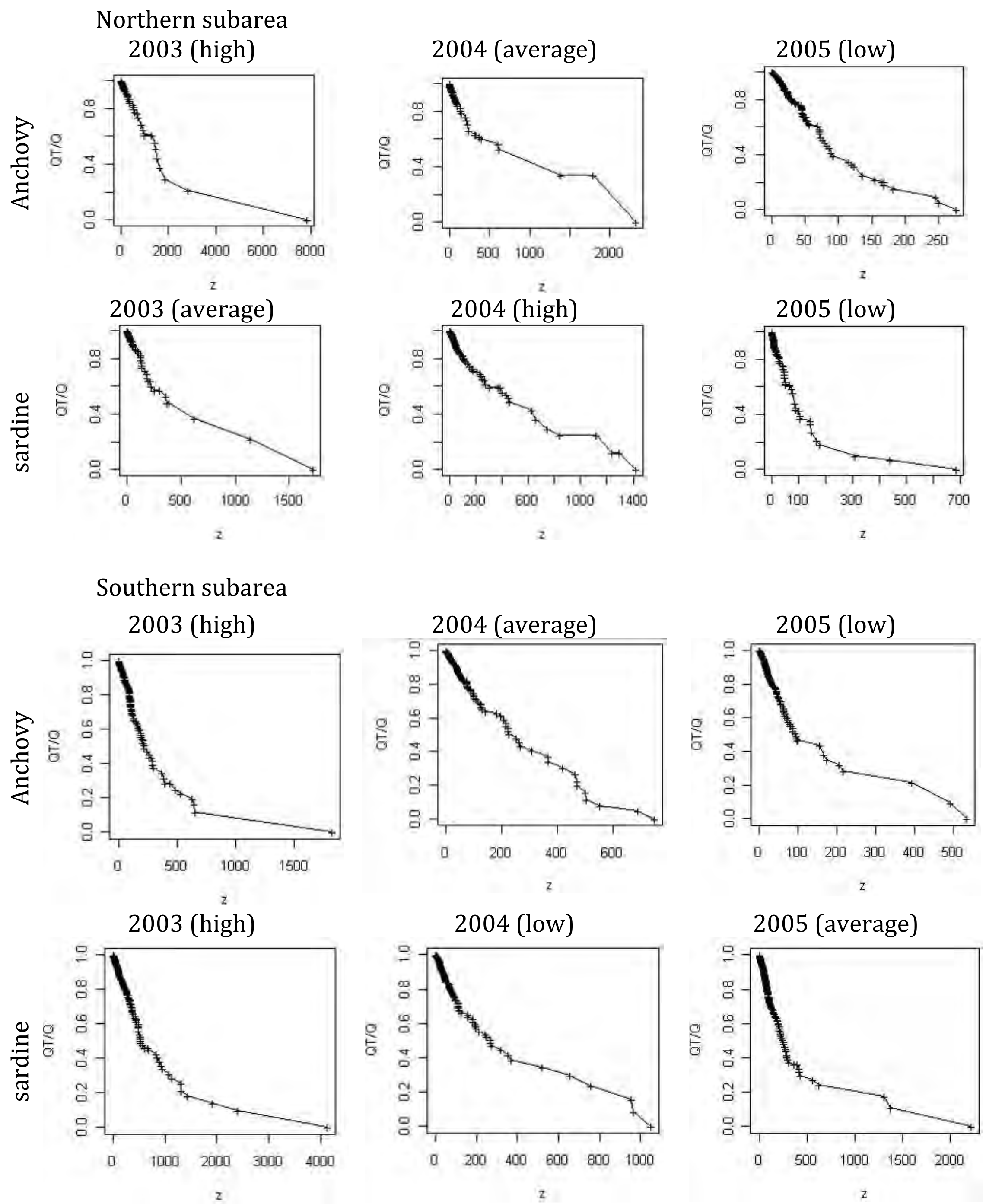


Figure 3.2.3. *Spanish Mediterranean waters:* Anchovy and sardine proportion of acoustic abundance related to abundance value.

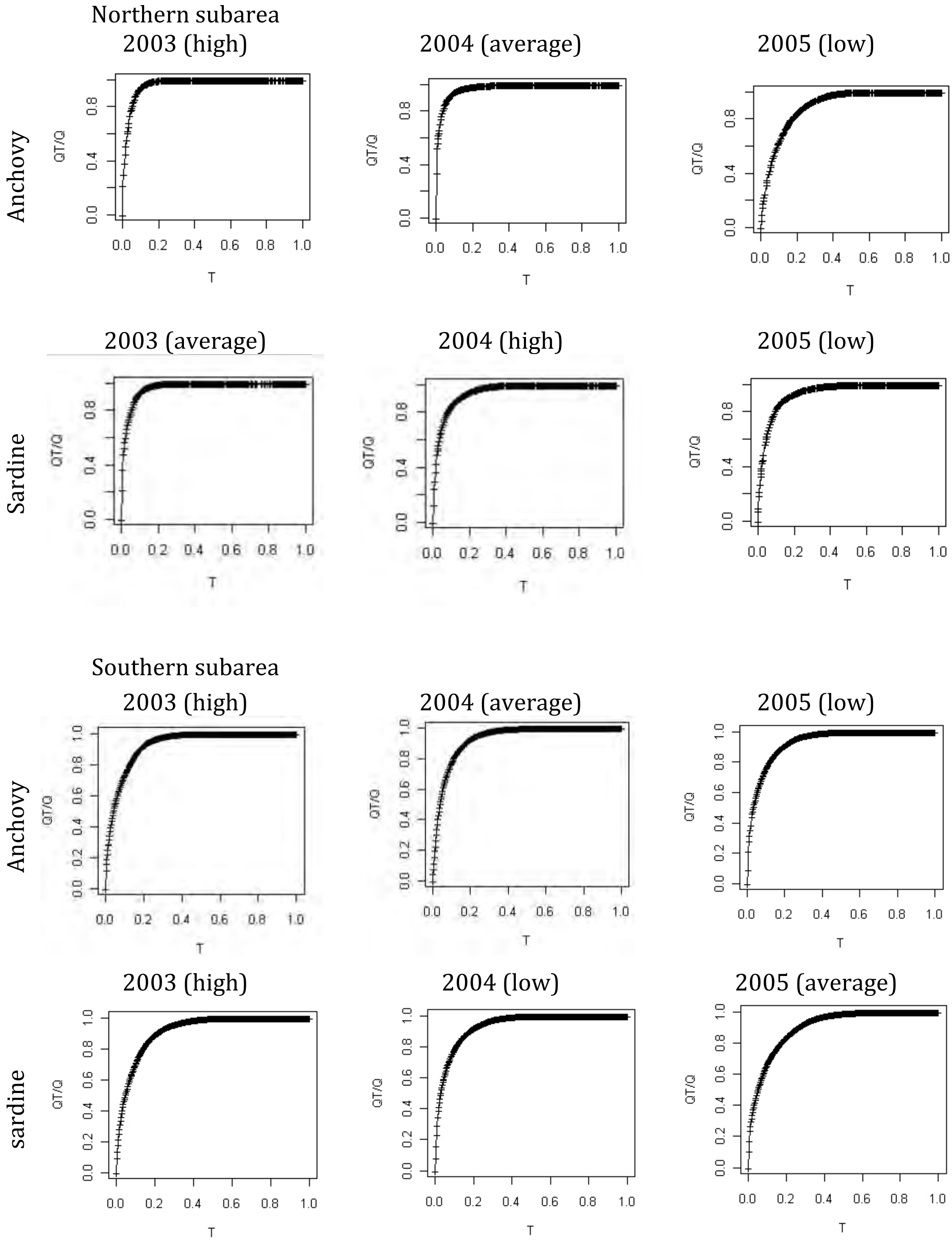


Figure 3.2.4. *Spanish Mediterranean waters:* Anchovy and sardine proportion of acoustic abundance related to percent area occupied.

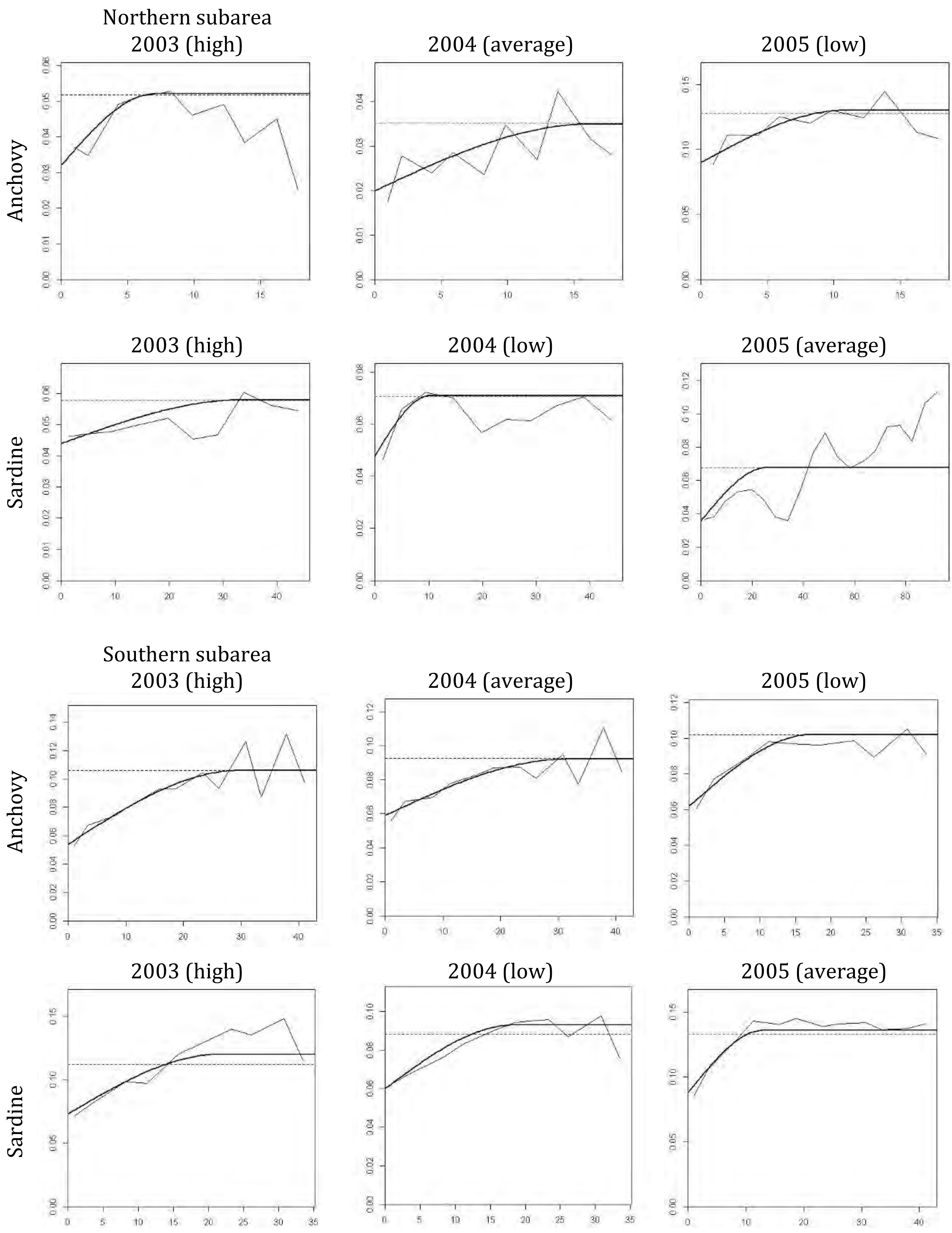


Figure 3.2.5. *Spanish Mediterranean waters:* Anchovy and sardine indicator variograms and fitted models in Southern subarea.

Table 3.2.2. *Spanish Mediterranean waters:* Threshold applied that retains an 80% of the abundance and probability of a value of being bigger than the applied threshold.

		Nothern Subarea		Southern Subarea	
Species	**Year**	**s**	**P(Z≥s)**	**s**	**P(Z≥s)**
Anchovy	2003	547	0.0518	98	0.1234
	2004	214	0.0352	77	0.1058
	2005	30	0.1275	31	0.1176
Sardine	2003	131	0.0578	253	0.1339
	2004	164	0.0706	80	0.1058
	2005	47	0.0680	85	0.1658

Table 3.2.3. *Spanish Mediterranean waters:* Mean s_A, spreading area (SA) and total biomass (in tons).

		Nothern Subarea			Southern Subarea		
Species	**Year**	**Mean s_A**	**SA**	**Biomass**	**Mean s_A**	**SA**	**Biomass**
Anchovy	2003	115.6	71.9	10932	111.1	413.2	1675
	2004	36.1	65.1	3358	33.6	390.5	1335
	2005	16.8	248.7	1680	15.2	392.2	437
Sardine	2003	31.6	90.2	3803	42.0	551.7	3476
	2004	52.5	128.5	7589	35.1	383.5	1050
	2005	14.1	148.8	2211	56.3	476.3	1422

Table 3.2.4. *Spanish Mediterranean waters:* Parameters of the models used to fit the indicator experimental variograms.

		Nothern Subarea				Southern Subarea			
Species	**Year**	**Abundance level**	**Nugget**	**Psill**	**Range (nm)**	**Abundance level**	**Nugget**	**Psill**	**Range (nm)**
Anchovy	2003	High	0.032	0.020	7.02	High	0.054	0.052	29.70
	2004	Average	0.020	0.015	16.20	Average	0.059	0.033	31.32
	2005	Low	0.090	0.040	10.80	Low	0.062	0.040	17.28
Sardine	2003	Average	0.044	0.014	33.48	High	0.073	0.047	21.60
	2004	High	0.048	0.023	10.26	Low	0.060	0.033	18.36
	2005	Low	0.036	0.032	25.92	Average	0.088	0.084	12.96

Table 3.2.5. *Spanish Mediterranean waters (Northern subarea):* For different inter-transect (IT) distances: precision (CVgeo) of the determination of the area occupied as computed by EVA2 and RGeoS. In bold, results for the applied sampling design.

Species	Year	Abundance	IT (nm)	RGeoS CVgeo	CVgeo (EVA2)	EVA2 Variance estimation	% var explained by nugget
Anchovy	2003	High	2	0.2134	0.1931	0.0001	96.2
			4	**0.3023**	**0.1931**	**0.0001**	**87.8**
			8	0.4378	0.2731	0.0002	63.2
	2004	Average	2	0.2451	0.2840	0.0001	98.5
			4	**0.3605**	**0.2840**	**0.0001**	**94.3**
			8	0.4579	0.2840	0.0001	79.1
	2005	Low	2	0.1431	0.0784	0.0001	98.3
			4	**0.1964**	**0.0784**	**0.0001**	**92.8**
			8	0.2606	0.1109	0.0002	78.4
Sardine	2003	High	2	0.2180	0.1729	0.0001	98.7
			4	**0.3043**	**0.1729**	**0.0001**	**97.1**
			8	0.3809	0.1729	0.0001	95.6
	2004	Low	2	0.1892	0.2004	0.0002	98.3
			4	**0.2601**	**0.2004**	**0.0002**	**92.9**
			8	0.3467	0.2004	0.0002	78.1
	2005	Average	2	0.1697	0.1472	0.0001	99.4
			4	**0.2603**	**0.1472**	**0.0001**	**95.4**
			8	0.3088	0.1472	0.0001	83.7

Table 3.2.6. *Spanish Mediterranean waters (Southern subarea):* For different inter-transect (IT) distances: precision (CVgeo) of the determination of the area occupied as computed by EVA2 and RGeoS. In bold, results for the applied sampling design.

Species	Year	Abundance	IT (nm)	RGeoS.new CVgeo	CVgeo (EVA2)	EVA2 Variance estimation	% var explained by nugget
Anchovy	2003	High	4	0.1122	0.0811	0.0001	94.4
			8	**0.1447**	**0.1146**	**0.0002**	**78.9**
			16	0.2658	0.1404	0.0003	54.4
	2004	Average	4	0.1335	0.1336	0.0002	96.6
			8	**0.1682**	**0.1336**	**0.0002**	**91.3**
			16	0.2900	0.1336	0.0002	68.7
	2005	Low	4	0.1252	0.1202	0.0002	93.0
			8	**0.1609**	**0.1202**	**0.0002**	**80.9**
			16	0.2900	0.1472	0.0003	49.7
Sardine	2003	High	4	0.1232	0.1057	0.0002	95.1
			8	**0.1582**	**0.1057**	**0.0002**	**81.3**
			16	0.2673	0.1294	0.0003	57.0
	2004	Low	4	0.1354	0.1336	0.0002	95.3
			8	**0.1710**	**0.1336**	**0.0002**	**82.2**
			16	0.2976	0.1637	0.0003	55.6
	2005	Average	4	0.1145	0.0603	0.0001	92.2
			8	**0.1499**	**0.0853**	**0.0002**	**78.8**
			16	0.2926	0.0853	0.0002	49.1

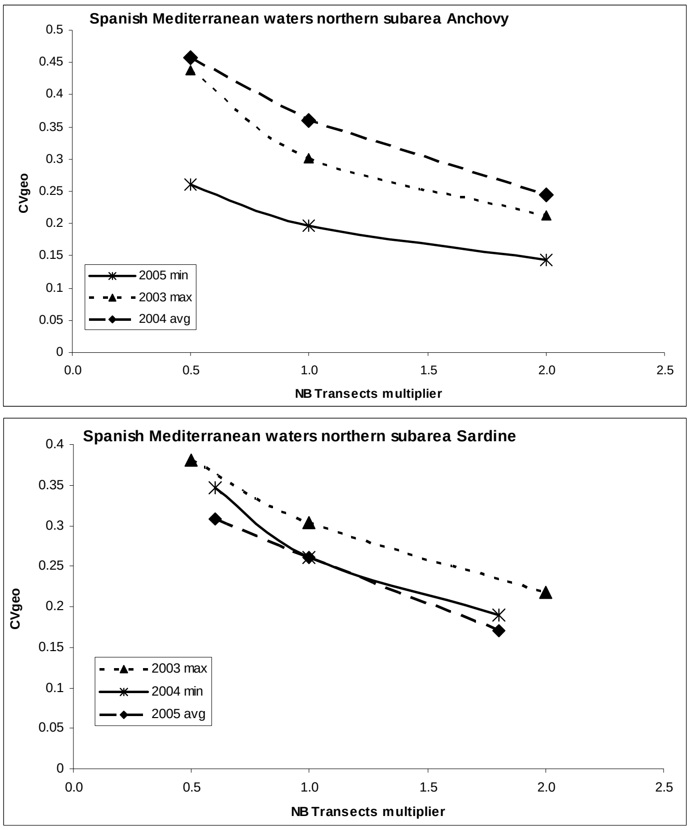


Figure 3.2.6. *Spanish Mediterranean waters (northern subarea)*: Results of different survey designs in terms of the geostatistical coefficient of variation as estimated by RGeoS for anchovy and sardine.

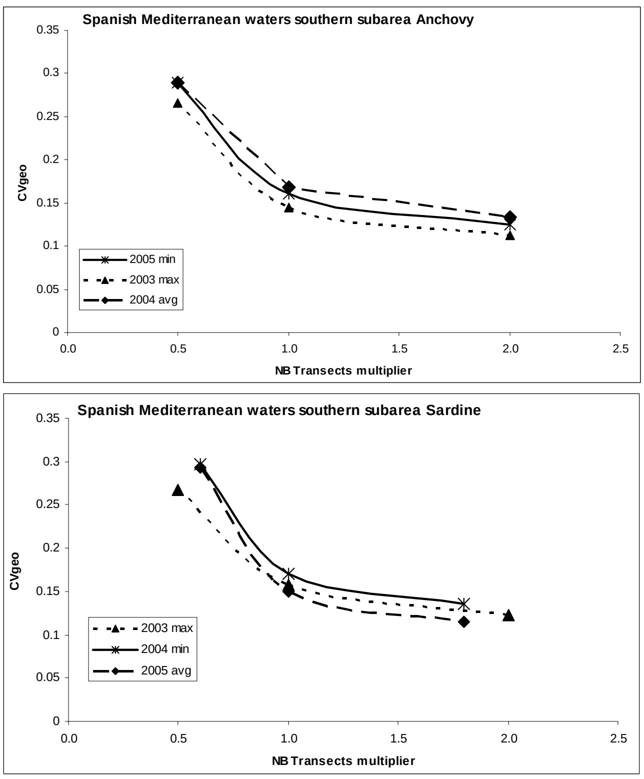


Figure 3.2.7. *Spanish Mediterranean waters (southern subarea):* Results of different survey designs in terms of the geostatistical coefficient of variation as estimated by RGeoS for anchovy and sardine.

North Aegean Sea

Study area

Anchovy and sardine s_A (m^2/nm^2) data, obtained from stock assessment acoustic surveys in Aegean Sea during early summer were used for evaluating different survey designs. Three years, one of high, low and average abundance for each of the species was analyzed. Maps of fish distribution at different years are presented in Figures 3.2.9 & 3.2.10. Inter-transect distance was 10 nm both in Thracian Sea and in Thermaikos gulf.

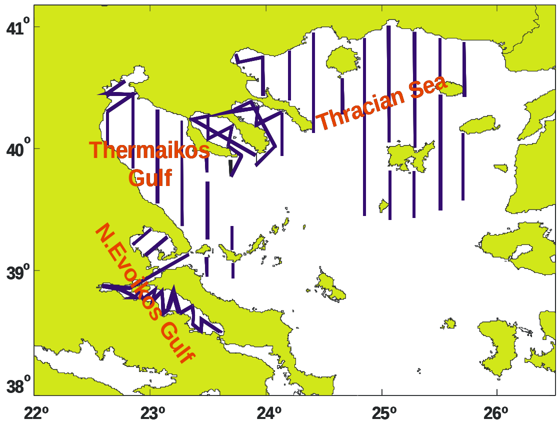


Figure 3.2.8. *Aegean Sea:* Study area, subareas established for data analysis and sampling design.

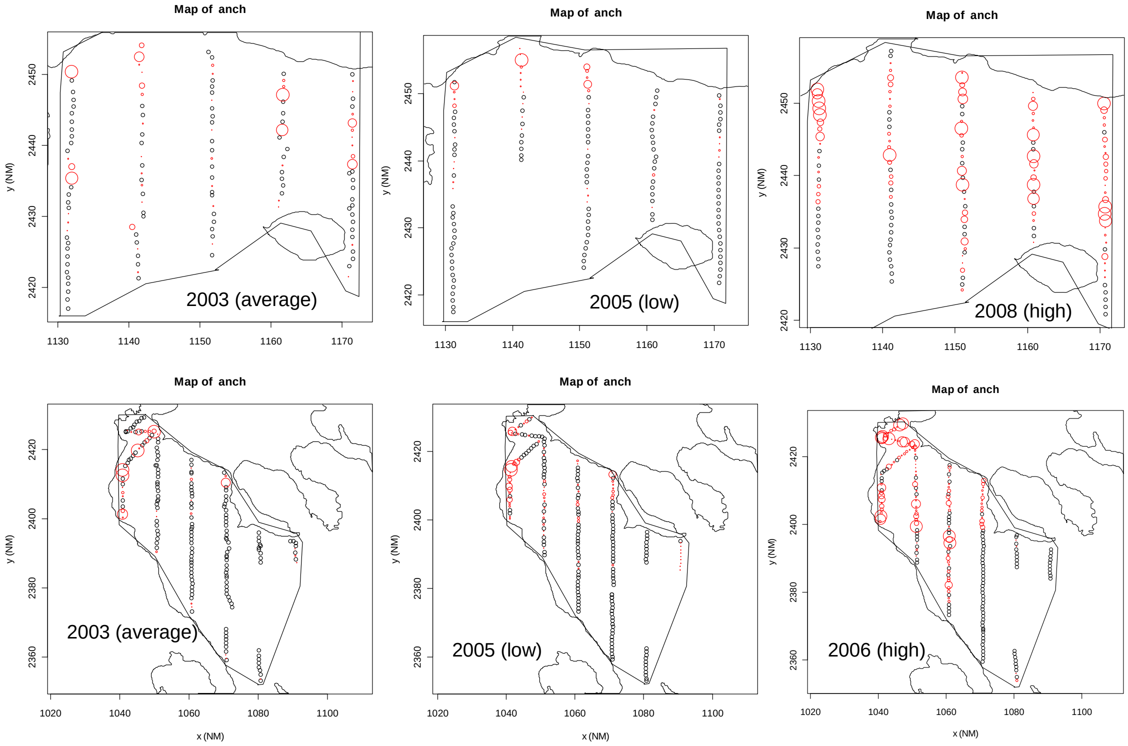


Figure 3.2.9. Anchovy distribution in Thracian Sea and Thermaikos gulf at years of average, low and high abundance. Coordinates are in projected units (lat*60, long*60*cos (latmoy)).

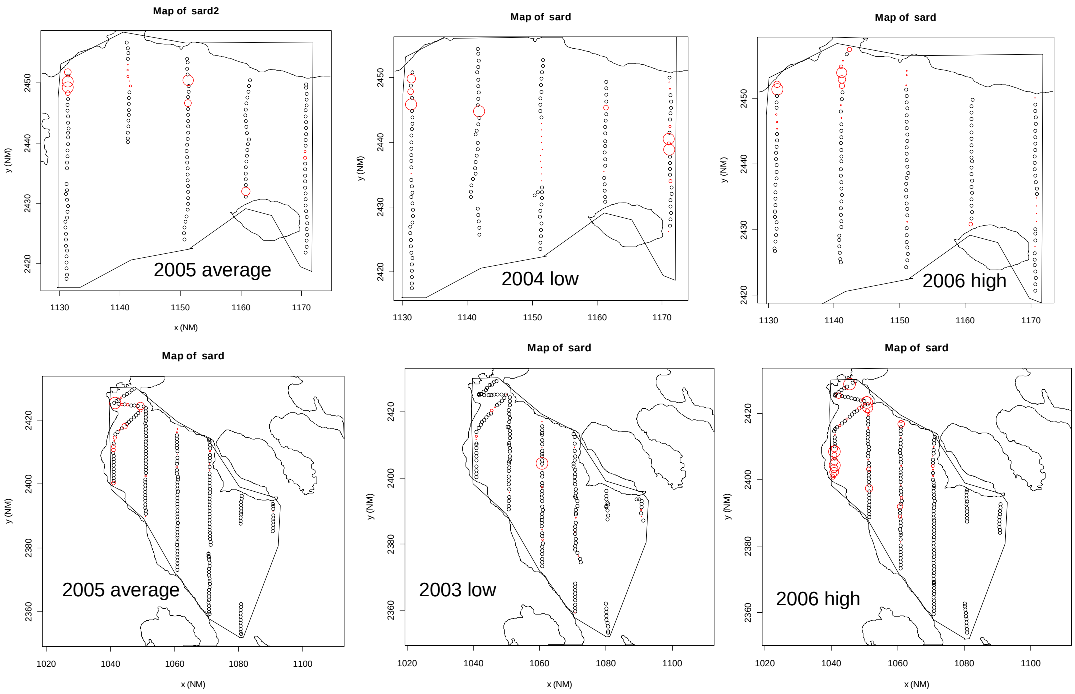


Figure 3.2.10. Sardine distribution in Thracian Sea and Thermaikos gulf at years of average, low and high abundance. Coordinates are in projected units (lat*60, long*60*cos (latmoy)).

Data analysis

For both anchovy and sardine selected lag width was set at 2 nm. Figures 3.2.11 and 3.2.12 show the proportion of acoustic abundance related to percent area occupied

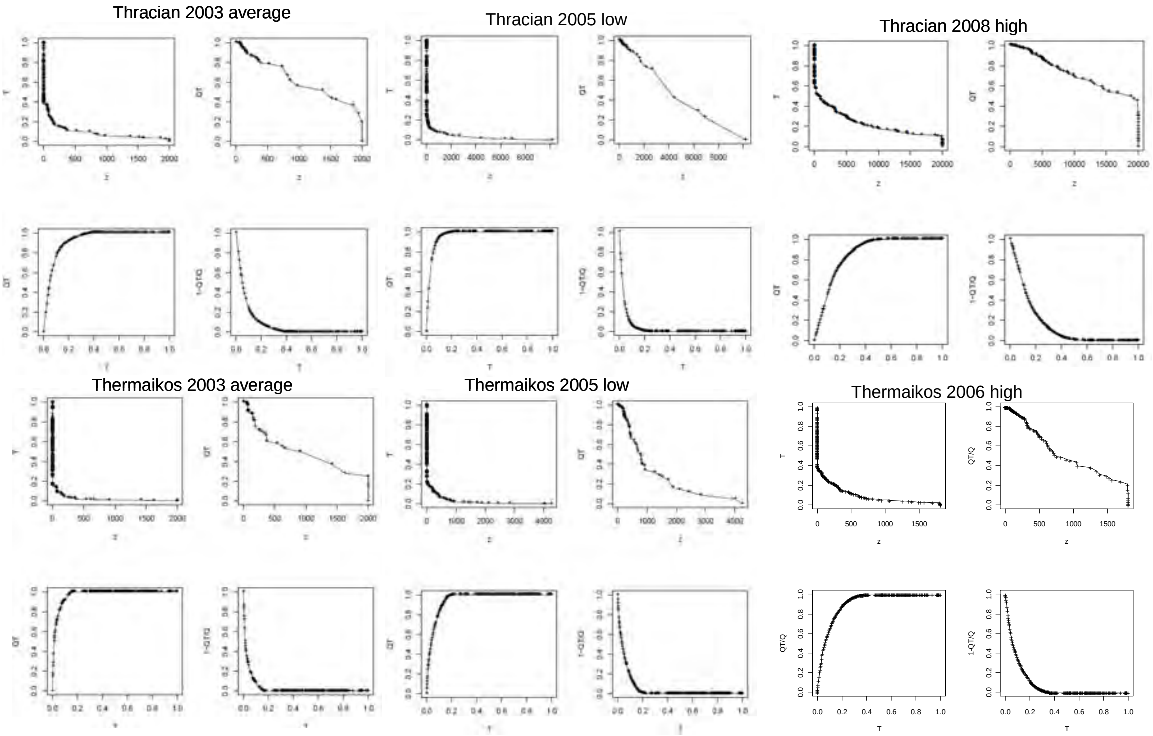


Figure 3.2.11. Anchovy proportion of acoustic abundance related to percent area occupied in Thracian Sea and Thermaikos gulf.

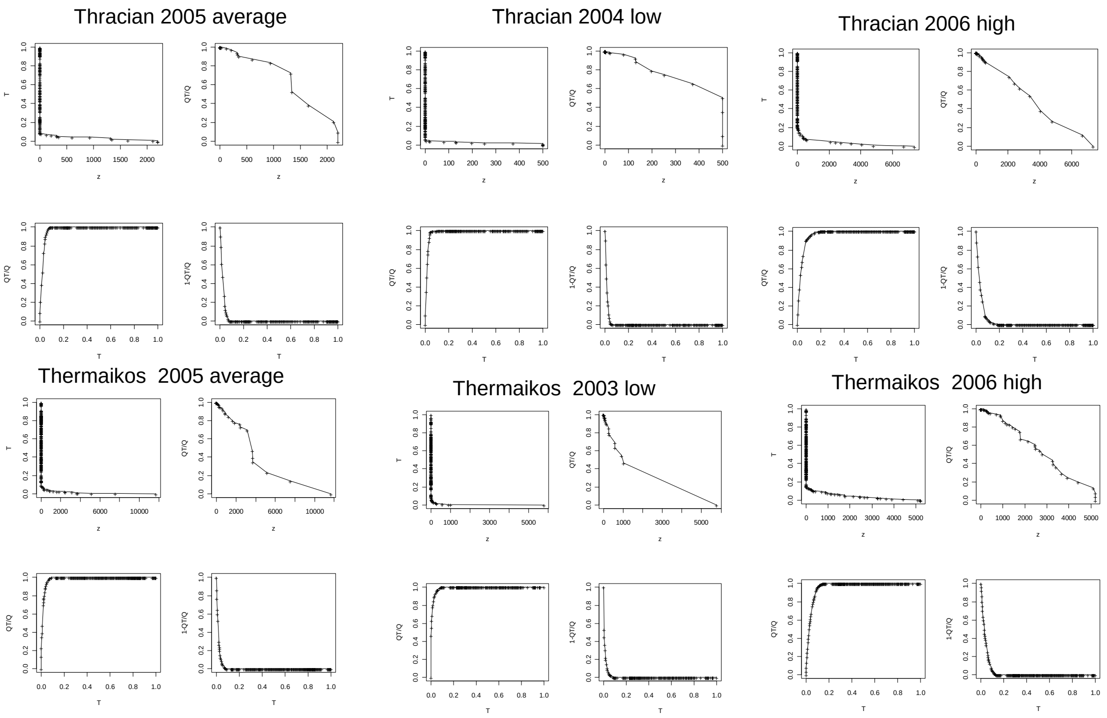


Figure 3.2.12. Sardine proportion of acoustic abundance related to percent area occupied in Thracian Sea and Thermaikos gulf.

Results and Discussion

The inspection of the aggregation curves showed that the spatial patches of sardine exhibited a very aggregating behavior in both Thracian Sea and Thermaikos gulf compared to the other study areas. Anchovy behavior was less aggregative, being more similar to what observed in other study areas.

Indicator variography results showed that both anchovy and sardine patches were well structured for the selected threshold. Specifically, for the given threshold the autocorrelation range of sardine (i.e. approximating maximum size of sardine patches) varied from 8 to 17 nm at Thracian Sea and from 3 to 7 nm at Thermaikos gulf, exhibiting the smaller patches in years of low abundance. Similarly, anchovy autocorrelation range varied from 4 to 15 nm at Thracian Sea and from 2.5 to 7 nm at Thermaikos gulf. Smaller spatial structures were identified consistently in Thermaikos gulf. The coefficient of variation concerning both species as estimated by geostatistics was generally high, estimated higher when in years of low abundance. Regarding anchovy for the given survey design (i.e., 10 nm inter transect distance) coefficient of variation varied from 0.21 (high abundance) to 0.32 (low abundance) at Thracian Sea and from 0.14 (high abundance) to 0.304 (average year) at Thermaikos gulf. For sardine that generally presented more aggregating behavior, the coefficient of variation was higher being around 0.4 at Thracian Sea independently of the year and varying from 0.29 (high abundance) to 0.48 (low abundance) at Thermaikos gulf, implying that at years of low abundance survey estimates under the current survey design can be quite imprecise. The contribution of the nugget (pure random spatial component) to the survey precision increased with increasing sampling effort; however, it was generally low, especially in certain years implying that the structural component is not well resolved by the survey spatial coverage. However, survey precision was often not a linear function of inter-transect distance and therefore, decreasing survey effort had a large negative impact on survey precision while increasing it had a moderate positive impact.

In the case of highly aggregated spatial distributions, like this, the probability of encountering rich density patches is low using a systematic survey design; so an adaptive sampling design could be a practical solution. However, adaptive sampling suffers the risk of bias in the design, because additional sample points tend to occur only in the vicinity of previously encountered ones. A combination of increasing the sampling effort by decreasing the inter transect distance in half, systematically up to 70 m depth where high concentrations of small pelagic fish occur could help to improve the ability of the survey to encounter rich density patches, especially when it comes to sardine.

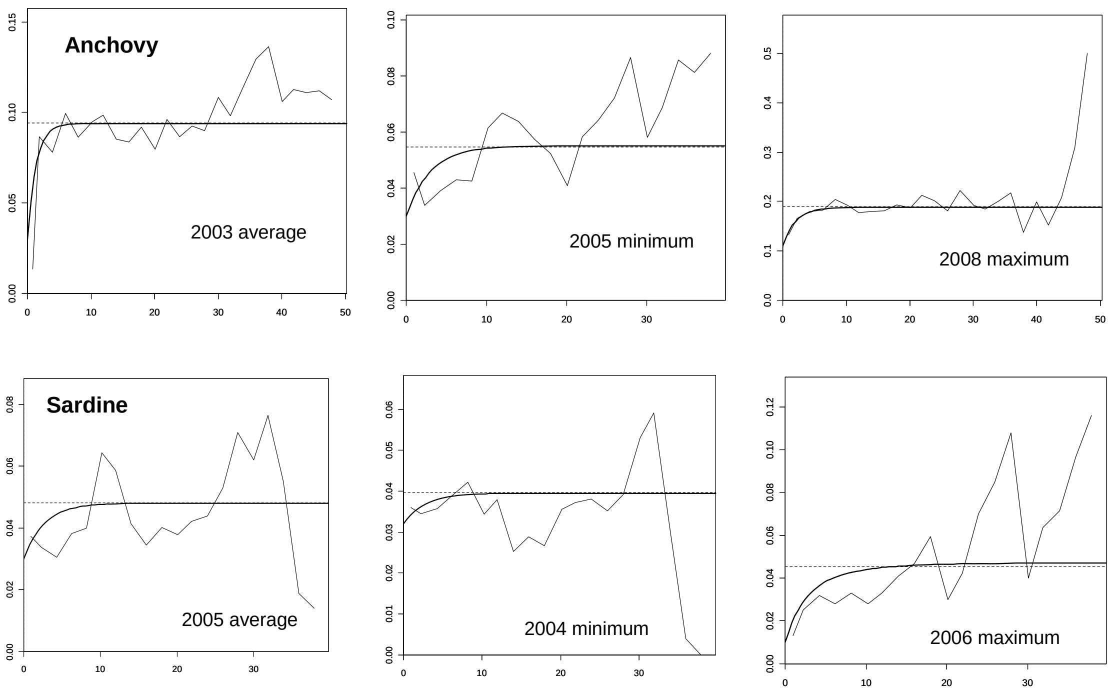


Figure 3.2.13. Anchovy and sardine fitted indicator variograms in Thracian Sea.

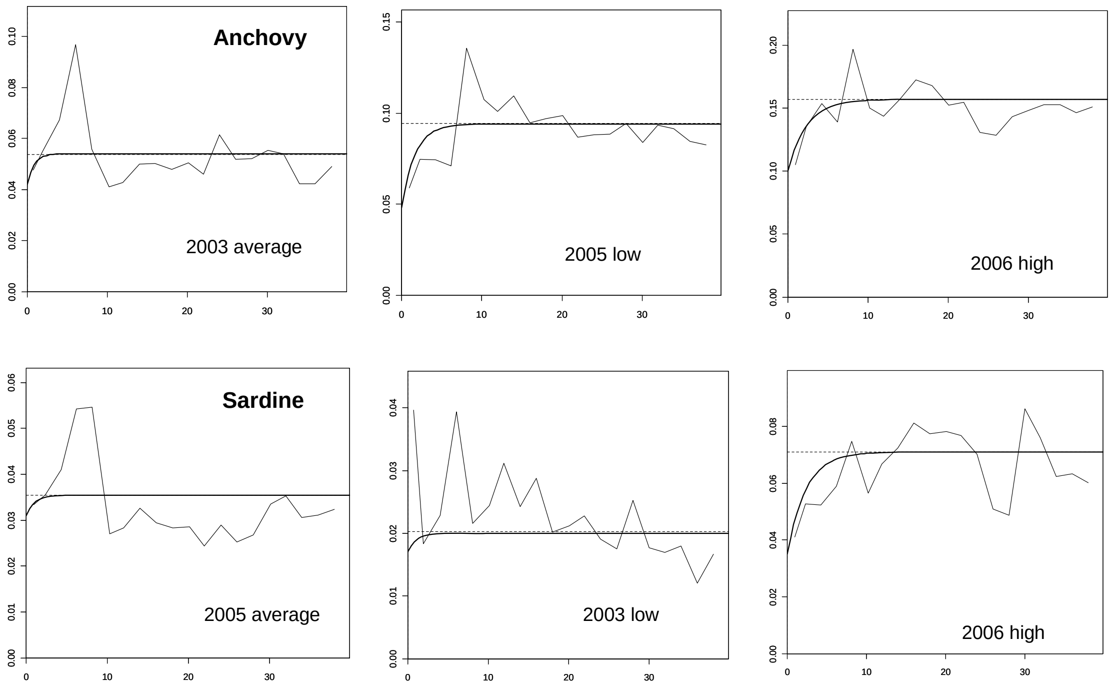


Figure 3.2.14. Anchovy and sardine fitted indicator variograms in Thermaikos gulf.

Table 3.2.7. *Thermaikos gulf and Thracian Sea:* Threshold applied that retains an 80% of the abundance and probability of a value of being bigger than the applied threshold.

	Thracian Sea			Thermaikos Gulf		
Species	**Year**	**s**	**P(Z≥s)**	**Year**	**s**	**P(Z≥s)**
Anchovy	2008	6243	0.253	2006	418	0.194
	2003	345	0.105	2003	365	0.057
	2004	3380	0.069	2005	436	0.105
Sardine	2006	2100	0.047	2006	1770	0.076
	2005	1000	0.043	2005	2400	0.037
	2004	198	0.041	2003	580	0.021

Table 3.2.8. *Thermaikos gulf and Thracian Sea:* Mean s_A, spreading area (SA) and total biomass (in tons).

	Thracian Sea				Thermaikos Gulf			
Species	**Year**	**Mean s_A**	**SA**	**Biomass**	**Year**	**Mean s_A**	**SA**	**Biomass**
Anchovy	2008	4533.5	0.289	44000	2006	175.8	0.179	44876
	2003	185	0.149	22696	2003	48.4	0.060	25142
	2004	1065.7	0.067	9992	2005	102.3	0.101	14454
Sardine	2006	299.2	0.073	9728	2006	241.1	0.075	33128
	2005	84.5	0.049	7821	2005	152.7	0.035	12643
	2004	14.5	0.033	2594	2003	32	0.022	10581

Table 3.2.9. *Thermaikos gulf and Thracian Sea:* Parameters of the models used to fit the indicator experimental variograms.

	Thracian Sea					Thermaikos Gulf				
Species	**Year**	**Abundance level**	**Nugget**	**Sill**	**Range (nm)**	**Year**	**Abundance level**	**Nugget**	**Sill**	**Range (nm)**
Anchovy	2008	High	0.110	0.079	6	2006	High	0.100	0.057	7
	2003	Average	0.030	0.064	4	2003	Average	0.042	0.011	2.5
	2004	Low	0.043	0.021	15	2005	Low	0.048	0.046	6
Sardine	2006	High	0.010	Sill 1: 0.020 Sill 2: 0.017	Range 1: 6 Range 2: 17	2006	High	0.032	0.044	7
	2005	Average	0.030	0.011	8	2005	Average	0.031	0.004	3
	2004	Low	0.032	0.007	8	2003	Low	0.017	0.003	3

Table 3.2.10. *Thracian Sea:* Survey precision estimates for different inter-transect (IT) distances. In bold, results for the applied sampling design.

Species	Year	Abundance	IT (nm)	% var explained by nugget	CVgeo (EVA2)	CVgeo (RGeoS)
Anchovy	2008	High	5	67.7	0.175	0.479
			10	**47.8**	**0.211**	0.174
			20	18.5	0.248	0.105
	2003	Average	5	39.3	0.213	0.181
			10	**24.6**	**0.269**	0.316
			20	18.5	0.393	0.393
	2004	Low	5	87.1	0.205	0.237
			10	**67.2**	**0.324**	0.423
			20	43.6	0.481	0.717
Sardine	2006	High	5	37.5	0.210	0.268
			10	**18.2**	**0.420**	0.510
			20	9.7	0.728	0.943
	2005	Average	5	84.5	0.230	0.266
			10	**66.6**	**0.398**	0.478
			20	50.2	0.563	0.735
	2004	Low	5	89.5	0.242	0.302
			10	**75.3**	**0.419**	0.450
			20	61.1	0.593	0.713

Table 3.2.11. *Thermaikos Gulf:* Survey precision estimates for different inter-transect (IT) distances. In bold, results for the applied sampling design.

Species	Year	Abundance	IT (nm)	% var explained by nugget	CVgeo (EVA2)	CVgeo (RGeoS)
Anchovy	2006	High	5	75.8	0.089	0.102
			10	**55.1**	**0.145**	**0.170**
			20	39.1	0.224	0.292
	2003	Average	5	81	0.176	0.220
			10	**74.2**	**0.304**	**0.311**
			20	69.7	0.393	0.487
	2005	Low	5	64.2	0.134	0.143
			10	**41.1**	**0.232**	**0.253**
			20	29.9	0.402	0.434
Sardine	2006	High	5	56.3	0.132	0.472
			10	**33.5**	**0.294**	**0.294**
			20	21.0	0.472	0.132
	2005	Average	5	90.7	0.273	0.275
			10	**85**	**0.385**	**0.366**
			20	81.9	0.472	0.596
	2003	Low	5	89.2	0.342	0.366
			10	**81.1**	**0.483**	**0.522**
			20	77.7	0.683	0.804

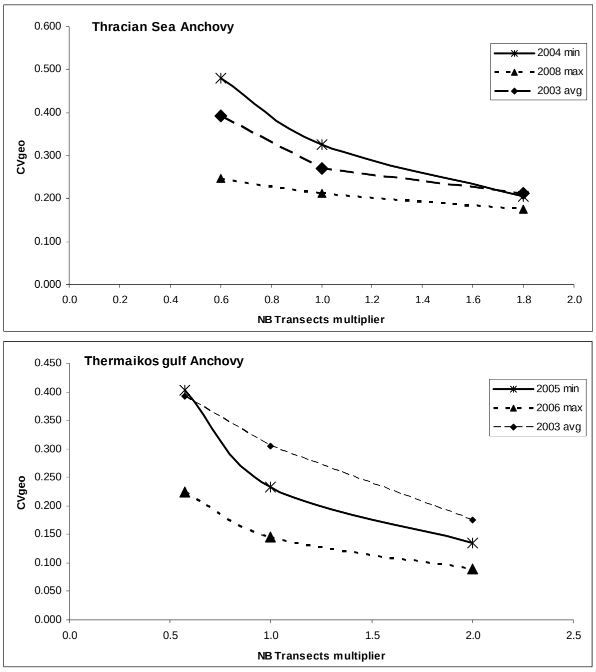


Figure 3.2.15. *Thermaikos gulf and Thracian Sea Anchovy:* Results of different survey designs in terms of the geostatistical coefficient of variation as estimated by EVA2 for the two study areas.

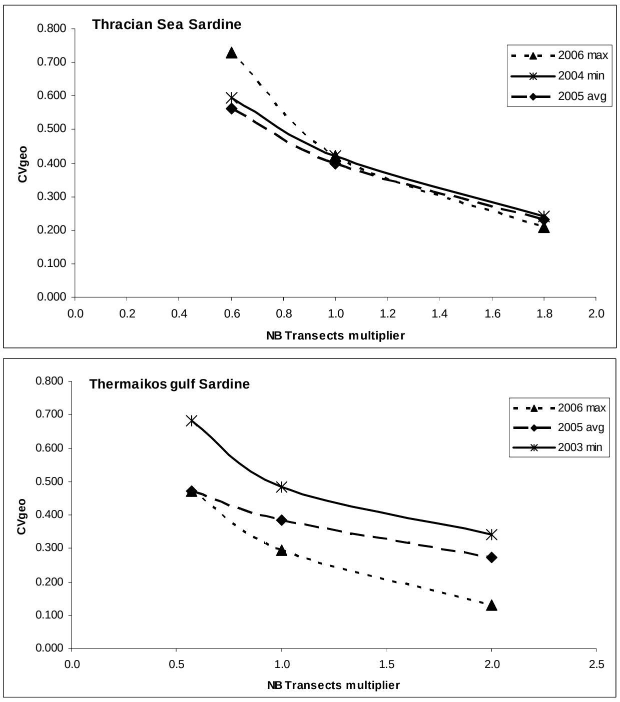


Figure 3.2.16. *Thermaikos gulf and Thracian Sea Sardine:* Results of different survey designs in terms of the geostatistical coefficient of variation as estimated by EVA2 for the two study areas.

Strait of Sicily waters

Study area

Analyzed data referred to 2002-2006 period. For each species (*Engraulis encrasicolus* and *Sardina pilchardus*) three surveys, carried out in the summer season, were selected based on total abundance values (minimum, average and maximum abundance). For all selected years parallel transects design (inter-transect distance ≅ 5nm) was used to investigate the study area (≅ 2000 nm^2).

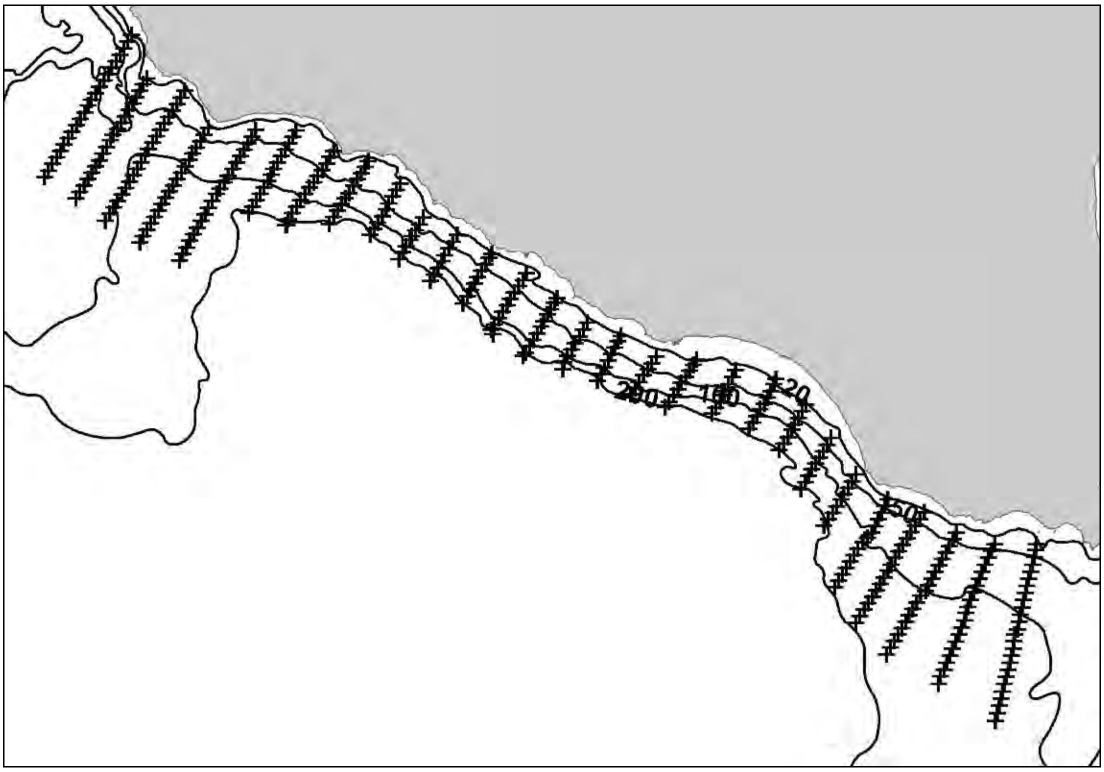


Figure 3.2.17. *Strait of Sicily:* Map of the study area with sampling design

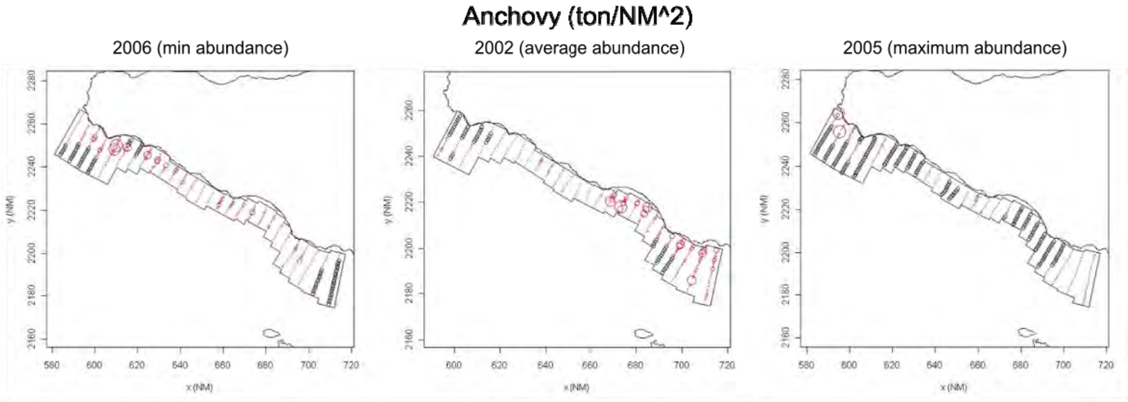


Figure 3.2.18. *Strait of Sicily:* Distribution maps of anchovy in years of min, max and average abundance

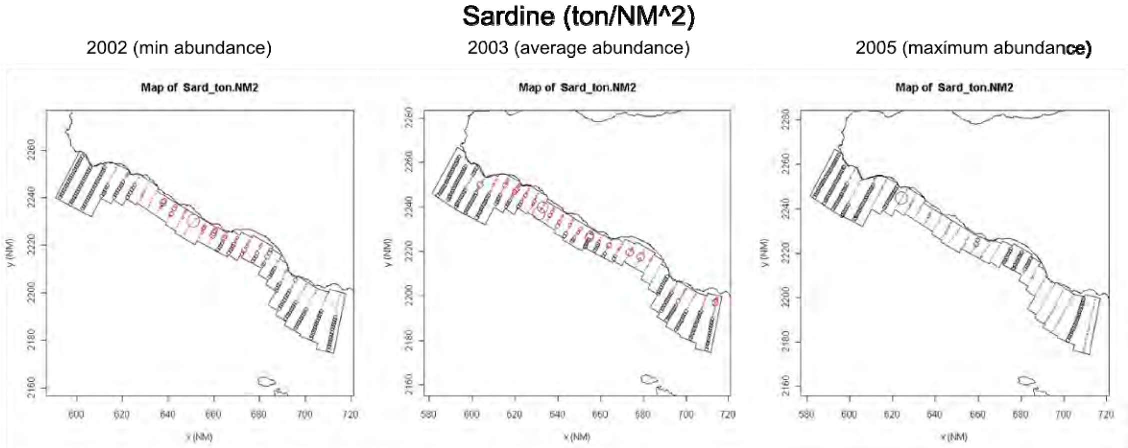


Figure 3.2.19. *Strait of Sicily:* Distribution maps of sardine in years of min, max and average abundance

Data analysis

All analyses were performed using density values (tons/nm^2), and spatial structure was computed by means of variogram (omnidirectional) using 3nm as lag distance.

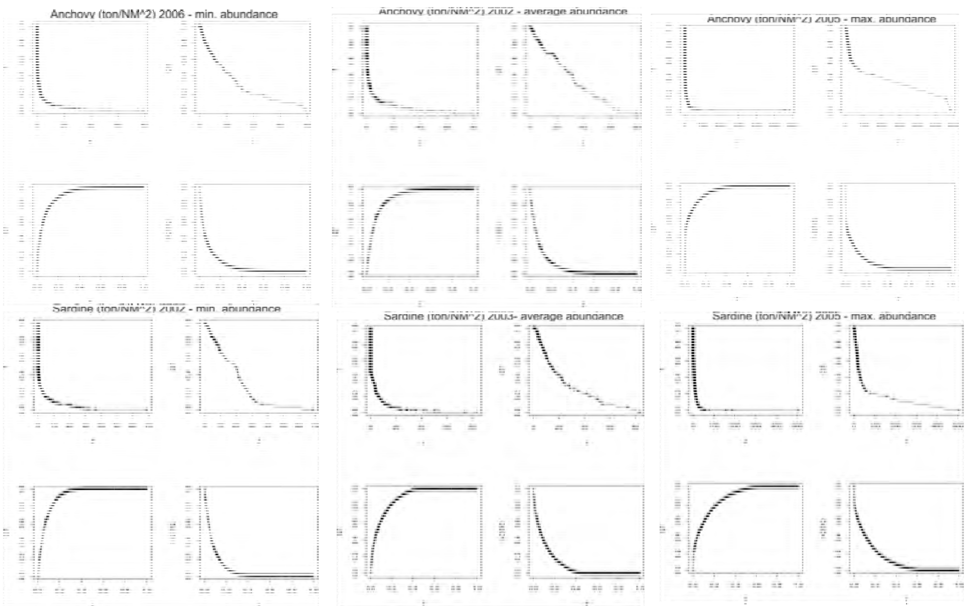


Figure 3.2.20. *Strait of Sicily:* Anchovy and sardine proportion of acoustic abundance related to percent area occupied.

Results and discussion

Despite the high inter annual variability in terms of range, sill, nugget and abundance, CVgeo values (related to the currently used inter-transect distance) were quite stable for Anchovy, ranging from 0.09 to 0.108. Sardine instead showed a greater inter-annual variability in terms of CVgeo ranging from 0.045 to 0.119.

Significant changes in CVgeo values were not recorded by using half of currently used inter-transect distance, while doubling it resulted in quite higher CVgeo values. Geostatistical analysis also showed that currently used inter-transect distance (5 nm) seems to be suitable to resolve adequately observed spatial structures. From the point of view of the spatial structure, experimental variograms and models were very different between anchovy and sardine. Anchovy variograms showed quite clear spatial structure, while sardine had short and large scale structures, resulting in a less clear spatial structure than anchovies. Changes in range value were not related to abundance for anchovy, while for sardine in years of lower and average abundance nested structures were found, with a small scale structure characterized by very short range. Spreading area investigation also showed differences between sardine and anchovy, as it seems related to abundance for sardine but not for anchovy.

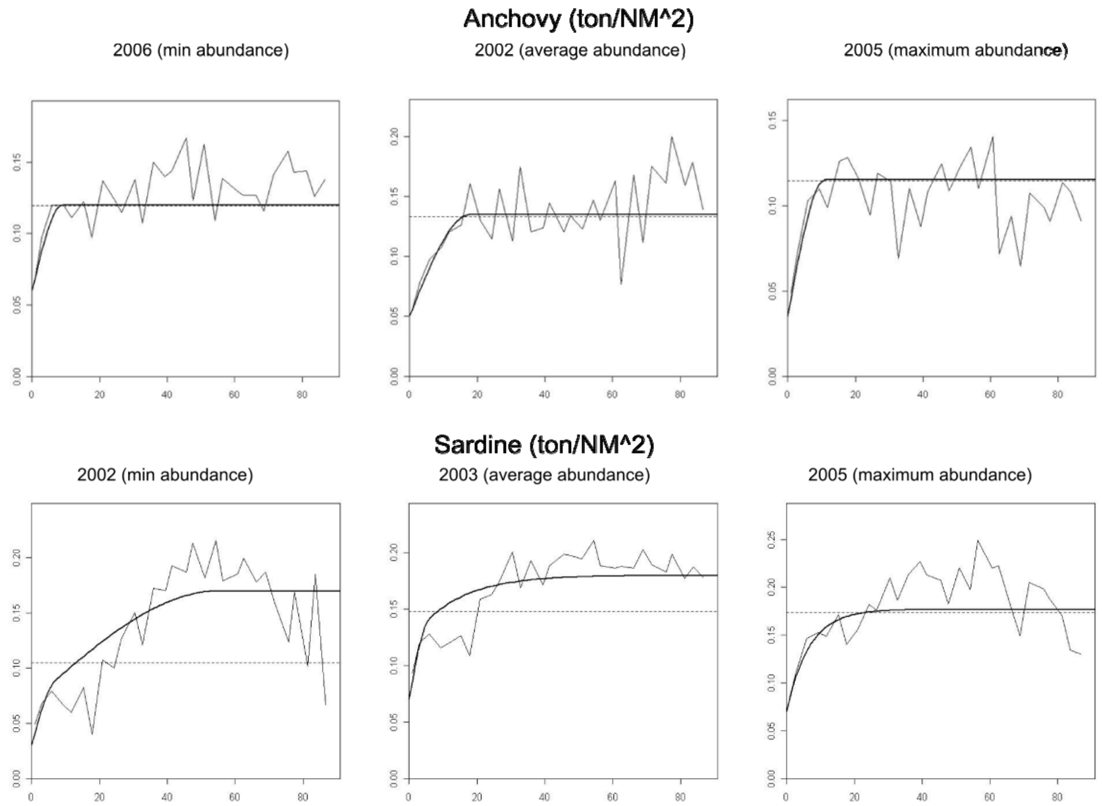
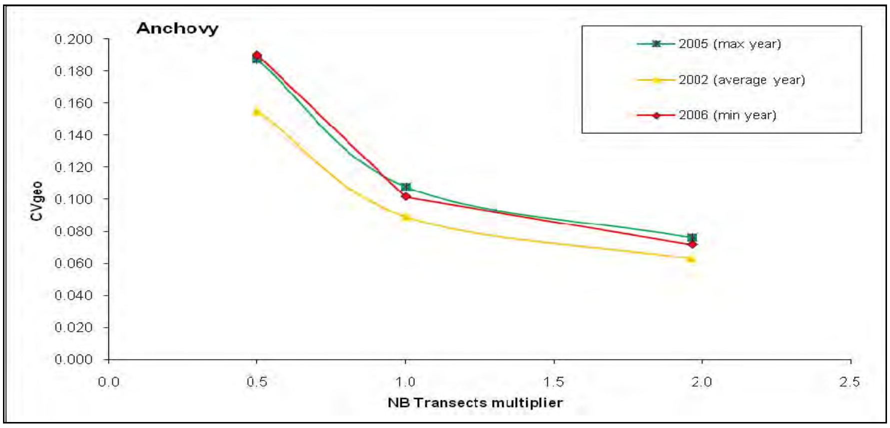


Figure 3.2.21. *Strait of Sicily:* Fitted exp. variograms for both Anchovy (top) and Sardine (bottom)



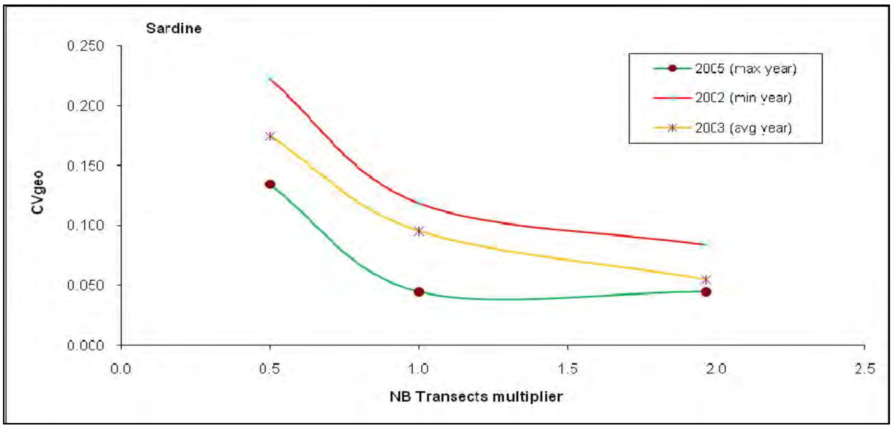


Figure 3.2.22. *Strait of Sicily:* CVgeo variability related to different inter-transect distances

Table 3.2.12. *Strait of Sicily:* Applied threshold retaining 80% of the abundance and probability of a value of being bigger than the applied threshold.

Species	Year	s	P(Z≥s)
Anchovy			
Max.	2005	14	0.131
Avg.	2002	7	0.158
Min.	2006	5	0.139
Sardine			
Max.	2005	10	0.224
Avg.	2003	7	0.181
Min.	2002	7	0.119

Table 3.2.13. *Strait of Sicily:* Mean s_A, spreading area (SA) and total biomass (in tons).

Species	Year	Mean density	SA (% of total area)	Biomass
Anchovy				
Max.	2005	8.50	15.3	15614.84
Avg.	2002	4.58	18.1	9149.97
Min.	2006	2.99	16.5	5930.35
Sardine				
Max.	2005	8.70	24.7	17896.68

Avg.	2003	4.59	20.5	8923.60
Min.	2002	2.79	15.2	5480.08

Table 3.2.14. *Strait of Sicily:* Parameters of the models used to fit the indicator experimental variograms.

Species	Year	Abundance level	Nugget	Psill	Range (nm)	Psill Model2	Range Model2 (nm)
Anchovy	2005	High	0.035	0.08	11		
	2002	Average	0.05	0.085	18		
	2006	Low	0.06	0.06	9		
Sardine	2005	High	0.07	0.107	20		
	2003	Average	0.07	0.05	6	0.06	40
	2002	Low	0.03	0.04	7	0.1	55

Table 3.2.15. *Strait of Sicily:* for different intert-transect (IT) distances: precision (CVgeo) of the determination of the area occupied by the medium-high values computed by RGeoS; variance estimation, percentage of variance estimate by the nugget effect and precision (CVgeo) computed by EVA2. In bold, results for the actual sampling design.

Species	Year	Abundance	IT (nm)	RGeoS CVgeo	% var explained by nugget	EVA2 CVgeo
Anchovy		High	2.5	0.083	86.2	0.076
			5	**0.118**	**64.5**	**0.108**
			10	0.193	32.3	0.187
		Average	2.5	0.082	95.8	0.063
			5	**0.114**	**80.1**	**0.090**
			10	0.181	54.4	0.155
		Low	2.5	0.099	93.8	0.072
			5	**0.137**	**77.6**	**0.102**
			10	0.223	46.4	0.190
Sardine		High	2.5	0.068	91.6	0.045
			5	**0.094**	**72.7**	**0.045**
			10	0.145	44.5	0.134
		Average	2.5	0.083	90.1	0.055
			5	**0.113**	**70**	**0.096**
			10	0.193	39.2	0.175
		Low	2.5	0.090	87.5	0.084
			5	**0.140**	**60.4**	**0.119**
			10	0.259	28.8	0.222

Western Adriatic Sea

Study area

Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) data were collected in September during three echo-survey years: 2008, 2009 and 2010. A parallel sampling design was adopted in the three years with an inter-transect distance of approximately 10 nautical miles while the length per transect was approximately 25 nautical miles. The variable used for the geostatistical analysis was the NASC (m^2/nm^2) for both pelagic species. Split Beam Simrad Echosounder EK 60 at 38, 120 and 200 kHz was used to collect echoes from the schools all along the cruise. During data processing EDSU was set to 1 nautical mile.

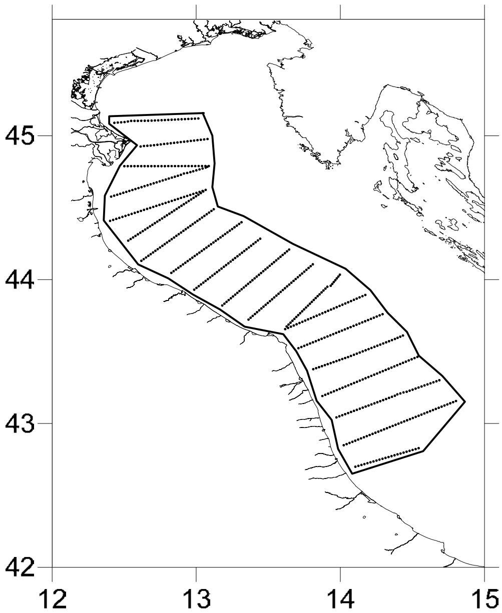


Figure 3.2.23. Map of the study area, sampling design and the polygon used for analysis in the Western Adriatic Sea.

Data analysis

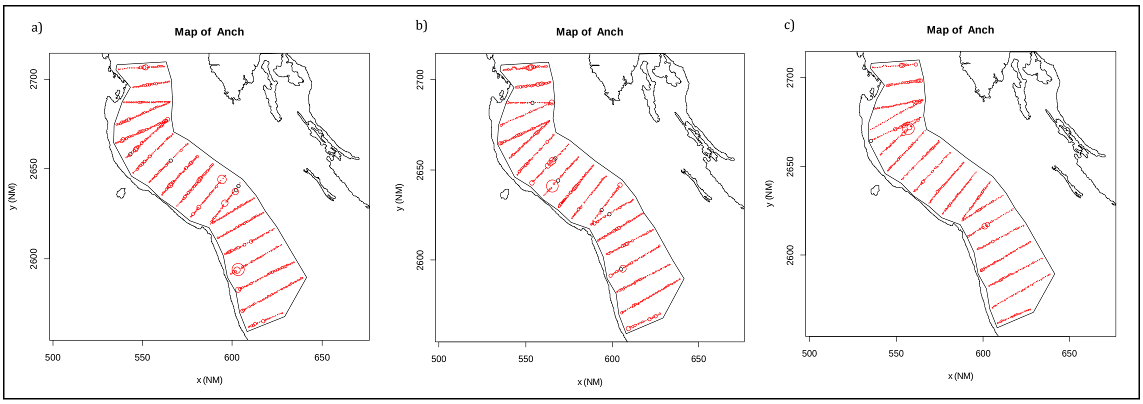


Figure 3.2.24. *Western Adriatic Sea:* Maps of anchovy distribution in year of a) high (2008), b) low (2009) and c) average (2010) abundance.

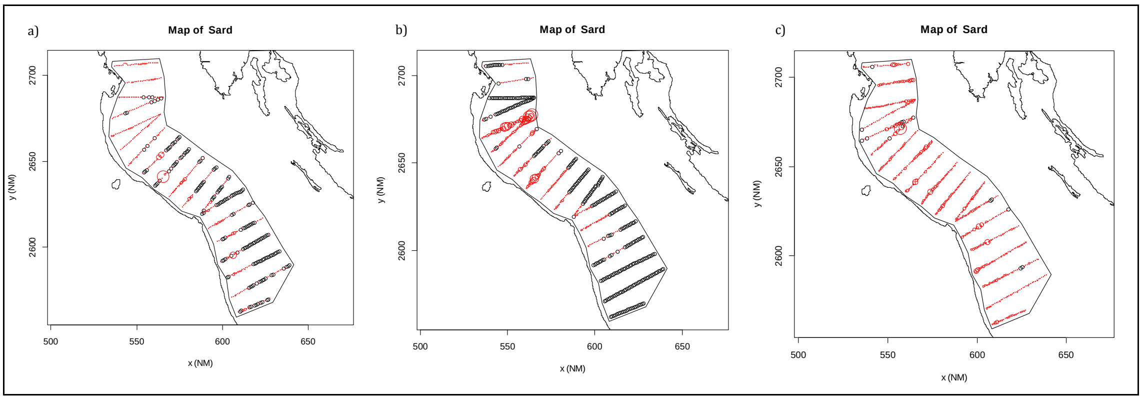


Figure 3.2.25. *Western Adriatic Sea:* Maps of sardine distribution in year of a) high (2009), b) low (2008) and c) average (2010) abundance.

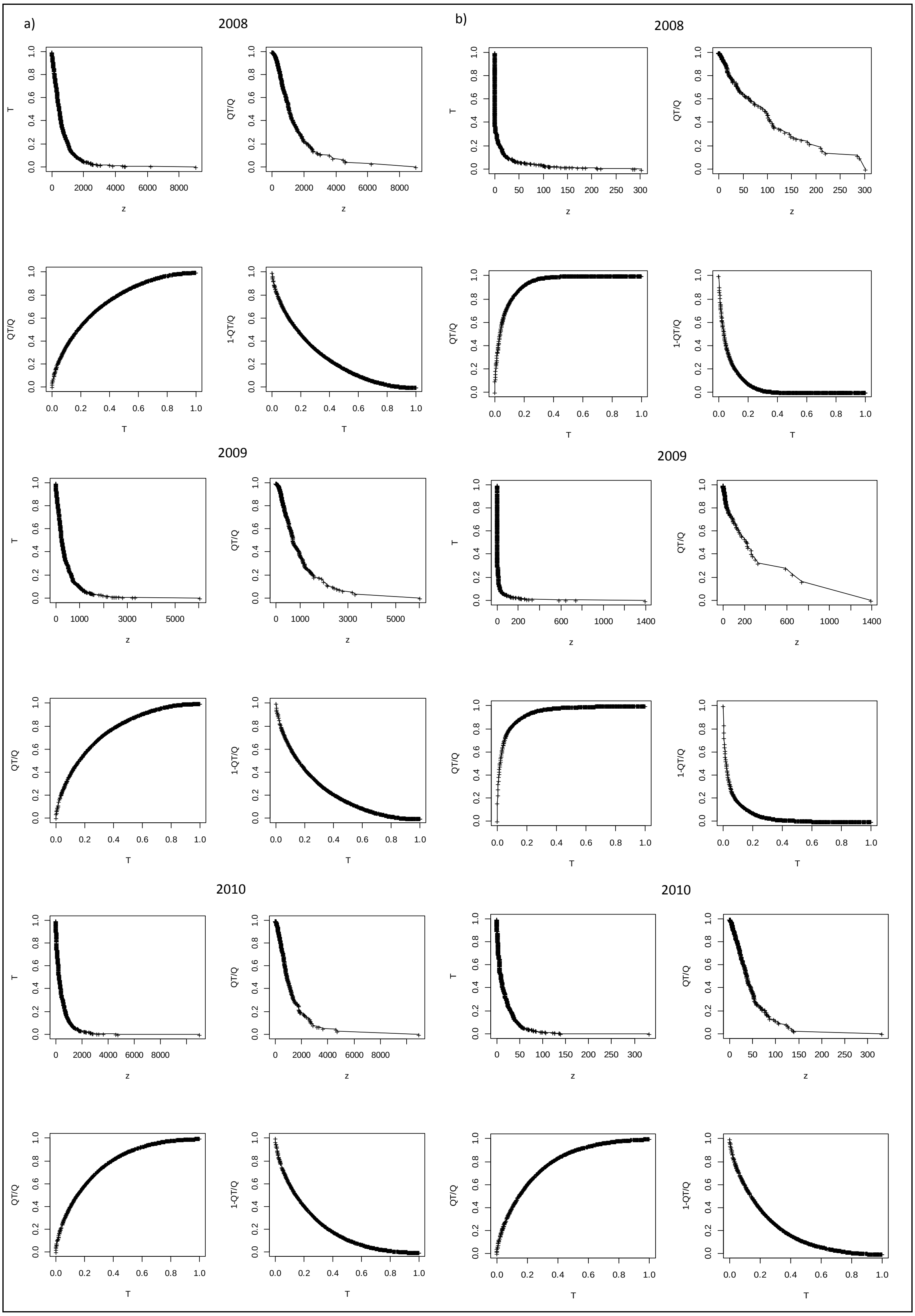


Figure 3.2.26. *Western Adriatic Sea:* Cumulative curves for a) anchovy and b) sardine along the three years of sampling.

Results and discussion

Indicator variography results showed that both anchovy and sardine patches were well structured for the selected threshold. Despite the high inter annual variability in terms of range, sill, nugget and abundance, CVgeo values related to the currently used inter-transect distance are quite stable, ranging from 0.047 to 0.060 for anchovy and from 0.064 to 0.149 for sardine. Pronounced changes in CVgeo values were not recorded by using half of currently used inter-transect distance, while doubling it resulted in quite higher CVgeo values. Changes in range value was not related to abundance values for both anchovy and sardine, while spreading area seems to be related to abundance for sardine but not for anchovy. Sardine variograms were characterized by shorter ranges (6 to 10 nm) compared to anchovy (9 to 15 nm). The contribution of the nugget (pure random spatial component) to the survey precision increased with increasing sampling effort; however it was generally low, especially in certain years implying that the structural component could not be well resolved by the survey spatial coverage.

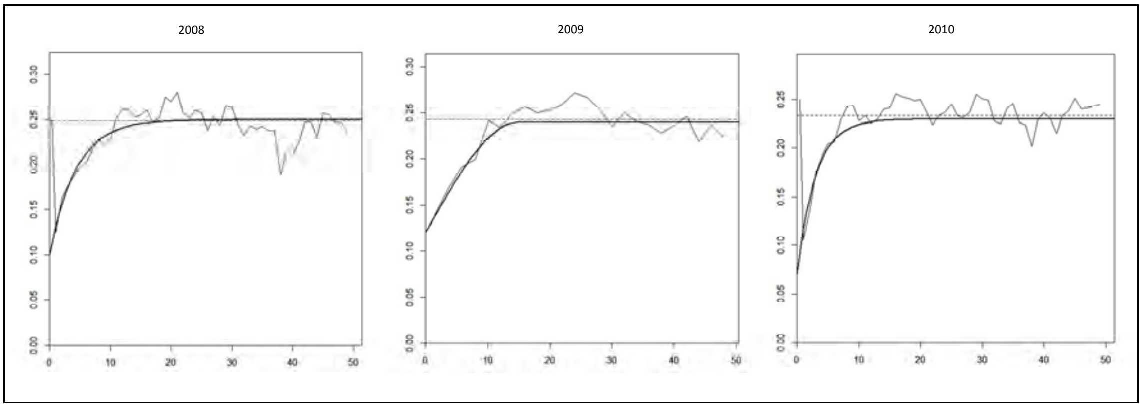


Figure 3.2.27. *Western Adriatic Sea:* Experimental and model fitted indicator - variograms of anchovy in the three years.

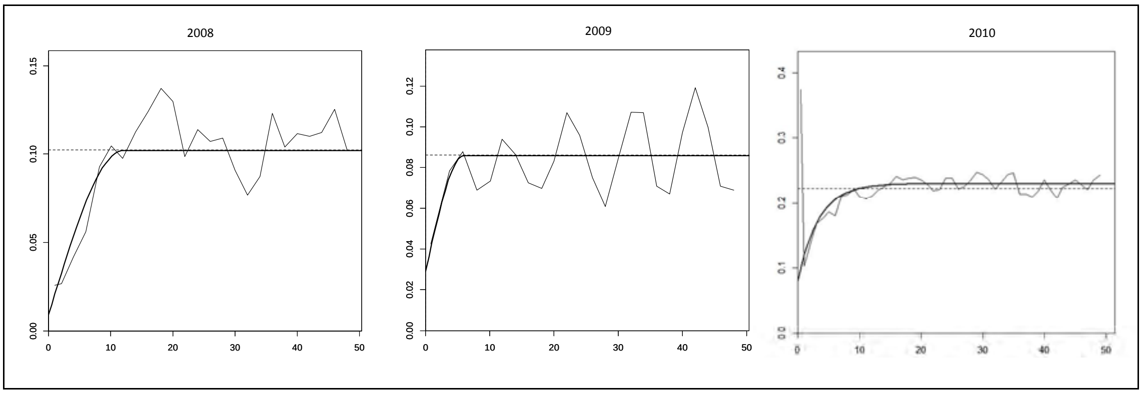


Figure 3.2.28. *Western Adriatic Sea:* Experimental and model fitted indicator - variograms of sardine in the three years.

Table 3.2.16. *Western Adriatic Sea:* Applied threshold retaining 80% of the abundance and probability of a value of being bigger than the applied threshold.

Species	Year	s	P(Z≥s)
Anchovy	2008	520	0.47
	2009	315	0.42
	2010	430	0.37
Sardine	2008	28	0.37
	2009	33	0.095
	2010	18	0.35

Table 3.2.17. *Western Adriatic Sea:* Mean s_A, spreading area (SA) and total biomass (in tons).

Species	Year	Mean s_A	SA	Biomass
Anchovy	2008	691.2	0.499	55366
	2009	432.4	0.463	30219
	2010	493.0	0.430	32255
Sardine	2008	11.8	0.134	4776
	2009	20.6	0.114	11369
	2010	18.5	0.417	10326

Table 3.2.18. *Western Adriatic Sea:* Parameters of the models used to fit the indicator experimental variograms.

Species	Year	Abundance level	Nugget	Psill	Range (nm)
Anchovy	2008	High	0.1	0.15	13
	2010	Average	0.07	0.16	9
	2009	Low	0.12	0.12	15
Sardine	2009	High	0.029	0.057	6
	2010	Average	0.08	0.015	10
	2008	Low	0.07	0.016	9

Table 3.2.19. *Western Adriatic Sea:* For different inter-transect (IT) distances: precision (CVgeo) of the determination of the area occupied by the high values computed by RGeoS and the common Rscript; variance estimation, percentage of variance estimate by the nugget effect and precision (CVgeo). In bold, results for the actual sampling design.

Species	Year	Abundance	IT (nm)	RGeoS CVgeo	% var explained by nugget	EVA2 CVgeo
Anchovy	2008	High	5	0.031	65.5	0.021
			10	**0.054**	**37.3**	**0.047**
			20	0.102	19.4	0.090
	2010	Average	5	0.038	48	0.027
			10	**0.069**	**24.5**	**0.060**
			20	0.129	13.5	0.111
	2009	Low	5	0.035	85.9	0.024
			10	**0.054**	**57.3**	**0.048**
			20	0.114	25.9	0.095
Sardine	2009	High	5	0.099	49.1	0.033
			10	**0.181**	**20.5**	**0.149**
			20	0.321	13.1	0.279
	2008	Low	5	0.054	26.2	0.026
			10	**0.119**	**8.6**	**0.115**
			20	0.312	2.5	0.230
	2010	Average	5	0.041	55.8	0.029
			10	**0.072**	**29.6**	**0.064**
			20	0.135	16.1	0.118

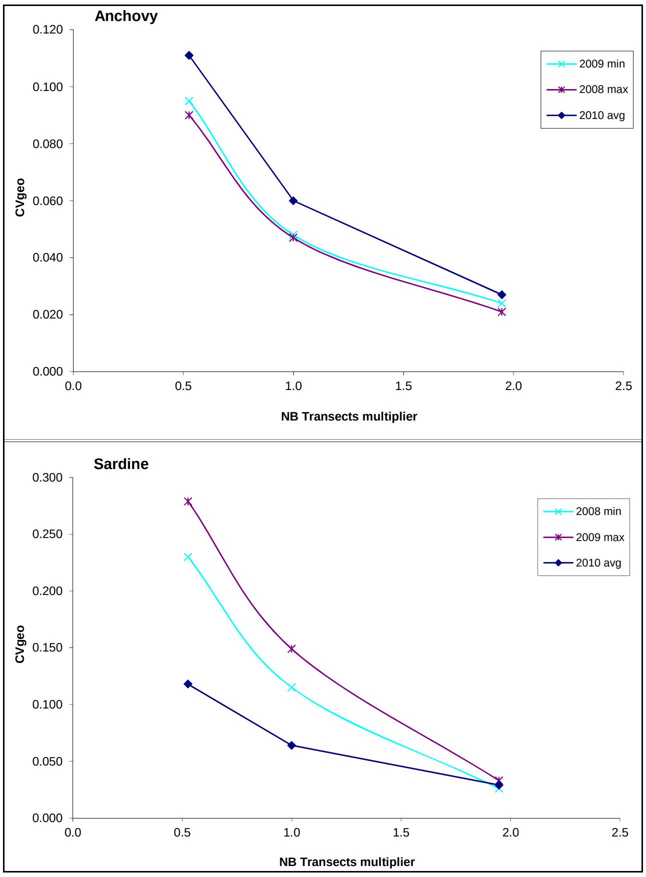


Figure 3.2.29. *Western Adriatic Sea:* Variability of CVGeo (EVA estimated) with inter-transect distance multiplier for anchovy and sardine in the three years.

Gulf of Lions

Study area

Pelmed surveys cover the gulf of Lions (3300 nm^2) and are performed annually in July since 1995 with N/O L'Europe to estimate the spatial distribution and abundance of all pelagic fish, including anchovy and sardine which are the target species. The survey design is made of parallel transects perpendicular to the isobath from 10 m to 200 m depths. The inter-transect distance is 12 nm. The EDSU is 1 nm. The surveying acoustic vessel speed is 8 knots. Echo traces are identified with a pelagic haul. Acoustic recording and trawl hauls are performed by day-time. The survey lasts approximately 26 days. The echosounder used is SIMRAD ER60. Frequencies used are 38, 70 and 120 kHz. The pulse duration is 1024 ms. The echosounder is calibrated at each survey. Data are saved in HAC format. The threshold for acquisition is –80 dB and the threshold for processing for the assessment is –60 dB. In the present analysis, the variable considered are the s_A values (units in m^2/nm^2) identified to anchovy and sardine for the years 2003 to 2007.

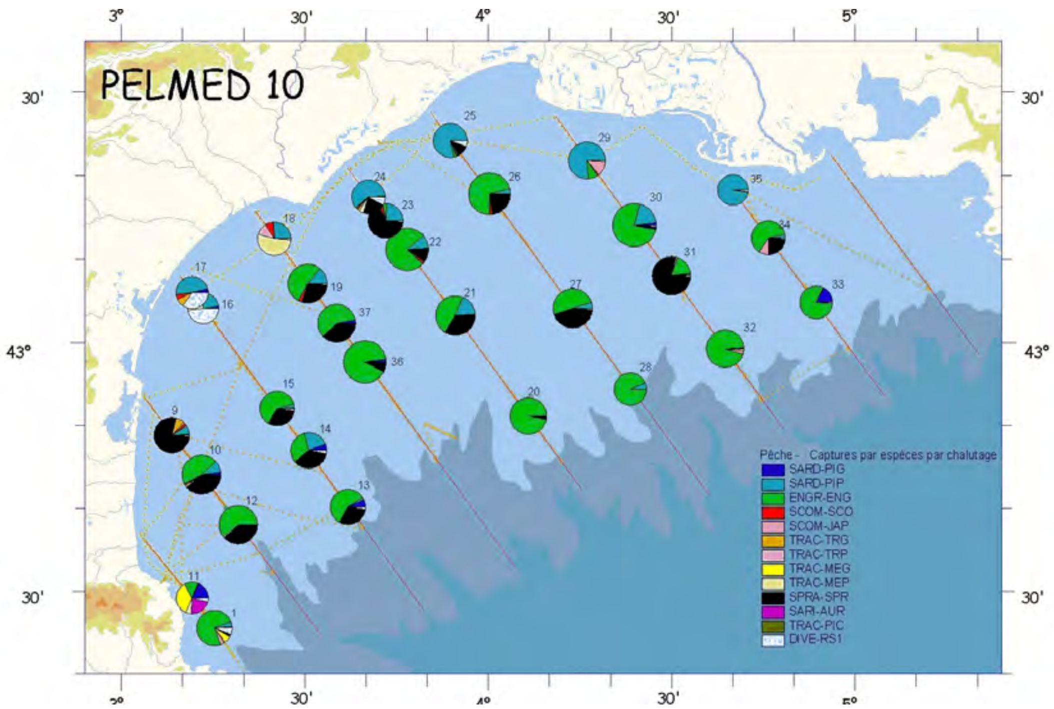


Figure 3.2.30. *Gulf of Lions:* Map of the study area and sampling design, 2010 survey as example showing the proportion of species in the trawl hauls.

Data analysis

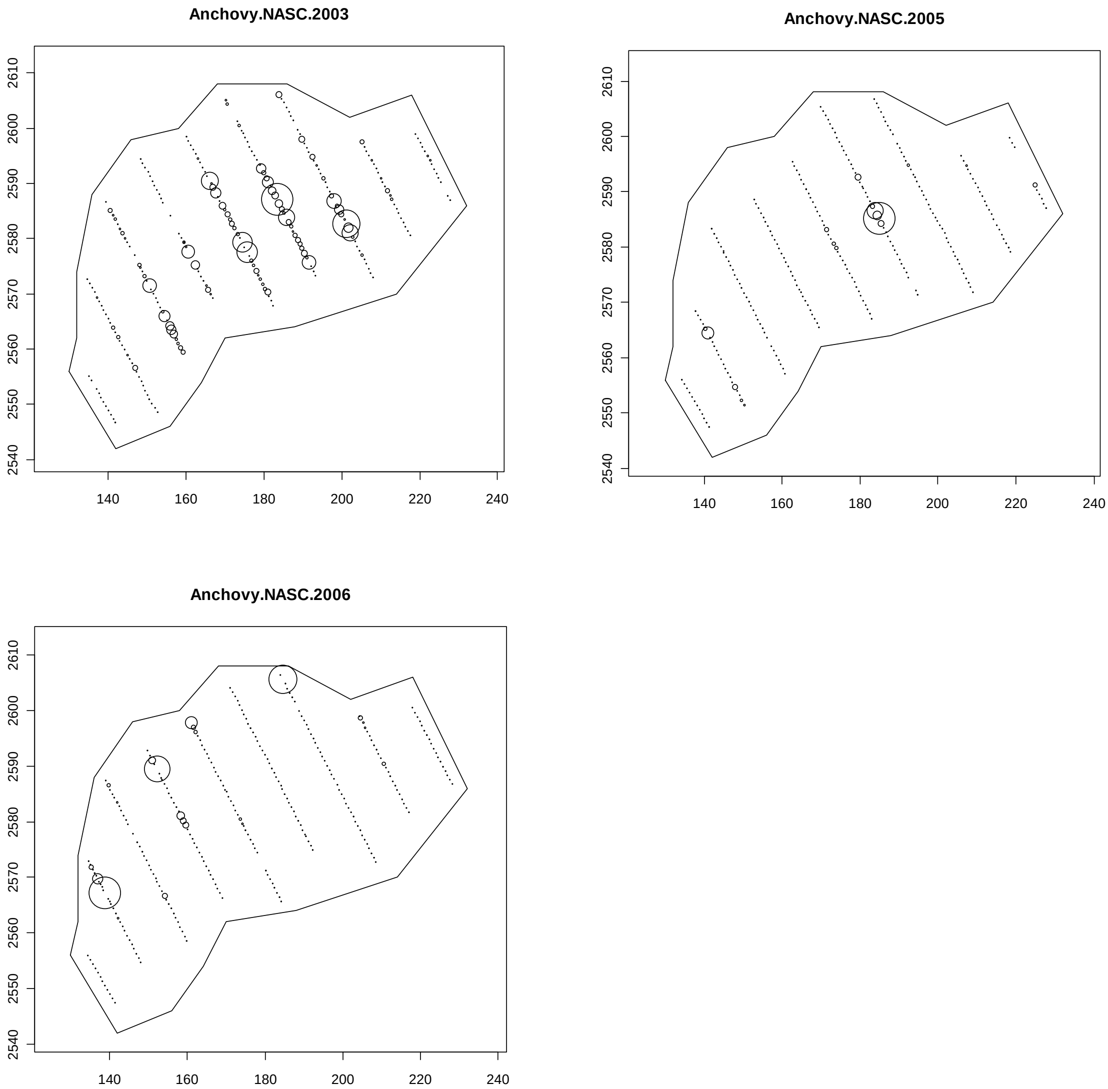


Figure 3.2.31. *Gulf of Lions:* Maps of anchovy distribution in year of a) high (2003), b) low (2005) and c) average (2006) abundance. Coordinates are in projected units (lat*60, long*60*cos (latmoy)).

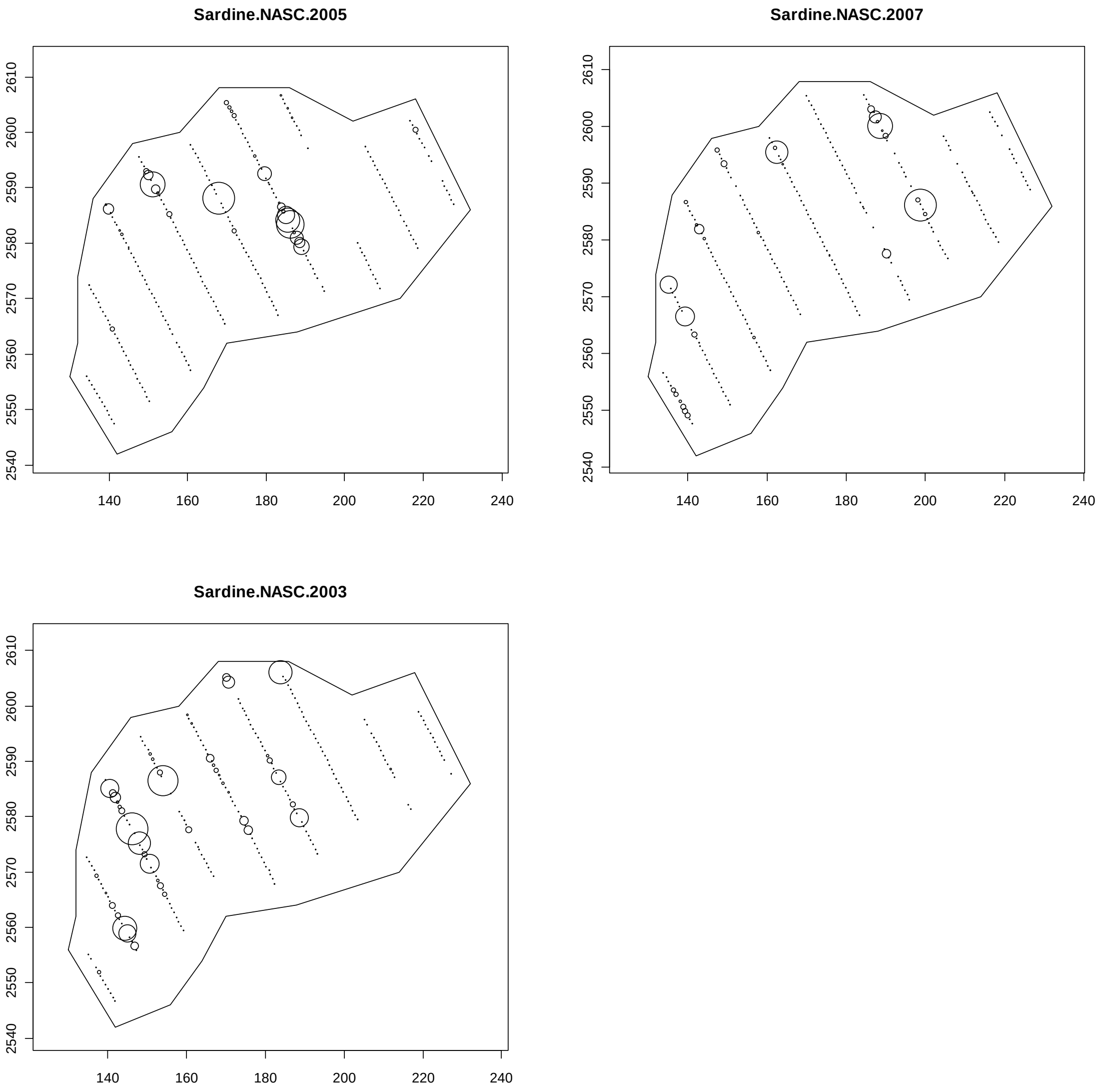


Figure 3.2.32. *Gulf of Lions:* Maps of sardine distribution in year of a) high (2005), b) low (2007) and c) average (2003) abundance. Coordinates are in projected units (lat*60, long*60*cos (latmoy)).

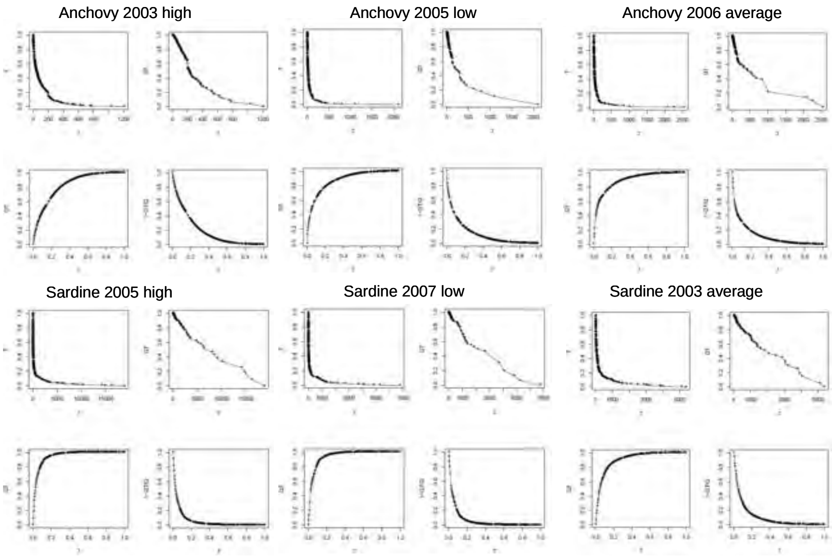


Figure 3.2.33. *Gulf of Lions:* Cumulative curves for a) anchovy and b) sardine along the three years of sampling.

Results and discussion

Indicator variography results showed that both anchovy and sardine patches were well structured for the selected threshold (range from 8 to 18 nm). The nugget (pure random structural component) remains high, representing 50% and more of the spatial variation. This can be due to local hotspots and time variability, which the survey design has difficulty to resolve. Despite the inter annual variability in terms of range, sill, nugget and abundance; CVgeo values related to the currently used inter-transect distance were quite stable and low, ranging from 0.10 to 0.14 for anchovy and from 0.17 to 0.21 for sardine. Pronounced changes in CVgeo values were not recorded by using half of currently used inter-transect distance, while doubling it resulted in almost double CVgeo values. Changes in range values do not seem to be related to abundance values for both species. Similarly, neither spreading area seems to be related to abundance for both anchovy and sardine. Both species presented comparable variograms in terms of range i.e., 8 to 18 nm for sardine and 8 to 15 for anchovy. The contribution of the nugget (pure random spatial component) to the survey precision increased with increasing sampling effort. However, nugget effect captured in most cases over 50% of the spatial component; besides in the year with minimum anchovy abundance that it was very low, implying that the structural component was not well resolved by the survey spatial coverage in this particular case.

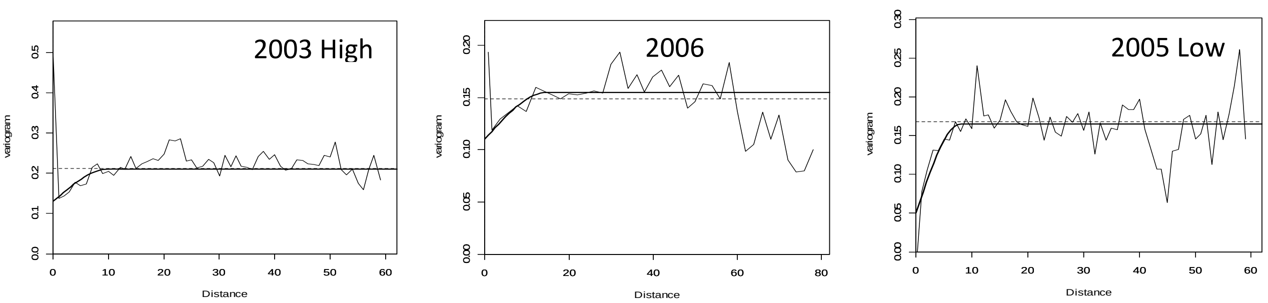


Figure 3.2.34. *Gulf of Lions:* Experimental and model fitted indicator - variograms of anchovy in the three selected years.

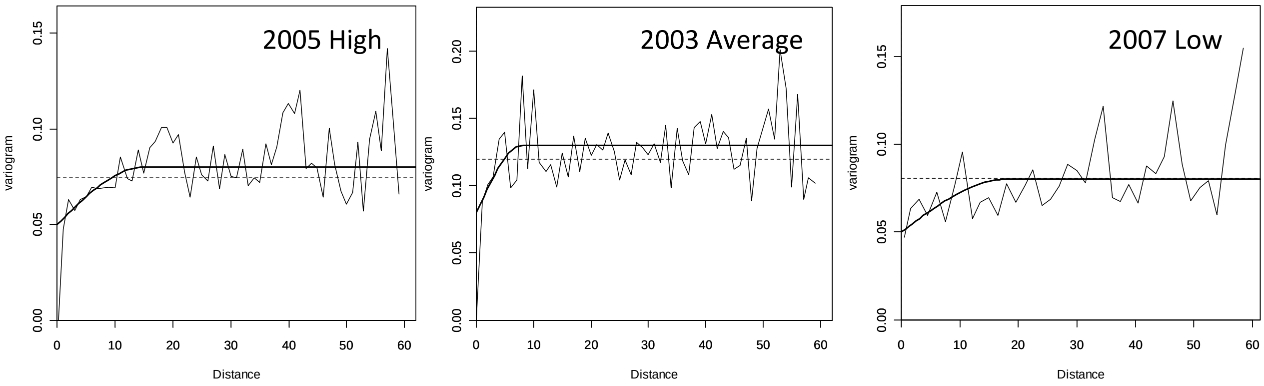


Figure 3.2.35. *Gulf of Lions:* Experimental and model fitted indicator - variograms of sardine in the three selected years.

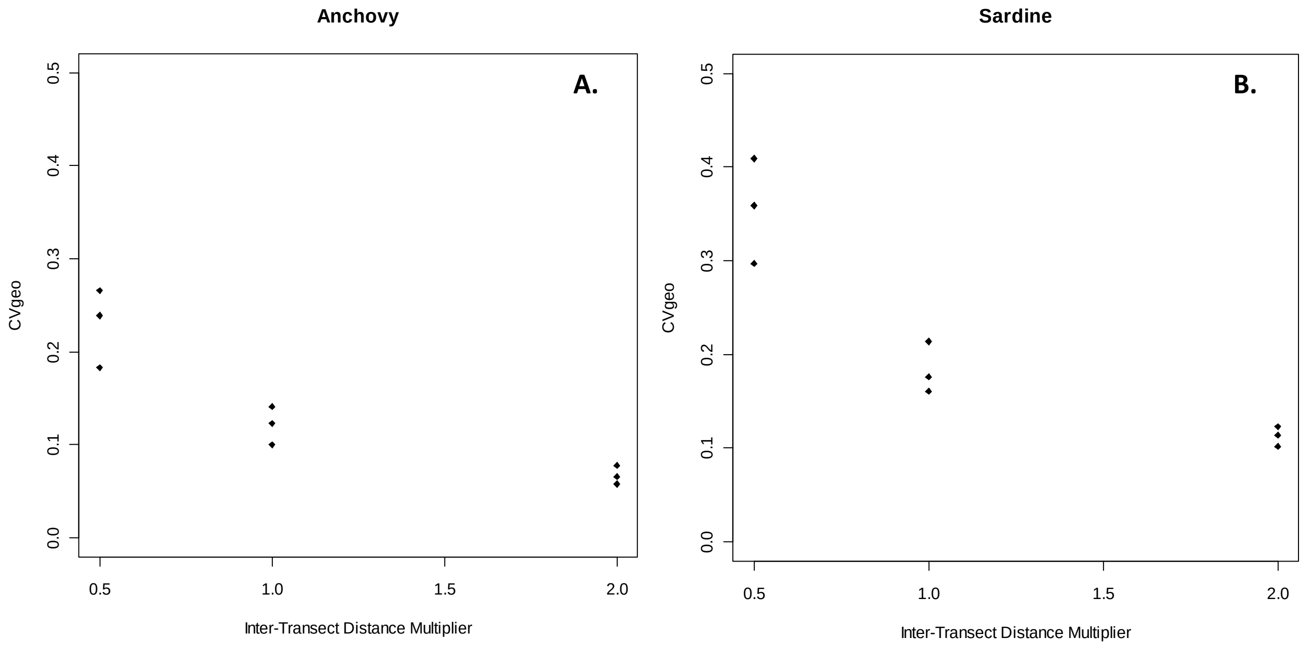


Figure 3.2.36. *Gulf of Lions:* Variability of CVGeo (EVA estimated) with inter-transect distance multiplier for anchovy (above) and sardine (below) in the three years.

Table 3.2.20. *Gulf of Lions:* Applied threshold retaining 80% of the abundance and probability of a value of being bigger than the applied threshold.

Species	Year	s	P(Z≥s)
Anchovy	2003	107.11	0.300
	2005	51.87	0.213
	2006	86.86	0.184
Sardine	2005	2084.62	0.081
	2007	791.49	0.088
	2003	491.76	0.139

Table 3.2.21. *Gulf of Lions:* Mean s_A, spreading area (SA) and total biomass (in tons).

Species	Year	Mean s_A	Spreading area: SA	Biomass
Anchovy	2003	102.7	0.352	ca. 58000
	2005	54.2	0.251	ca. 20000
	2006	82.8	0.218	ca. 25000
Sardine	2005	679.2	0.105	ca. 230000
	2007	237.7	0.114	ca. 50000
	2003	325.0	0.186	ca. 52000

Table 3.2.22. *Gulf of Lions:* Parameters of the spherical models used to fit the indicator experimental variograms.

Species	Year	Abundance level	Nugget	Sill	Range (nm)
Anchovy	2003	High	0.13	0.08	10
	2006	Average	0.12	0.045	15
	2005	Low	0.05	0.115	8
Sardine	2005	High	0.05	0.03	15
	2003	Average	0.08	0.05	8
	2007	Low	0.05	0.03	18

Table 3.2.23. *Gulf of Lions:* Results for different inter-transect (IT) distances within the polygon of estimation (i.e., different survey efforts): relative precision (CVgeo) of the estimation of the area occupied by the high values (P(Z≥s): Table 1) as computed by EVA2. In bold, results for the actual sampling design.

Species	**Year**	**Abundance**	**IT (nm)**	**NB Transects**	**% var explained by nugget**	**EVA2 CVgeo**
Anchovy	2003	High	6	17	0.800	0.058
			12	**9**	0.489	**0.100**
			24	5	0.278	0.183
	2006	Average	6	17	0.903	0.078
			12	**9**	0.725	**0.123**
			24	5	0.407	0.240
	2005	Low	6	17	0.441	0.066
			12	**9**	0.178	**0.141**
			24	5	0.100	0.267
Sardine	2005	High	6	17	0.869	0.123
			12	**9**	0.661	**0.214**
			24	5	0.301	0.410
	2003	Average	6	17	0.749	0.102
			12	**9**	0.443	**0.176**
			24	5	0.293	0.297
	2007	Low	6	17	0.884	0.114
			12	**9**	0.660	**0.161**
			24	5	0.331	0.356

3.2.2 Overall Discussion, Conclusions, Recommendations, Difficulties encountered

The optimization of the design was evaluated only in terms of the spatial coverage of the acoustic transects. The estimation variance for other designs than the one currently in use was calculated as well as for the same design but other effort e.g., number of transects, depending on the case studies. These computations were possible, because the estimation variance depends on the estimated variogram model and the sampling configuration only, not on the data values (Petitgas, 2001). For most of the survey series, the design was made of parallel regularly spaced transects. We then explored the effect of increasing / decreasing the number of transects and inter-transect distance. In the Adriatic Sea, the design was changed from zigzag transects to parallel ones. We tested how that change affected survey precision. In the North Evoikos gulf, the design was a mix between zigzag and parallel transects due to the complexity of the coast line. Different combinations of zigzag and parallel transects were generated and their precision evaluated. In computing survey precision (CVgeo) for different survey designs, the variogram models and procedures used were the same as for computing the CVgeo of the design currently in use.

The twofold methodology followed (i.e., traditional variography and indicator approach) concerning the application of geostatistical analysis proved to be effective and thoroughly examined the suitability of currently applied survey design in the different study areas. First the spatial structure of the target species in the study areas was analyzed by means of variogram modeling on raw data. In each study area the type of applied variogram was adapted to the peculiarities of the local populations. Subsequently, enhanced spatial analysis and the indicator function approach were applied in order to assess the geometric perspective of fish patches in terms of the applied survey design.

The applied framework of linear geostatistics was flexible and robust enough to allow the analysis of all case studies, extract the underlying spatial correlation structure, estimate survey precision for the current survey design and evaluate other designs. In most cases, only one correlation range (one spatial component) was modelled on the variogram that was often close in value to the inter-transect distance. As a consequence the survey designs seemed adapted to the underlying spatial correlation range.

The indicator approach revealed that anchovy and sardine populations in North Aegean Sea (i.e., Thracian Sea and Thermaikos gulf) present a high degree of aggregation, that especially in years of low abundance results into high uncertainty in the estimates. Subsequently, improvement of the current survey design, applying smaller inter-transect distance could be a suggestion that would benefit the precision of survey estimates in this study area. Concerning the acoustic surveys in the Spanish Mediterranean waters, the Strait of Sicily, the western part of the Adriatic and the Gulf of Lions, the current survey design seems to provide quite precise survey estimates. In the Spanish Mediterranean waters, the North Aegean Sea and the Strait of Sicily the currently applied survey design seems to resolve adequately the existing spatial structure of fish aggregations (i.e., contribution of nugget to the estimation variance is generally above 70%); whereas in the western part of the Adriatic this percentage was quite low being below 30% in the majority of the years, implying that the structural component is not likely well resolved by the survey spatial coverage. In the Gulf of Lions the existing survey design seems to resolve moderately well the structural component of fish aggregations, indicating that there is potentially some room for improvement.

More specifically, key elements for the interpretation were the variogram model parameters (nugget and correlation range) and the contribution of the nugget component to the estimation variance. The variogram parameters revealed how the survey design resolved the spatial structure. The nugget percent in the estimation variance quantified whether the spatial coverage was enough. In the Aegean case studies, the variogram range was short and the nugget component important, which indicated that decreasing inter-transect distance could help identify better the short range spatial structure. In contrast, in the Adriatic Sea, the variograms were well behaved with long correlation range and small nugget, meaning that the survey design resolved well the spatial components. In between these case studies, the other case studies showed examples of variograms with correlation range values larger or fluctuating around the inter-transect distance and with high nugget components ca. 50% of the variance. Such high variability at very short spatial scale on the variogram can be due to local hotspots and also time variability, which the survey design has difficulty to resolve. It is questionable therefore whether controlling time variability by dedicated experiments could be more appropriate than decreasing the inter-transect distance to optimise survey design from the current situation. In addition, it should be clarified that any change of existing survey design should also take into consideration other parameters, like the time availability of the survey vessel and time to spend at sea as well as the cost of the survey that are often practical impediments for reducing the inter-transect distance and increasing the number of transects.

AcousMed results related to the optimization of the currently applied survey design in acoustic surveys will be presented and discussed into the 5th annual meeting of the PanMediterranean Acoustic Surveys (MEDIAS) in order to incorporate project suggestions to MEDIAS protocol.

During the workshops held within the framework of this task a small part of geostatistical methods was used only, which was sufficient to estimate survey precision. No exercise on mapping (kriging) was applied. So, an ICES training course was recommended in order to allow practicing with a broader range of geostatistical tools.

3.2.3 References

Giannoulaki, M., Machias, A., Koutsikopoulos, C.and Somarakis, S., 2006. The effect of coastal topography on the spatial structure of anchovy and sardine. *ICES Journal of Marine Science,* 63: 650–662.

ICES. 1997. Report of the Workshop on Time Variability and Space-Time Interaction in Fisheries Acoustic Surveys. pp.35-43, In: WGFAST report. ICES CM1997/D:5.

Matheron, G. 1971. The theory of regionalized variables and their applications. Les Cahiers du Centre de Morphologie Mathématique, Fasc. 5. Fontainebleau, Ecole Nationale Supérieure des Mines de Paris.

Petitgas, P. 1993. Geostatistics for fish stock assessments: a review and an acoustic application. ICES Journal of Marine Science, 50: 285-298.

Petitgas, P. 1998. Biomass dependent dynamics of fish spatial distributions characterized by geostatistical aggregation curves. ICES, Journal of Marine Science, 55: 443-453.

Petitgas, P. 2001. Geostatistics in fisheries survey design and stock assessment: models, variances and applications. Fish and Fisheries, 2: 231-249.

Petitgas, P. and Lafont, T. 1997. EVA2: estimation variance version 2 - a geostatistical software on windows95 for the precision of fish stock surveys. ICES CM 1997/Y:22.

Renard, D. and Bez, N. 2008. RGeoS: Geostatistical package. http://www.cg.ensmp.fr/rgeos/

Renard D. and Bez N., Desassis, Laporte F., 2010. RGeoS: The Geostatistical package. Ecole des Mines de Paris. Free download from www.geosciences.mines-paristech.fr

Rivoirard, J., Simmonds, J., Foote, K., Fernandes, P. and Bez, N. 2000. Geostatistics for estimating fish abundance, Blackwell Science Ltd.

Simmonds, J. and MacLennan, D. 2005. Fisheries acoustics: theory and practice. Blackwell Science, Oxford. 2nd Edition.

Tugores, P., Iglesias, M., Díaz, N., Oñate, D., Miquel, J. and Giráldez, A. 2010. Latitudinal and interannual distribution of the European anchovy (Engraulis encrasicolus) and sardine (Sardina pilchardus) in the western Mediterranean, and sampling uncertainty in abundance estimates. ICES Journal of Marine Science, 67: 1574-1586.

Woillez, M., Rivoirard, J. and Fernandes, J. 2009. Evaluating the uncertainty of abundance estimates from acoustic surveys using geostatistical simulations. ICES Journal of Marine Science, 66: 1377-1383.

4 Harmonization and the optimization of the acoustic methodology (Task 3)

(Involved participants: IFREMER, HCMR, IEO, CNR-ISMAR, CNR-IAMC)

Background/State of the art

Besides the optimization of survey design, within the objectives of the present study is the harmonization and the optimization of the acoustic methodology used in each past acoustic survey in the Mediterranean. This covers three major issues i.e. (a) the Target Strength equation used for the target species in each area, (b) the effect of the time of day on the acoustic and biological sampling as well as (c) the standardization of a common format for acoustic data and the estimated parameters that would allow a comparable presentation of the data for the requirement of the DCR as well as their integration for common analysis.

The target strength (TS) is the main scaling factor required to convert echo intensity to fish density. It is length dependent, normally expressed in the form: $TS = a_i + b_i \, Log10\,(L_i)$ where a_i and b_i are species specific constants for the i^{th} species and L_i is the length expressed in centimeters (Simmonds & MacLennan, 2005). Knowledge of TS and the equations used is of primary importance for acoustic, stock assessment and behavioral studies. It is a stochastic parameter described by a probability distribution. It is species specific, strongly determined by factors such as fish size, the presence and the size of the swimbladder, fish orientation, the physiology of the fish (e.g. gonad, lipids, stomach fullness) (Ona 1990; Machias & Tsimenides 1996). As these factors differentiate per season and area subsequently they differentiate the TS values (Simmonds & MacLennan, 2005; Fréon & Misund, 1999; Szczucka, 2000; Barange *et al.*, 1996). The TS equation applied in acoustic surveys for the target species is a key- issue that could easily result into non comparable biomass estimates among the five different areas.

Furthermore, the effect of the time of day on acoustic and biological data sampling comprises an issue that has raised several contradictions regarding the introduction of error in the abundance estimates (ICES, 1998; Iglesias *et al.*, 2003; Zwolinski *et al.*, 2007). The latter might largely depend on parameters, such as species behavior. Small pelagics are known to exhibit diel vertical migrations, forming dense schools during day-time and dispersing at loose aggregations during night-time (Masse, 1996; Fréon & Misund, 1999; Giannoulaki *et al.*, 1999; Szczucka, 2000; Zwolinski *et al.*, 2007). This diurnal behavior of fish schools makes fish either unavailable to the acoustic apparatus used or difficult to distinguish acoustically from other scatterers, which could generate a degree of bias on the echo density used for abundance estimates (ICES, 2005). Variations in the schooling behavior and in the factors affecting the diel migration of small pelagics might further differentiate the degree of bias in acoustic sampling between night-time and day-time among the different areas (Iglesias *et al.*, 2003; Zwolinski *et al.*, 2007). Within the purpose of this study is the clarification of the effect of the time of day on acoustic sampling.

Acoustic surveys are strongly connected to midwater trawl sampling. It is common practice that fishing trawls are carried out within the standard framework of an acoustic survey. However they are not held regularly but rather opportunistically on the unknown echo traces or on dense fish aggregations (Simmonds & MacLennan, 2005). The allocation of echo-traces to species is governed by the catches of trawl hauls. The trawl hauls are also used for biological information such as length frequency and age distribution of the target species population. Therefore, different species due to their diurnal behavior might present different catchabilities (ICES, 2005), and the question raised is whether the catch composition of trawl during day-time or night-time (i.e., species and length composition) is representative of the true population mixture. Within the purpose of this project is to examine the difference between night and day-time hauls in terms of species catch composition and length frequency distribution of the target species.

The standardization of acoustic methodology also involves the need for a common format of a database specialized for acoustic surveys to facilitate survey needs and the exchange of comparable data between the different parties. For this purpose, within the framework of the current study, a common protocol on the format of acoustic data from all areas will be suggested for incorporation into the MEDIAS protocol.

4.1 Target strength equations for anchovy and sardine (Subtask 3.1.)

(Lead participant: IEO, Involved participants: IFREMER, HCMR, IEO, CNR-ISMAR, CNR-IAMC)

Objectives

In the Mediterranean acoustic surveys we currently lack one common TS equation for anchovy and sardine.

Target strength (TS) is the main scaling factor required to convert echo intensity to fish density. It is length dependent, normally expressed in the form:

$$TS = a_i \, Log10\,(L_i) + b_i \quad (3)$$

where a_i and b_i are species specific constants for the ith species and L_i is the length expressed in centimetres (Simmonds & MacLennan, 2005). Knowledge of TS and the equations used is of primary importance for acoustic, stock assessment and behavioral studies.

According to the proposal, the objectives of this sub-task were to use available acoustic data (2002-2006) collected from 38 kHz split beam echosounder, deriving from all five areas (i.e., the Iberian coast, the Gulf of Lions, the western part of the Adriatic Sea, the Strait of Sicily and the Aegean Sea) in order to re-evaluate currently applied TS equations in the different areas and estimate common *in situ* TS equations for anchovy and sardine. In additional to what it was initially proposed, due to the fact that the available appropriate historic acoustic data were not found adequate, appropriate acoustic data from previous or recent years' acoustic surveys (2000-2011) were also gathered and used for the purposes of this subtask.

4.1.1 Work achieved

According to the proposal, 3 workshops were carried out within the framework of this subtask. In the first year of the project, two workshops on TS analysis were carried out. The first one was held during the kick off meeting of the project in March 2010 at Capo Granitola (Italy) hosted by CNR-IAMC. During this workshop a preliminary review of available data from all study areas was done and a common protocol for the estimation of initial *in situ* equations analysis was agreed in order to achieve compatibility of results. Moreover, based on data available from each area/partner, it was agreed to proceed on *in situ* estimations of TS per area before going into a common equation.

Initial results based on this protocol were presented and discussed in the second meeting-workshop that was held in 22nd November 2010 in Palma de Mallorca (Spain) hosted by IEO. This second workshop was part of a joined meeting with the annual ICES WGACEGG meeting that comprised an initial step to bring together scientists involved in acoustic surveys in the Atlantic and the Mediterranean, promoting the collaboration, the exchange of ideas, the identification of common problems and solutions between ICES and Mediterranean surveys. During this workshop initial results from the Mediterranean areas were presented. A review on TS equations was presented as well by Dr. M. Doray (IFREMER). The protocol agreed in the first meeting was re-evaluated and adjusted based on problems encountered, the plan of work for the next year was also agreed and the basis for a future collaboration between the two bodies towards solutions to common problems was set.

A third workshop in accordance to the proposal was organized during the third project meeting that was held in 14th December 2011 in Iraklion (Greece) hosted by HCMR. During this workshop the progress of the work in each Mediterranean area was presented, problems encountered were discussed and data were processed in order to examine if a single, common equation per species could be estimated.

4.1.2 Methodological approach followed

A common protocol to select appropriate acoustic data and analyze available information in a standardized way was agreed in the kick off meeting of the project, re-evaluated in the second meeting and is presented below. The selection of appropriate insonified hauls was based on the principle that for the estimation of *in situ* equations for TS it is essential to have fish communities scattered enough to limit multiple targets detection, roughly monospecific fish assemblages, distinct length modes in haul catches and a clear relationship between modes in TS distribution and catches distribution.

The general procedures suggested in the agreed protocol, were based on the methodology described and the parameters suggested in respective literature (e.g., Foote, 1979; Simmonds & MacLennan, 2005; Henderson, 2005; Kasatkina, 2009; ICES WGACEGG, 2008 report).

Specifically, the following were suggested and agreed:

- Only monospecific night hauls (i.e. >80% of anchovy or sardine) or hauls with discrete modes on TS and TL distributions were used
- The use of acoustic data from 38 kHz only. Data from 120 kHz were used on an auxiliary basis for plankton filtering
- The software for TS analysis was Myriax Echoview
- A common TS threshold for acquisition was set at -60 dB, decreasing depending on TS distribution per haul
- Analysis was applied on single targets and in an auxiliary basis on fish tracks
- The split beam method 2 was used to detect single targets and fish tracks in the case of Simrad EK60 and Biosonic DTX echosounder and split beam method 1 in the case of Simrad EK500.
- Acoustic parameters for single targets selection were set following those suggested in WGACEGG 08 for the Bay of Biscay (ICES WGACEGG report 2008, p. 149)
- Myriax Echoview default values were suggested for acoustic parameters associated with fish tracks selection.
- Single targets and/or fish tracks data were selected from the hauling range area and/or the entire water column depending on bottom depth i.e. selection of the entire water column in case of shallow waters
- Concerning the TS distribution per haul bin range of 0.1 dB was suggested.

- Concerning the TL distribution per haul bin range of 0.5 cm was suggested
- Concerning the matching process of TS-TL distributions a twofold approach was suggested:
    1) matching modal TL and TS based on an automatic method suggested by Kasatkina (2009), and
    2) matching mean TL and mean TS but maintaining TS distribution between -60 dB and -44 dB.
- Two kind of regressions were suggested to be conducted for each data set:
    1) a best-fit regression, and
    2) a regression with a slope forced to 20 (Foote, 1979).
- Comparison of both equations to test whether slopes of the best-fit regressions are significantly different from 20.
- Evaluation of regression fit based on least squares.
- Single targets will be filtered based on major axis angle.
- Fish tracks will be filtered based on the tortuosity value.

Moreover a common export format to allow *post hoc* analysis was agreed.

Kasatkina's algorithm allowed matching TS to length frequency distribution in an objective, automatic way instead of being subjective and manually selecting modes in the distribution. An Excel template was circulated for this purpose during the second workshop in order to allow the standardization of the analysis. However, where the distributions were clearer the second process was used.

Specifically, in each case study depending on available data the *in situ* TS estimation was based on the following:

In the Adriatic Sea, the available set of monospecific night hauls concerning anchovy included hauls where acoustic data were recorded by a Simrad EK500 echosounder (period 2006-2008) as well as hauls where acoustic data were recorded by a Simrad EK60 (period 2009-2011). In the first case the "Sv (volume backscatter) to TS" operator was applied in Myriax Echoview and then single beam method 1 was applied for single targets identification. In the second group of hauls (2009-11), the split beam method 2 was applied for single target identification. In a successive step, the TS frequency distribution was compared with the respective length frequency distribution based on the algorithm proposed by Kasatkina (2009). This procedure provided a set of measurements (TL_{mean}, TS_{mean}) suitable for estimating the parameters of the TS function. The best-fit regression and a regression with a slope forced to 20 were estimated for each species.

Concerning the Aegean Sea, TS data were collected from 2004 to 2010 with a Split beam Biosonic DTX echosounder. The algorithm proposed by Kasatkina (2009) was used to match TS and Total Length frequency distribution. This procedure provided a set of measurements (TL_{mean}, TS_{mean}) suitable for estimating the parameters of the TS function.

In Spanish Mediterranean waters, TS data were collected from 2003 to 2009 during seven acoustic surveys (Ecomed survey) carried out mainly in late autumn (November-December) within the Spanish

Mediterranean continental shelf. During the period 2003-2005 the acoustic data were recorded with Simrad EK500 and from 2006 to 2009 with EK60. In the first case the “Sv to TS” operator was applied in Myriax Echoview due to the lack of E telegrams corresponding to TS data and then single beam method 1 was applied for single targets identification. In the second group of hauls (2006-2009), the split beam method 2 was applied for single target identification. All trawls were carried out with a midwater trawl net, with a 20 mm mesh codend. Trawl location and depth was determined (from 2006 to 2009) by the use of a netsonder FR20/25 (Simrad). Both fish tracks and single targets were estimated from the selected hauls. However, the fish tracking filtering from the fishing range resulted into very scarce TS data, so TS data from the entire water column were selected (with the subsequent error added).

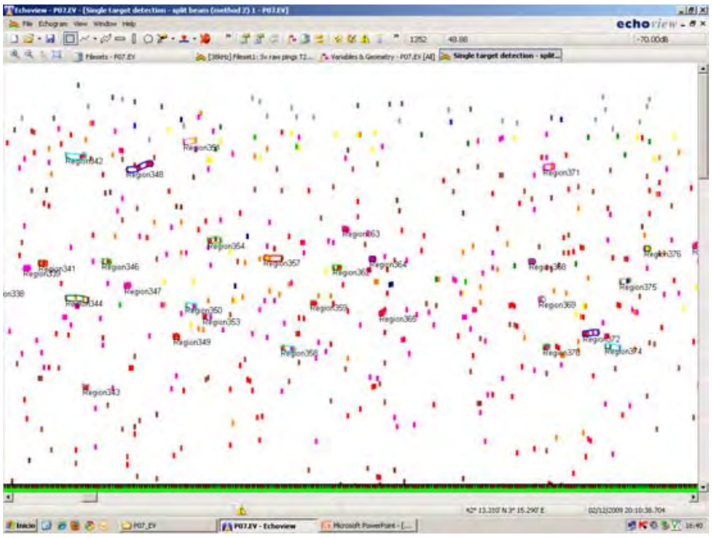


Figure 4.1.1 Fish track data on echogram (Echoview software)

In a successive step, the TS frequency distribution was compared by matching the mean TL and mean TS with the respective length frequency distribution. This procedure provided a set of measurements (TL_{mean}, TS_{mean}) suitable for estimating the parameters of the TS function. In the case of fish tracks, minimum and maximum TS data were additionally included in the data set to cover the stochastic variation in analysis (MacLenan and Menz, 1996). The best-fit regression was estimated for each species.

Concerning the Strait of Sicily, TS data were collected from 2002 to 2011 during seven acoustic surveys. In the case of acoustic data recorded with Simrad EK500, the “Sv to TS” operator was applied in Myriax Echoview and then single beam method 1 was applied for single targets identification. In the case of acoustic data recorded with Simrad EK60 the split beam method 2 was applied for single target identification. This procedure provided a set of measurements (TL_{mean}, TS_{mean}) suitable for estimating the parameters of the TS function. Among the 10 monospecific night-time hauls, acoustic data were collected only in five hauls were analyzed; thus the small number of hauls (3 for anchovy and 2 for sardine) prevented the application of a specific regression for this area.

Finally, towards a synthetic perspective for the estimation of a single TS equation, TS –TL values from all areas were merged. TS (i.e., logarithmic measurements) estimates were back transformed to backscattering cross-section values. TS is a stochastic variable and a range of estimations for a given Length is expected, thus average TS values per length class at 0.5 cm interval were calculated based on the pooled data from different areas.

4.1.3 Results

4.1.3.1 Literature review on TS equations

A review of TS equations adapted in Atlantic and in Mediterranean waters per Institute-study area is presented in Table 4.1.1.

During the second workshop a study on literature review for TS of clupeids was presented by Dr M. Doray (IFREMER) as summarized below.

Table 4.1.1 *b20* values used for anchovy and sardine acoustic biomass assessment in Europe per Institute.

b20	sardine	anchovy
IFREMER	-71.2	-71.2
IEO	-72.6	-72.6
AZTI	-72.6	-72.6
IPIMAR	-72.6	-72.6
CNR-IAMC	-70.51	-75.3
CNR-ISMAR	-72.5	-74.6
HCMR	-72.6	-71.2
IOF (Croatia)	-72.5	-74.6

TS~length equations established for clupeid fish are shown in Figure 4.1.2. These equations are relatively concentrated close to the origin of the PCA plane defined with the equations whose *a* coefficient is set to 20 (Figure 4.1.3), except for a Japanese anchovy studied at the 200 kHz frequency, that is clearly segregated. Distributions of b_{20} coefficients per species are shown in Figure 4.1.3. TS~length equations established for anchovy and sardine are shown in Figures 4.1.4 and 4.1.5.

In the case of anchovy, TS~length equations were established for different species in South Africa (*Engraulis capensis: in situ* direct TS measurements by Barange *et al.*, 1996), Peru (*Engraulis rigens*: cage experiments by Guttierez and MacLennan, 1998) and Asia (*Engraulis japonicus*: cage experiments by Kang *et al.*, 2009; in situ direct TS measurements by Zhao *et al.*, 2008 and Sawada *et al.*, 2009). TS~length equations commonly used for the acoustic assessment of European anchovy, *Engraulis encrasicolus*, stocks include a generic equation for physostomous fish derived using all methods (Foote, 1987) and an equation for clupeids, based on *in situ* direct TS measurements of a mixture of herring and sprat (ICES, 1983). Generic equations in use for *E. encrasicolus* provide intermediate values, between higher-TS equations obtained for *E. japonicus* (Kang *et al.*, 2009; Sawada *et al.*, 2009; Zhao *et al.*, 2008) and lower-TS equations reported for *E. capensis* (Barange *et al.*, 1996) and *E. rigens* (Guttierez and MacLennan, 1998; Figure 4.1.3).

In the case of sardine, TS~length equations were solely established for *Sardinops ocellatus*, based on *in situ* direct TS measurements conducted in South Africa (Barange *et al.*, 1996), and for *Sardinops sagax*, based *in situ* direct TS measurements in Peru (IMARPE unpublished data). TS~length equations commonly used for the acoustic assessment of the European sardine, *Sardina pilchardus*, are the same as those used for European anchovy (Figure 4.1.4). TS equations established for southern hemisphere sardine species provide lower TS values than generic ones (Figure 4.1.5).

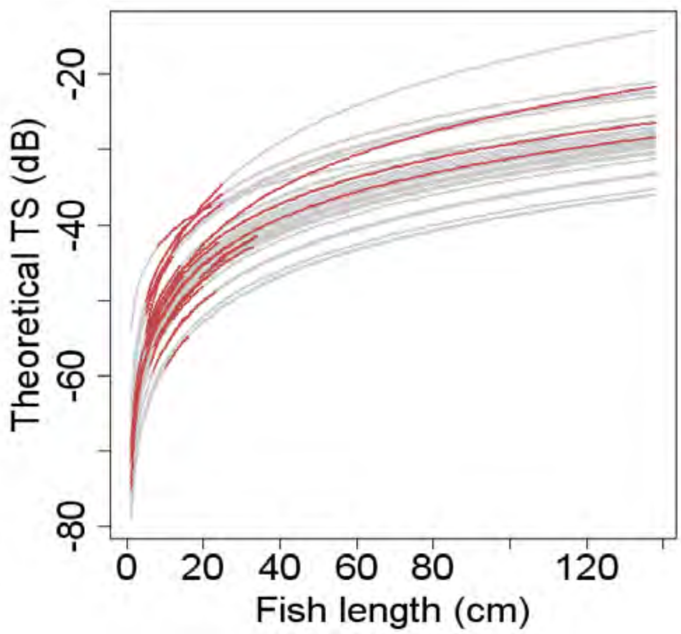


Figure 4.1.2. TS~length equations for clupeid fish. Red line: TS~length curve for the studied fish length range; grey lines: TS~length curve outside the studied fish length range.

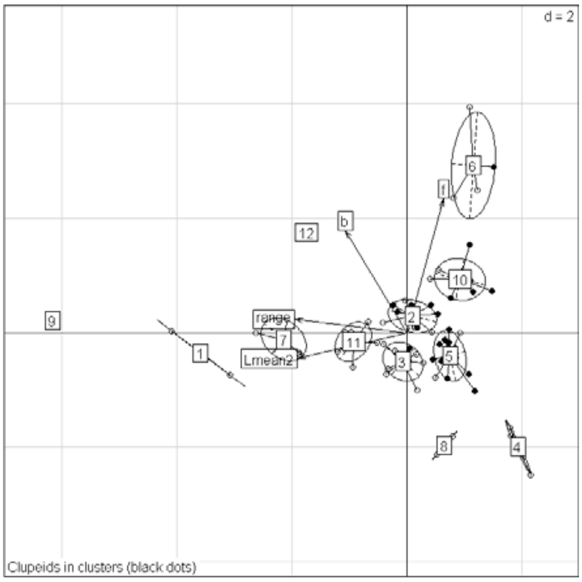


Figure 4.1.3. Clupeid fish equations (black dots) in the Principal Component Analysis (PCA) first eigenvectors plane defined for TS~length equations with *a* set to 20 (dots).

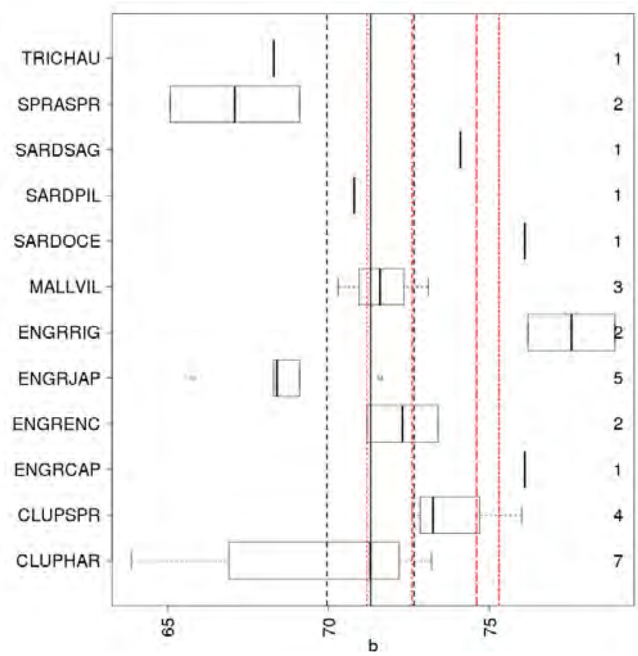


Figure 4.1.4. Boxplots of b values established for clupeid species. TRICHAU: *Trichiurus haumela*; SPRASPR: *Sprattus sprattus*; SARDSAG: *Sardinops sagax*; SARDPIL: *Sardina pilchardus*; SARDOCE: *Sardinops ocelattus*; MALLVIL: *Mallotus villosus*; ENGRRIG: *Engraulis rigens*; ENGRJAP: *Engraulis japonicus*; ENGRENC: *Engraulis encrasicolus*; ENGRCAP: *Engraulis capensis*; CLUPSPR: mix of *Clupea harengus* and *Sprattus sprattus*; CLUPHAR: *Clupea harengus*. Straight black line: mean b values with confidence interval (dashed lines); red lines: b values used for anchovy and sardine acoustic biomass assessment in Europe: red dotted line: b = -71.2; red dotted-dashed line: -72.6; red long dashed line: b = -74.6; red double dashed line: b = -75.3. Number of equation established for each species in the right column.

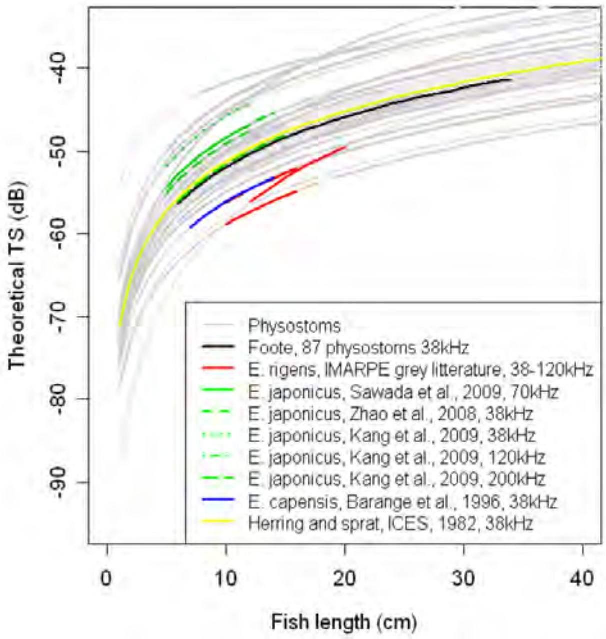


Figure 4.1.5. TS~length equations for anchovy. Colored lines: TS~length curve for the studied anchovy length range; grey lines: TS~length curve of physostomous fish, outside the studied fish length range.

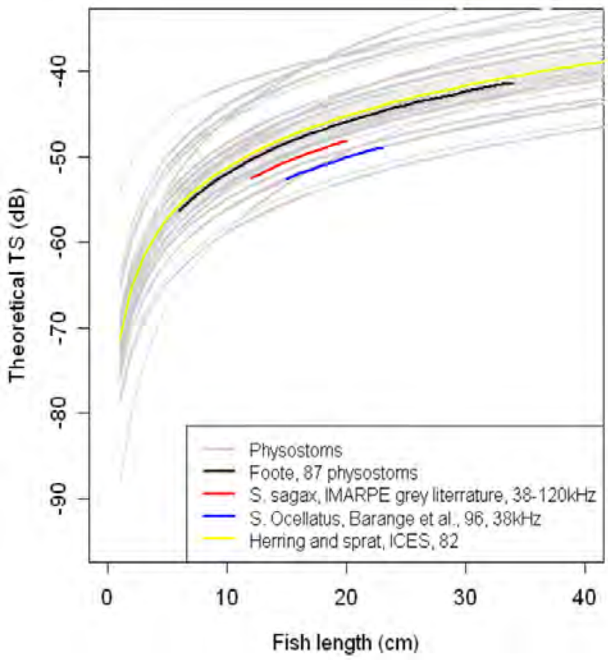


Figure 4.1.6. TS~length equations for sardine. Colored lines: TS~length curve for the studied sardine length range; grey lines: TS~length curve of physostomous fish, outside the studied fish length range.

4.1.3.2 Biomass estimates from past data based on different TS equations

According to the proposal, biomass estimates of past acoustic data were made in each case study (i.e. Aegean, Adriatic, Strait of Sicily, Gulf of Lions and Spanish Mediterranean waters) based on a) currently applied TS equations b) equations with minimum b_{20} values and c) maximum b_{20} values, among those used in the Mediterranean acoustic surveys. As minimum and maximum b_{20} values for anchovy and sardine we used the values currently applied in CNR-IAMC and HCMR. Results are presented in Tables 4.1.2 to 4.1.6.

Table 4.1.2. Aegean Sea (HCMR): Average, standard deviation (sd) and coefficient of variation (CV) of fish stock estimates and ratio, computed over the years 2003–2006 and 2008, with different b_{20} values for anchovy and sardine. Biomass ratio: biomass b_{20} re-estimate/biomass currently applied b_{20}.

		Biomass (in tons)							
Anchovy	***b*₂₀**	**2003**	**2004**	**2005**	**2006**	**2008**	**Mean value**	**Stand. Dev.**	**CV**
	Curr.applied (-71.2)	47838	46508	31852	62685	60601	49897	12444	0.25
	Min (-75.3)	138024	90684	60545	152422	85891	105513	38355	0.36
Biomass ratio (max/Current)		2.89	1.95	1.90	2.43	1.42	**2.12**	0.56	
	Max(-71.2)	47838	46508	31852	62685	60601	49897	12444	0.25
Biomass ratio (min/Current)		1	1	1	1	1	**1**	1	
Sardine									
	Curr.applied (-72.6)	19281	14857	20464	42856	39395	27370.60	12787.85	0.47
	Max (-70.5)	12746	11817	15119	24523	25402	17921.4	6546.80	0.37
Biomass ratio (max/Current)		0.66	0.80	0.74	0.57	0.65	**0.68**	0.09	
	Min (-72.6)	19281	14857	20464	42856	39395	27370.60	12787.85	0.47
Biomass ratio (min/Current)		1	1	1	1	1	**1**	1	

Applying the min b_{20} values the estimates for anchovy biomass were about double than the ones currently estimated by HCMR (ratio ~ 2.12). Concerning sardine, applying the max b_{20} value the estimates for sardine biomass were about half (ratio~0.68) that the ones currently estimated by HCMR (Table 4.1.2).

Table 4.1.3. Gulf of Lions (IFREMER) Average, standard deviation (sd) and coefficient of variation (CV) of fish stock estimates and ratio, computed over the years 2003–2008, with different b_{20} values for anchovy and sardine in the Gulf of Lions. Biomass ratio: biomass b_{20} re-estimate/ biomass currently applied b_{20}.

		Biomass (in tons)								
Anchovy	b_{20}	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Mean value**	**Stand. Dev.**	**CV**
	Curr.applied (-71.2)	29172	25582	16911	26506	21227	22717	23686	3969	0.17
	Min (-75.3)	54319	54906	29678	47919	45311	41286	45570	8565	0.19
Biomass ratio (min/Current)		1.86	2.15	1.75	1.81	2.13	1.82	**1.92**	2.16	
	Max (-71.2)	27124	24663	15617	24820	20379	21341	22324	3752	0.17
Biomass ratio (max/Current)		0.93	0.96	0.92	0.94	0.96	0.94	**0.94**	0.95	
Sardine										
	Curr.applied (-71.2)	111328	232493	289415	102455	90590	89298	152598	78709	0.52
	Min (-72.6)	165736	327868	405463	149040	129589	128933	217771	108359	0.50
Biomass ratio (min/Current)		1.49	1.41	1.40	1.45	1.43	1.44	**1.43**	1.38	
	Max (-70.5)	97064	199446	248602	90099	78405	78236	131975	66938	0.51
Biomass ratio (max/Current)		0.87	0.86	0.86	0.88	0.87	0.88	**0.86**	0.85	

Concerning biomass estimates by IFREMER (based on mixed species echo allocation) applying the min b_{20} values, anchovy biomass was about double than the one currently estimated by IFREMER (ratio ~ 1.9) and applying the max b_{20} value anchovy biomass estimates remained almost the same (ratio ~ 0.9). Concerning sardine, the application of max b_{20} value resulted into one and a half times higher estimate than the ones currently estimated (ratio~1.4). When the max b_{20} value was applied, sardine biomass estimates remained close to those currently estimated (ratio ~ 0.86) (Table 4.1.3).

Table 4.1.4. Spanish waters (IEO): Ratios of the sardine and anchovy biomass estimates computed in Delta Ebro area of the Spanish Mediterranean waters for June 2009 with different b_{20} values. Biomass ratio: biomass b_{20} re-estimate/biomass currently applied b_{20}.

		Biomass (in tons)
Anchovy	***b_{20}***	**Delta Ebro area**
	Curr.applied (-72.6)	19037
	Min (-75.3)	31205
Biomass ratio		**1.63**
	Max (-71.2)	18605
Biomass ratio		**0.98**
Sardine		
	Curr.applied (-72.6)	24971
	Min (-72.6)	26942
Biomass ratio		**1.07**
	Max (-70.5)	16014
Biomass ratio		**0.64**

Concerning biomass estimates by IEO (based on mixed species echo allocation) applying the min b_{20} values, anchovy biomass was almost one a half times higher compared to the one currently estimated (ratio ~ 1.6) and applying the max b_{20} values anchovy biomass estimate remained almost the same (ratio ~ 0.98). Concerning sardine, the application of min b_{20} value resulted into similar estimate for sardine compared to the one currently estimated (ratio~1.07). When the max b_{20} values were applied, sardine biomass estimate was almost half compared to the one currently estimated (ratio ~ 0.64) (Table 4.1.4).

Table 4.1.5. Western Adriatic (CNR-ISMAR): Ratios of the sardine and anchovy biomass estimates computed in three different parts of the western Adriatic Sea for 2009 with the b_{20}s values used by various institutes. Biomass ratio: biomass b_{20} re-estimate/ biomass currently applied b_{20}.

		Biomass (in tons)			
Anchovy	b_{20}	**North Adriatic**	**Central Adriatic**	**South Adriatic**	**Total**
	Curr.applied (-74.6)	310232	98818	133557	542608
	Min (-75.3)	347832	111464	149780	609076
Biomass ratio (min/Current)		**1.12**	**1.13**	**1.12**	**1.12**
	Max (-71.2)	167941	51867	71643	291451
Biomass ratio (max/Current)		**0.54**	**0.52**	**0.54**	**0.54**
Sardine					
	Curr.applied (-72.5)	134210	13807	50682	198700
	Min (-72.6)	135230	13833	50947	200011
Biomass ratio (min/Current)		**1.01**	**1.00**	**1.01**	**1.01**
	Max (-70.5)	112750	13173	44704	170627
Biomass ratio (max/Current)		**0.84**	**0.95**	**0.88**	**0.86**

Concerning biomass estimates by CNR-ISMAR (based on mixed species echo allocation) applying the min b_{20} values, anchovy biomass estimates were almost the same compared to the ones currently estimated (ratio ~ 1.1); and applying the max b_{20} values, anchovy biomass estimates were almost half (ratio ~ 0.54). Concerning sardine, the application of min b_{20} value resulted into similar estimates for sardine compared to the ones currently estimated (ratio~1.01). When the max b_{20} values were applied, sardine biomass estimates remained close to those currently estimated (ratio ~ 0.86) (Table 4.1.5).

Table 4.1.6. Strait of Sicily (CNR-IAMC) Ratios of the sardine and anchovy biomass estimates computed in Strait of Sicily for 2005 with the b_{20}s values used by various institutes. Biomass ratio: biomass b_{20} re-estimate/biomass currently applied b_{20}.

Anchovy	$\boldsymbol{b_{20}}$	**Biomass** (in tons)
	Curr.applied (-75.3)	20196.5
	Min TS (-75.3)	20567.9
Biomass ratio (min/Current)		**1.018**
	Max TS (-71.2)	14442.6
Biomass ratio (max/Current)		**0.715**
Sardine		
	Curr.applied (-70.5)	21782.4
	Min TS (-72.6)	23890.5
Biomass ratio (min/Current)		**1.097**
	Max TS (-70.5)	21845.8
Biomass ratio (max/Current)		**1.003**

Concerning the CNR-IAMC biomass assessment (based on mixed species echo allocation), the ratios of the biomass estimates by using the minimum b_{20} and the currently used b_{20} is 1.02 for anchovy and 1.1 for sardine. The relative ratios when using the maximum b_{20} is 0.7 for anchovy and nearly 1 for sardine (Table 4.1.6).

4.1.3.3 *In situ* TS estimations

Final results on TS equations are presented in Tables 4.1.7 and 4.1.8. Hauls used refer to the period 2002 to 2010. No appropriate data for *in situ* estimation of TS equation were available from the Gulf of Lions area. In the case of Strait of Sicily the small number of available hauls prevented the estimation of TS equation for both anchovy and sardine. However, available hauls were used for the estimation of a single overall TS equation.

Table 4.1.7. Anchovy: Results per area of TS *in situ* estimations.

		Iberian coast (Spain)	N. Aegean (Greece)	Adriatic Sea (Italy)	Gulf of Lion (France)	Strait of Sicily (Italy)
No Hauls		10 (Fish track)/23 (single target detection)	19	15	2	3
Period sampling		2003-2009	2004-2010	2005-2009	2011	2002-2008
TL range (in cm)		6-15	4.7-15.9	3-16.5	10.3	7-16
Single targets* b20	Entire water column	-	-	-76.11	not enough data	Not available***
	Fishing range	-71.2	-75.04		not enough data	-
Fish tracks** b20	Entire water column	-72.1	-		not enough data	-
	Fishing range	-	-74.65		not enough data	-

**Targets within major axis angle -1°- 1°*
***Tracks with tortuosity 3D <3*
**** Used only in the overall Length-TS equation*

Table 4.1.8. Sardine: Results per area of TS *in situ* estimations.

Area		Iberian coast (Spain)	N. Aegean (Greece)	Strait of Sicily (Italy)
No Hauls		21	4	2
Period sampling		2003-2009	2004-2010	2002-2008
TL range (in cm)		9.5-21.5	5.8-16.2	12.8
Single targets* b20	Entire water column	-	-	Not available***
	Fishing range	-72.4	-71.70	-
Fish tracks** b20	Entire water column	-	-	-
	Fishing range	-	-70.47	-

** Targets within major axis angle -1º- 1º*
*** Tracks with tortuosity 3D <3*
**** Used only in the overall Length-TS equation*

Fish tracks are usually analyzed to provide information about fish's orientation (tilt, yaw, and distance off the transducer axis) (Henderson, 2005). Fish tracks determination for TS estimates can be biased due to the effect of the filtering processes and the reduced number of targets that often include the strongest echoes. This explains why in some cases the "fish tracks" analysis resulted into bigger b_{20} values compared to the "single targets" analysis (Table 4.1.8). In order to avoid biased estimates during the second workshop there was an agreement to keep single targets for the estimation of TS equation following the commonly applied approach (Barange *et al.*, 1996; MacLennan & Menz, 1996; Soule *et al.*, 1996; Torgersen & Kaartvedt, 2001; Peltonen & Balk, 2005; Henderson & Horne, 2007; Sawada *et al.*, 2009).

Results by area

Results per area based on available hauls are presented below. Specifically, concerning the N. Aegean Sea, the Adriatic Sea and the Spanish Mediterranean waters the best-fit regression between logarithmic TL and TS, and the regression with slope forced to 20 for both species derived from single target analysis are shown in Figures 4.1.6 to 4.1.8. No data were provided from the Gulf of Lions and the number of hauls from the Strait of Sicily was too low to fit any regression.

Additionally, estimations of TS based on past *ex-situ* experiments in the Adriatic Sea and the Strait of Sicily are presented in Table 4.1.9.

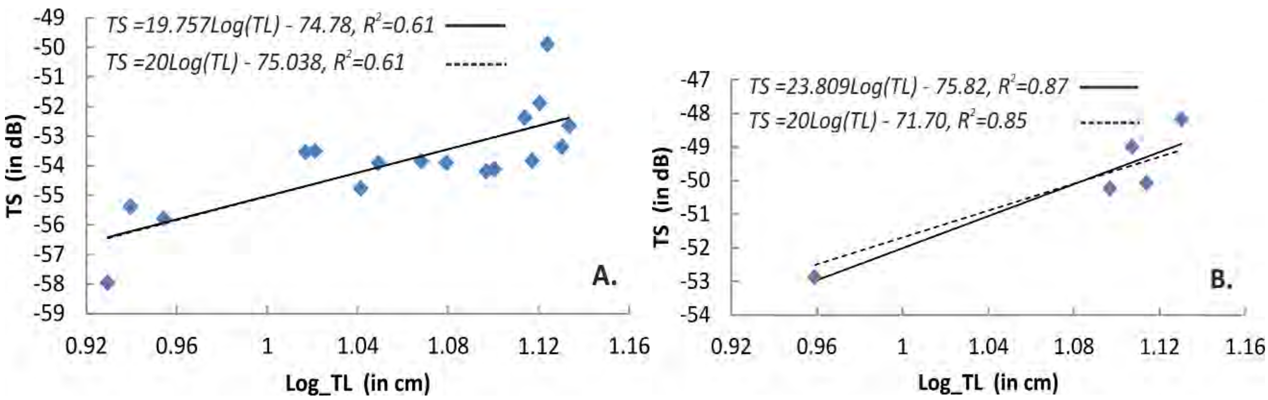


Figure 4.1.6. *North Aegean Sea:* The best-fit regressions (compact line) between logarithmic TL and TS and the regressions with slope forced to 20 (dashed line) for (A) anchovy and (B) sardine by using single target data.

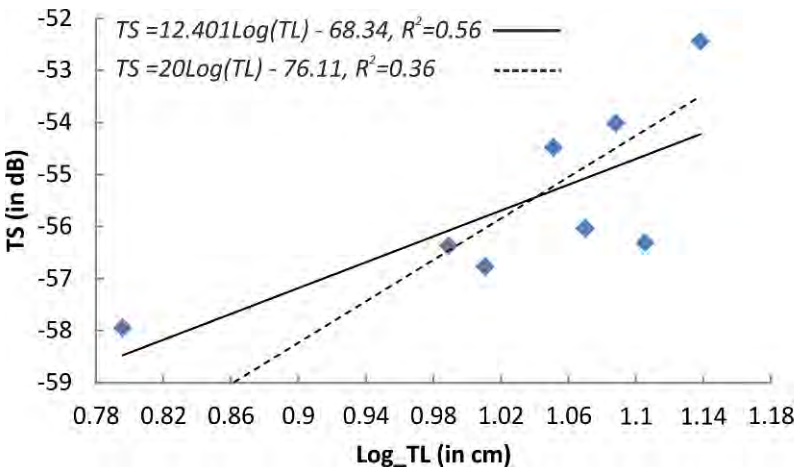


Figure. 4.1.7. *Western Adriatic Sea:* The best-fit regression (compact line) between logarithmic TL and TS and the regression with slope forced to 20 (dashed line) for anchovy by using single target data.

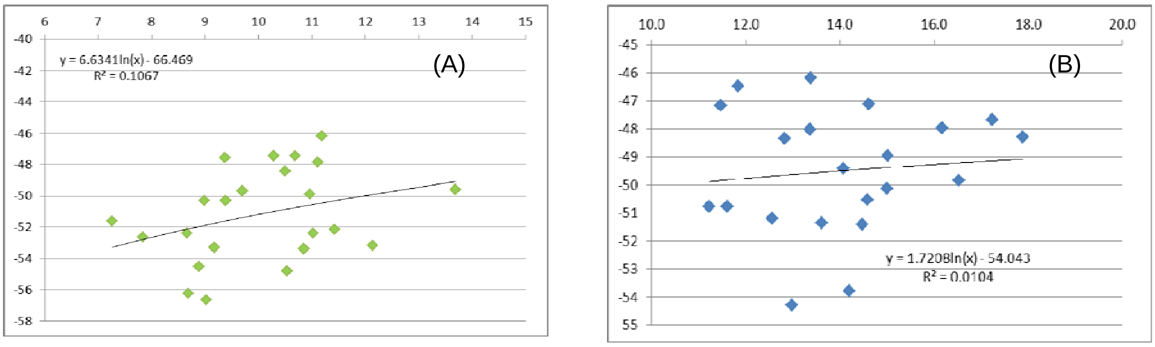


Figure. 4.1.8. *Spanish Mediterranean waters:* The best-fit regressions (compact line) between logarithmic TL and TS for (A) anchovy and (B) sardine by using single target data. b20 =-71.2 for anchovy and b20 =-72.44 for sardine

Table 4.1.9. TS *ex situ* estimations in two different study areas concerning anchovy and sardine.

Area		Adriatic Sea (Italy)*	Strait of Sicily (Italy)
Frequency		38 kHz	200 kHz
b_{20}	Anchovy	-74.6	-68.9
	Sardine	-72.5	-68.07

* Azzali *et al.*, 1997

In a further step, pooled data from Spanish Mediterranean waters, the Strait of Sicily, the Adriatic Sea and the Aegean Sea were used to estimate one single TS equation for anchovy and sardine (Table 4.1.10, Table 4.1.11). Results concerning anchovy indicated that no significant relationship can be estimated for pooled data (Fig. 4.1.9). However, a significant relationship was obtained only when data from the central and eastern Mediterranean were used (see Fig. 4.1.10). Moreover, a much better equation from a statistical aspect is obtained if we consider the average TS (following the back-transformation to (σ)) per length class at 0.5 cm interval (Fig. 4.1.11). This approach is justified since TS is a stochastic variable and a range of values for a given Length is expected. Thus the mean TS for a given TL class is more representative.

Similarly, results concerning sardine indicated also that no significant relationship can be estimated for pooled data (Fig. 4.1.12). However, a significant equation was obtained when we considered the average TS (following the back-transformation to (σ)) per length class at 0.5 cm interval (Fig. 4.1.13).

Table 4.1.10. Anchovy: Target Strength (TS) and Total Length (TL) values per haul from all study areas that were used for the estimation of a single TS-TL equation.

Area	TL (cm)	TS (db)
N.Aegean	8.50	-57.96
N.Aegean	8.70	-55.38
N.Aegean	9.00	-55.79
N.Aegean	10.40	-53.54
N.Aegean	10.50	-53.51
N.Aegean	11.00	-54.76
N.Aegean	11.20	-53.91
N.Aegean	11.70	-53.85
N.Aegean	12.00	-53.91
N.Aegean	12.50	-54.19
N.Aegean	12.60	-54.13
N.Aegean	13.00	-52.37
N.Aegean	13.10	-53.83
N.Aegean	13.20	-51.89
N.Aegean	13.30	-49.89
N.Aegean	13.50	-53.36
N.Aegean	13.60	-52.65
Strait of Sicily	12.50	-55.75
Strait of Sicily	10.00	-53.45
Strait of Sicily	14.00	-52.08
Spanish Waters	10.29	-47.43
Spanish Waters	10.69	-47.47
Spanish Waters	13.69	-49.62
Spanish Waters	7.27	-51.63
Spanish Waters	8.66	-52.40
Spanish Waters	10.54	-54.81
Spanish Waters	11.03	-52.39
Spanish Waters	8.81	-45.84
Spanish Waters	9.37	-47.56
Spanish Waters	7.84	-52.64
Spanish Waters	10.14	-44.56
Spanish Waters	10.50	-48.43
Spanish Waters	10.96	-49.90
Spanish Waters	12.14	-53.18
Spanish Waters	9.02	-56.66
Spanish Waters	9.87	-58.73
Spanish Waters	10.85	-53.41
Spanish Waters	8.69	-56.26
Spanish Waters	11.43	-52.16
Spanish Waters	9.39	-50.30
Spanish Waters	8.89	-54.50
Spanish Waters	9.18	-53.30
Western Adriatic	6.29	-57.95
Western Adriatic	13.63	-53.15

Area	TL (cm)	TS (db)
Western Adriatic	9.69	-57.65
Western Adriatic	10.27	-57.05
Western Adriatic	11.45	-55.54
Western Adriatic	9.75	-55.10
Western Adriatic	13.14	-54.02
Western Adriatic	12.79	-56.07
Western Adriatic	10.20	-56.49
Western Adriatic	12.77	-56.57
Western Adriatic	11.33	-52.77
Western Adriatic	11.76	-54.55
Western Adriatic	11.63	-57.53
Western Adriatic	13.51	-51.75
Western Adriatic	11.19	-55.16

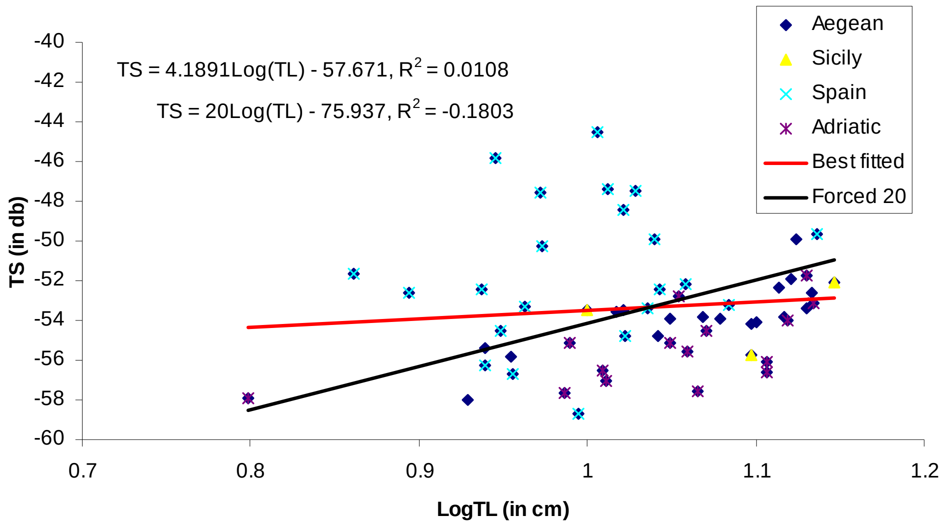


Figure 4.1.9. Anchovy (Pooled data – all areas): The best-fit regression (compact line) and the regression with slope forced to 20 (dashed line) using single target data.

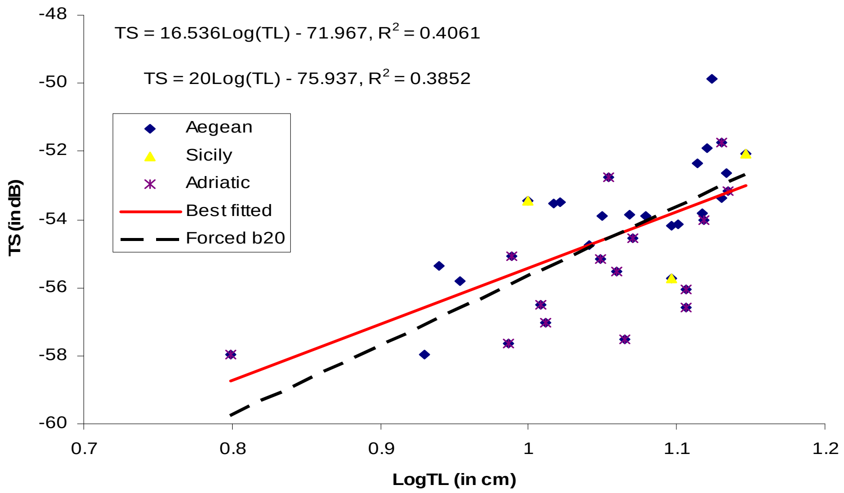


Figure 4.1.10. Anchovy (Pooled data – Eastern and Central Mediterranean): The best-fit regression (compact line) and the regression with slope forced to 20 (dashed line) for anchovy by using single target data.

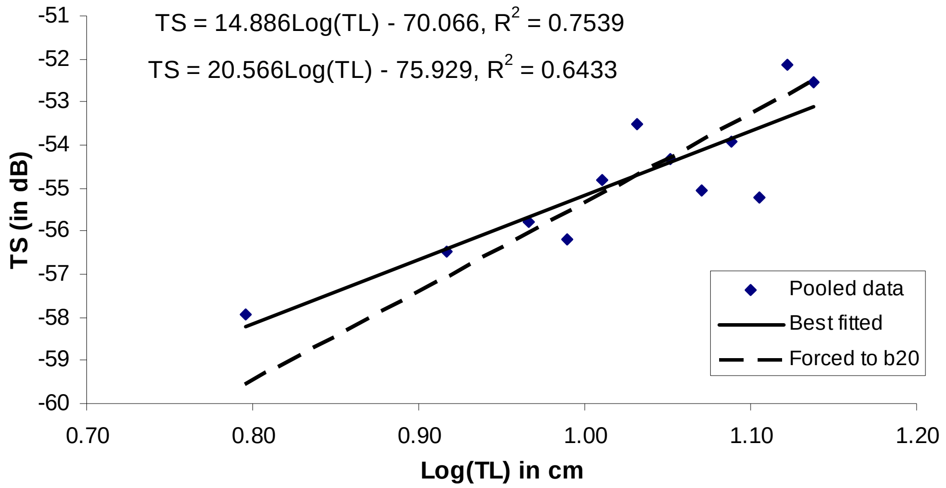


Figure 4.1.11. Anchovy (Pooled data – Eastern and Central Mediterranean): The best-fit regression (compact line) and the regression with slope forced to 20 (dashed line) using average TS (following the back-transformation to (σ)) per length class at 0.5 cm interval on single target data.

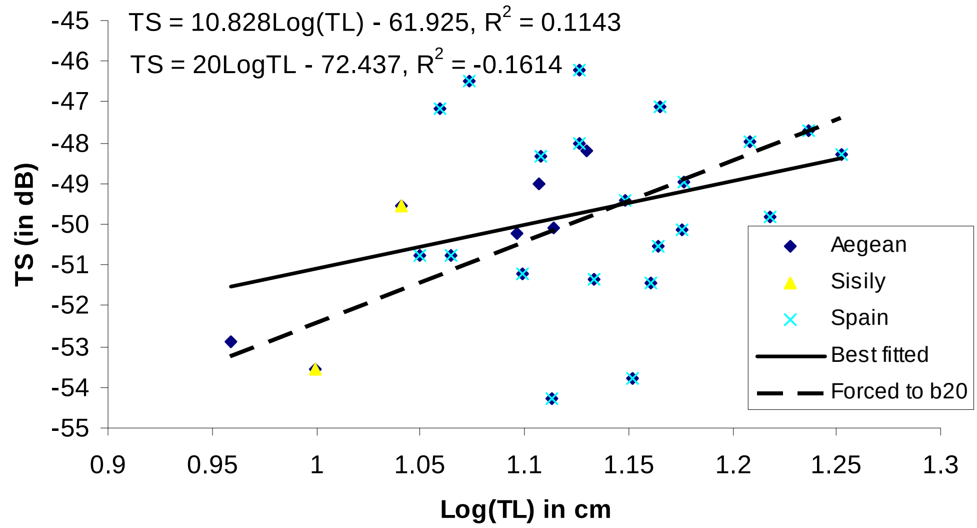


Figure 4.1.12. Sardine (Pooled data – all areas): The best-fit regression (compact line) and the regression with slope forced to 20 (dashed line) using single target data.

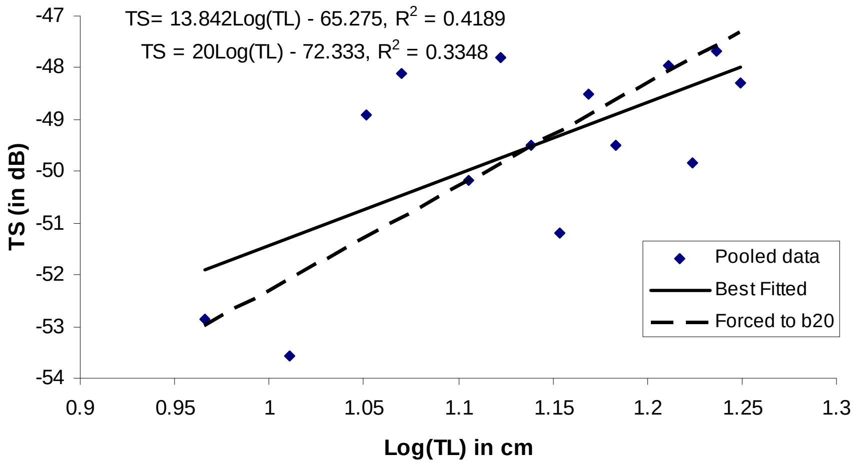


Figure 4.1.13. Sardine (Pooled data – all areas): The best-fit regression (compact line) and the regression with slope forced to 20 (dashed line) using average TS (following the back-transformation to (σ)) per length class at 0.5 cm interval on single target data.

Table 4.1.11. Sardine: Target Strength (TS) and Total Length (TL) values per haul from all study areas that were used for the estimation of a single TS-TL equation.

Area	Length (cm)	TS (dB)
N.Aegean	13.00	-50.07
N.Aegean	13.50	-48.18
N.Aegean	9.10	-52.87
N.Aegean	12.80	-49.00
N.Aegean	12.50	-50.24
Strait of Sicily	10.00	-53.56
Strait of Sicily	11.00	-49.56
Spanish Waters	11.22	-50.77
Spanish Waters	14.20	-53.79
Spanish Waters	16.17	-47.96
Spanish Waters	15.00	-50.12
Spanish Waters	12.57	-51.21
Spanish Waters	11.46	-47.18
Spanish Waters	11.61	-50.77
Spanish Waters	14.47	-51.42
Spanish Waters	14.62	-47.11
Spanish Waters	12.83	-48.34
Spanish Waters	11.84	-46.48
Spanish Waters	17.23	-47.69
Spanish Waters	13.37	-48.02
Spanish Waters	12.98	-54.29
Spanish Waters	17.88	-48.29
Spanish Waters	15.02	-48.96
Spanish Waters	14.07	-49.42
Spanish Waters	13.38	-46.19
Spanish Waters	16.52	-49.83
Spanish Waters	14.59	-50.54
Spanish Waters	13.61	-51.36

4.1.3.4 Biomass estimates based on new TS equations

Biomass estimations of past acoustic data in N. Aegean Sea, Spanish Mediterranean waters and Adriatic Sea were made based on new estimated TS equations and were compared with estimations based on currently applied TS equations (Tables 4.1.10 and 4.1.11).

Table 4.1.12. *North Aegean Sea:* Average, standard deviation (sd) and coefficient of variation (CV) of fish stock estimates and ratio, computed over the years 2003–2006 and 2008, with different b_{20} values for anchovy and sardine. Biomass ratio = biomass estimate with new estimated b_{20}./biomass estimate with currently applied b_{20}

		Biomass (in tons)							
Anchovy	b_{20}	**2003**	**2004**	**2005**	**2006**	**2008**	**Mean value**	**Stand. Dev.**	**CV**
	Curr.applied (-71.2)	47838	46508	31852	62685	60601	49896.80	12444.43	0.25
	New estimated (-75.04)	127933	86953	58208	144226	84525	100369	34970.64	0.35
Biomass ratio		2.67	1.87	1.83	2.30	1.40	**2.01**	0.49	
Sardine									
	Curr.applied (-72.6)	19281	14857	20464	42856	39395	27370.60	12787.85	0.47
	New estimated (-71.70)	15866	13481	17921	33246	34890	23080.8	10168.84	0.44
Biomass ratio		0.82	0.91	0.88	0.78	0.89	**0.85**	0.05	

Table 4.1.13. *Spanish Mediterranean waters:* Average, standard deviation (sd) and coefficient of variation (CV) of fish stock estimates and ratio, computed over the years 2009–2011, with different b_{20} values for anchovy and sardine. Biomass ratio = biomass estimate with new estimated b_{20}./biomass estimate with currently applied b_{20}

		Biomass (in tons)					
Anchovy	b_{20}	**2009**	**2010**	**2011**	**Mean value**	**Stand. Dev.**	**CV**
	Curr.applied (-72.6)	21861	23324	19405	21530	1980.36	0.09
	New estimated (-71.2)	16922	18027	15453	16800.67	1291.28	0.08
Biomass ratio		0.77	0.77	0.80	**0.78**	0.01	
Sardine							
	Curr.applied (-72.6)	26262	21715	31841	26606	5071.76	0.19
	New estimated (-72.4)	24041	19264	29539	24281.33	5141.71	0.21
Biomass ratio		0.92	0.89	0.93	**0.91**	0.02	

Table 4.1.14. *Western Adriatic Sea:* Average, standard deviation (sd) and coefficient of variation (CV) of fish stock estimates and ratio, computed in three different parts of the western Adriatic Sea for 2009 with different b20 values for anchovy and sardine. Biomass ratio = biomass estimate with new estimated b_{20}./biomass estimate with currently applied b_{20}

		Biomass (in tons)			
Anchovy	b_{20}	**North Adriatic**	**Central Adriatic**	**South Adriatic**	**Total**
	Curr.applied (-74.6)	310232	98818	133557	542608
	New estimated (-76.1)	394195	127111	169595	690901
Biomass ratio		**1.27**	**1.29**	**1.27**	**1.27**

4.1.4 Overall Discussion, Conclusions, Difficulties encountered, Recommendations

The main issue for standardization of the past acoustic surveys in the Mediterranean is the lack of one common TS equation for the main target species, anchovy and sardine. This is also an issue concerning the acoustic surveys in the ICES Atlantic areas. Target strength (TS) is the main scaling factor required to convert echo intensity to fish density. Knowledge of TS and the equations used is of primary importance for acoustic, stock assessment and behavioral studies. On the other hand the need for consistency among the time series of biomass estimates in each area often prevents the re-evaluation of the historically applied TS equation.

To assess the actual effects of the TS~length equations parameters on fish stock acoustic estimates taking into account the observed species proportions, fish stock biomass estimates have been computed using various equations in the Aegean Sea, the Gulf of Lions, the Adriatic Sea, the Strait of Sicily and the Spanish Mediterranean waters (Tables 4.1.2 to 4.1.6). Specifically, even small differences in the b_{20} values can lead to a significant underestimation or overestimation of the fish stock biomass, as the sensitivity analysis revealed. In the Aegean Sea and the Gulf of Lions, anchovy and sardine acoustic biomass estimates have been compared for the period 2003-2008 and three b_{20} values for anchovy and sardine. In Aegean Sea applying the min b_{20} values the estimates for anchovy biomass were almost double than the ones currently estimated by HCMR (ratio ~ 2.12). Concerning sardine, applying the max b_{20} value the estimates for sardine biomass were about half (ratio~0.68) than the ones currently estimated by HCMR (Table 4.1.2). Similarly, in the Gulf of Lions applying the min b_{20} value, anchovy biomass was about double than the one currently estimated by IFREMER (4 dB difference resulted into ratio ~ 1.9) and applying the max b_{20} value (less than 1 dB difference) anchovy biomass estimates remained almost the same (ratio ~ 0.9). Concerning sardine, the application of max b_{20} value resulted into one and a half times higher estimates than the ones currently estimated (1.4 dB difference resulted into ratio~1.4). When the max b_{20} value was applied, sardine biomass estimates remained close to those currently estimated (less than 1 dB difference resulted into ratio ~ 0.86). Concerning Spanish acoustic survey, applying the min b_{20} values, anchovy biomass estimate was almost one a half times higher compared to the one currently estimated (2.7 dB difference resulted into ratio ~ 1.6); and applying the max b_{20} values, anchovy biomass estimate remained almost the same (1.4 dB difference resulted into ratio ~ 0.98). Concerning sardine, the application of min b_{20} value resulted into similar estimate for sardine compared to the one currently estimated (ratio~1.07). When the max b_{20} values were applied, sardine biomass estimate was almost half compared to the one currently estimated (2 dB difference resulted into ratio ~ 0.64). Concerning the Adriatic surveys, biomass estimates by CNR-ISMAR applying the min b_{20} value for anchovy were almost the same compared to those currently estimated (less than 1 dB difference resulted into ratio ~ 1.1); and applying the max b_{20} value for anchovy, biomass estimates were almost half (3 dB difference resulted into ratio ~ 0.54). Concerning sardine, the application of min b_{20} value resulted into similar estimates for sardine compared to the ones currently estimated (ratio~1.01). When the max b_{20} values were applied, sardine biomass estimates remained close to those currently estimated (2.5 dB difference resulted into ratio ~ 0.86). In the Strait of Sicily acoustic surveys, the biomass assessment for anchovy showed ratio close to 0.7 for 4 dB difference; while for sardine, biomass ratios were close to 1 even with 2 dB difference. These results confirm that acoustic fish biomass estimates heavily depend on the TS~length equation selection, even in the case of mixed species echo allocation. Anchovy biomass estimates can for instance vary up to 2-fold, depending the choice of the TS~length equation within those in use in the Mediterranean, and sardine biomass estimates can vary up to 1.5-fold.

Thus, for the purposes of the project acoustic data from previous or recent years' acoustic surveys (2000-2011) derived from the Iberian coast, the western part of the Adriatic Sea, the Strait of Sicily and the Aegean Sea were analyzed towards the *in situ* TS estimation for anchovy and sardine. Analysis was done in a standardized way per area and also regarding pooled data. Both single targets and fish track analysis was applied. Fish tracks resulted into bigger b_{20} values compared to the "single targets" analysis. This can largely be attributed to the filtering procedures applied and the reduced number of targets that comprise mainly strong targets. The reduced number of targets that remained after fish tracks analysis was applied comprises one of the main impediments for this analysis. Moreover, fish tracks are usually analyzed to provide information about fish's orientation (tilt, yaw, and distance off the transducer axis) (Henderson, 2005). In order to avoid biased TS estimates there was a common agreement to keep single targets for the estimation of TS equation.

Different TS-TL equations were estimated per study area upon data adequacy (i.e., Aegean Sea, western Adriatic and Spanish Mediterranean waters) based on single target estimations for anchovy. The b_{20} estimates in Aegean Sea and in the Adriatic Sea were only 1 dB apart, -75.038 dB and -76.11 dB, respectively. The equation in Spanish waters indicated b_{20} at -71.2 dB was significant when based on fish tracks and selecting the modal TS from the entire water column. In the case of single target detection based on the fishing range provided b_{20} at -71.4 dB although not significant, most likely due to the observed high variability. Aegean Sea and Adriatic Sea estimates are outside the confidence intervals of the b_{20} distributions for clupeid species (Figure 4.1.3), but still higher than b_{20} values of the lower-TS equations reported for *E. capensis* (Barange *et al.*, 1996) and *E. rigens* (Guttierez and MacLennan, 1998; Figure 4.1.3).

Moreover, they are close but smaller than the b_{20} values estimated by Azzali *et al.*, (1997) in the Adriatic Sea that are currently applied in the Adriatic acoustic surveys.

Concerning sardine, equations from two areas were estimated. One for Aegean Sea based on a small number of hauls estimating b_{20} at -71.70 dB and one for Spanish Mediterranean waters estimating b_{20} at -72.44 dB. These estimates presenting less than 1 dB difference and lie within the confidence intervals of the b_{20} distributions for clupeid species (Figure 4.1.3), they are considered preliminary; since the first is based on a very small number of hauls, whereas the second one was not found significant. Although much lower values are currently applied for southern hemisphere sardine species (Barange *et al.*, 1996; IMARPE unpublished data; ICES, 2008), the estimated values are quite close to the ones currently applied in the Mediterranean surveys (Table 4.1.1).

The large variation in the TS equations estimated for anchovy from the different areas impaired the need to integrate all available data towards the estimation of a global equation. Such an equation was not found significant when considering data from all areas. However, a significant relationship was found concerning the central and eastern Mediterranean where b_{20} was estimated at -75.93 dB. This value similar to the regional ones is outside the confidence intervals of the b_{20} distributions for clupeid species (Figure 4.1.3), but still higher than b_{20} values of the lower-TS equations reported for *E. capensis* (Barange *et al.*, 1996), presenting 1 dB difference compared to the one estimated by Azzali *et al.*, (1997) in the Adriatic.

Similarly, for sardine the small number of available hauls further impaired the need to integrate all available data towards the estimation of a more reliable equation. Specifically, available data for sardine derived from the North Aegean Sea, Spanish Mediterranean waters and the Strait of Sicily. The overall relationship was found significant using the average TS per length class indicating b_{20} at -72.33 dB, estimate which is quite close to the value currently applied in most areas in the Mediterranean.

The aforementioned results clearly indicate that a re-evaluation for the currently applied b_{20} values for anchovy is required. This re-evaluation needs further work and cautiousness, since it would have a direct impact on the current biomass assessments for this species, requiring specifically planned *in situ* experiments instead of the re-analysis of existing data. Selecting and analyzing suitable hauls among the available ones for the purposes of the project along with the discussion among scientists from different areas during the dedicated workshops revealed a series of difficulties and impediments towards the estimation of a reliable TS equation. Specifically the following difficulties were encountered:

- the number of monospecific hauls is usually small when it comes to the Mediterranean, where mixed fisheries and mixed small pelagic fish population occur. This is even more pronounced in the western part of the basin. Thus, in past data when the target is the collection of biological data or schools identification instead of a specifically planned *in situ* TS experiment, suitable hauls is often difficult to be identified. This was even more pronounced in the case of sardine.
- Besides Aegean Sea, data were collected at 1 ms (pulse length interval), not at 0.5 as recommended for 38 kHz frequency. This is an insuperable impediment for past data.
- The selection of suitable threshold for data acquisition.

- The selection of a cut-off upper point in the TS histogram, since these parameters can largely differentiate depending on the area and the haul.
- Selecting past data impairs the need to merge data from different echosounders like the EK500 and the EK60 in the same area. These echosounders require different algorithm for single target detection that could potentially be another source of bias for TS estimates (Jech *et al.,* 2005).
- Plankton filtering can be a significant cause of bias. It can easily cause a reduction in the TS estimates if it has not been applied properly especially in periods with increased plankton production.
- Sampling at high densities over the scattered layers at night makes difficult the discrimination of single targets and results into biased TS values that derive from overlapping echoes. This is further enhanced when sampling takes place in the recruitment period for a certain species like the case of anchovy and the ECOMED surveys.

Future work to anticipate problems occurred has been an issue for discussion especially during the second workshop of the AcousMed that it was held jointly with the ICES WGACEGG and established the basis for a future collaboration between the Atlantic and Mediterranean bodies (MEDIAS). This collaboration between acoustic surveys focusing on the same species is expected to continue and highly promote the standardization of TS estimation, concerning both data collection and analysis, and facilitate the identification of possible solutions to common problems. Specifically, for TS being by essence highly variable it was suggested:

- to conduct more TS measurements of European anchovy and sardine, in various environmental conditions, to further investigate the range of variations of their TS.
- Specifically planned *in situ* TS experiments should be applied for this purpose at different areas, taking into account the same parameters at echo recording e.g. pulse duration at 0.5 msec. The protocol suggested by WGACCEG, updated by the AcousMed project for data recording and analysis will be endorsed in these experiments. Assessing the range of TS variability is in fact crucial to the accurate computation of the estimation error around the fish biomass estimates, and then to adequately interpret the fish acoustic index fluctuations (either in an absolute or relative way).
- To improve echogram filtering through the use of frequency difference information. The application of specialized algorithms in Echoview for this purpose should be promoted. This also requires the extensive collaboration with Echoview experienced personnel to apply the algorithm depending on area peculiarities in terms of plankton density. Moreover, the additional cost of the Virtual echogram module in Echoview should be foreseen since it is not available to all partners at the moment.
- *Ex situ* TS experiments should ideally be conducted in controlled experimental conditions: either in cage (e.g. Kang *et al.*, 2009), or using remotely operated vehicles equipped with both video and acoustics devices (e.g. Sawada *et al.*, 2009, Doray *et al.* 2011).

The above mentioned results and suggestions will be presented for discussion in the 5th Annual Steering Committee Meeting of the Pan Mediterranean Acoustic Surveys in order to disseminate the project results to other Mediterranean scientists and incorporate suggestion into the MEDIAS protocol. Moreover, the cooperation of MEDIAS with similar groups like WGACEGG dealing with acoustic and egg surveys of small pelagics in the Atlantic will be promoted, in order to share knowledge and experience among the members of these groups. Given the positive result of this experience the WGACEGG endorsed the continuation of these common initiatives at least every two years.

4.2 Acoustic sampling: Comparison day-night (Subtask 3.2.)

(Lead participant: CNR-IAMC, Involved participants: HCMR, CNR-ISMAR, CNR-IAMC)

Objectives

The target of this sub-task of the project was to improve the harmonization of acoustic sampling procedure among the different past acoustic surveys held in the Mediterranean within the DCF and determine the effect of the time of day on acoustic sampling. The diurnal behavior of small pelagic fish like anchovy and sardine makes fish either unavailable to the acoustic apparatus used or difficult to distinguish acoustically from other scatterers, which could generate a degree of bias on the echo density used for abundance estimates (ICES, 2005). Variation in the schooling behavior and in the factors affecting the diel migration of small pelagics might further differentiate the degree of bias in acoustic sampling between night-time and day-time among the different areas (Iglesias *et al.*, 2003; Zwolinski *et al.*, 2007).

4.2.1 Work achieved

Within this sub task available historic acoustic data (2002-2006) from three study areas (i.e., the western part of the Adriatic Sea, the Strait of Sicily and the Aegean Sea) were examined in respect to the time of day and the surveyed area. Appropriate data from the different areas were selected and comparisons between acoustic estimates (i.e. echo abundance, biomass/abundance estimates) sampled at the same area during day-time and night-time were carried out. Moreover, appropriate data from recent years (2007-2009) as well as acoustic data collected within targeted surveys held within the period of the project (2010-11) simultaneously with the ongoing MEDIAS surveys in certain study areas were used to examine the effect of the time of day. The targeted surveys were held additionally to the proposed actions in order to cover the existing gaps in data availability from certain areas.

According to the proposal two workshops were held during the first year of the project in the framework of respective meetings and one workshop in the second year. During the kick off meeting, hosted by CNR-IAMC in Capo Granitola in March 2010, the first workshop took place. During this workshop a preliminary review of available data from all study areas was done and a common protocol for data analysis and comparisons was discussed and agreed. The progress of work during the first year of the project was presented in the second workshop that was held in Palma de Mallorca in November 2010, hosted by IEO. This second workshop was part of a joined meeting with the annual ICES WGACEGG meeting that comprised an initial, successful step to bring together scientists involved in acoustic surveys in the Atlantic and the Mediterranean, promoting the collaboration, the exchange of ideas, the identification of common problems and solutions between ICES and Mediterranean surveys. The third workshop took place in accordance to the proposal was organized during the third project meeting that was held in 14th December

2011 in Iraklion (Greece) hosted by HCMR. During this workshop the progress of the work in each Mediterranean area was presented and the problems encountered were discussed.

4.2.2 Methodological approach followed

Three types of data were identified as suitable for this sub-task: (a) data from the insonified pelagic hauls that were held during day-time and night-time, (b) data from insonified transects that were held in the past and c) data from insonified transects/ specific surveys that were held simultaneously with the ongoing MEDIAS surveys within the period of the AcousMed project, targeting specifically the project needs. The general procedures suggested in the agreed protocol for acoustic data analysis, were based on the methodology described and the parameters suggested in the respective literature (e.g. Jolly and Hampton, 1990; Simmonds & MacLennan, 2005; ICES, 2006; O'Driscoll *et al.*, 2009).

Specifically, the following were suggested and agreed:

Hauls echo trace comparison

- Comparisons per haul or transect sampled day-time and night-time
- Define night-time per area and survey: e.g. 21:00 to 4:00
- Comparisons were done concerning the total NASC of the total water column
- Software for data analysis was defined as the Myriax Echoview
- Sv threshold during day-time was set at -70 dB or -60 depending on the area. Concerning night-time, sensitivity analysis with different thresholds was agreed to be applied from -70 dB to -55dbB
- Two frequencies were used for comparison: 38 kHz and 120 kHz
- The maximum time separation between day-night sampling it was agreed not to exceed 48 h

Transect comparison

A protocol for the collection of acoustic data along transects concerning the specific surveys was proposed by CNR-ISMAR based on previously gained experience in the Adriatic Sea and agreed by all partners involved. Data for this purpose were collected during additional specific surveys held in 2010 and 2011 within the MEDIAS DCF action at certain study areas.

- According to the agreed protocol the same area should be sampled at least twice during day-time and once during night-time
- At least two different areas in terms of bathymetry and species compositions should be sampled.

- In case that survey time does not allow this sort of additional specific sampling then one or two transects (5-10 nm depending on the area) should be sampled twice or three times during day-time in order to catch the day-time variability, and subsequently during night-time in order to allow comparisons.
- Echograms are to be scrutinized and comparisons of acoustic estimates (i.e. echo abundance, abundance estimates) are to be done.
- Since day-time and night-time data refer to different statistical populations a mean s_A for each transect will be calculated, treated as random point samples
- An overall transect estimate per area (specific survey) will be calculated and comparisons will address NASC for day1, NASC for night and NASC for day2. Mean NASC & variance estimates will be based on the Jolly & Hampton (1990) formula (similar to O'Driscoll *et al.*, 2009):

$$\overline{NASC} = \frac{\sum_{i=1}^{N} \overline{NASC_i}\,(n_i)}{\sum_{i=1}^{N} n_i} \qquad \& \qquad Var(\overline{NASC}) = \frac{N}{N-1} \frac{\sum_{i=1}^{N} \left(\overline{NASC_i} - \overline{NASC}\right)^2 n_i^2}{\left(\sum_{i=1}^{N} n_i\right)^2} \qquad (4)$$

  where $\overline{NASC_i}$ is the mean NASC for the i-*th* haul, n_i is the EDSU numbers for the i-*th* haul, and N is the number of transects.
- A specific R script to perform statistical analysis written specifically for the purposes of the project by Marco Barra (CNR-IAMC) will be used to compare day and night sampling
- Differences among the various areas should be examined in order to estimate the associated degree of error as well as potential correction approaches.
- Suggestions should be made concerning the optimization of acoustic sampling

4.2.3 Work achieved

The work done per case study is presented below:

North Aegean Sea

Data from North Aegean Sea involved past acoustic data from random pelagic hauls that were held night-time and day-time at the same area within 48 hours time difference. Data were collected within the period 2005-2010 during summer and winter surveys.

Specifically:

- 16 day-night pairs in total were used (15 hauls and 1 transect, Figure 4.2.1) and

- 14 were collected during summer time whereas
- 2 were collected during winter time

Defining night-time period in Aegean Sea as stated below:

- Summer 21:30 – 5:00 (sunset time LT= 20:30, sunrise 6:15)
- Winter 18:15 - 5:00 (sunset time LT=17:15, sunrise 5:15)

Sampling was mainly referring to shallow waters with maximum bottom depth not exceeding 60 m.

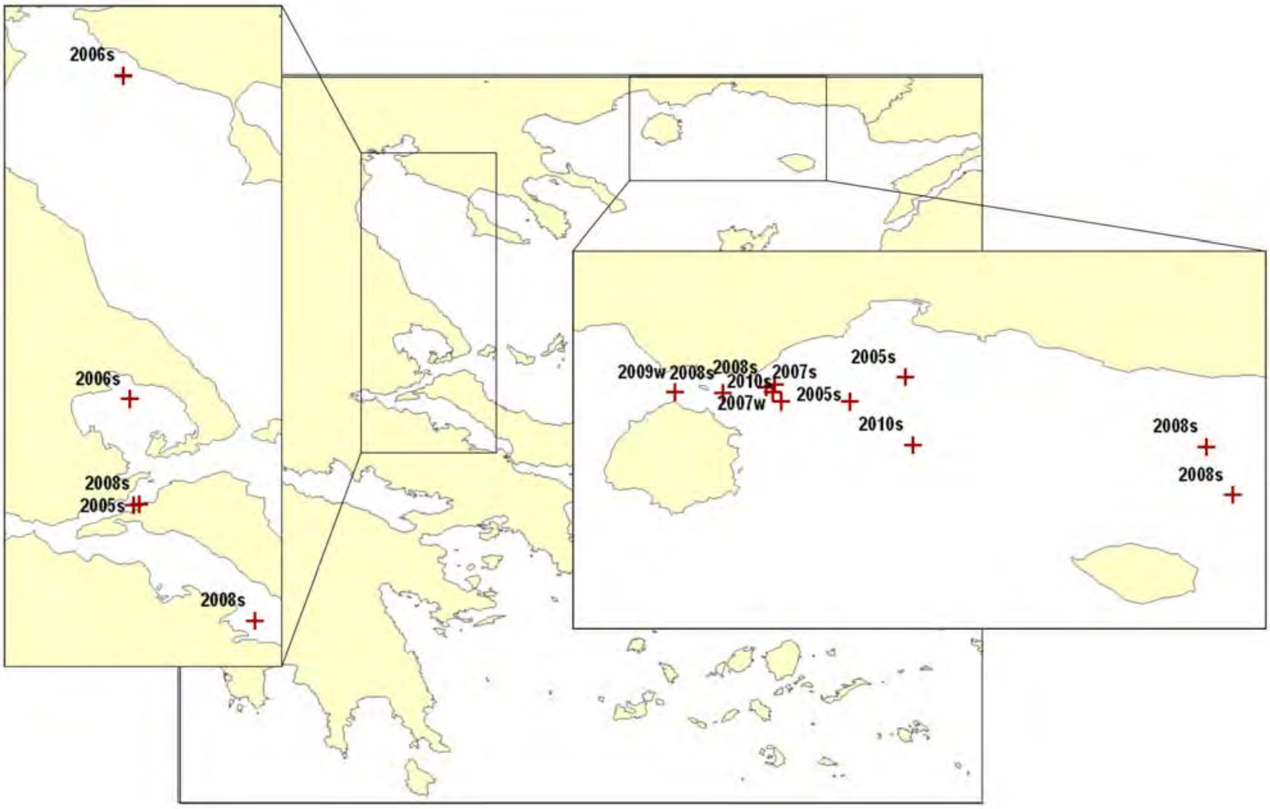


Figure 4.2.1. Hauls positions used from North Aegean Sea, held within the period 2005-2010

According to the proposed protocol Echoview used for analysis, night-time echograms analyzed for 2 m above bottom, Sv threshold for day-time acquisition was set at -70 dB & -60 dB and for night-time acquisition was set at -75 dB, -70 dB, -65 dB, -60 dB and the entire water column was considered. Moreover, for analysis purposes a Horizontal Integration Unit of 600 pings (approximate 0.25 nm) corresponding to 5 min of acoustic sampling on average was defined. Subsequently, the total NASC of the entire water column was estimated per horizontal integration unit.

Mean NASC & variance values are estimated by the Jolly & Hampton (1990) formula (equation 4). Additionally, analysis of Variance (ANOVA) was conducted between day-time results with acquisition threshold -70 dB and nigh-time results with acquisition threshold -70 dB, -65 dB and -60 dB, respectively. The significance level was set to 0.05.

Differences in acoustic estimates (NASC) between Day and Night are presented in Figures 4.2.2, 4.2.3 and Table 4.2.1 for 38 kHz and 120 kHz.

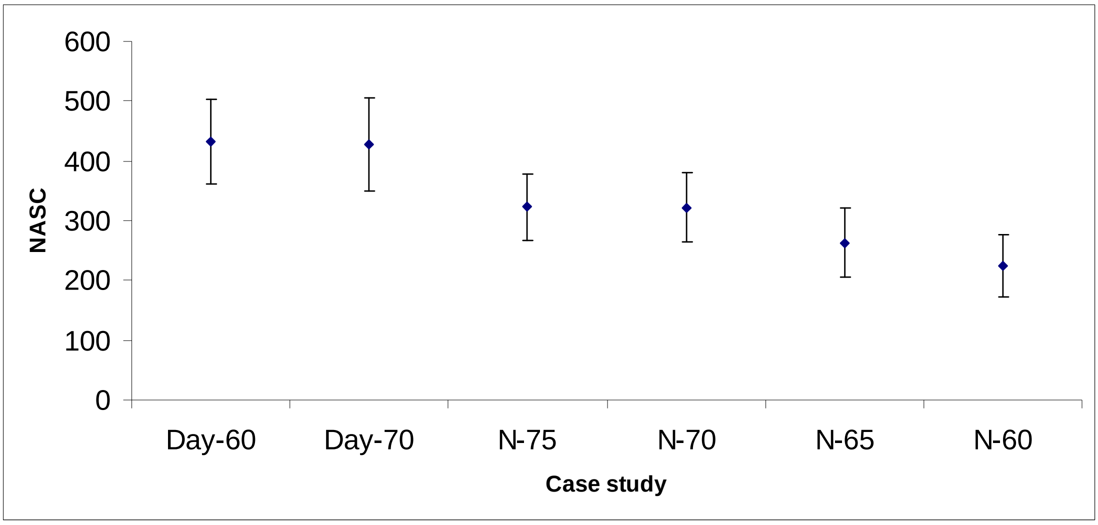


Figure 4.2.2 Total acoustic-abundance indices for North Aegean Sea based on mean area backscatter (NASC) at 38 kHz. Error bars are +2 s.e.

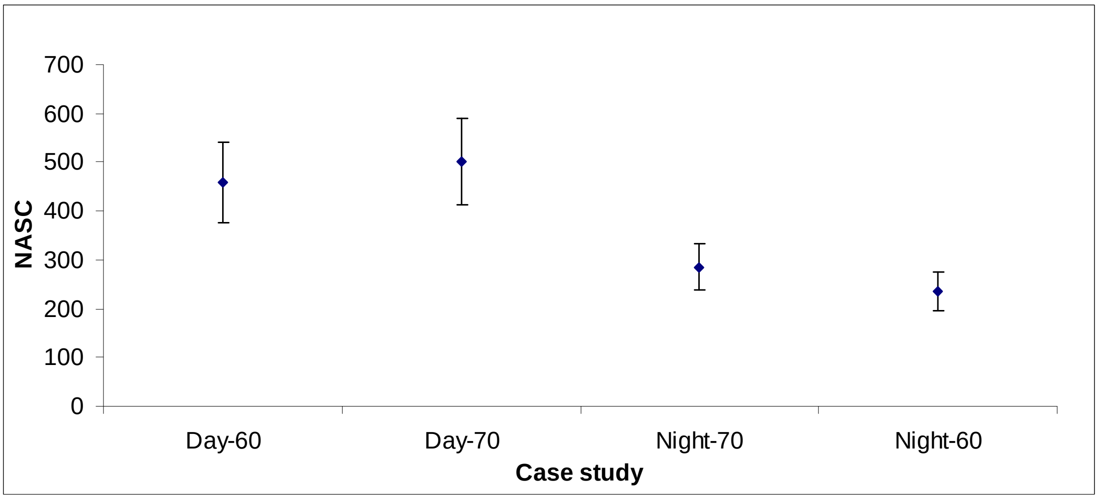


Figure 4.2.3 Total acoustic-abundance indices for North Aegean Sea based on mean area backscatter (NASC) at 120 kHz. Error bars are +2 s.e.

Table 4.2.1. *Aegean Sea:* Differences in acoustic estimates (NASC) between Day and Night pairs. D: Day, N: Night, Period of survey 2005-2010. Mean NASC was estimated per 0.25 nm horizontal sampling distance.

			Mean NASC (m^2/nm^2)					
Area	**Frequency**	**No pairs**	**D-60**	**D-70**	**N-60**	**N-65**	**N-70**	**N-75**
N. Aegean (Greece)	38 kHz	16	448.84	481.44	181.77	217.62	322.08	322.40
N. Aegean (Greece)	120 kHz	15	458.73	501.62	235.60	267.82	285.74	253.45

Results indicate that NASC values estimated during night-time were lower compared to day-time values. Day-time NASC values were similar both for -60 dB and -70 dB acquisition threshold. The difference between night-time and day-time estimates increases with the increase in the acquisition threshold during night-time. Night differences were mostly attributed to the reduction of NASC in the epipelagic zone (0-30m). Concerning the frequency 120 kHz, differences between day-time and night-time NASC were bigger compared to the 38 kHz. Moreover, night-time NASC values were similar independently of the acquisition threshold used.

The results of the Analysis of Variance (ANOVA) conducted between day-time results with acquisition threshold -70 dB and nigh-time results with acquisition threshold -70 dB, -65 dB and -60 dB, respectively, are presented in Tables 4.2.2 and 4.2.3 for each pair of hauls separately and in Tables 4.2.4, 4.2.5 for the sum of hauls.

Table 4.2.2. *Aegean Sea:* ANOVA p-values between Day and Night pairs at 38 kHz. The comparisons are conducted between Day-70 and Night-70, Night-65, Night-60. The significance level is set to 0.05.

	P-value		
Code	**NightThres. -70**	**NightThres. -65**	**NightThres. -60**
1	0.278	0.274	0.268
4	**0**	**0**	0.056
5	**0**	**0**	**0**
6	**0.01**	**0.007**	**0.005**
7	**0.018**	0.081	0.538
8	**0.022**	**0.014**	**0.009**
9	0.1999	0.955	0.071
10	0.053	**0.047**	**0.035**
11	**0.022**	**0.022**	**0.022**
12	**0.005**	**0.006**	**0.01**
14	0.188	0.284	0.446
15	**0**	**0.0001**	**0.001**
16	0.224	0.215	0.202
17	0.503	0.5	0.497
18	-	-	-
19	**0.006**	**0.032**	0.234
21	0.868	0.95	0.753

Table 4.2.3. *Aegean Sea:* ANOVA p-values between Day and Night pairs at 120 kHz. The comparisons are conducted between Day-70 and Night-70, Night-65, Night-60. The significance level is set to 0.05.

	P-value		
Code	**NightThres. -70**	**NightThres. -65**	**NightThres. -60**
1	0.817	0.633	0.507
4	**0.006**	0.058	0.973
5	0.94	0.49	0.066
6	**0.004**	**0.004**	**0.003**
7	0.908	0.713	0.344
8	**0.002**	**0.002**	**0.001**
9	-	-	-
10	**0.022**	**0.02**	**0.016**
11	**0.006**	0.13	0.762
12	**0.003**	**0.005**	**0.008**
14	0.127	0.218	0.291
15	**0.001**	**0.001**	**0.001**
16	-	-	-
17	0.472	0.47	0.469
18	0.068	**0.011**	**0.007**
19	0.841	0.561	0.449
21	0.252	0.391	0.967

Table 4.2.4. *Aegean Sea:* ANOVA p-values between Day and Night at 38 kHz. The comparisons are conducted between Day-70 and Night-70, Night-65, Night-60. The significance level is set to 0.05.

Mean Day	**Mean Night**	**P-value**	**Night threshold**
428.04	322.18	0.276	-70
428.04	302.99	0.198	-65
428.04	264.11	0.089	-60

Table 4.2.5. *Aegean Sea:* ANOVA p-values between Day and Night at 120 kHz. The comparisons are conducted between Day-70 and Night-70, Night-65, Night-60. The significance level is set to 0.05.

Mean Day	Mean Night	P-value	Night threshold
501.62	285.74	0.067	-70
501.62	267.82	**0.047**	-65
501.62	235.6	**0.023**	-60

Concerning the -70 dB acquisition threshold, no significant difference was apparent. Marginally significant differences exist between day and night concerning the acquisition threshold at -65 dB. Significant differences were found only at -60 dB acquisition threshold.

Strait of Sicily

Data from the Strait of Sicily involved data collected within the following targeted surveys that were held along the southern coast of Sicily:

- one targeted mini survey during the1st and 2nd August 2010. The experiment was conducted in the Gulf of Gela (Fig. 4.2.4) onboard the R/V Maria Grazia, and the acoustic data were collected both during two day-time and one night-time (the night between the two days);
- five targeted mini surveys during the "Ancheva 2011" echosurvey in the period 20th June – 5th July. Such experiments were performed in different sub-areas of the southern coast of Sicily (Fig. 4.2.4) onboard the R/V Dallaporta. Acoustic data were collected during one day and one night.

The following table shows some details of the six mini surveys:

	Depth range (m)	Day-time interval	Night-time interval	Track length (nm)
Minisurvey 2010	20 – 320	09:00 – 14:00	22:00 – 03:00	48.0
Minisurvey 2011 – 1	15 – 160	09:00 – 14:00	00:30 – 05:40	45.5
Minisurvey 2011 – 2	15 – 195	06:45 – 12:00	23:45 – 04:30	33.0
Minisurvey 2011 – 3	15 – 194	07:10 – 12:10	00:05 – 04:50	33.5
Minisurvey 2011 – 4	15 – 195	13:00 – 20:00	22:00 – 05:20	50.0
Minisurvey 2011 – 5	15 – 193	06:10 – 12:10	00:30 – 05:20	48.0

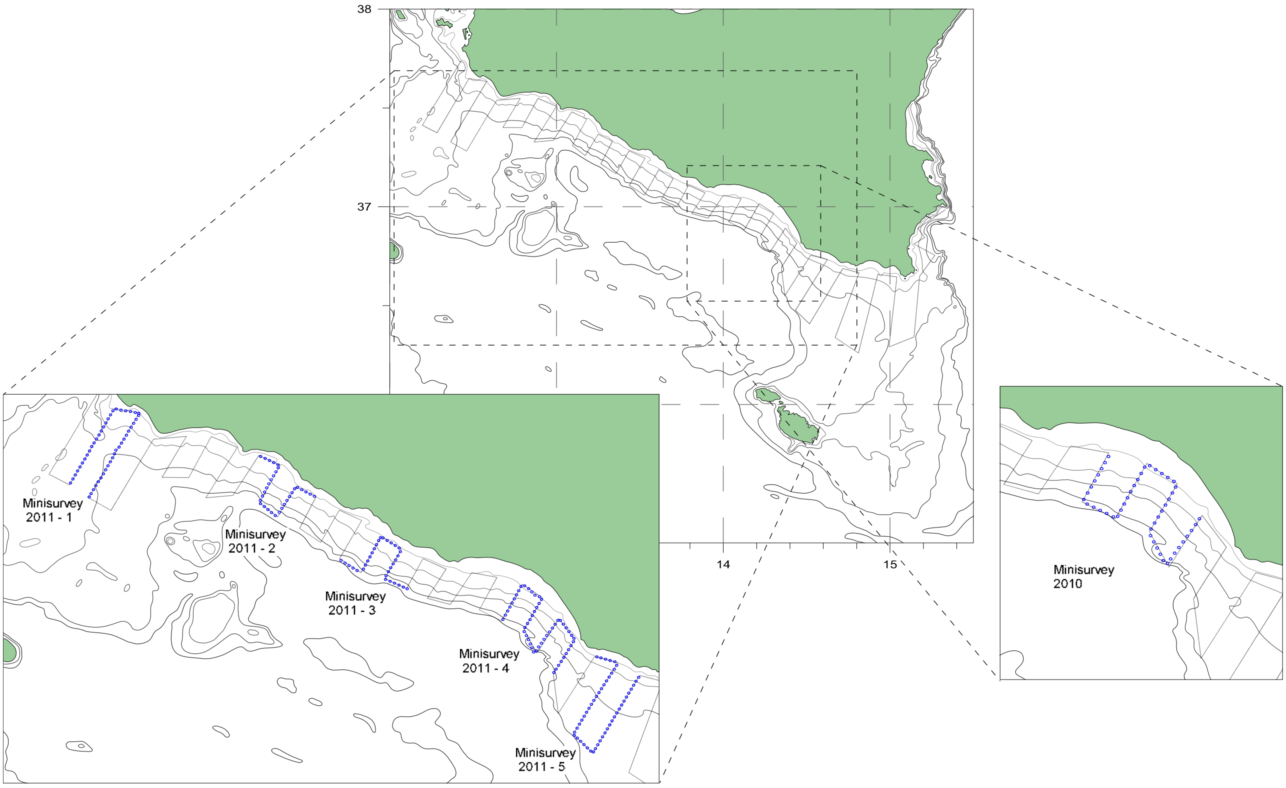


Figure 4.2.4. Targeted mini surveys (blue lines) carried out in 2010 and in 2011 in the Strait of Sicily.

The acoustic data analysis was performed according to the agreed protocol as described below:

- horizontal integration unit was set at 0.25 nm;
- night-time echograms were analyzed from 2 m above bottom;
- Sv threshold during day-time was set at -70 dB, -60 dB and -56 dB, while in night-time it was set at -75 dB, -70 dB, -65 dB, -60 dB, -56 dB and -55dB;
- two frequencies used: 38 kHz and 120 kHz (for the minisurvey 2010 only the 38 kHz was analyzed);
- NASC was evaluated for the total water column (20 – 200 m);
- transects perpendicular to the coast were included in the analysis;
- mean NASC & variance estimates are estimated by the Jolly & Hampton (1990) formula (equation 4);
- paired day-time and night-time values were used to estimate the proportion of the total backscatter according to O’Driscoll *et al.* (2009)

$$\log(p) = \overline{\left(\log\left(\frac{N_i}{D_i} \right) \right)} \qquad (5)$$

where N_i and D_i are the night-time and the day-time values for the i-*th* horizontal integration unit.

- the uncertainty of p and mean NASC values was estimated by bootstrapping. The data were resampled (with replacement) 1000 times, each time selecting a sample of the same size as the original dataset. Values of p and associated values were calculated for each bootstrapped sample and 95% confidence intervals were generated.
- Analysis was done with an R script that was written specifically for the purposes of the project by Marco Barra (CNR-IAMC).

Only the acoustic data at 38 kHz were analyzed concerning the mini survey carried out in summer 2010, because the second transducer (120 kHz) was not calibrated and the recorded data were not considered reliable for analysis. The results of the mini survey 2010 at 38 kHz are reported in Table 4.2.6 and Figure 4.2.5.

Table 4.2.6. *Strait of Sicily mini survey 2010:* Differences in acoustic estimates (NASC) between Day and Night pairs are presented. CI L: Lower Confidence Interval CI U: Upper Confidence Interval. p ratio denotes the proportion of night compared to the total backscatter

Minisurvey 2010									
		Day1		**Day2**		**Day1**		**Day2**	
	Threshold	**Mean_38**	**Variance_38**	**Mean_38**	**Variance_38**	**CI L**	**CI U**	**CI L**	**CI U**
NIGHT	N -55	189.12	2618.50			139.57	240.39		
	N -56	195.02	2707.98			141.36	255.65		
	N -60	221.28	2913.63			168.40	278.88		
	N -65	283.41	3069.84			232.14	344.34		
	N -70	372.40	4424.94			319.82	433.07		
	N -75	435.94	6133.99			381.76	493.34		
DAY	D -56	102.74	1267.26	148.03	2809.28	73.64	135.74	105.24	195.02
	D -60	134.23	1311.08	162.01	3056.60	89.82	181.27	115.91	206.22
	D -70	193.37	2517.10	222.52	3108.82	150.36	243.56	174.97	271.61

p ratio						
Threshold	**p_day1**	**CIL day1**	**CIU day1**	**p_day2**	**CIL day2**	**CIU day2**
-56	2.01	1.37	3.47	1.55	1.05	2.88
-60	1.48	1.12	2.70	1.33	1.01	2.33
-70	1.90	1.53	2.62	1.51	1.19	2.30

During the 2nd day of the survey higher mean NASC values were observed compared to the 1st day. Mean NASC estimated during night-time was higher with decreasing Sv threshold value. Moreover, we observed a higher NASC value during night-time (Table 4.2.6 and Fig. 4.2.5). The proportion of night echo to the total backscatter is estimated using the same night-time values for both days (Table 4.2.6).

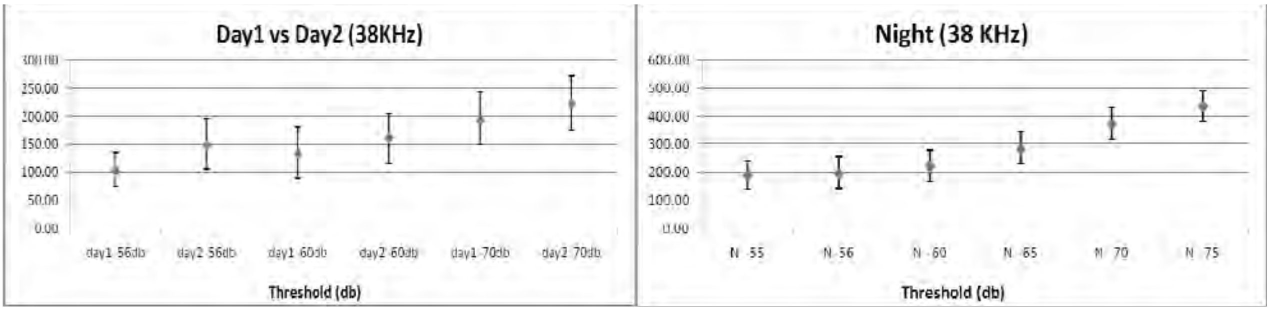


Figure 4.2.5. *Strait of Sicily Minisurvey 2010:* Mean NASC of the entire water column at 38 kHz with Sv thresholds for day-time at -56 dB, -60 dB and -70 dB, and for night-time at -55 dB, -56 dB, -60 dB, -65 dB, -70 dB and -75 dB.

The results of the “Minisurvey 2011 – 1” at 38 kHz and 120 kHz are reported in Table 4.2.7 and Figure 4.2.6.

Table 4.2.7. *Strait of Sicily Minisurvey 2011 – 1:* Differences in acoustic estimates between Day and Night pairs. CI L: Lower Confidence Interval CI U: Upper Confidence Interval. p ratio denotes the proportion of night compared to the total backscatter

Mini survey 2011 – 1									
						38KHz		120KHz	
	Threshold	**Mean_38**	**Variance_38**	**Mean_120**	**Variance_120**	**CI L**	**CI U**	**CI L**	**CI U**
NIGHT	N -55	104.90	5302.99	121.36	5629.43	27.69	247.56	41.20	263.82
	N -56	122.69	3975.37	137.62	5136.35	44.48	261.23	57.11	277.96
	N -60	122.92	4864.07	146.64	3771.62	43.73	265.18	65.57	291.01
	N -65	166.00	4076.90	193.31	1771.24	86.53	307.97	109.03	336.96
	N -70	212.74	3675.38	244.85	999.60	132.27	353.03	162.39	391.32
	N -75	240.96	3471.76	279.43	803.08	162.05	380.57	195.59	425.50
DAY	D -56	68.52	269.80	89.08	138.38	29.24	126.01	50.31	142.55
	D -60	79.52	260.42	100.28	325.42	40.97	137.01	61.89	155.54
	D -70	161.81	509.30	184.06	2937.41	123.09	220.73	144.47	233.49

p ratio						
Threshold	**p_38**	**CIL 38**	**CIU 38**	**p_120**	**CIL 120**	**CIU 120**
-56	1.88	0.85	4.51	1.43	0.74	2.96
-60	1.52	0.71	2.97	1.46	0.72	2.80
-70	1.51	0.95	2.23	1.47	0.92	2.16

Mean NASC estimated during night-time increases with decreasing Sv threshold value. Higher mean NASC values are observed during night-time than in day-time for both frequencies and for the same Sv threshold, even though the differences are not statistically significant (Table 4.2.7 and Fig. 4.2.6). The comparison between the mean NASC values of the two frequencies singles out that the abundance of plankton biomass in the minisurvey area is very poor. The estimate of the proportion of night echo to the total backscatter observed at both frequencies is about 1.5 for the three Sv thresholds (Table 4.2.7).

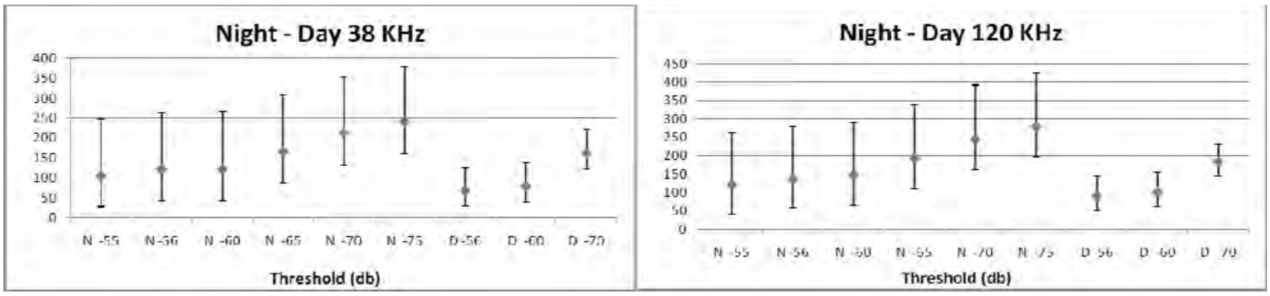


Figure 4.2.6 – Strait of Sicily Minisurvey 2011 – 1: Mean NASC of the entire water column at 38 kHz and 120 kHz, with Sv thresholds for day-time at -56 dB, -60 dB and -70 dB, and for night-time at -55 dB, -56 dB, -60 dB, -65 dB, -70 dB and -75 dB.

The results of the "Minisurvey 2011 – 2" at 38 kHz and 120 kHz are reported in Table 4.2.8 and Figure 4.2.7.

Table 4.2.8. *Strait of Sicily Minisurvey 2011 – 2:* Differences in acoustic estimates between Day and Night pairs. CI L: Lower Confidence Interval CI U: Upper Confidence Interval. p ratio denotes the proportion of night compared to the total backscatter

Minisurvey 2011 – 2									
						38KHz		**120KHz**	
	Threshold	**Mean_38**	**Variance_38**	**Mean_120**	**Variance_120**	**CI L**	**CI U**	**CI L**	**CI U**
NIGHT	N -55	72.30	767.98	435.17	16697.54	56.43	89.97	337.17	554.33
	N -56	76.85	852.88	461.71	18050.31	59.30	97.60	359.10	575.49
	N -60	101.63	1245.60	602.73	24091.67	83.02	122.69	500.78	725.66
	N -65	153.08	1847.91	816.94	33403.52	131.98	175.77	706.54	929.84
	N -70	207.79	3057.63	963.47	44008.59	183.96	231.97	841.65	1087.73
	N -75	240.87	4205.15	1016.83	49258.80	215.21	267.19	910.18	1149.58
DAY	D -56	118.23	1084.41	575.93	7629.88	67.03	178.86	450.49	710.38
	D -60	129.51	1170.54	754.86	16172.63	78.47	192.96	614.59	901.62
	D -70	191.02	1126.48	1191.86	71870.01	138.90	253.00	1047.32	1348.90

p ratio						
Threshold	**p_38**	**CIL 38**	**CIU 38**	**p_120**	**CIL 120**	**CIU 120**
-56	0.96	0.73	1.64	0.62	0.47	0.91
-60	0.96	0.75	1.52	0.66	0.53	0.90
-70	0.97	0.79	1.31	0.72	0.60	0.90

In this minisurvey mean NASC values are higher during day-time than in night-time for both frequencies and for common Sv threshold (Table 4.2.8 and Fig. 4.2.7). Smaller confidence intervals are estimated for the night-time echograms. The proportion of the night echo to the total backscatter observed at 38 kHz is close to 1 for the three Sv thresholds (Table 4.2.8).

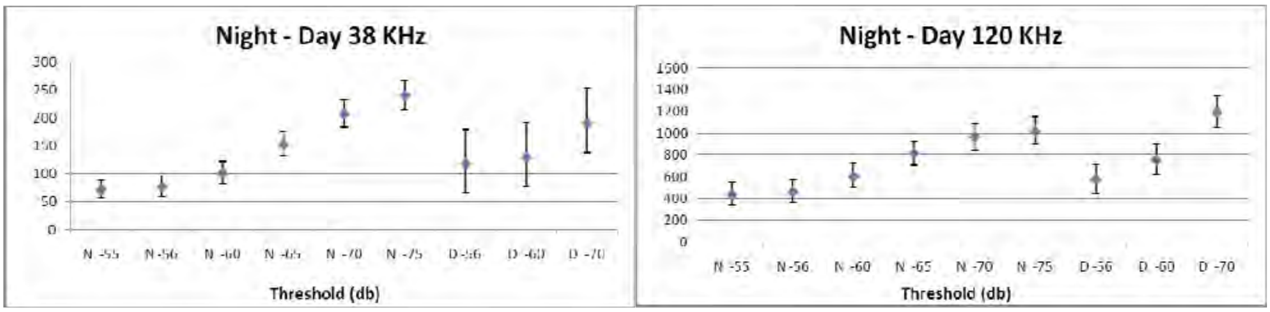


Figure 4.2.7. *Strait of Sicily Minisurvey 2011 – 2:* Mean NASC of the entire water column at 38 kHz and 120 kHz, with Sv thresholds for day-time at -56 dB, -60 dB and -70 dB, and for night-time at -55 dB, -56 dB, -60 dB, -65 dB, -70 dB and -75 dB.

The results of the “Minisurvey 2011 – 3” at 38 kHz and 120 kHz are reported in Table 4.2.9 and Figure 4.2.8.

Table 4.2.9. *Strait of Sicily Minisurvey 2011 – 3:* Differences in acoustic estimates between Day and Night pairs. CI L: Lower Confidence Interval CI U: Upper Confidence Interval. p ratio denotes the proportion of night compared to the total backscatter

Minisurvey 2011 – 3									
						38KHz		120KHz	
	Threshold	**Mean_38**	**Variance_38**	**Mean_120**	**Variance_120**	**CI L**	**CI U**	**CI L**	**CI U**
NIGHT	N -55	110.11	2213.30	722.05	20564.40	88.85	136.14	603.74	844.95
	N -56	118.44	2452.98	794.09	26363.35	94.90	146.35	673.15	920.15
	N -60	158.07	2891.23	1146.32	90044.79	132.52	187.66	1015.48	1285.06
	N -65	230.47	2305.84	1579.61	242553.20	203.25	259.91	1413.89	1732.97
	N -70	303.13	2737.18	1837.10	365393.39	273.46	335.29	1678.74	2015.28
	N -75	354.44	4231.34	1927.34	411503.88	324.77	385.01	1764.54	2096.19
DAY	D -56	68.02	858.69	657.38	48746.95	45.91	93.24	526.88	786.62
	D -60	82.35	1041.46	869.31	95753.34	59.77	105.87	723.82	1021.56
	D -70	159.62	965.28	1283.76	200259.46	134.66	188.19	1129.63	1461.13

p ratio						
Threshold	**p_38**	**CIL 38**	**CIU 38**	**p_120**	**CIL 120**	**CIU 120**
-56	2.37	1.75	5.12	1.41	1.09	2.43
-60	2.45	1.91	3.90	1.52	1.21	2.31
-70	2.04	1.70	2.68	1.56	1.29	2.02

For this minisurvey mean NASC values are higher during night-time than in day-time for both frequencies and for common Sv threshold. Small confidence intervals are estimated for both night-time and day-time values.

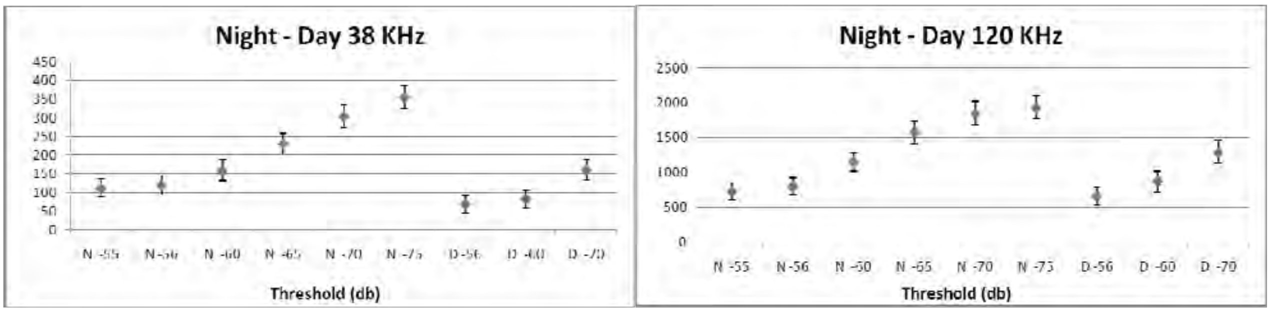


Figure 4.2.8. *Strait of Sicily Minisurvey 2011 – 3:* Mean NASC of the entire water column at 38 kHz and 120 kHz, with Sv thresholds for day-time at -56 dB, -60 dB and -70 dB, and for night-time at -55 dB, -56 dB, -60 dB, -65 dB, -70 dB and -75 dB.

The results of the "Minisurvey 2011 – 4" at 38 kHz and 120 kHz are reported in Table 4.2.10 and Figure 4.2.9.

Table 4.2.10. *Strait of Sicily Minisurvey 2011 – 4:* Differences in acoustic estimates between Day and Night pairs. CI L: Lower Confidence Interval CI U: Upper Confidence Interval. p ratio denotes the proportion of night compared to the total backscatter

Minisurvey 2011 – 4										
						38KHz		120KHz		
	Threshold	Mean_38	Variance_38	Mean_120	Variance_120	CI L	CI U	CI L	CI U	
NIGHT	N -55	120.59	1123.84	874.10	45362.09	83.24	162.96	694.45	1055.46
	N -56	125.53	1162.42	933.04	52184.99	87.37	168.69	740.90	1131.49
	N -60	155.71	1315.08	1198.06	90057.86	117.09	199.47	1001.68	1425.16
	N -65	221.84	1730.09	1492.93	142986.90	181.20	267.60	1289.01	1717.14
	N -70	285.31	2467.32	1662.80	174904.24	244.77	332.17	1414.21	1911.58
	N -75	324.91	3169.01	1728.60	185590.14	283.40	368.88	1495.65	1957.68
DAY	D -56	67.32	305.04	594.68	77724.14	44.44	99.74	472.61	728.29
	D -60	96.70	779.03	812.39	126762.33	70.16	129.00	674.99	952.85
	D -70	219.16	3474.68	1231.06	179014.06	187.97	254.24	1083.11	1393.21

p ratio						
Threshold	p_38	CIL 38	CIU 38	p_120	CIL 120	CIU 120
-56	1.89	1.39	4.10	1.66	1.25	4.58
-60	1.91	1.44	3.20	1.54	1.22	3.14
-70	1.59	1.34	2.02	1.33	1.07	2.10

Also for the minisurvey 2011 – 4 higher mean NASC values are observed in night-time for both frequencies (Table 4.2.10 and Fig. 4.2.9).

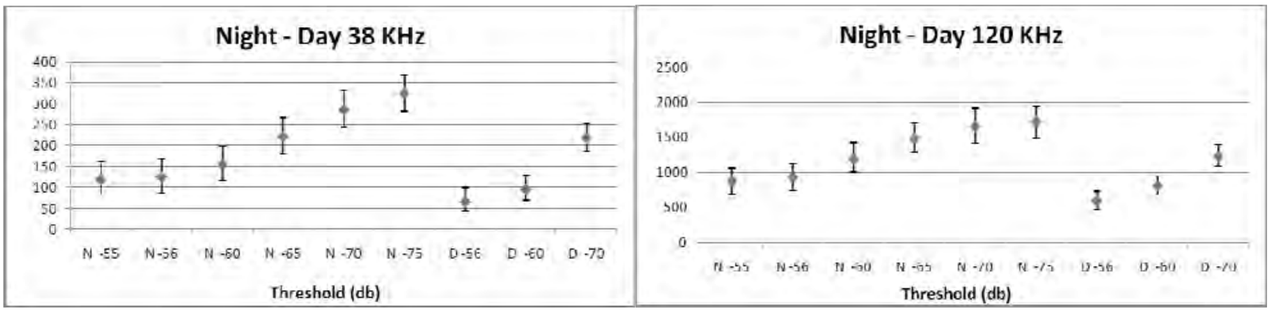


Figure 4.2.9. *Strait of Sicily Minisurvey 2011 – 4:* Mean NASC of the entire water column at 38 kHz and 120 kHz, with Sv thresholds for day-time at -56 dB, -60 dB and -70 dB, and for night-time at -55 dB, -56 dB, -60 dB, -65 dB, -70 dB and -75 dB.

The results of the “Minisurvey 2011 – 5” at 38 kHz and 120 kHz are reported in Table 4.2.11 and Figure 4.2.10.

Table 4.2.11. *Strait of Sicily Minisurvey 2011 – 5:* Differences in acoustic estimates between Day and Night pairs. CI L: Lower Confidence Interval CI U: Upper Confidence Interval. p ratio denotes the proportion of night compared to the total backscatter

Minisurvey 2011 – 5									
						38KHz		**120KHz**	
	Threshold	**Mean_38**	**Variance_38**	**Mean_120**	**Variance_120**	**CI L**	**CI U**	**CI L**	**CI U**
NIGHT	N -55	173.18	1453.94	967.83	58231.50	152.09	196.15	891.54	1042.49
	N -56	208.66	2108.62	1066.03	63802.94	182.98	233.61	988.13	1143.61
	N -60	365.62	5913.45	1422.86	80881.08	328.56	404.51	1330.19	1517.07
	N -65	545.62	10591.83	1772.54	99382.77	503.35	589.58	1662.57	1870.93
	N -70	662.86	13287.07	1971.92	109070.03	611.70	714.15	1863.22	2074.61
	N -75	716.73	14194.72	2043.48	110580.66	666.99	767.09	1943.43	2149.32
DAY	D -56	122.14	682.13	626.87	4168.13	88.96	160.62	501.13	763.18
	D -60	209.76	260.48	929.71	6991.90	170.37	254.75	795.87	1073.65
	D -70	462.90	1314.07	1468.26	18716.33	416.53	513.59	1327.79	1622.24

p ratio						
Threshold	**p_38**	**CIL 38**	**CIU 38**	**p_120**	**CIL 120**	**CIU 120**
-56	0.49	0.35	1.05	0.76	0.63	0.96
-60	0.67	0.50	1.27	0.83	0.72	1.04
-70	0.79	0.64	1.04	0.86	0.76	1.03

Day-time values at both frequencies are lower than night-time mean NASC (Table 4.2.11 and Fig. 4.2.10). Nevertheless, this is not evident in the proportion of total backscatter (Table 4.2.11). Probably, such effect is due to the bias produced by antilog transformation of mean *p*.

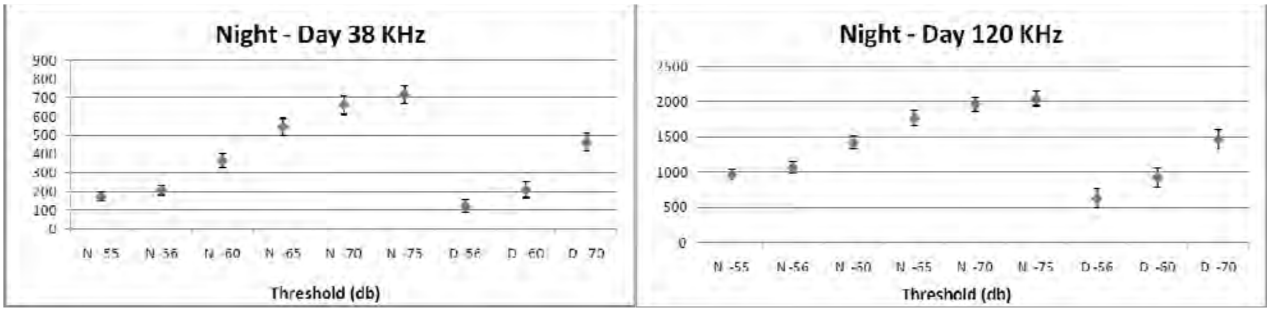


Figure 4.2.10. *Strait of Sicily Minisurvey 2011 – 5:* Mean NASC of the entire water column at 38 kHz and 120 kHz, with Sv thresholds for day-time at -56 dB, -60 dB and -70 dB, and for night-time at -55 dB, -56 dB, -60 dB, -65 dB, -70 dB and -75 dB.

The results of "All Minisurvey 2011" at 38 kHz and 120 kHz are reported in Table 4.2.12 and Figure 4.2.11. In this case all data collected during the five night-time and day-time intervals were grouped in one "day set" and one "night set".

Table 4.2.12. *Strait of Sicily All Minisurveys 2011:* Differences in acoustic estimates between Day and Night pairs. CI L: Lower Confidence Interval CI U: Upper Confidence Interval. p ratio denotes the proportion of night compared to the total backscatter

All Minisurvey 2011										
							38KHz		120KHz	
	Threshold	**Mean_38**	**Variance_38**	**Mean_120**	**Variance_120**	**CI L**	**CI U**	**CI L**	**CI U**
NIGHT	N -55	120.41	485.90	636.74	16215.92	96.15	151.68	579.22	704.05
	N -56	135.82	559.84	692.26	18813.87	111.17	169.18	633.55	758.56
	N -60	189.40	1666.48	915.25	32829.87	162.74	223.93	853.32	989.90
	N -65	275.58	3255.44	1175.49	50735.99	248.67	309.27	1105.69	1253.27
	N -70	347.87	4312.67	1335.18	61616.26	319.65	383.71	1263.12	1407.87
	N -75	389.00	4736.09	1397.07	64758.40	362.07	425.80	1325.28	1472.93
DAY	D -56	88.19	102.67	494.72	9036.50	70.87	104.93	441.70	550.47
	D -60	121.99	268.69	678.95	17562.31	104.63	141.33	622.47	738.91
	D -70	249.82	1533.39	1052.16	35784.20	229.97	270.81	995.11	1113.82

p ratio						
Threshold	**p_38**	**CIL 38**	**CIU 38**	**p_120**	**CIL 120**	**CIU 120**
-56	1.88	0.85	4.51	1.43	0.74	2.96
-60	1.52	0.71	2.97	1.46	0.72	2.80
-70	1.51	0.95	2.23	1.47	0.92	2.16

Mean NASC values at both frequencies during night-time are higher than the ones estimated during day-time for common Sv thresholds.

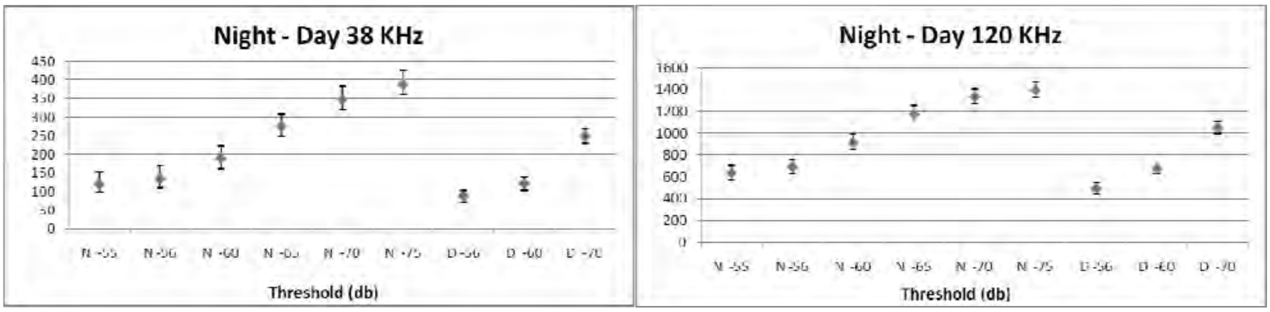


Figure 4.2.11. *Strait of Sicily All Minisurveys 2011:* Mean NASC of the entire water column at 38 kHz and 120 kHz, with Sv thresholds for day-time at -56 dB, -60 dB and -70 dB, and for night-time at -55 dB, -56 dB, -60 dB, -65 dB, -70 dB and -75 dB.

The six minisurveys carried out in the Strait of Sicily in 2010 and 2011 singled out a high variability of results in terms of both mean NASC values and proportion of total backscatter (*p*) depending on the surveyed area and its characteristics in terms of fish and plankton density. Day-time surveys at both frequencies indicated lower values than those estimated during night-time surveys except for the “Minisurvey 2011 – 2”. Only in the “Minisurvey 2011 – 1” and in the “Minisurvey 2011 – 2” the proportion of total backscatter (*p*) was not significantly different from 1. Probably, such results and the observed variability are linked to the complex water masses circulation of the Strait of Sicily that may influence fish and plankton distribution patterns in the different zones of the study area. In particular, in the first two minisurveys of 2011 day-time NASC values at both frequencies are not significantly different from the night-time ones. For the other minisurveys differences between day and night mean NASC values are significant for most of the Sv thresholds.

The mean NASC values at 120 kHz better highlighted the presence of plankton organisms in the water column. In the "Minisurvey 2011 – 3", "Minisurvey 2011 – 4" and "Minisurvey 2011 – 5" the estimated values, both during day and night at 120 kHz, are higher than the ones estimated for the first two minisurveys, singling out the high level of plankton biomass in the easternmost part of the study area.

The overall results also confirm the results obtained in the last three minisurveys. The effects of plankton density are mainly singled out by the 120 kHz acoustic data and are less evident compared to the easternmost minisurveys.

Western Adriatic Sea

For the purposes of the project, because no suitable data were retrieved from past surveys, four field experiments were carried out in the Adriatic Sea to compare day-time and night-time acoustic data: 3 surveys in 2009 and 1 survey in 2010. Each surveyed area was sampled three times, twice during day-time and once during night-time.

During 2009 surveys were carried out in Manfredonia Gulf (South Adriatic Sea, 9-10 August 2009) and in two different locations in the Middle Adriatic Sea (near Vasto 11-12 August and near San Benedetto 30 September – 1 October). Each survey had a maximum length of about 40 nm and a maximum transect length of about 14 nm. Areas varied in terms of bathymetry (22-35 m 1st survey, 43-56 m 2nd survey and 68-92 m 3rd survey), therefore hauls were carried out at different depths. The area is shown in Figure 4.2.12.

The 2010 survey was carried out near Barletta, in the Southern Adriatic Sea, during 21 - 22 July 2010. The study area is shown in Figure 4.2.13. This survey had a length of about 35 nm and a maximum transect length of about 9 nm. Bottom depth was 94 - 105 m.

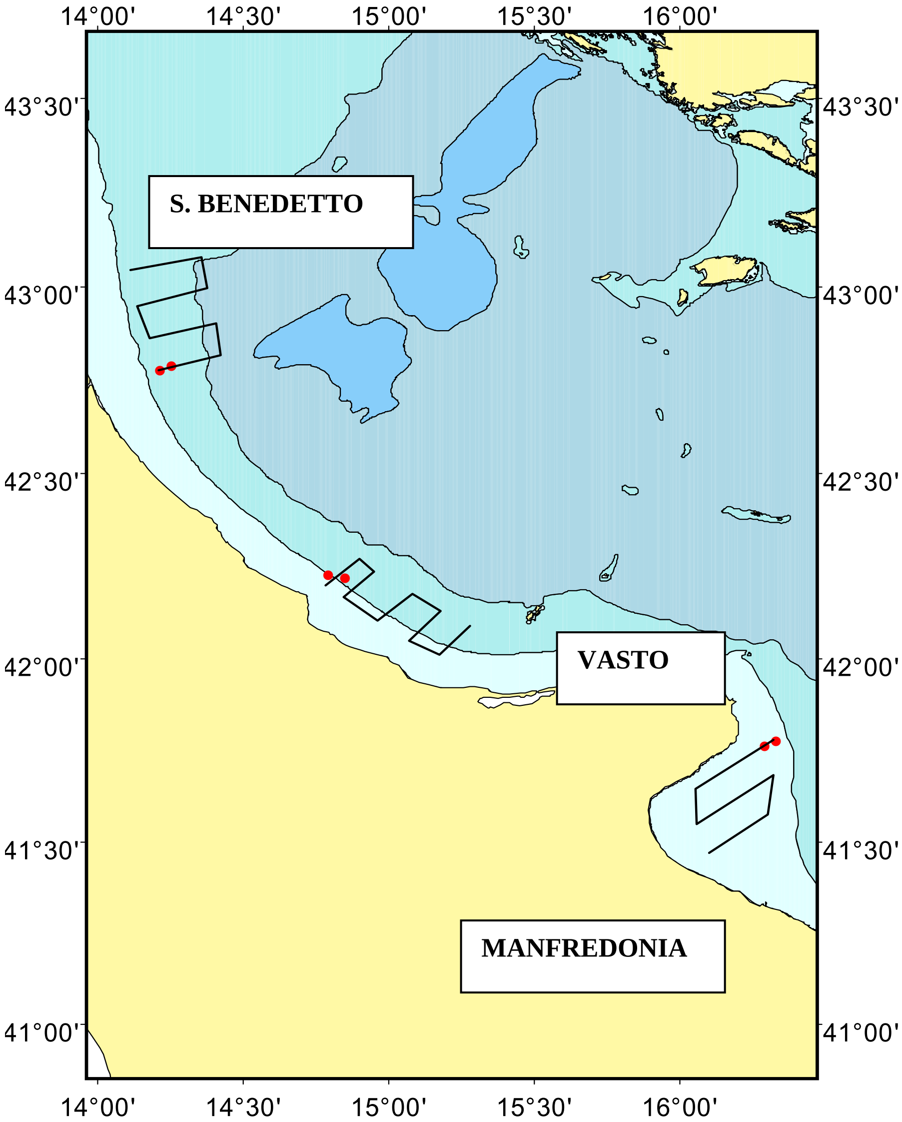


Figure 4.2.12. Surveys carried out in 2009 in the Adriatic Sea.

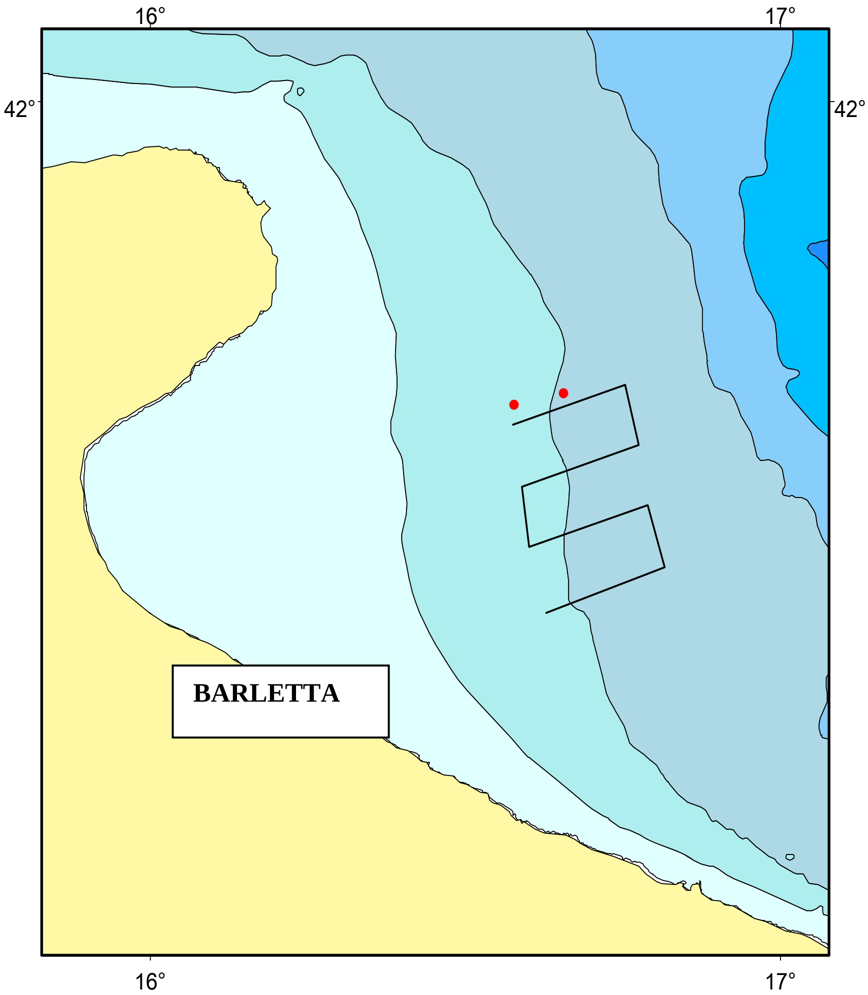


Figure 4.2.13. Survey carried out in 2010 in the Adriatic Sea.

Acoustic data collected during each survey were analyzed in order to identify any significant differences in terms of total NASC of the entire water column between the day-time and the night-time recordings.

- The horizontal integration unit was fixed to 300 pings (150 m: about 0.34 nm) so mean area backscattering coefficients were estimated for each 300 ping unit.
- According to the agreed protocol Myriax Echoview software was used for the data analysis. Data were analyzed at two frequencies: 38 kHz and 120 kHz.
- Sv threshold during day-time and during night-time was set at -70 dB, -60 dB and -55dB.
- Mean area backscattering coefficients and their confidence intervals were calculated (Jolly & Hampton formula of (1990)) for each survey held during the first day, the night after and the second day.
- Transect parallel to the coast were excluded from the analysis.
- mean NASC & variance estimates were obtained using the formula of Jolly & Hampton (1990) (equation 4) as described by Coombs and Cordue (1995).

- paired day-time and night-time values were used to estimate the proportion of the total backscatter according to O'Driscoll *et al.* (2009) (equation 5).
- the uncertainty of p ratio and mean NASC values was estimated by bootstrapping.

1 - 1° case study – Survey MANFREDONIA, Southern Adriatic Sea, 9 - 10 August 2009

The Total NASC of the entire water column was estimated per horizontal integration unit of 300 pings (~0.34 nm) at 38 kHz applying different Sv thresholds. The results are reported in Table 4.2.13 and Figure 4.2.14. At 120 kHz, the results are reported in Table 4.2.14 and Figure 4.2.15.

Table 4.2.13. *Manfredonia survey:* Differences in acoustic estimates (Total NASC at 38 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	**Total NASC at 38 kHz**		
	Mean	Confidence Interval	
D1-55	448.37	262.42	634.32
D1-60	465.45	278.27	652.63
D1-70	481.68	292.36	671.01
N-55	485.10	354.40	615.80
N-60	532.42	391.06	673.78
N-70	578.42	423.72	733.11
D2-55	605.05	391.26	818.83
D2-60	621.85	405.18	838.52
D2-70	638.34	420.17	856.50

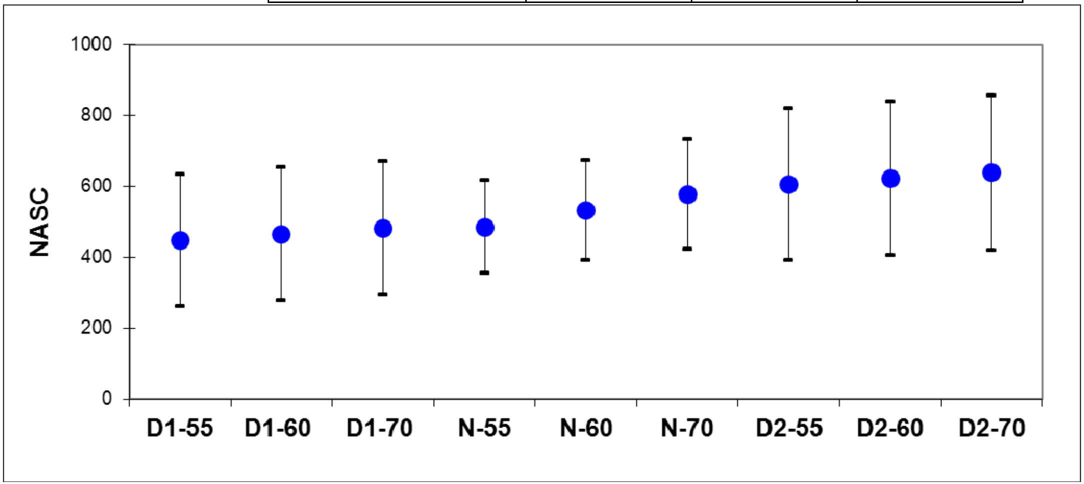


Figure 4.2.14. *Manfredonia survey:* Mean total NASC of the entire water column at 38 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

Table 4.2.14. *Manfredonia survey:* Differences in acoustic estimates (Total NASC at 120 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	Total NASC at 120 kHz		
	Mean	Confidence Interval	
D1-60	417.41	210.65	624.16
D1-70	448.35	241.16	655.54
N-55	263.33	231.03	295.62
N-60	297.17	256.84	337.50
N-70	358.75	298.31	419.18
D2-60	426.58	244.54	608.61
D2-70	472.68	284.41	660.94

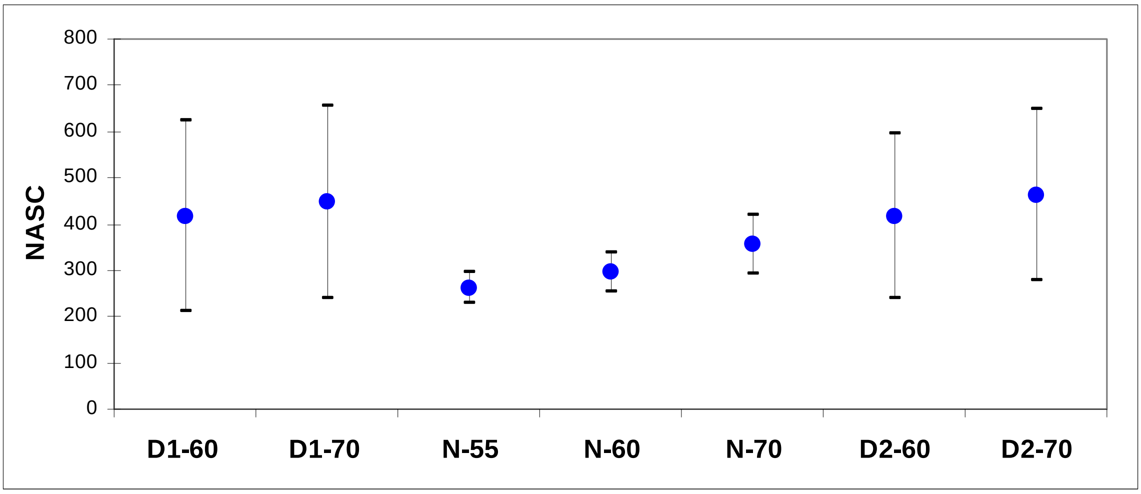


Figure 4.2.15. *Manfredonia survey:* Mean total NASC of the entire water column at 120 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

Results indicated small differences between NASC values estimates during day-time and night-time. At 120 kHz, estimated confidence intervals during day-time were much higher compared to night-time sampling. Concerning the proportion of the total backscatter according to O'Driscoll *et al.* (2009) (equation 5), the proportion of Day1 and Day2 backscatter observed at Night are presented in Table 4.2.15. Considering Day1 as total backscatter the proportion of the Day 1 backscatter observed at Day 2 is higher then the proportion observed during the night with larger differences between Day1 and Day2 NASC values.

Table 4.2.15. *Manfredonia survey:* The proportion (p) of the total backscatter between N-D1, N-D2 and the confidence Intervals at 38 kHz. D: Day, N: Night.

Day1-Night-Day2	Manfredonia 2009 - 38 kHz			
	threshold (dB)	p	Confidence Interval	
N-D1	-55	1.28	0.98	1.91
	-60	1.33	1.03	1.97
	-70	1.38	1.07	1.99
N-D2	-55	0.82	0.60	1.34
	-60	0.87	0.63	1.47
	-70	0.92	0.69	1.42

2 - 2° case study – survey VASTO, Middle Adriatic Sea, 11-12 August 2009

The results of the Vasto survey, at the frequency of 38 kHz, are reported in Table 4.2.16 and Figure 4.2.16. The Total NASC of the entire water column was estimated per horizontal integration unit of 300 pings applying different Sv thresholds.

Table 4.2.16. *Vasto survey:* Differences in acoustic estimates (Total NASC at 38 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	Total NASC at 38 kHz		
	Mean	Confidence Interval	
D1-55	173.01	109.04	236.99
D1-60	316.08	210.08	422.08
D1-70	506.33	388.07	624.59
N-55	789.44	646.92	931.95
N-60	1127.20	1002.62	1251.78
N-70	1397.58	1287.77	1507.40
D2-55	145.65	109.33	181.97
D2-60	292.79	242.82	342.76
D2-70	482.57	419.95	545.18

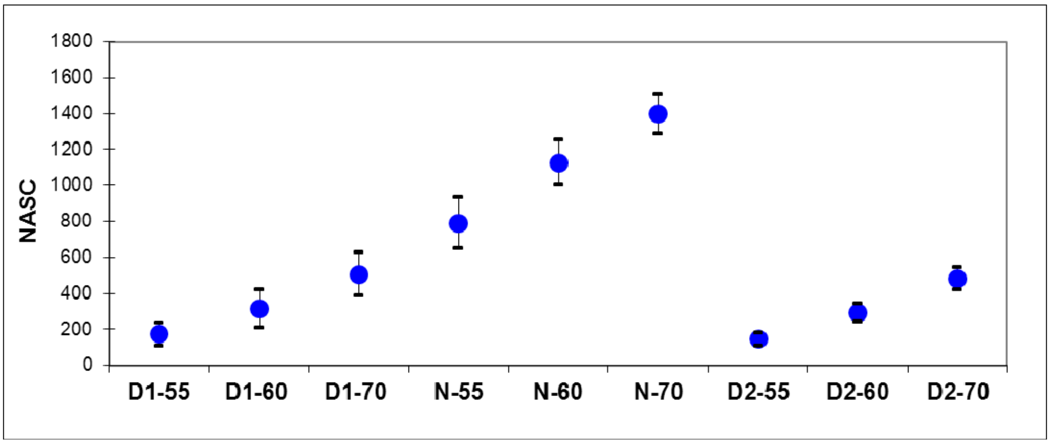


Figure 4.2.16. *Vasto survey:* Mean total NASC of the entire water column at 38 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

The Day1 and Day2 NASC mean value were quite similar for the same threshold and lower compared to Night mean NASC value for each Sv threshold. Estimated confidence intervals were smaller for Day 2 than Night and Day 1 sampling. At 120 kHz, the results are reported in Table 4.2.17 and Figure 4.2.17.

Table 4.2.17. *Vasto survey:* Differences in acoustic estimates (Total NASC at 120 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	**Total NASC at 120 kHz**		
	Mean	Confidence Interval	
D1-60	147.70	124.56	170.83
D1-70	360.58	317.16	403.99
N-55	445.92	267.32	624.52
N-60	511.16	363.31	659.02
N-70	744.56	572.33	916.80
D2-60	139.21	128.16	150.26
D2-70	305.08	290.80	319.37

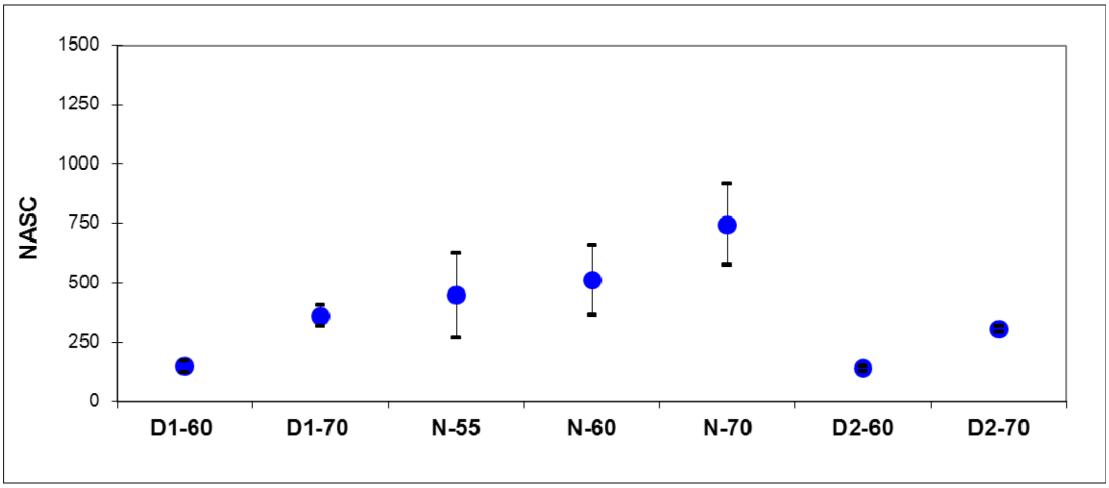


Figure 4.2.17. *Vasto survey:* Mean total NASC of the entire water column at 120 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

The Day1 and Day 2 NASC mean value were quite similar for the same threshold and lower compared to Night mean NASC value for each Sv threshold. Estimated confidence intervals were smaller for Day than Night sampling. Concerning the proportion of the total backscatter according to O'Driscoll *et al.* (2009) (equation 5), the proportion of Day1 and Day2 backscatter observed at Night are presented in Table 4.2.18.

Table 4.2.18. *Vasto survey:* The proportion (p) of the total backscatter between N-D1, N-D2, D1-D2 and the confidence Intervals at 38 kHz. D: Day, N: Night.

Day 1-Night-Day2	Vasto 2009 - 38 kHz			
	threshold (dB)	p	Confidence Interval	
N-D1	-55	6.38	5.00	8.93
	-60	4.67	4.03	5.55
	-70	3.20	2.91	3.53
N-D2	-55	6.05	4.74	8.10
	-60	4.10	3.49	4.97
	-70	3.00	2.61	3.46

3 - 3° case study – survey SAN BENEDETTO, Middle Adriatic Sea, 30 September - 01 October 2009

The results of the San Benedetto survey at 38 kHz are reported in Table 4.2.19 and Figure 4.2.18. The total NASC of the entire water column was estimated per horizontal integration unit of 300 pings applying different Sv thresholds. The results at 120 kHz applying different Sv thresholds are reported in Table 4.2.20 and Figure 4.2.19.

Table 4.2.19. *San Benedetto survey:* Differences in acoustic estimates (Total NASC at 38 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	Total NASC at 38 kHz		
	Mean	Confidence Interval	
D1-55	295.76	172.07	419.46
D1-60	477.17	268.32	686.01
D1-70	622.42	387.99	856.85
N-55	358.23	274.54	441.91
N-60	511.35	388.47	634.24
N-70	799.64	637.70	961.58
D2-55	572.27	303.05	841.48
D2-60	743.14	381.16	1105.13
D2-70	887.58	524.92	1250.25

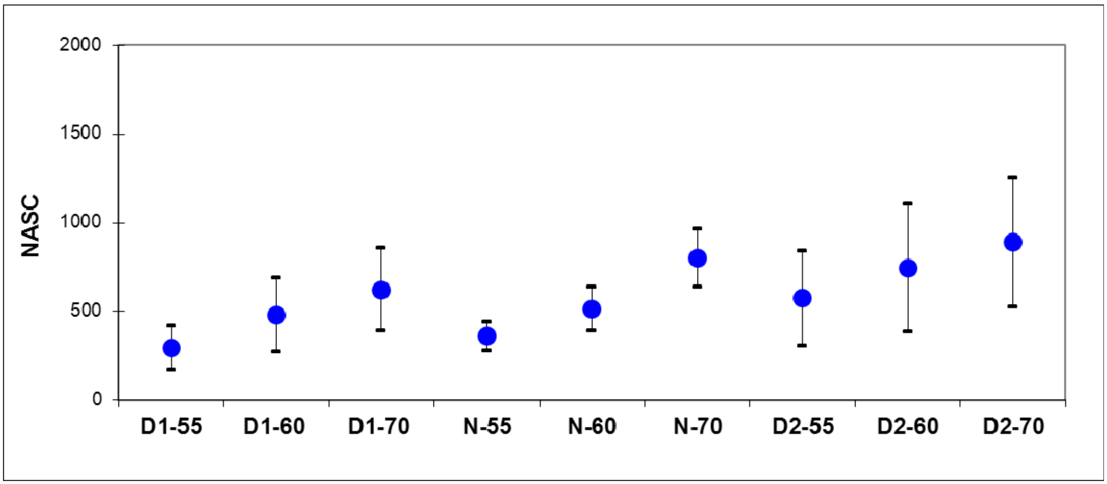


Figure 4.2.18. *San Benedetto survey:* Mean total NASC of the entire water column at 38 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

Table 4.2.20. *San Benedetto survey:* Differences in acoustic estimates (Total NASC at 120 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	**Total NASC at 120 kHz**		
	Mean	Confidence Interval	
D1-60	354.45	215.95	492.95
D1-70	453.89	298.38	609.40
N-55	190.76	144.99	236.53
N-60	254.19	192.47	315.91
N-70	407.84	323.66	492.03
D2-60	664.29	330.26	998.32
D2-70	750.93	420.28	1081.59

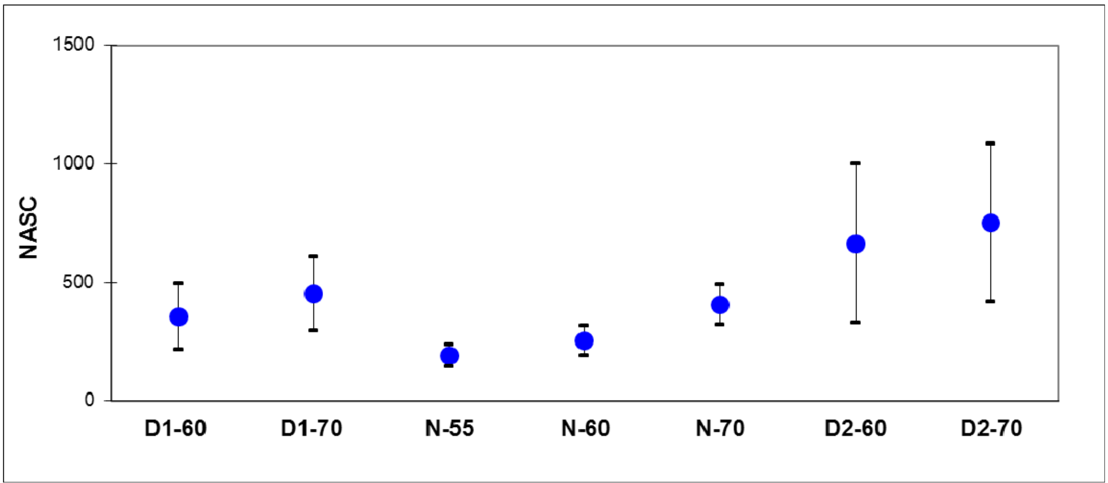


Figure 4.2.19. *San Benedetto survey:* Mean total NASC of the entire water column at 120 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

There are small differences between NASC values estimates during day-time and night-time. At 120 kHz the Night NASC mean value was lower compared to Day1 and Day 2 mean NASC value for each

Sv threshold. Concerning the proportion of the total backscatter according to O'Driscoll *et al.* (2009) (equation 5), the proportion of Day1 and Day2 backscatter observed at Night are presented in Table 4.2.21. Considering Day1 as total backscatter, the proportion of the Day 1 backscatter observed at Day 2 is higher than the proportion observed during the night with larger differences between Day1 and Day2 NASC values.

Table 4.2.21. *San Benedetto survey:* The proportion (p) of the total backscatter between N-D1, N-D2, D1-D2 and the confidence Intervals at 38 kHz. D: Day, N: Night.

Day 1-Night-Day2	**San Benedetto 2009 - 38 kHz**			
	threshold (dB)	p	Confidence Interval	
N-D1	-55	1.57	1.15	3.84
	-60	1.41	1.09	2.47
	-70	1.56	1.29	2.18
N-D2	-55	0.83	0.53	2.25
	-60	0.88	0.59	1.93
	-70	1.09	0.78	1.81

4 - 4° case study – survey BARLETTA, Middle Adriatic Sea, 21-22 July 2010

The results of the Barletta survey, at the frequency of 38 kHz, are reported in Table 4.2.22 and Figure 4.2.20. The Total NASC of the entire water column was estimated per horizontal integration unit of 300 pings applying different Sv thresholds.

Table 4.2.22. *Barletta survey:* Differences in acoustic estimates (Total NASC at 38 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	**Total NASC at 38 kHz**		
	Mean	Confidence Interval	
D1-55	135.13	101.33	168.94
D1-60	263.19	214.61	311.77
D1-70	456.63	402.29	510.96
N-55	746.93	347.16	1146.71
N-60	1115.29	693.26	1537.31
N-70	1382.22	967.74	1796.70
D2-55	140.25	112.71	167.79
D2-60	320.43	279.09	361.77
D2-70	538.22	493.00	583.45

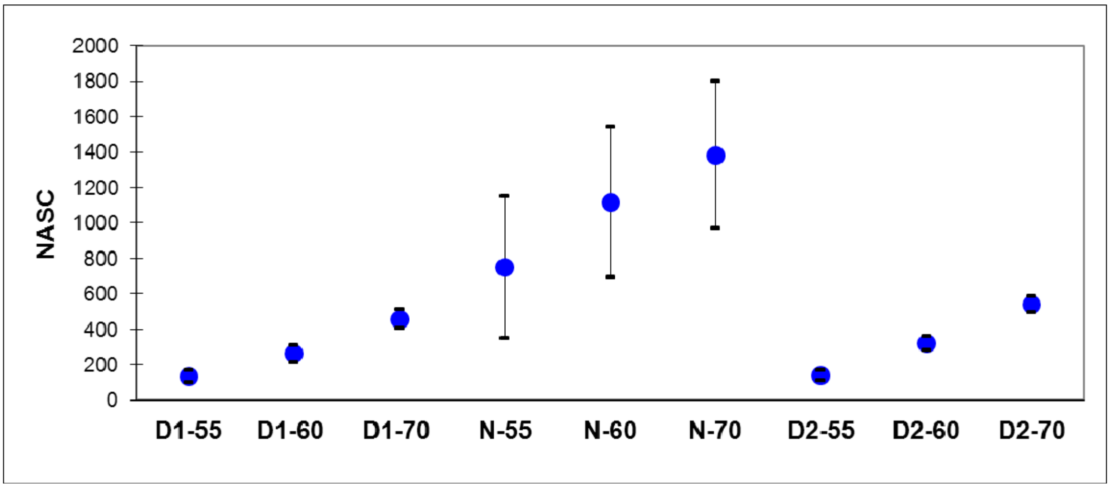


Figure 4.2.20. *Barletta survey:* Mean total NASC of the entire water column at 38 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

The Day1 and Day2 NASC mean values were quite similar for the same threshold and lower compared to Night mean NASC value for each Sv threshold. Estimated confidence intervals were smaller for Day than Night sampling. At 120 kHz, the results are reported in Table 4.2.23 and Figure 4.2.21.

Table 4.2.23. *Barletta survey:* Differences in acoustic estimates (Total NASC at 120 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	**Total NASC at 120 kHz**		
	Mean	Confidence Interval	
D1-55	49.22	13.77	84.67
D1-60	49.29	16.45	82.14
D1-70	118.02	79.70	156.35
N-55	576.22	169.40	983.04
N-60	759.48	303.85	1215.12
N-70	928.27	467.53	1389.02
D2-55	15.13	7.87	22.38
D2-60	22.24	14.05	30.44
D2-70	96.83	79.36	114.30

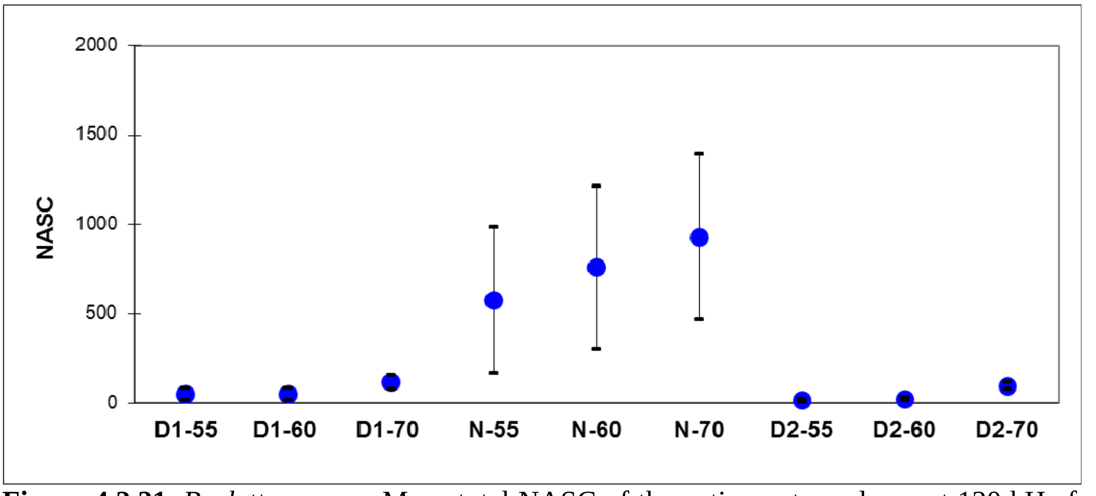


Figure 4.2.21. *Barletta survey:* Mean total NASC of the entire water column at 120 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

The Day1 and Day 2 NASC mean value were quite similar for the same threshold and lower compared to Night mean NASC value for each Sv threshold. Estimated confidence intervals were much smaller for Day than Night sampling. The proportion of Day1 and Day2 backscatter observed at Night are presented in Table 4.2.24.

Table 4.2.24. *Barletta survey:* The proportion (p) of the total backscatter between N-D1, N-D2, and the confidence Intervals at 38 kHz. D: Day, N: Night.

Day 1-Night-Day2	**Barletta 2010 - 38 kHz**			
	threshold (dB)	p	Confidence Interval	
N-D1	-55	4.46	3.66	5.72
	-60	3.79	3.34	4.38
	-70	2.77	2.50	3.07
N-D2	-55	4.26	3.57	5.22
	-60	3.08	2.77	3.49
	-70	2.37	2.20	2.56

The results of the specific surveys carried out in the Adriatic Sea in the years 2009-10, at the frequency of 38 kHz, are reported in Table 4.2.25 and Figure 4.2.22. The Total NASC of the entire water column was estimated per horizontal integration unit of 300 pings applying different Sv thresholds.

Table 4.2.25. *Adriatic Sea:* Differences in acoustic estimates (Total NASC at 38 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	**Total NASC at 38 kHz**		
	Mean	Confidence Interval	
D1-55	248.87	222.29	275.46
D1-60	369.52	336.78	402.26
D1-70	513.50	478.95	548.05
N-55	617.30	558.39	676.20
N-60	861.56	793.26	929.87
N-70	1088.89	1016.06	1161.71
D2-55	337.84	294.24	381.44
D2-60	470.71	423.21	518.20
D2-70	620.35	575.38	665.32

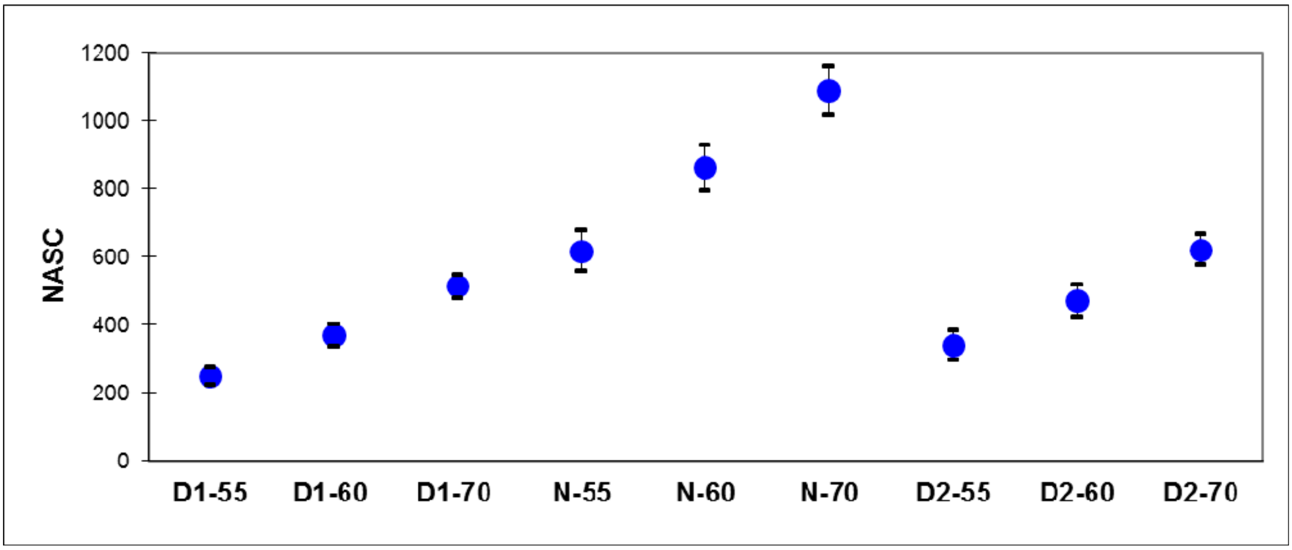


Figure 4.2.22. *Adriatic Sea:* Mean total NASC of the entire water column at 38 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

The Day1 and Day2 NASC mean values were quite similar for the same threshold and lower compared to Night mean NASC value for each Sv threshold. Estimated confidence intervals were smaller for Day than Night sampling. At 120 kHz, the results are reported in Table 4.2.26 and Figure 4.2.23.

Table 4.2.26. *Adriatic Sea:* Differences in acoustic estimates (Total NASC at 120 kHz) between Day and Night pairs. D1: Day 1, D2: Day 2, N: Night, Mean NASC was estimated per 0.34 nm horizontal sampling distance.

Day 1-Night-Day2 Sv threshold	**Total NASC at 120 kHz**		
	Mean	Confidence Interval	
D1-60	224.78	195.80	253.75
D1-70	335.10	305.46	364.74
N-55	384.54	324.80	444.28
N-60	475.76	410.91	540.61
N-70	638.21	569.32	707.11
D2-60	284.84	236.76	332.91
D2-70	382.27	335.21	429.33

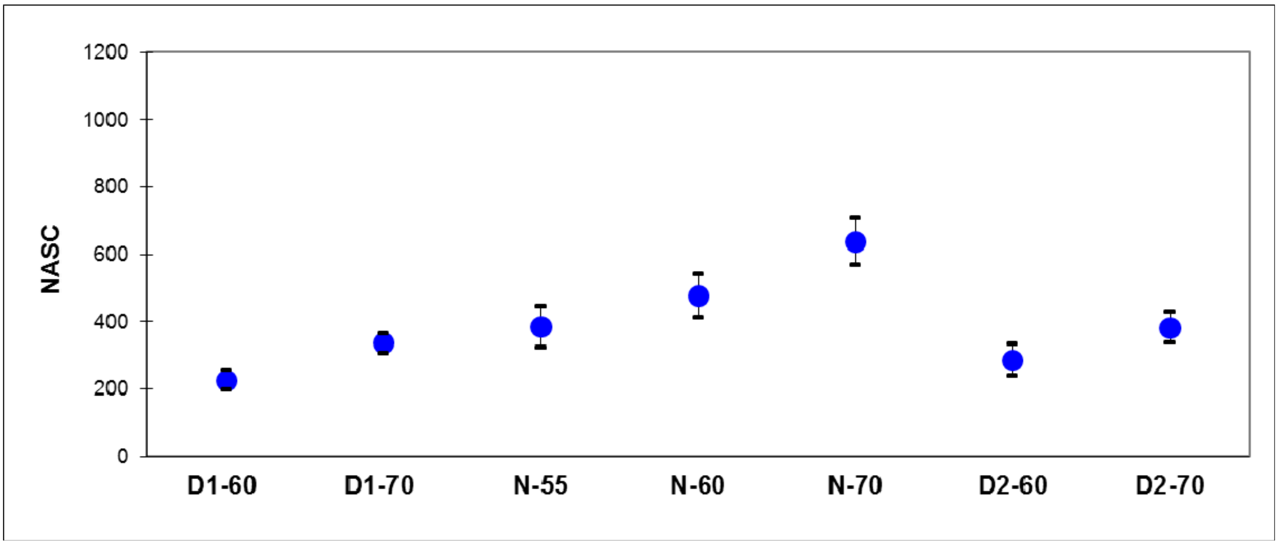


Figure 4.2.23. *Adriatic Sea:* Mean total NASC of the entire water column at 120 kHz for different Sv thresholds, D1: Day 1, D2: Day 2, N: Night.

The Day1 and Day 2 NASC mean value were quite similar for the same threshold and lower compared to Night mean NASC value for each Sv threshold. Estimated confidence intervals were smaller for Day than Night sampling.

The Day – Night comparison in acoustic sampling in the Adriatic Sea indicated on average higher NASC estimates during night-time although not always statistical significant. Differences were more pronounced at certain acquisition thresholds especially the -70 dB. Moreover, area differences were observed. Higher night-time estimates were observed in Barletta and Vasto area, whereas estimates between day and night were closer in Manfredonia and San Benedetto area. These differences could be partly attributed to area differences in terms of plankton and fish density. More productive areas like Barletta and Vasto presenting medium to high plankton density present higher night-time estimates compared to day. In areas like San Benedetto with high fish densities and lower plankton densities night-time and day-time estimates are quite similar and this is even more pronounced in Manfredonia gulf, an area with low plankton densities. This implies a reduction in the error between night-time and day-time in areas with low plankton and fish densities.

Approach towards the correction of night-time acoustic estimates

It is a common suggestion in acoustic surveys that sampling should stop when the schools disperse (ICES, 2006). Thus according to the proposal, an approach towards the correction of night-time and day-time differences was attempted; assuming that the day-time acoustic estimates when schools are well formed provide an unbiased estimate of the total backscatter echo. Since different trends between day – night estimates were obtained per study area, different approaches were followed concerning the estimation of a potential unbiased estimate at night.
Specifically:

Concerning the Aegean Sea lower night-time estimates compared to day-time were recorded possibly due to the oligotrophic character of the area and the low plankton and fish densities that enhances the effect of a surface dead zone at night from 0 to 15 m depth. Thus, following the approach of O'Driscoll *et al.*, (2009) we subtracted the observed backscatter component that remains between 15 m and 30 m at night (i.e., the component of the migrating small pelagic fish from deeper layers).

We attempted to correct night-time estimates for loss of backscatter into the surface dead zone by assuming that backscatter in the dead zone (0–15 m) was equivalent to the observed area backscattering coefficient in the equivalent region immediately below the dead zone (i.e. 15–30 m from the surface). For this purpose surface-corrected, night-time values, $N_{i,sc}=N_i + N_i^{15–30m}$, were calculated and compared with day-time values to estimate a surface-corrected value for the proportion of the total backscatter (p) that remains in the acoustic-detection zone (deeper than 15 m) at night (O' Driscoll *et al.*, 2009). A correction factor (CF) was then calculated to scale up the observed pelagic backscatter to account for the estimated missing backscatter (1–p);

$$CF = \frac{(1-p) + pN_{15-bot}}{pN_{15-bot}} \qquad (6)$$

where $pN_{15\text{-}bot}$ is the estimated average proportion of total backscatter in the pelagic zone at night.

Thus, the corrected night backscatter would be:

$$N_{cor} = N_i + CF * N_{15-30m} \qquad (7)$$

Based on this, the following results were obtained (Fig. 4.2.24 & Table 4.2.27) for 38 kHz frequency, indicating a good correction for an acquisition threshold at -70 dB, whereas big differences remained for -60 dB acquisition threshold.

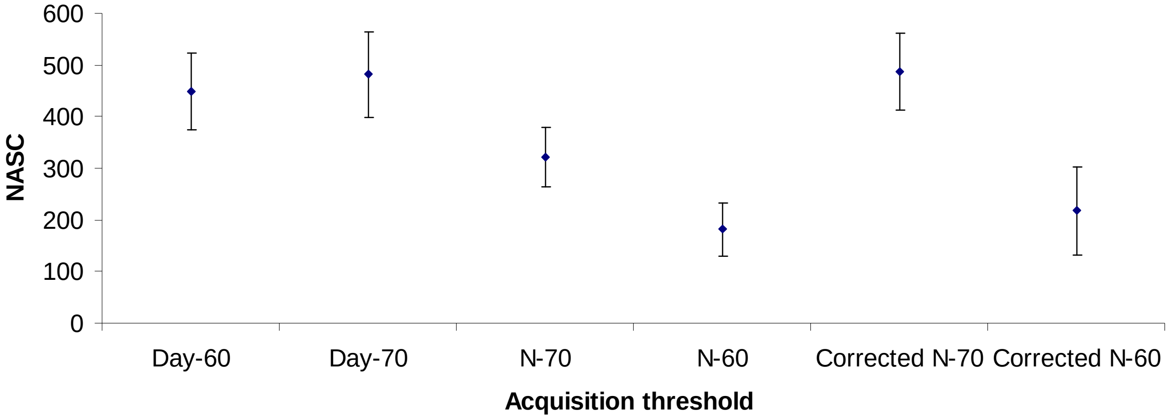


Figure 4.2.24. *Aegean Sea:* Acoustic-abundance indices for pelagic fish. Corrected night-time estimates at -70 dB and -60 dB acquisition threshold were based on night-time estimates of pelagic backscatter (15–30 m), with a correction for the estimated proportion of backscatter migrating into the surface dead zone.

These results showed that densities in the surface dead zone often had to be a factor of 1.5 higher than densities in the zone immediately below to explain the reduction in backscatter. Moreover, the loss of echo when filtering at a high acquisition threshold at night (e.g. -60 dB) cannot be compensated by this approach.

Table 4.2.27 *Aegean Sea.* Night-time, Day and corrected night-time back scattered estimates at -70 dB and -60 dB acquisition threshold.

	Day-60	**Day-70**	**N-70**	**N-60**	**Corrected N-70**	**Corrected N-60**
Mean	448.84	481.44	322.08	181.77	486.65	217.30
CI	74.96	82.50	57.49	51.71	74.70	85.20

Concerning the Strait of Sicily, where higher night-time estimates compared to day-time were recorded, based on the 6 mini surveys results; our approach adapted the estimation of a linear model, i.e. multiple regression that associates the day-time with the night-time estimates at different acquisition threshold along with the effect of the acquisition threshold used. Three different acquisition thresholds were used -56 dB, -60 dB and -70 dB, commonly applied in both day-time and nightime analysis. Moreover, two different models were built; one addressing the mini surveys with low plankton densities and one overall with all mini surveys held. Results are shown in Table 4.2.28.

Table 4.2.28 *Sicily Channel***:** Multiple regression model for Day-time NASC (m^2/nm^2) in relation to Night-time NASC (m^2/nm^2) and acquisition threshold. R^2: coefficient of determination; F: value of F-test. 'Significance at the $p < 0.05$

	Regression Model	$\mathbf{R^2}$	**F**	**P value**
Pooled 6 miniSurveys	Day NASC = -389.38+51.48 *LOG(Night NASC) + 4.09*Acq Thresh	65.8	16.40	0.0002
2 mini surveys (miniSurvey1-2010, miniSurvey1-2011 with low plankton densities)	Day NASC = -474.365 + 74.2776*LOG(Night NASC) + 3.33643* Acq Thresh	98.3	144.30	0.0010

Results showed that both models were statistically significant and especially in the minisurveys with low plankton density model fit was very good fit explaining over 95% of total variance. The difference in model fit also highlighted the plankton effect and that less “biased estimates” can be obtained when night sampling occurs at low plankton density areas.

In the case of Adriatic Sea, on average higher night-time estimates were also recorded compared to day-time but presenting less pronounced differences especially in certain cases. A multiple regression model was built, similarly to the Strait of Sicily that associates the day-time with the night-time estimates at different acquisition threshold along with the effect of the acquisition threshold used. Day 1 estimates were used only, as they considered more representative of the fish community insonified during the successive night. Two different acquisition thresholds were used -60 dB and -70 dB, commonly applied in both day-time and night-time analysis. Results are shown in Table 4.2.29.

Table 4.2.29. *Adriatic Sea***:** Multiple regression model for Day-time NASC (m^2/nm^2) in relation to Night-time NASC (m^2/nm^2) and acquisition threshold. R^2: coefficient of determination; F: value of F-test. 'Significance at the $p < 0.05$

	Regression Model	$\mathbf{R^2}$	**F**	**P value**
Pooled 4 miniSurveys	DAY NASC = -151.012* LOG(NIGHT NASC) + 22.5142* Acq Thresh	95.77	113.69	0.0000

Results showed that although the model included different areas in terms of plankton and fish density, model fit was very good explaining over 95% of total variance.

4.2.4 Overall Discussion, Conclusions, Difficulties encountered, Recommendations

One of the most important issues in acoustic surveys is the time of acoustic sampling. Night-time sampling has raised several contradictions regarding the introduction of error in the abundance estimates (ICES, 1998; Iglesias *et al.*, 2003; Zwolinski *et al.*, 2007). This diurnal behavior of small pelagic fish schools (Masse, 1996; Fréon & Misund, 1999; Giannoulaki *et al.*, 1999; Szczucka, 2000; Zwolinski *et al.*, 2007) makes fish either unavailable to the acoustic apparatus used or difficult to distinguish acoustically from other scatterers, which could generate a degree of bias on the echo density used for abundance estimates (ICES, 2005). In the Mediterranean Sea, acoustic surveys often have to be conducted over extended areas in order to cover the main distribution of a stock implying increased cost in terms of days at sea, vessel and crew availability. To overcome these difficulties, the investigation of flexible research strategies in several cases becomes essential and impairs the need to work both day-time and night-time. The target of this sub-task of the project was to improve the harmonization of acoustic sampling procedure among the various past acoustic surveys held in the Mediterranean and determine the effect of the time of day on acoustic sampling. Past data from insonified transects and pelagic hauls held during both day-time and night-time, along with specifically designed mini surveys that were held simultaneously to the ongoing MEDIAS surveys within the period of the AcousMed project, were analyzed under a common protocol to fulfill these objectives.

Results indicated differences depending on the area surveyed and its characteristics in terms of plankton and fish density. However, in most cases no large deviations between day-time and night-time estimations were observed especially when night-time data were analyzed at -70 dB threshold. In two out of three study regions, in the Strait of Sicily and the western Adriatic Sea higher NASC values were estimated on average during night-time compared to day-time, although these differences were not always found significant. Differences were recorded even within different areas in the same region depending most likely on plankton and fish density like the Manfredonia and San Benedetto area in the Adriatic Sea, where day-time and night-time estimates were quite close opposed to Vasto and Barletta area. Similarly, in the Strait of Sicily at the low productivity western part, less pronounced and non-significant differences were recorded between day and night; opposed to the more productive eastern part, where higher NASC values were estimated at night. These results are similar to the Vasto and Barletta area estimates possibly highlighting the effect of plankton density. Opposed to these areas, haul comparisons from Aegean Sea presented higher day-time estimations compared to night-time. This is attributed to the loss of backscatter echo from the surface dead zone (0–15 m) during night-time. Area differences are due to the oligotrophic character of Aegean Sea and the low fish densities observed compared to the Adriatic. The two areas largely differentiate in terms of zooplankton density, fish density as well as in terms of the spatial structure of small pelagic fish aggregations. Area differences can also reflect differences in topography that can influence fish and plankton distribution patterns in the water column especially when comparisons address total NASC estimates. In this framework, it is worth noting that the mean length of transects in the Strait of Sicily was about 8.5 nm and that height of the insonified water column for each transect ranged from 20 m to 200 m. Such aspects should be studied more in depth.

Going further within the framework of this sub task, an attempt to anticipate the error in acoustic estimates between day-time and night-time was made. In the case of Aegean Sea the loss of echo during the night was corrected by adding a surface-corrected value for the proportion of the total backscatter (p) that remains in the acoustic-detection zone. Results were satisfactory for -70 dB acquisition threshold but not for the much bigger -60 dB threshold that is usually applied during day-time. Concerning the Adriatic Sea and the Strait of Sicily, areas with higher NASC values during night-time a multiple regression model was built for the 38 kHz to relate day-time estimates with night-time, estimates along with the effect of the applied threshold. Separate models were built for each area respecting ecosystem differences. Model fit was very good indicating that this approach might be able to give satisfactory results anticipating the deviation in acoustic estimates between day and night. Correction of night-time acoustic estimates would allow the reduction of sampling time that can be essential strategy in certain areas in order to complete acoustic sampling. Based on these results the following suggestions can be made:

- Day – Night differences exist but their significance and order of magnitude largely depend on the area and the specific ecosystem characteristics.
- Further work is needed concerning the effect of day-night sampling on fish NASC instead of total NASC. This is especially required in areas with high plankton densities. So, cautiousness concerning plankton filtering is required.
- Further work with data from additional areas is required to strengthen models that can anticipate/correct day – night differences.
- Any corrections should be area specific.
- The issue of error estimation in model estimates needs to be addressed.
- A similar model like the one proposed here should be examined for the 120 kHz frequency.
- The issue of effective plankton filtering during both day-time and night-time is strongly related to the bias in acoustic estimates. This was an important issue also concerning sub-Task 4.1. Thus the application of specialized algorithms in Myriax Echoview for this purpose should be promoted within the framework of collaboration with Myriax experienced personnel to apply an algorithm adapted on area peculiarities in terms of plankton and fish density.

- The optimum time of acoustic sampling is day-time, however when night-time sampling cannot be avoided it is advisable to be corrected and adjusted to day-time echo using different approaches depending on the area.

The above mentioned results and suggestions will be presented for discussion in the 5th Annual Steering Committee Meeting of the Pan Mediterranean Acoustic Surveys in order to disseminate the project results to other Mediterranean scientists and incorporate suggestion into the MEDIAS protocol. Moreover, the cooperation of MEDIAS with similar groups like WGACEGG dealing with acoustic and egg surveys of small pelagic in the Atlantic will be promoted, in order to share knowledge and experience among the members of these groups.

4.3 Biological sampling: Comparison day-night (Subtask 3.3.)

(Lead participant HCMR, Involved participants: IFREMER, IEO, CNR-ISMAR, CNR-IAMC)

Objectives

In the framework of acoustic surveys pelagic hauls are routinely used to collect representative fish samples of the insonified echoes. The aim of the task is to determine the effect of the time of day on biological sampling in terms of catch composition. The sources of error between day-night sampling will be investigated and discussed based on the biology of the species and the requirement of acoustic surveys. Proposals on the optimum time of biological sampling will be done to be used into future acoustic surveys.

In the Mediterranean Sea acoustic surveys require on average over 40 days at sea that implies increased cost in terms of days at sea. To overcome these difficulties the investigation of flexible research strategies in several cases becomes essential. For example, working day-time and night-time can significantly reduce survey time in many cases. Within the framework of the present study, we investigated the differences in the catch composition between day and night using catch data of pelagic trawls collected within acoustic surveys from four different regions over the European Mediterranean. Comparisons between day-time and night-time pairs of pelagic hauls were done involving certain diversity indices as well as the length frequency distributions of anchovy and sardine, the main small pelagic species in Mediterranean Sea. Finally, the efficiency of trawl fishing during day and night, the possible bias in acoustic estimates, as well as the advantages and disadvantages between the two sampling strategies were discussed.

4.3.1 Methodological approach followed

Sampling Description

Within the framework of this sub-task catch data from hauls held day and night within acoustic surveys in the Aegean Sea, the western part of the Adriatic Sea, the Strait of Sicily, the Gulf of Lions and the Mediterranean Spanish waters (Fig. 1) were analyzed. Day-time and nightime pairs of pelagic hauls from historic acoustic surveys as well as from recent surveys were selected or held respectively, according to a specific common protocol for all regions. It was of special concern that hauls were held in the same geographic position during day and night-time. Comparisons involved certain diversity indices as well as the length frequency distributions of anchovy and sardine, the main small pelagic species in Mediterranean Sea. Specifically:

All items in the catch were sorted to species level. Length measurements were made to 0.5 cm accuracy. In order to study the differences between day and night sampling, we used samples from targeted experimental hauls as well as hauls from historic surveys in the study areas based on a common protocol. The groups of hauls contain replicate hauls at the same site during day and night and we compared day – night differences regarding their species composition and length frequency.

Specifically Day-Night haul groups selection was based on the following criteria:

- hauls were held at the same site, within a range of a maximum 3 nm distance
- hauls were held maximum within 32 hours' time period at the same site
- replicates in day-time and night-time hauls were available
- all replicates have been collected using of the same gear e.g. pelagic trawl with the same technical characteristics

Comparisons were made by area between Day-Night haul groups. In addition, in cases where more than one group of Day – Night hauls occurred within the same survey, an accessional comparison was made between day-time and night-time hauls on a survey basis. These results are presented separately. The analysis scheme is summarized in Figure 4.3.1.

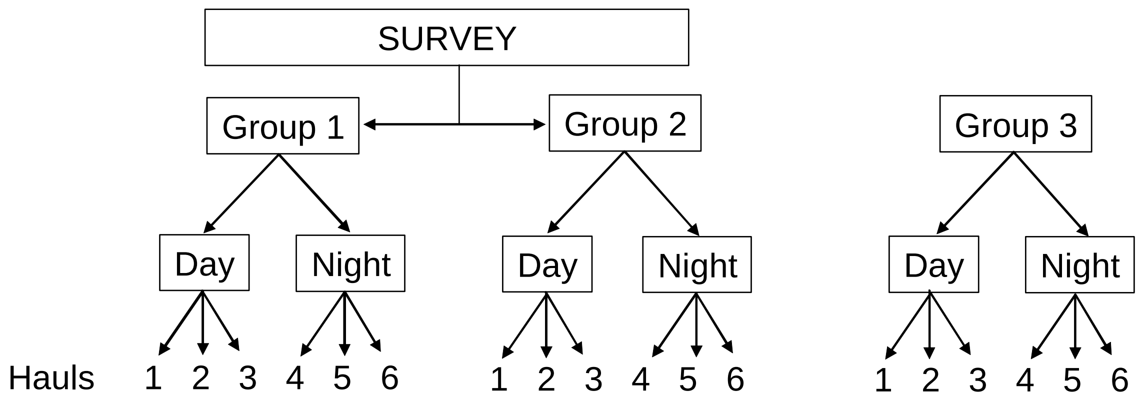


Figure 4.3.1. The scheme of the analysis

4.3.2 Work achieved

According to the proposal two workshops were held during the first year of the project in the framework of respective meetings and one workshop in the second year. During the kick off meeting, hosted by CNR-IAMC in Capo Granitola in March 2010, the first workshop took place. During this workshop a preliminary review of available data from all study areas was done and a common protocol for data analysis and comparisons was discussed and agreed. The progress of work during the first year of the project was presented in the second workshop that was held in Palma de Mallorca in November 2010, hosted by IEO. This second workshop was part of a joined meeting with the annual ICES WGACEGG meeting that comprised an initial, successful step to bring together scientists involved in acoustic surveys in the Atlantic and the Mediterranean, promoting the collaboration, the exchange of ideas, the identification of common problems and solutions between ICES and Mediterranean surveys. The third workshop took place in accordance to the proposal was organized during the third project meeting that was held in 14th December 2011 in Iraklion (Greece) hosted by HCMR. During this workshop the progress of the work in each Mediterranean area was presented and a synthetic approach was applied and discussed.

A description of the hauls used from each area is presented in Table 4.3.1. Tow speeds were on average at 3.5 knots (range 2.5 – 4.5 knots), similar to all cases, and tow length was approximate 2 nautical miles. Specifically,

a) North Aegean Sea: 22 groups of day – night pairs derived from 11 surveys were used for species composition comparison. The surveys were conducted in North Aegean Sea on board the R/V PHILIA. Two surveys took place in winter period (December, February) and nine during the summer period (June, July). 16 groups of day-night pairs derived from 10 surveys were used for length frequency distribution concerning anchovy and 14 groups distributed in 10 surveys were used concerning sardine. Four groups of hauls derived from targeted surveys aiming to investigate the differences in day-time – night-time sampling. The others were selected from historic surveys according to the common protocol. In all cases fish sampling was conducted by means of a pelagic trawl with codend of 16 mm.

b) Adriatic Sea: Eight groups of day – night pairs were used for both species composition and length frequency comparison. The data were collected within four targeted surveys aiming to investigate the differences in day-time – night-time sampling (3 surveys in 2009 and 1 survey in 2010). Within each survey two hauls were repeated three times, initially during day-time, once during the night and a third time during the day after. Surveys took place during July – October in Manfredonia Gulf, Barletta (Southern Adriatic Sea), Vasto and San Benedetto (Middle Adriatic Sea). All surveys were conducted on board the R/V G. Dallaporta and a pelagic trawl with codend of 18 mm was used for fish sampling.

c) Strait of Sicily: Two groups of day – night pairs were used for both species composition and length frequency comparison in the Strait of Sicily in August 2010. The data were collected within one targeted survey aiming to investigate the differences in day-time – night-time sampling. The survey was conducted in the Gulf of Gela on board of the R/V Maria Grazia. A pelagic trawl with codend of 18 mm was used for fish sampling. The area was selected because of the occurrence of high fish density. Similarly to the targeted surveys in the Adriatic Sea within the survey 2 hauls were repeated three times, initially during day-time, once during the night and a third time during the day after.

d) Gulf of Lions: Two groups of day-night pairs derived from two surveys were available for comparisons in the Gulf of Lions area. The first survey took place in January 2009 and the second one in July 2011. The surveys were conducted in the Gulf of Lions on board of the R/V L' Europe. A pelagic trawl with codend of 20 mm was used for fish sampling.

e) Iberian coast: One group of day-night pairs was used for both species composition and length frequency comparison in the Iberian continental shelf. Data were collected during the 2009 MEDIAS acoustic survey in the area of Cape La Nao in June 2009 within targeted hauls aiming to investigate the differences in day-time – night-time sampling. The survey was conducted on board the R/V Cornide de Saavedra. A pelagic trawl with codend of 20 mm was used for fish sampling. Within the survey three hauls were repeated during day-time and night-time.

Table 4.3.1. Description of samples.

Area	Year/Season	Group	**Date**	**Bottom Depth**	**No of hauls (Day)**	**No of hauls (Night)**
Aegean Sea	1995 Summer	1	14/06/1995	84	1	2
	1996 Summer	1	13/06/1996	60	1	1
	2003 Summer	1	15/06/2003	40	1	2
	2004 Summer	1	14/06/2004	45	1	2
	2005 Summer	1	5/06/2005	50	1	3
	2005 Summer	2	11/06/2005	46	1	2
	2005 Summer	3	12/06/2005	38	1	2
	2005 Summer	4	29/06/2005	57	1	2
	2006 Summer	1	28/05/2006	76	1	1
	2006 Summer	2	31/05/2006	76	1	2
	2006 Summer	3	2/06/2006	68	1	2
	2006 Summer	4	12/06/2006	90	1	1
	2006 Summer	5	13/06/2006	47	1	2
	2006 Summer	6	29/06/2006	30	1	1
	2008 Summer	1	13/06/2008	66	1	1
	2008 Summer	2	18/06/2008	64	1	3
	2008 Summer	3	14/07/2008	79	1	2
	2008 Summer	4	16/07/2008	28	1	1
	2008 Summer	1	19/07/2008	30	6	3
	2007 Summer	1	30/07/2007	65	7	4
	2007 Winter	1	11/12/2007	50	7	6
	2009 Winter	1	13/2/2009	50	5	5
Adriatic Sea						
Mafredonia	2009 Summer	1	09/08/2009	29	2	2
Mafredonia	2009 Summer	2	10/08/2009	29	2	2
Vasto	2009 Summer	3	11/08/2009	50	2	2
Vasto	2009 Summer	4	12/08/2009	50	2	2
San Benedetto	2009 Autumn	5	30/09/2009	80	2	2
San Benedetto	2009 Autumn	6	01/10/2009	80	2	2
Barletta	2010 Summer	7	21/07/2010	100	2	2
Barletta	2010 Summer	8	22/07/2010	100	2	2
Strait of Sicily						
Gulf of Gela	2010 Summer	1	01-02/08/2010	40	2	2
Gulf of Gela	2010 Summer	2	02-03/08/2010	70	2	2
Gulf of Lions	2009 Winter	1	15/1/2009	70	2	2
	2011 Summer	2	28/7/2011	70	2	2
Iberian coast						
Sueca	2009 Summer	1	11/06/2009	59	1	1
Gandía	2009 Summer	1	12/06/2009	115	1	1
Cape La Nao	2009 Summer	1	13/06/2009	81	1	1

4.3.2.1 Comparison of species composition between day and night

In order to examine any possible differences in the catch between day and night, we compared certain indices from paired groups of hauls. Specifically, we examined the following diversity indices:

- Number of species = S;
- Species richness (Margalef) d= (S-1)/log(N) (N= Number of individuals);

- Shannon-Wiener diversity (H);
- J-evenness indices which standardize the sample size with respect to abundance and species number; as well as
- the Simpson ($1 - \lambda$) index (i.e. dominance), which is known to be one of the least affected by sample size (Karakassis *et al.*, 1996).

Comparisons of the estimated diversity indices between day and night samples were made by means of analysis of variance (ANOVA) after checking for homogeneity of variance (Zar, 1984). The diversity indices were estimated using the PRIMER-5 software (Clarke & Warwick, 1994).

4.3.2.2 Comparison of length frequencies between day and night

We investigated the possible differences in the length frequency distribution of the specimens caught in day-time and night-time samples. Comparisons refer to the length frequency distribution of anchovy and sardine, the two main small pelagic species which are the targets of the MEDIAS (MEDIterranean Acoustic Survey) acoustic surveys in the Mediterranean Sea. Kruskal – Wallis test was used for this purpose. Geometric mean was selected for the calculation of the mean fish size of each sample, instead of the arithmetic mean which is susceptible to the influence of a few large specimens and does not represent accurately the mode in fish size at a given station (Stefanescu *et al.*, 1992). In addition, a Paired-Sample Comparison Analysis was applied for the mean, min, max, range, skewness and kurtosis of Total Length (TL) distribution of the specimens caught during day-time and night-time in the group of hauls, considered as a possible index of bias.

4.3.2.3 Comparison of trawl efficiency during day-time and night-time.

In order to obtain an indication regarding the possible bias of fishing during day-time and night-time, the trawl efficiency was estimated according to the approach described by Doray *et al.* (2010). We used the available trawl data from monospecific hauls (one species contribute over 95% to the total catch) that have simultaneously been insonified. For this analysis, we used 13 hauls held during day and 23 hauls held during night. In 25 cases (9 during day-time, 16 during night-time) anchovy contribute over the 95% to the total catch, while to the rest of the hauls sardine contribute in the same proportion.

Volume backscattering coefficients (MacLennan *et al.*, 2002) greater than -60 dB were allocated to fish and integrated with Myriax software. Specifically, fish nautical area scattering coefficients (NASCs) estimated using elementary sampling units (ESUs) 500 m (0.25 nautical miles) long at a mean speed of 3-4 knots. Values of fish NASC were then summed over the depth range sampled by the pelagic trawl. As the effective fishing height of the trawl is expected to be wider than the trawl opening, 5 meters above and below the trawl were used. Total NASC values, NASC(t), recorded during trawl station t were calculated as the total NASC values in the trawled layer, along the haul tracks.

To transform catch data to equivalent acoustic data, equivalent NASC (Simmonds and MacLennan, 2005), ENASCs(t), were computed for each of the main species s caught at station t (Doray *et al.,* 2010) by

$$\text{ENASCs(t)}= \frac{4\pi \text{Ns(t)}\sigma_{bs}}{\text{A}} \qquad (8)$$

where A is the area swept during a haul (in square nautical miles), Ns is the (estimated) catch in numbers of individuals of species s at station t and σ_{bs} is the theoretical backscattering cross section (MacLennan *et al.,* 2002) of species s. Values of σ_{bs} were computed from $\sigma_{bs} = 10^{TS/10}$, where TS is the theoretical (literature) value of target strength by species. The σ_{bs} used were -71.2 dB for anchovy and -72.6 dB for sardine.

We assumed the value of NASC(t) recorded on board during station t to be a reasonable estimate of the true density of fish encountered along the trawl track

$$\text{ENASCs(t)}= \text{Q [NASC (t)]}^{b} \qquad (9)$$

where Q is the trawl efficiency, defined as the proportion of animals within the swept volume captured by the trawl of vessel and b is a parameter. Q and b were estimated by log transformation of the equation. If b is 1, the relationship between catch and density is linear; for b<1, it is non-linear. Hauls by day and night were analyzed separately, as well as the monospecific hauls of anchovy. The monospecific hauls of sardine are not presented here because they were few in number.

4.3.2.4 Sensitivity analysis

We examined the possible error that could be introduced into the biomass estimations by means of acoustics because of inappropriate time of sampling and the subsequent error in the estimation of the mean length. For this purpose, we assessed the subsequent changes in biomass estimations taking into account an increase/decrease of the mean length by 1 and 2 cm according to the estimated maximum differences of mean TL during day and night. Similarly, a sensitivity analysis was applied concerning the effect of b20 in the target strength equation (MacLennan and Simmonds 2005) and the subsequent biomass estimates.

4.3.3 Results

4.3.3.1 Species composition

Comparisons concerning the diversity indices between the pairs of haul are presented in Table 4.3.2.

Table 4.3.2. ANOVA table for diversity indices of each group. In the first row and second row of each cell the test results and the probability is presented respectively. Significant probabilities are in bold. Empty cells represent groups with only one species or those groups where only anchovy and sardine were caught. S (number of species per haul), d (Margalef species richness), J (evenness index), H' (Shannon-Wiener diversity index), 1 – λ (Simpson index). Asterisk indicates sampling experiment executed according to the protocol targeting to investigate day – night differences.

Area	Groups	S	d	J'	H'	1-λ
Aegean Sea	1995 Summer					
	1996 Summer					
		3	0.09	7.34	10.32	30.81
	2003 Summer	0.333	0.818	0.225	0.192	0.113
		0.75	0.78	7.34	0.59	0.51
	2004 Summer	0.545	0.540	0.194	0.5839	0.6049
		0.33	0.77	0.87	2.19	1.05
	2005-1 Summer	0.667	0.530	0.450	0.277	0.413
		0.33	0.01	282.22	99.24	255.18
	2005-2 Summer	0.666	0.946	0.037	0.063	0.0400
		0.33	0.81	34.12	46.02	33.21
	2005-3 Summer	0.667	0.532	0.107	0.093	0.109
				8.27	9.24	20.07
	2005-4 Summer	equal No of species	equal No of species	0.213	0.202	0.139
	2006-1 Summer					
	2006-2 Summer			34.11	109.47	30.72
		equal No of species	equal No of species	0.107	0.060	0.113
	2006-3 Summer					
	2006-4 Summer					
	2006-5 Summer	0.33	0.04	6.01	2.44	2.12
		0.667	0.882	0.246	0.367	0.383
	2006-6 Summer					
	2008-1 Summer					
		2.25	2.07	0.02	0.13	0.13
	2008-2 Summer	0.272	0.286	0.893	0.751	0.749
		0.33	1.57	1.34	7.68	2.18
	2008-3 Summer	0.667	0.428	0.454	0.220	0.378
	2008-4 Summer					
		1.31	1.02	0.01	0.01	0.15
	2007 Summer	0.282	0.339	0.928	0.928	0.708
		6.44	5.83	47.72	0.15	0.55
	2008 Summer	**0.04**	**0.046**	**0.002**	0.706	0.484
		5.48	9.39	3.01	1.88	2.28
	2007 Winter	**0.039**	**0.011**	0.110	0.197	0.159
		1.8	0.65	3.03	3.44	5.63
	2009 Winter	0.216	0.444	0.119	0.101	0.055
Adriatic Sea		1.80	0.98	0.60	1.20	0.80
	2009-1 Summer	0.312	0.427	0.519	0.387	0.465
		0.00	0.04	6.15	6.87	5.85
	2009-2 Summer	1.000	0.870	0.131	0.120	0.137
		0.00	0.00	1.08	3.17	2.06
	2009-3 Summer	0.083	0.121	0.408	0.217	0.288
		0.00	7.47	4.13	6.79	4.50
	2009-4 Summer	0.083	0.112	0.179	0.121	0.168
		9.00	1.12	0.164	0.50	0.59
	2009-5 Autumn	0.095	0.400	0.725	0.554	0.522
	2009-6 Autumn	0.00	0.01	0.51	0.38	0.39

Area	Groups	S	d	J'	H'	1-λ
		1.000	0.929	0.551	0.600	0.595
	2010-7 Summer					
	2010-8 Summer					
Strait of Sicily		0.20	0.25	3.42	1.05	1.69
	2010-1 Summer	0.699	0.666	0.205	0.414	0.323
		0.50	0.14	6.23	2.38	4.12
	2010-2 Summer	0.553	0.742	0.130	0.263	0.179
Gulf of Lions		2.1	20.23	1.67	0.77	0.44
	2009-Winter	0.157	0.0139	0.419	0.542	0.629
		9.0	0.41	**14.42**	**12.48**	**6.03**
	2011- Summer	0.105	0.587	**0.063**	**0.721**	**0.133**
Iberian coast		1.13	0.61	1.75	1.44	1.78
	2009 Summer	0.349	0.477	0.256	0.296	0.253

Comparisons of the diversity indices per survey (i.e. all haul groups of each survey are merged) are presented in Table 4.3.3.

Table 4.3.3. ANOVA table for diversity indices estimated per survey (i.e., merged haul groups). In the first row and second row of each cell, the test results and the probability is presented, respectively. Significant probabilities are in bold. Empty cells represent surveys with only one species or those surveys where only anchovy and sardine were caught. S (number of species per haul), J (evenness index), H' (Shannon-Wiener diversity index), 1 – λ (Simpson index).

Area	**Survey**	**S**	**d**	**J'**	**H'**	**1-λ**
Aegean Sea	1995 Summer					
	1996 Summer					
	2003 Summer	3.00	0.90	7.34	10.32	30.81
		0.333	0.818	0.225	0.192	0.113
	2004 Summer	0.75	0.78	0.29	0.001	1.08
		0.545	0.540	0.684	0.979	0.487
	2005 Summer	0.47	0.35	1.05	0.51	0.6
		0.505	0.568	0.327	0.489	0.454
	2006 Summer	2.34	1.62	1.33	2.37	2.69
		0.150	0.226	0.269	0.147	0.124
	2008 Summer	1.15	1.84	0.31	0.52	0.38
		0.363	0.220	0.744	0.611	0.698
	2007 Summer	1.31	1.02	0.01	0.01	0.15
*		0.282	0.339	0.928	0.928	0.708
	2008 Summer	6.44	5.83	47.72	0.15	0.55
		0.040	**0.0464**	**0.002**	0.706	0.484
	2007 Winter	5.48	9.39	3.01	1.88	2.28
*		**0.039**	**0.010**	0.110	0.197	0.159
	2009 Winter	1.80	0.65	3.03	3.44	5.63
*		0.216	0.444	0.119	0.106	0.055
Adriatic Sea	2009-12 Summer	0.57	0.25	0.22	0.04	0. 14
		0.492	0.642	0.661	0.844	0.732
	2010- 78 Summer					
	2009-56 Summer	0.92	0.35	0.20	0.40	0.44
		0.391	0.584	0.676	0.559	0.545
	2009 34 Summer	5.33	4.58	3.99	0.01	5. 89
		0.082	0.099	0.116	0.064	0.072
Strait of Sicily	2010 Summer	0.001	0.032	6.51	2.47	4.25
		1.000	0.867	0.063	0.191	0.108
Gulf of Lions	2009-Winter	2.1	20.23	1.67	0.77	0.44
		0.157	0.0139	0.419	0.542	0.629
		9.0	0.41	**14.42**	**12.48**	**6.03**
	2011- Summer	0.105	0.587	**0.063**	**0.721**	**0.133**
Iberian coast	2009 Summer	1.13	0.61	1.75	1.44	1.78
		0.349	0.477	0.256	0.296	0.253

* indicates sampling experiment executed according to the protocol targeting to investigate day – night differences

In general, no differences were estimated for the diversity indices, except the case of the Gulf of Lions. The other cases indicated significant differences, correspond to haul groups that included demersal species in the catch of the day-time hauls. A limited number of specimens from demersal species in the catch were often the case, when fishing operation was held close to the bottom.

4.3.3.2 Length frequency comparisons

Comparisons of the length frequency distribution of anchovy between day and night, estimated per haul group are presented in Table 4.3.4, while comparisons per survey (i.e. merging all haul groups that belong to the same survey) are presented in the Table 4.3.5. The results for the length frequency distribution of sardine are presented in Tables 4.3.6 and 4.3.7, respectively.

Table 4.3.4. Anchovy. Results of the Kruskal Wallis Test comparisons in each pair of hauls applied to Anchovy length frequency distributions. D=Day; N=Night; ND=No Difference.

Area	Groups	Results	Kruskal-Wallis Test	p-value
Aegean Sea	1995 Summer	N>D	22.35	0.000
	1996 Summer	D>N	92.60	0.000
	2003 Summer	ND	0.26	0.612
	2005-1 Summer	ND	0.01	0.932
	2005-2 Summer	D>N	24.18	0.000
	2005-3 Summer	D>N	27.36	0.000
	2006-1 Summer	ND	1.57	0.210
	2006-2 Summer	N>D	16.72	0.000
	2006-3 Summer	N>D	23.99	0.000
	2006-4 Summer	D>N	23.99	0.002
	2008-1 Summer	N>D	45.58	0.000
	2008-2 Summer	N>D	6.87	0.009
*	2007 Summer	D>N	34.23	0.000
*	2007 Winter	ND	0.03	0.864
*	2008 Summer	D>N	16.97	0.000
*	2009 Winter	D>N	25.52	0.000
Adriatic Sea(*)	2009-1 Summer	D>N	50.39	0.000
	2009-2 Summer	D>N	47.19	0.000
	2009-3 Summer	D>N	64.16	0.000
	2009-4 Summer	ND	21.52	0.227
	2009-5 Autumn	N>D	35.62	0.010
	2009-6 Autumn	N>D	54.87	0.000
	2010-7 Summer	D>N	156.53	0.000
	2010-8 Summer	D>N	115.12	0.000
Strait of Sicily(*)	2010-1 Summer	D>N	75.22	0.001
	2010-2 Summer	ND	2.64	0.104
Gulf of Lions(*)	2011-1 Summer	ND	3.074	0.082

* indicates sampling experiment executed according to the protocol targeting to investigate day – night differences.

In the Aegean Sea, the comparisons of the anchovy length frequency distribution revealed that in five out of 16 cases bigger individuals were caught during night than day-time, in seven out of 16 cases bigger individuals were caught during day than night-time and in four cases no difference was estimated. In the Adriatic Sea in two out of eight cases bigger individuals were caught during night than day-time; in five out of eight cases bigger individuals were caught during day than night-time and in one case no difference was estimated. In the Strait of Sicily similarly to the Gulf of Lions no difference found between day and night-time. Overall, in 13 cases bigger individuals caught during day, in seven cases bigger individuals were caught during night, while in seven cases no difference was estimated.

Table 4.3.5. *Anchovy.* Results of the Kruskal Wallis Test comparisons in each survey by merging all the pairs of hauls applied to Anchovy length frequency distributions. D=Day; N=Night; ND=No Difference. Asterisk indicates sampling experiment executed according to the protocol targeting to investigate day – night differences.

Area	Survey	Results	Kruskal-Wallis Test	p-value
Aegean Sea	1995 Summer	N>D	22.35	0.000
	1996 Summer	D>N	92.60	0.000
	2003 Summer	ND	0.26	0.612
	2005 Summer	ND	0.19	0.659
	2006 Summer	ND	0.12	0.727
	2008 Summer	N>D	16.97	0.000
*	2007 Summer	D>N	34.23	0.000
*	2007 Winter	ND	0.03	0.864
	2008 Summer	D>N	16.97	0.000
*	2009 Winter	D>N	25.52	0.000
Adriatic Sea(*)	2009-12 Summer	D>N	14.74	0.000
	2009-34 Summer	D>N	11.25	0.001
	2009-56 Summer	N>D	14.72	0.000
	2010-78 Summer	D>N	122.55	0.000
Strait of Sicily(*)	2010 Summer	D>N	16.92	0.001
Gulf of Lions(*)	2011-1 Summer	ND	3.074	0.082

Results of the length frequency comparisons per survey were quite similar. Anchovy comparisons in the Aegean Sea revealed that in two out of 10 cases bigger individuals were caught in night than in day-time, in four out of 10 cases bigger individuals were caught in day than in night-time and in four cases no difference was estimated. In the Adriatic Sea in one out of four cases bigger individuals were caught during night than day-time, whereas in three out of four cases bigger individuals were caught during day than night-time. In the Strait of Sicily results indicated that bigger individuals were caught during day than night-time. In Gulf of Lions no difference found between day and night-time. Overall, in three surveys bigger individuals were caught during night, in eight surveys bigger individuals were caught during the day, while in five surveys no difference was estimated.

Table 4.3.6. *Sardine.* Results of the Kruskal Wallis Test comparisons in each pair of hauls applied to Sardine length frequency distributions. D=Day; N=Night; ND= No Difference. Asterisk indicates sampling experiment executed according to the protocol targeting to investigate day – night differences.

Area	**Groups**	**Results**	**Kruskal-Wallis Test**	**p-value**
Aegean Sea	1996 Summer	D>N	64.71	0.000
	2003 Summer	ND	0.73	0.393
	2004 Summer	D>N	9.30	0.002
	2005-1 Summer	D>N	25.96	0.000
	2005-2 Summer	D>N	89.95	0.000
	2005-3 Summer	N>D	48.62	0.000
	2006-1 Summer	ND	0.72	0.395
	2006-2 Summer	ND	0.06	0.812
	2006-3 Summer	ND	1.13	0.289
	2008-1 Summer	N>D	3.30	0.069
*	2007 Summer	D>N	2.74	0.098
*	2007 Winter	ND	0.09	0.762
*	2008 Summer	ND	0.01	0.906
*	2009 Winter	D>N	22.57	0.000
Adriatic Sea(*)	2009-1 Summer	D>N	32.54	0.007
	2009-2 Summer	D>N	64.72	0.000
	2009-3 Summer	ND	0.69	0.408
	2009-4 Summer	ND	1.97	0.160
	2009-5 Autumn	ND	14.10	0.735
	2009-6 Autumn	N>D	56.28	0.000
Strait of Sicily (*)	2010-1 Summer	D>N	37.50	0.000
	2010-2 Summer	D>N	8.31	0.004
Gulf of Lions	2009-1 Winter	ND	0.143	0.706
Iberian coast(*)	2009 -1 Summer	ND	2.91	0.106

In the Aegean Sea the comparisons of length frequency distribution concerning sardine revealed that in two out of 14 cases bigger individuals were caught in night than day-time; in six out of 14 cases bigger individuals were caught during day than night-time; and in six cases no difference was estimated. In the Adriatic Sea, in one out of six cases bigger individuals were caught in night than day-time; in two out of six cases bigger individuals were caught in day than night-time was estimated, while in three cases no difference was estimated. In the Strait of Sicily, no difference was estimated between day and night. In Gulf of Lions and Iberian coast no difference was estimated between day and night. Overall, in three cases bigger individuals caught during the night, in 10 cases bigger individuals caught during the day, while in 11 cases no difference was estimated.

Table 4.3.7. *Sardine.* Results of the Kruskal Wallis Test comparisons in each survey by merging all the pairs of hauls applied to Sardine length frequency distributions. D=Day; N=Night; ND= Non Difference. Asterisk indicates sampling experiment executed according to the protocol targeting to investigate day – night differences.

Area	**Survey**	**Results**	**Kruskal-Wallis Test**	**p-value**
Aegean Sea	1995 Summer	D>N	64.71	0.000
	2003 Summer	ND	0.73	0.393
	2004 Summer	D>N	9.30	0.002
	2005 Summer	D>N	6.30	0.012
	2006 Summer	D>N	4.24	0.039
	2008 Summer	ND	3.30	0.069
*	2007 Summer	ND	2.74	0.098
*	2007 Winter	ND	0.09	0.762
*	2008 Summer	ND	0.01	0.906
*	2009 Winter	D>N	22.57	0.000
Adriatic Sea (*)	2009-12 Summer	D>N	13.93	0.000
	2009-34 Summer	ND	0.59	0.809
	2009-56 Autumn	N>D	7.25	0.007
Strait of Sicily (*)	2010 Summer	D>N	27.55	0.000
Gulf of Lions	2009-1 Summer	ND	0.143	0.706
Iberian coast (*)	2009 Summer	ND	2.91	0.106

The results per survey were quite similar. In the Aegean Sea, the comparisons of the length frequency distribution concerning sardine revealed that in five out of 10 cases bigger individuals were caught during day than night-time; and in five cases no difference was estimated. In the Adriatic Sea, in one case bigger individuals were caught during night-time, in one case bigger individuals were caught during day-time and in the third case no difference was indicated. In the Strait of Sicily, the overall comparison indicated that bigger individuals were caught during day than night-time, while in Gulf of Lions and Iberian coast no difference was detected between day and night. Overall, in one survey bigger individuals were caught during night, in seven surveys bigger individuals were caught during day, while in eight surveys no difference was estimated.

The results of Paired-Sample Comparison Analysis indicated no differences between day and night in the examined parameters of the length frequency distribution per sampling area (not presented here), neither for the pooled groups (Table 4.3.8).

Table 4.3.8. Paired-Sample Comparison Analysis for Average, min, max, range, Standard skewness and standard kurtosis. t-test statistics and sign test are presented for the cases that meet the assumptions of the t-test, otherwise only sign test are presented. In the first row the sample test statistic is presented, while in the second row the possibility is presented in brackets.

	Average	Min	Max	Range	Stnd. skewness	Stnd. kurtosis
Anchovy						
t-test	2.006	2.023	-0.465	-2.019		0.141
	(0.065)	(0.054)	(0.646)	(0.058)		(0.889)
sign test	0.981	1.492	0.213	1.429	1.765	1.600
	(0.327)	(0.136)	(0.831)	(0.153)	(0.078)	(0.110)
Sardine						
t-test	1.080	1.693	-0.074	-1.027		0.583
	(0.292)	(0.105)	(0.942)	(0.315)		(0.566)
sign test	1.485	1.455	0.001	0.001	0.001	0.417
	(0.137)	(0.146)	(0.999)	(0.999)	(0.999)	(0.677)

4.3.3.3 Trawl efficiency during day-time and night-time.

The average trawl efficiency coefficient of anchovy-dominated hauls held during night was 0.88, and concerning all species during night was 0.83, while no statistical model was estimated for the hauls held during day for both cases (Table 4.3.9, Figure 4.3.2). At night, estimates differed markedly from those by day, presenting trawl efficiency close to 1; while the trawl efficiency seems to be random during the day. It should be noticed that the available data were rather restricted; especially those concerning day-time, and more data or targeted experiment are needed for safe conclusions.

Table 4.3.9. Estimates of trawl efficiency coefficients (Q) and exponents (b) from the models relating ENASC derived from trawl catches to observed NASC, along with the R^2 representing the variance explained by the model, with s.e. values in parenthesis

Species	No of hauls	Diel period	Q estimate	b estimate	R^2
Anchovy	9	D	Non-significant estimates		
Anchovy	16	N	0.88 (0.11)	-0.28 (0.32)	0.896
All Species	13	D	Non-significant estimates		
All Species	23	N	0.83 (0.11)	-0.25 (0.32)	0.84

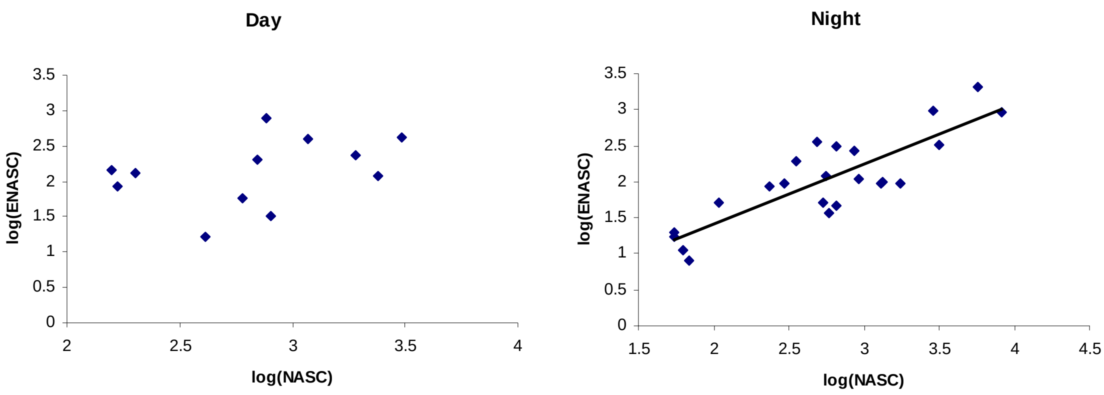


Figure 4.3.2. Relationship between total ENASCs per haul and total NASCs per haul, during day-time and night-time, combined for all species.

4.3.3.4 Sensitivity analysis

Higher mean TL estimates from the catch results into an overestimation of the total biomass and similarly lower TL results into the underestimation of the total biomass. Results concerning anchovy and sardine in Aegean Sea are presented in Table 4.3.10. Results concerning the effect of changes in the b_{20} coefficient of the target strength equation are also presented in Table 4.3.10. One centimeter difference in TL, the most usual one between day and night whenever a difference was estimated, resulted into 8-10% difference in biomass; whereas two centimeters difference which is the highest significant difference estimated, resulted into 14% - 15% difference in biomass. This range of error in the biomass was comparable to an approximate difference of 0.5 dB in the Target Strength estimated function.

Table 4.3.10. The percentages of change in the biomass estimations when the Total length increases by 1 (TL+1) or by 2 (TL+2) cm, or decreased by 1 (TL-1) or by 2 (TL-2) cm. The estimated percentages of variation in the biomass estimation if b_{20} changes by 0.5 and 1 dB is also presented.

	Anchovy	Sardine
TL+1	+9.69%	+7.61%
TL+2	+14.53%	+13.77%
TL-1	-10.51%	-9.01%
TL-2	-14.94%	-14.56%
$b_{20}\pm0.5$	±12.56%	±12.36%
$b_{20}\pm1$	±21.96%	±23.36%

4.3.4 Overall Discussion, Conclusions, Difficulties encountered, Recommendations

Ground truthing comprises essential information, closely related to the successful application of acoustic surveys. Obtaining representative samples of the pelagic assemblage by using appropriate trawl hauls is one of the main targets in any acoustic survey, and is associated to one of the most usual sources of error in biomass assessments by means of acoustics. Time of sampling is among the main factors that could cause bias in the catch of haul sampling mainly due to the known behavior of small pelagics that present diel vertical migration, form dense schools during day-time and disperse at loose aggregations during night-time (Woodhead, 1966; Masse, 1996; Giannoulaki *et al.*, 1999; Zwolinski *et al.*, 2007; Tsagarakis *et al.*, 2012). Time of fishing might also affect trawl selectivity by increasing the possibility for the smaller individuals to escape easier from the nets during the day-time. In addition, the dispersing, loose aggregations of fish during night can facilitate the application of more random and more representative sampling during night.

In order to investigate the difference in the catch during day-time and night-time sampling in Mediterranean acoustic surveys, certain comparisons were made by using paired groups of day-time and night-time hauls from different parts of the Mediterranean. Hauls were selected or conducted based on a common protocol. The differences in species composition were examined using certain diversity indices, while differences in the size of specimens were examined by comparing the length frequency distribution. The latter comparison focuses on the two main target species in the Mediterranean acoustic surveys, anchovy and sardine.

In general, no significant differences were estimated in the diversity indices. The cases in which significant differences were estimated correspond to haul groups that include a small number of specimens from demersal species in the catch, because day-time fishing operation was held close to the bottom. These differences were found significant only for those indices that are more susceptible to the number of individuals caught, whereas no differences were observed in the indices that were standardized by the number of specimens caught (especially H' and Simpson 1-λ). The absence of significant difference in these indices is the result of the very small contribution of demersal species to the total catch. Anyway, these species do not contribute to the echo used for assessment; and the region near the bottom called “dead zone” is generally excluded by the integration of the acoustic echograms.

Regarding the length frequency distribution analysis of certain pair groups indicated difference between day and night, no intense trends on these differences were observed. The Paired-Sample Comparison Analysis verifies that the estimated differences between day and night were random and did not indicate an overall systematic difference regarding the estimation of mean length, as well as the other parameters.

The main questions raised from the above results are: if there is any bias between day and night sampling, and which sampling could be considered as the most unbiased one. Regarding the species composition, the absence of any difference in the diversity indices between day and night, imply that both day and night sampling could result into representative samples of the pelagic community. One point that requires cautiousness is when the trawl operates in proximity to the bottom. In these cases, it is advisable that the demersal or benthic species are excluded from the analysis, as it is obvious that they do not contribute to the echo used for assessment.

The analysis of the length frequency distribution showed no statistical trend in the differences between day and night. Moreover, it seems that bigger individuals were caught more frequently during day-time. The latter has been observed also in other species like pollock (Wilson *et al.*, 1996), as fish present diel variation in aggregation patterns, disperse at night to feed and form schools during day-time. However, the overall pair examination indicated that no difference occurs between day and night.

The analysis of the trawl efficiency from the available data indicated that the trawling during night was more efficient than during day. This implies the possibility that a bias could be introduced during the day fishing at least to the examined target species, anchovy and/or sardine. This is an issue that need further investigation as well as targeted experiments, as the data used were restricted, especially those of day and sardine.

Moreover, a change in mean length by 1 or 2 cm results into smaller or similar percentage of under- or overestimation of the biomass (i.e. less than 10%) compared to the effect of 0.5 dB difference in the b_{20} coefficient of the Target Strength equation that can lead to an error of about 13%. Fishing along with acoustic recording has the advantage that targeted trawling can be held, and the insonified targets can be closely related to catches. Day-time sampling is essential and practically obligatory in order to identify acoustic targets, species associations and schools (Simmonds and MacLennan, 2005). From the other hand, fishing during night seems to be more random (less selective), less biased and more representative of the local populations at sea, as the preliminary results from the trawl efficiency analysis indicated.

Significant issues directly related to research surveys at sea is the duration and the cost of the survey which increases substantially when duration often exceeds 40 days at sea. Results of the present study imply that:

- a more flexible strategy can be adapted, depending on the needs of each acoustic survey.
- Day-time sampling can be combined with night-time sampling reducing the survey time.
- night-time sampling seems to provide a more unbiased length frequency distribution, merging results from night-time along with day sampling can mitigate possible errors.

- On top, if we consider the benefits that can derive from such a flexible sampling strategy, the subsequent error seems small compared to other common sources of error in acoustic estimates.

The above mentioned results and suggestions will be presented for discussion in the 5th Annual Steering Committee Meeting of the Pan Mediterranean Acoustic Surveys in order to disseminate the project results to other Mediterranean scientists and incorporate suggestion into the MEDIAS protocol. Moreover, the cooperation of MEDIAS with similar groups like WGACEGG dealing with acoustic and egg surveys of small pelagics in the Atlantic will be promoted, in order to share knowledge and experience among the members of these groups.

4.4 Standardization of a common format for an acoustic data database (Sub Task 3.4)

(Lead participant: CNR-ISMAR,, Involved participants: IFREMER, HCMR, IEO, CNR-IAMC, CNR-ISMAR)

Objectives

The aim of this task was the proposal of fields and algorithms for a common database that will serve the needs of acoustic surveys in order to fulfill DCF requirements and standardize the output of surveys estimations. The standardization of acoustic methodology also involves the need for a common protocol for the format of acoustic data, in order to facilitate the exchange of information between the different parties. For this purpose, within the framework of the current project, a common protocol on the format of acoustic data from all areas will be decided. This will assure the comparable presentation of acoustic data coming from different areas and surveys for joint analysis, facilitate the submission of acoustic data following the DCF requirements as well as provide the necessary estimations for stock assessment purposes (i.e. total abundance indices, abundance at age indices).

4.4.1 Work achieved

In the framework of this sub task two workshops took place within the first year of the project. One workshop took place during the kick-off meeting at Capo Granitola (Sicily) in March 2010, where the basic fields that an acoustic database should have, were discussed. It was agreed that all existing databases from the five surveyed areas will be reviewed in respect to: i) the data input requirements, ii) the necessary estimations that are applied within the database queries and iii) the database output. Towards this approach and within the first year of the project each partner reviewed the respective regional survey database in terms of:

1) the general information about the survey,
2) electroacoustic calibration report
3) trawl data (i.e. general information on hauls location, sampling time, technical characteristics, catch data)
4) environmental data,
5) sex, maturity, age data,
6) acoustic survey results.

A second workshop took place at Palma de Mallorca in November 2010. This allowed the standardization of the database information from the different partners/areas for the purposes of the project. This second workshop was held jointly with the ICES WGACEGG, allowing the exchange of ideas, opinions and expertise on common problems among participants promoting the collaboration between the Atlantic and Mediterranean bodies (MEDIAS). Within this second workshop the aforementioned reviewed information from each partner was discussed towards the proposal of a common data format to be adopted for database input. Moreover, the output of the different software used for acoustic data analysis (i.e. Movies and Myriax Echoview) was reviewed and considered.

A third workshop that took place along with the MEDIAS meeting in March 2011 at Ancona (Italy) examined data requirements of the DCF concerning the acoustic surveys data (i.e. total abundance indices, abundance at age indices) and proposed how these requirements can be incorporated in the proposed database format by the end of the project.

A fourth half day workshop was held in the final meeting of the project in December 2011. The workshop focused on the incorporation of queries related to data output needs as well as the inclusion of database fields related to ecosystem indicators.

4.4.2 Methodological approach followed

The revision of the format of existing databases related to acoustic surveys per study area and partner is presented below.

CNR-ISMAR

Type of Raw data: 1) acoustic data 2) SST & chl-a satellite data, 3) *in situ* environmental data (CTD), 4) biological sampling data (including general information on hauls, biological measurements data, net position and trawl geometry while fishing)

File formats to be stored: *.txt, *.cnv

Time frame of the data included in the database:

1) acoustic data period: 1976-1978, 1980-1983, 1985, 1987-2001, 2004-2010; GSA: 17
period: 1987, 1988, 1992-2002, 2005-2010; GSA: 18

2) SST&chl-a satellite data SST=> period: 1987-2007; GSA: 17, 18
chl-a => period: 1998-2007; GSA: 17, 18

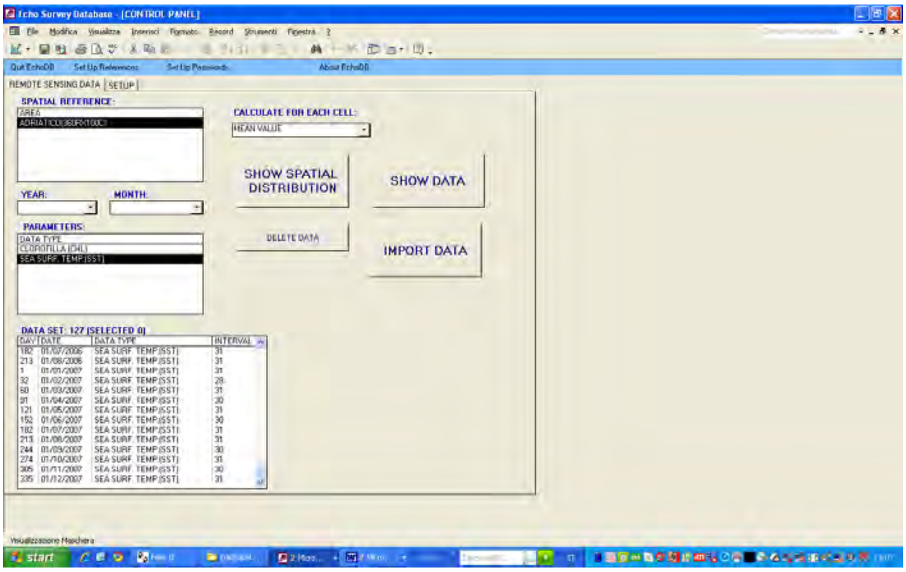
3) *in situ* environmental data (CTD) period: 2004-2010; GSA: 17, 18

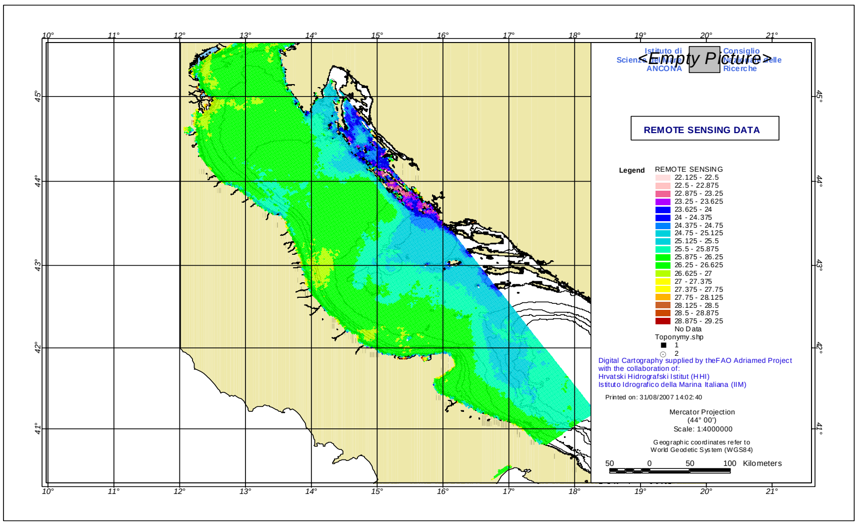
4) biological sampling data period: 1980, 1982, 1983, 1985, 1987-2001, 2004-2010; GSA: 17
period: 1987, 1988, 1992-2002, 2005-2010; GSA: 18

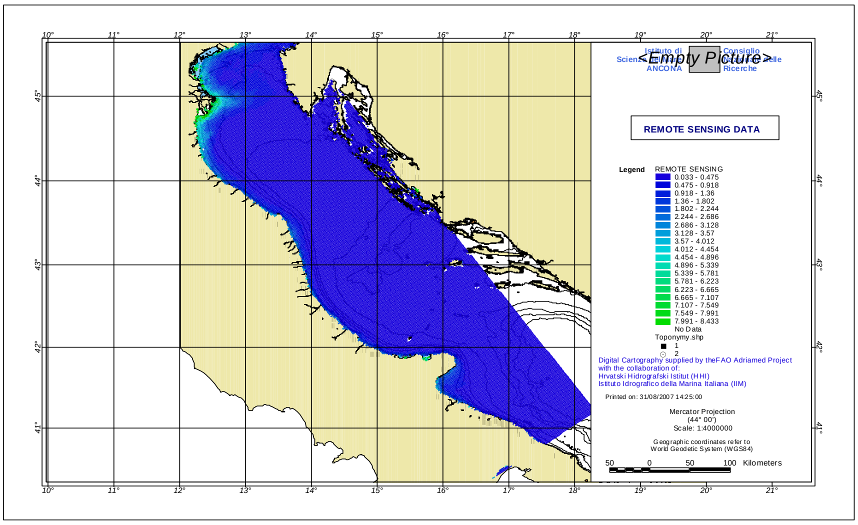
Structural software(s) for database:

Microsoft Excel (archiving)	Microsoft Access (archiving, querying)	ESRI ArcView (mapping)
Acoustic data		Acoustic data
	SST&CHL-a satellite data	SST&CHL-a satellite data
	CTD data	CTD data
	Net sampling stations data	Net sampling stations data

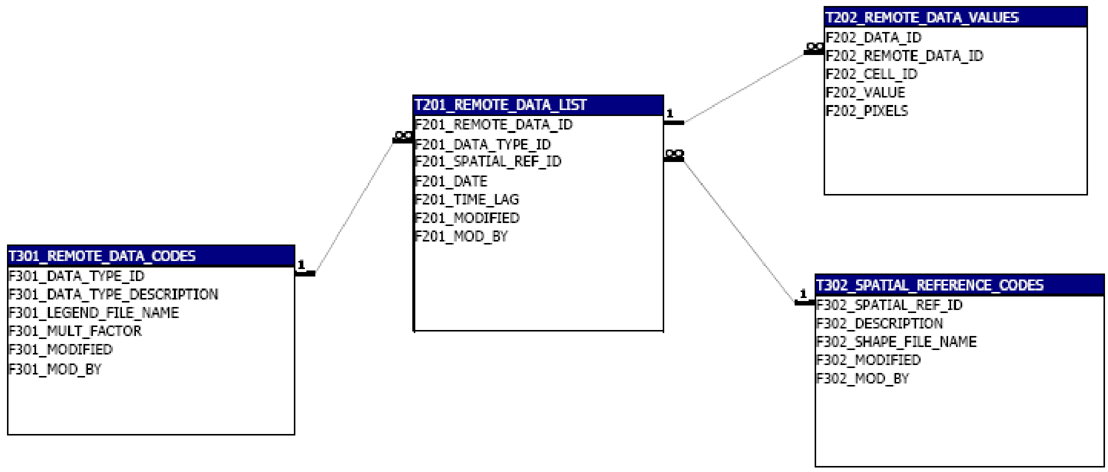
Graphic outputs (i.e. maps, charts):







Basic flow chart of the database fields:



T302_SPATIAL_REFERENCE_CODES : Tabella

Nome campo	Tipo dati	
F302_SPATIAL_REF_ID	Contatore	The record ID
F302_DESCRIPTION	Testo	The textual desscription of the content of shape file
F302_SHAPE_FILE_NAME	Testo	The name of the shape file
F302_MODIFIED	Data/ora	The date of modification
F302_MOD_BY	Testo	The user ID that modified the record

T301_REMOTE_DATA_CODES : Tabella

Nome campo	Tipo dati	
F301_DATA_TYPE_ID	Contatore	The record ID
F301_DATA_TYPE_DESCRIPT	Testo	The textual description of the parameter
F301_LEGEND_FILE_NAME	Testo	The ArcView legend file to use for the parameter representation
F301_MULT_FACTOR	Numerico	The factor to use for multiply the value
F301_MODIFIED	Data/ora	The date of modification
F301_MOD_BY	Testo	The User ID that modified the record

T201_REMOTE_DATA_LIST : Tabella

Nome campo	Tipo dati	
F201_REMOTE_DATA_ID	Contatore	The record ID
F201_DATA_TYPE_ID	Numerico	The type of parameter recordered (see Table T301_REMOTE_DATA_CODES)
F201_SPATIAL_REF_ID	Numerico	The ID of shape file with cells (see Table T302_SPATIAL_REFERENCE_CODES)
F201_DATE	Data/ora	The Date
F201_TIME_LAG	Numerico	The time lag
F201_MODIFIED	Data/ora	the date of modification
F201_MOD_BY	Testo	the user thaa modified

T202_REMOTE_DATA_VALUES : Tabella

Nome campo	Tipo dati	
F202_DATA_ID	Contatore	The record ID
F202_REMOTE_DATA_ID	Numerico	The ID of Remote Data Set (see Table T201_REMOTE_DATA_LIST)
F202_CELL_ID	Numerico	The ID of the cell corresponding to the cells in the shape file
F202_VALUE	Numerico	The Value of parameter in the cell
F202_PIXELS	Numerico	The Number of pixels

HCMR

Type of Raw data:

1) Acoustic data: NASC values per EDSU per species, Total NASC values per EDSU, Geographic coordinates of EDSU, Echosounder Frequency, Bottom Depth.

2) Haul data: including general information of hauls, biological measurements data and net position.

3) Environmental data: CTD data, geographic coordinates of sampling stations, vertical profile of temperature, salinity, fluorescence, photosynthetic active radiation, density

File formats to be stored: *.txt

Time frame of the data included in the database:

1) Acoustic data period: 1995-1996, 1999-2001, 2003-2006, 2008; GSA: 22; 1999-2001:GSA 20

2) Haul data period: 1995-1996, 1999-2001, 2003-2006, 2008; GSA: 22; 1999-2001:GSA 20

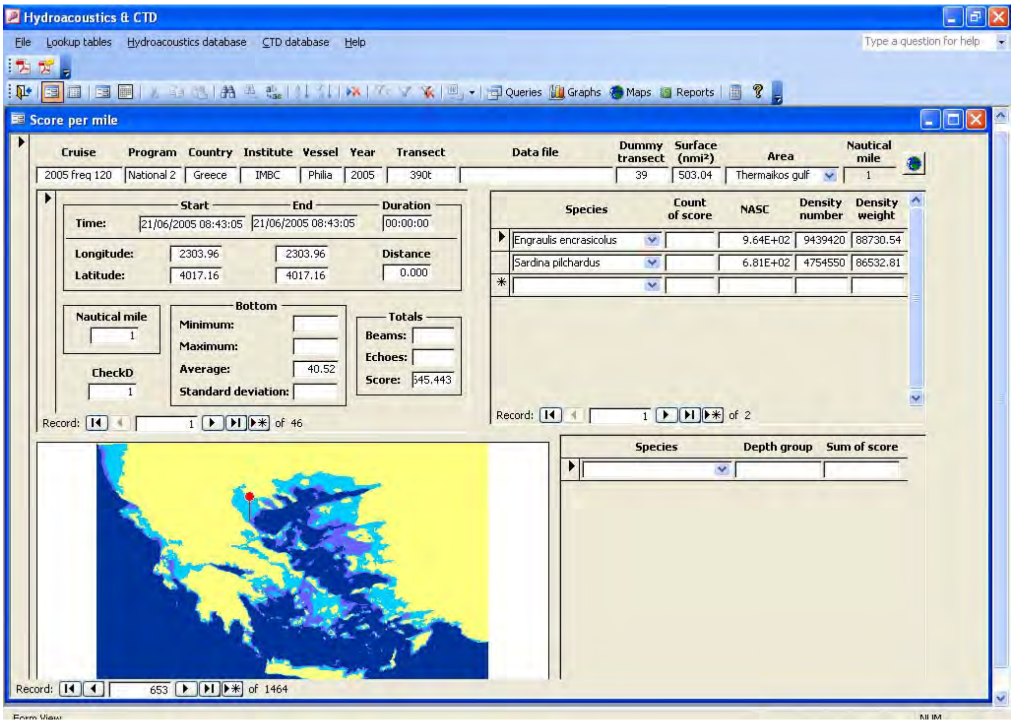
3) Environmental data period: 1995-1996, 1999-2001, 2003-2006, 2008; GSA: 22; 1999-2001:GSA 20

Structural software(s) for database:

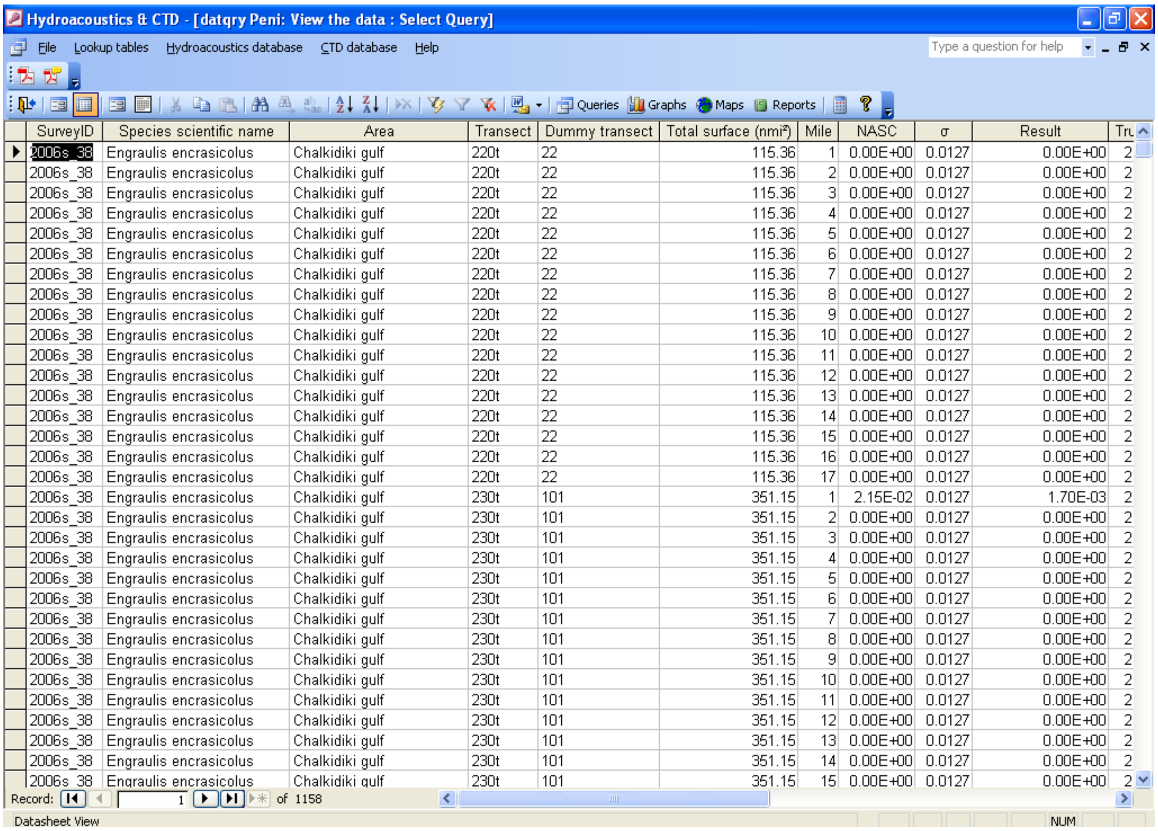
Microsoft Access (archiving, querying)
Acoustic data
Haul data
Environmental data

Graphic outputs (i.e. maps, charts):

Acoustic data



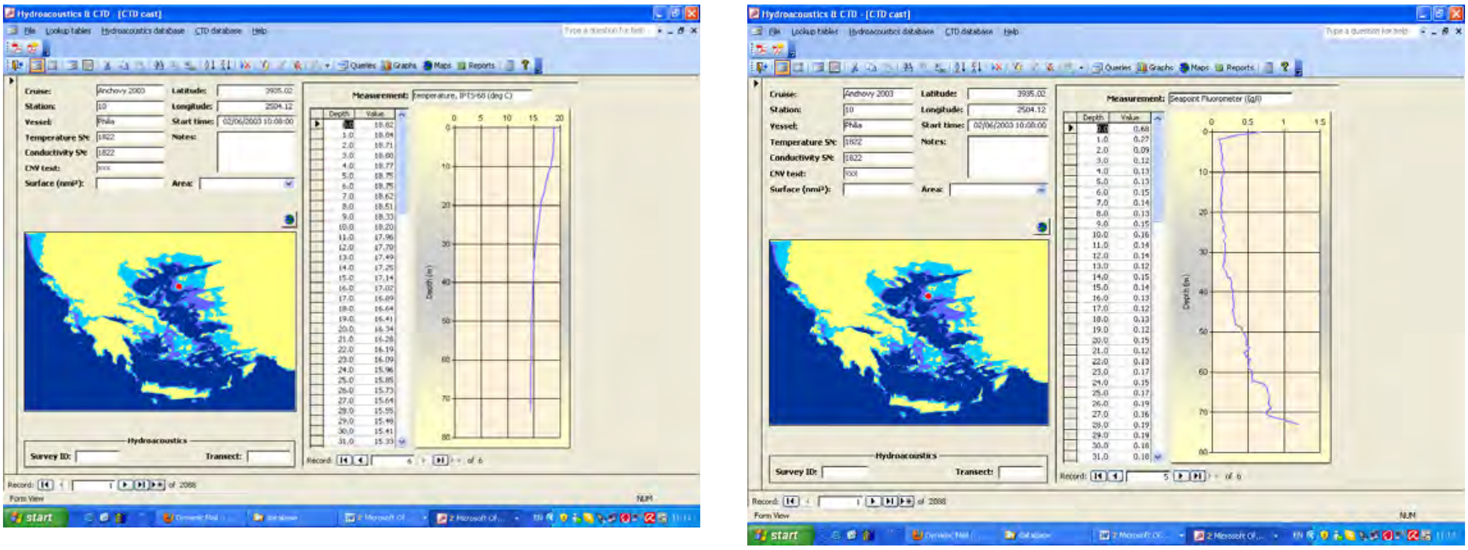
Example image of the position of transect, EDSU, NASC values per species



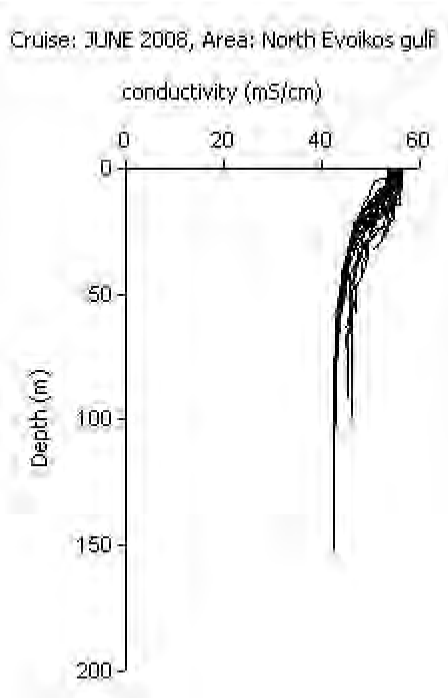
SurveyID	Species scientific name	Area	Transect	Dummy transect	Total surface (nmi²)	Mile	NASC	σ	Result	Tr
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	1	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	2	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	3	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	4	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	5	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	6	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	7	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	8	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	9	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	10	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	11	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	12	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	13	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	14	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	15	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	16	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	220t	22	115.36	17	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	1	2.15E-02	0.0127	1.70E-03	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	2	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	3	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	4	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	5	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	6	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	7	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	8	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	9	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	10	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	11	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	12	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	13	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	14	0.00E+00	0.0127	0.00E+00	2
2006s_38	Engraulis encrasicolus	Chalkidiki gulf	230t	101	351.15	15	0.00E+00	0.0127	0.00E+00	2

Example output of NASC values per species, EDSU, transect and area

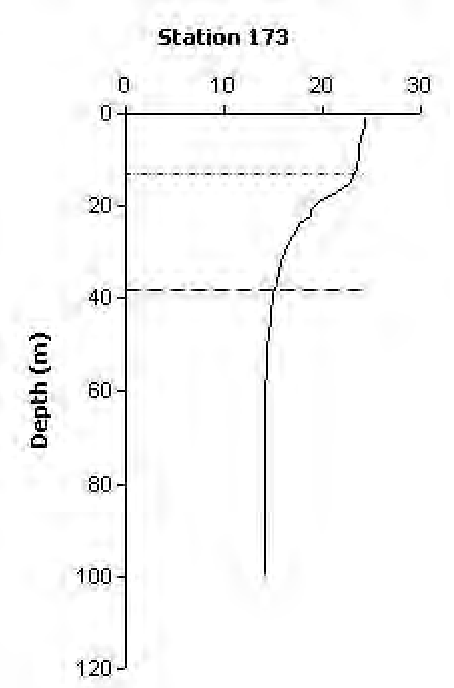
Environmental data



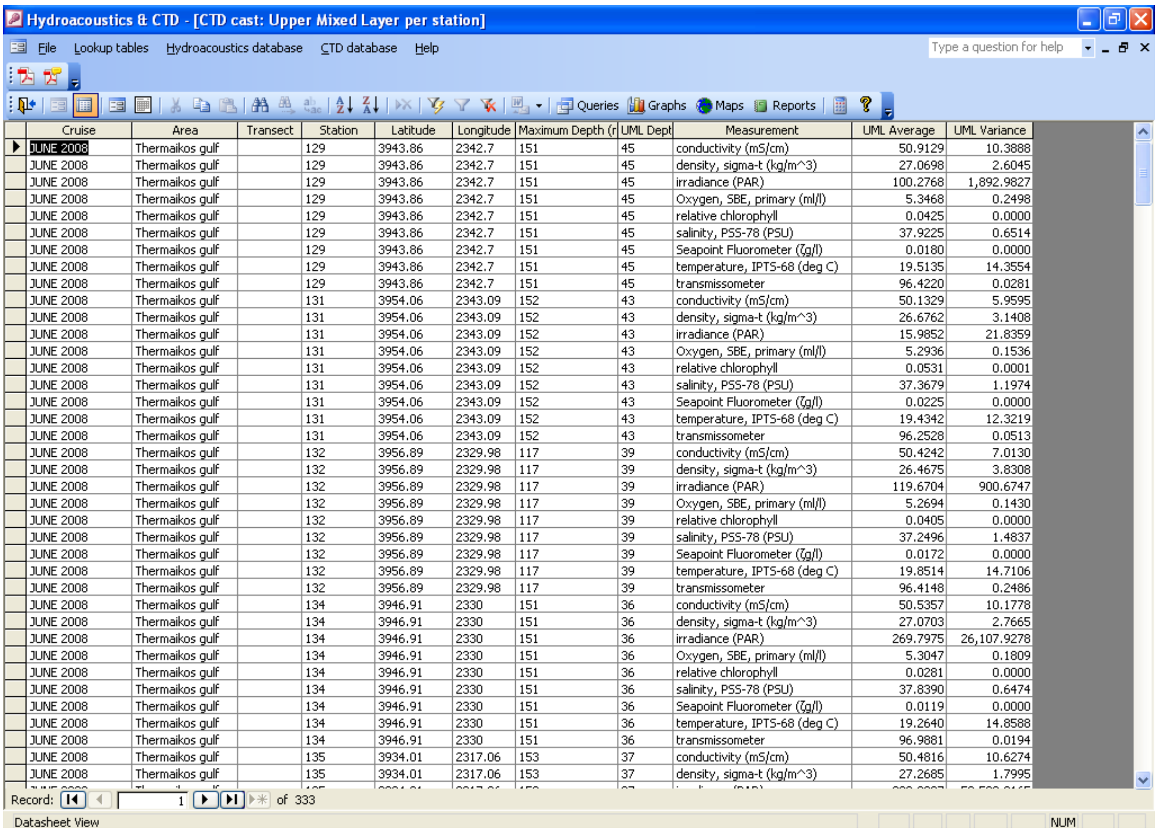
Example image of the position of CTD station, vertical profiles of environmental parameters: graphical & numerical presentation



Example vertical profiles of parameters e.g. temperature over an entire area



Example image of vertical profiles of temperature in a certain station indicating the position of the Surface Mixed Layer and the Upper Mixed Layer



Hydroacoustics & CTD - [CTD cast: Upper Mixed Layer per station]

File Lookup tables Hydroacoustics database CTD database Help

Queries Graphs Maps Reports

Cruise	Area	Transect	Station	Latitude	Longitude	Maximum Depth (r	UML Dept	Measurement	UML Average	UML Variance
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	conductivity (mS/cm)	50.9129	10.3888
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	density, sigma-t (kg/m^3)	27.0698	2.6045
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	irradiance (PAR)	100.2768	1,892.9827
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	Oxygen, SBE, primary (ml/l)	5.3468	0.2498
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	relative chlorophyll	0.0425	0.0000
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	salinity, PSS-78 (PSU)	37.9225	0.6514
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	Seapoint Fluorometer (ζg/l)	0.0180	0.0000
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	temperature, IPTS-68 (deg C)	19.5135	14.3554
JUNE 2008	Thermaikos gulf		129	3943.86	2342.7	151	45	transmissometer	96.4220	0.0281
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	conductivity (mS/cm)	50.1329	5.9595
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	density, sigma-t (kg/m^3)	26.6762	3.1408
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	irradiance (PAR)	15.9852	21.8359
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	Oxygen, SBE, primary (ml/l)	5.2936	0.1536
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	relative chlorophyll	0.0531	0.0001
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	salinity, PSS-78 (PSU)	37.3679	1.1974
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	Seapoint Fluorometer (ζg/l)	0.0225	0.0000
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	temperature, IPTS-68 (deg C)	19.4342	12.3219
JUNE 2008	Thermaikos gulf		131	3954.06	2343.09	152	43	transmissometer	96.2528	0.0513
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	conductivity (mS/cm)	50.4242	7.0130
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	density, sigma-t (kg/m^3)	26.4675	3.8308
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	irradiance (PAR)	119.6704	900.6747
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	Oxygen, SBE, primary (ml/l)	5.2694	0.1430
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	relative chlorophyll	0.0405	0.0000
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	salinity, PSS-78 (PSU)	37.2496	1.4837
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	Seapoint Fluorometer (ζg/l)	0.0172	0.0000
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	temperature, IPTS-68 (deg C)	19.8514	14.7106
JUNE 2008	Thermaikos gulf		132	3956.89	2329.98	117	39	transmissometer	96.4148	0.2486
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	conductivity (mS/cm)	50.5357	10.1778
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	density, sigma-t (kg/m^3)	27.0703	2.7665
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	irradiance (PAR)	269.7975	26,107.9278
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	Oxygen, SBE, primary (ml/l)	5.3047	0.1809
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	relative chlorophyll	0.0281	0.0000
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	salinity, PSS-78 (PSU)	37.8390	0.6474
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	Seapoint Fluorometer (ζg/l)	0.0119	0.0000
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	temperature, IPTS-68 (deg C)	19.2640	14.8588
JUNE 2008	Thermaikos gulf		134	3946.91	2330	151	36	transmissometer	96.9881	0.0194
JUNE 2008	Thermaikos gulf		135	3934.01	2317.06	153	37	conductivity (mS/cm)	50.4816	10.6274
JUNE 2008	Thermaikos gulf		135	3934.01	2317.06	153	37	density, sigma-t (kg/m^3)	27.2685	1.7995

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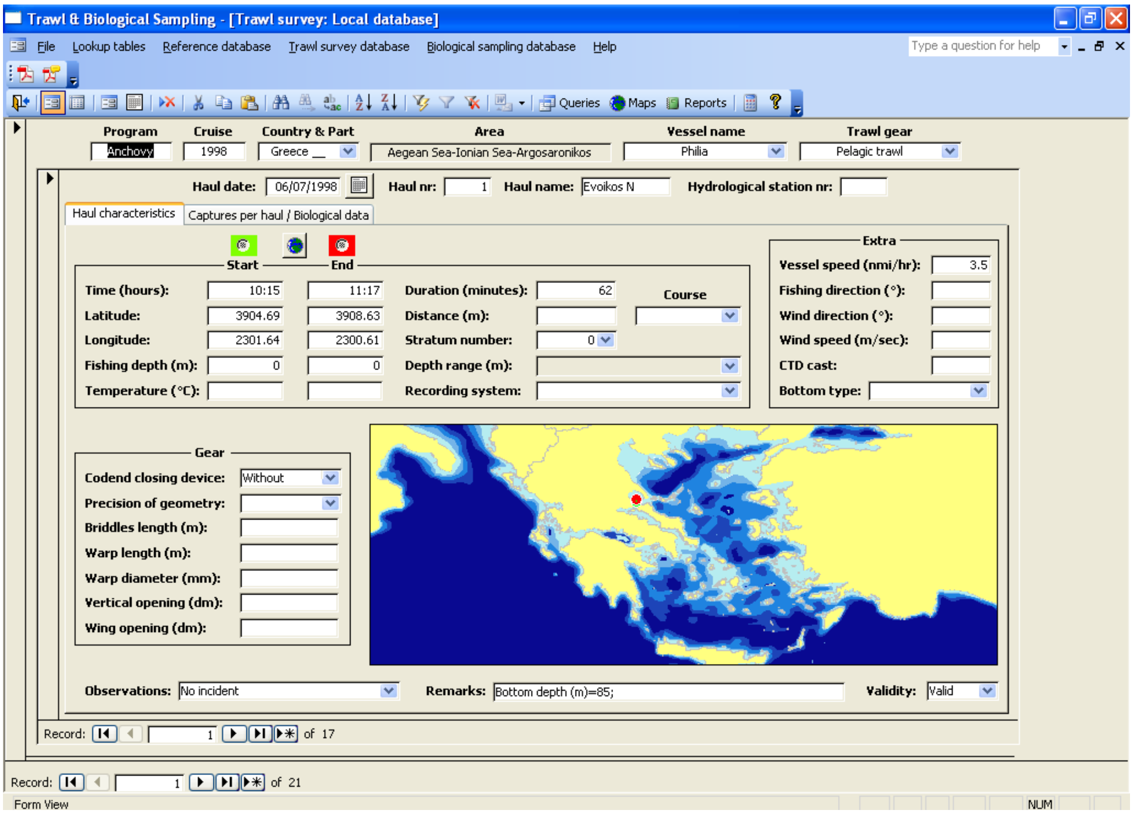
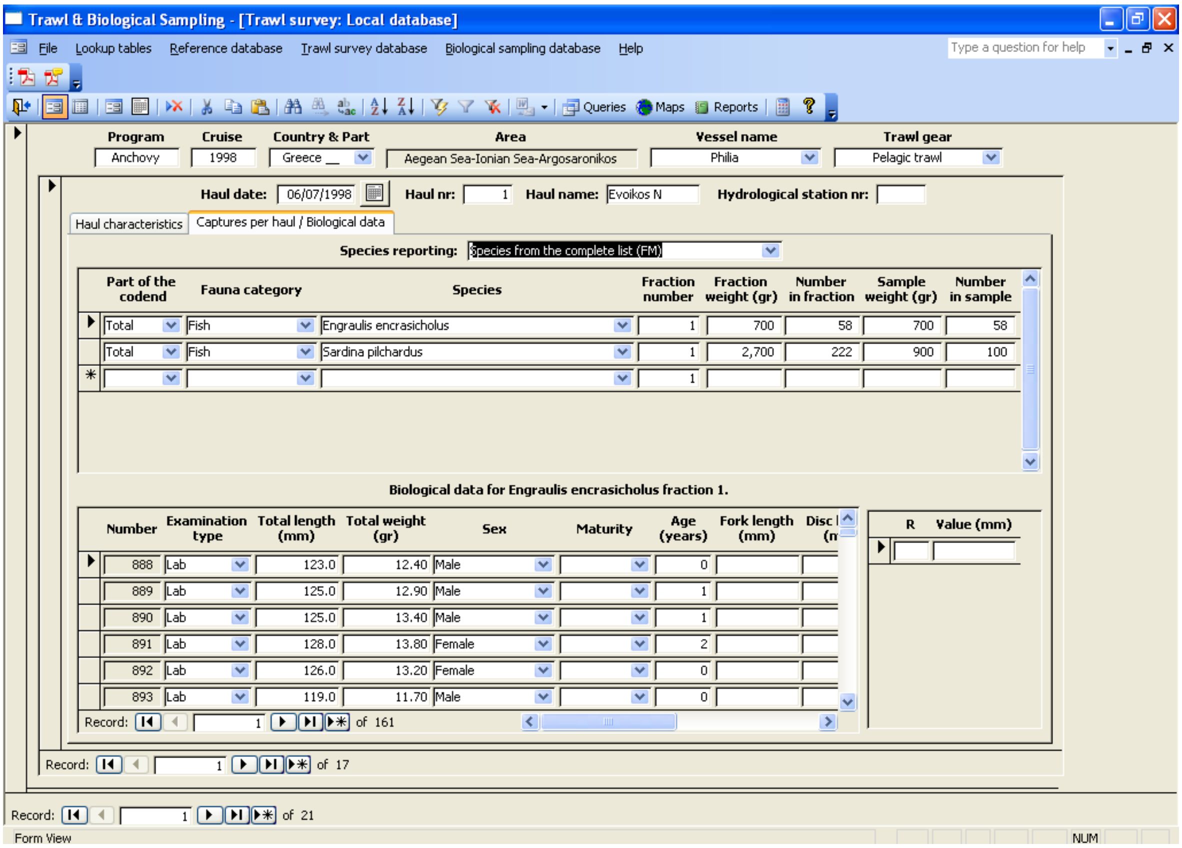
Datasheet View

Example output of the mean values of the environmental parameters at a certain station in the Upper Mixed Layer (numerical presentation)

Haul data



Example image of the general characteristics of sampling haul



Example input of biological data per sampling haul

Trawl & Biological Sampling - [locqry Traw: Geometric mean length per haul : Select Query]

Program	Cruise	Gear	Haul	Scientific name	Examination type	Sample	Geometric	Geometric mean length per haul (m	Variance per haul
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	250	117.0	116.6	1.25
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	248	118.8	118.2	1.29
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	150	135.0	134.4	1.14
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	149	131.2	130.3	1.76
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Field	200	122.9	122.6	1.03
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	199	121.9	121.2	1.43
National 2	2005	Pelagic trawl	4	Engraulis encrasicholus	Field	126	124.1	123.3	1.62
National 2	2005	Pelagic trawl	4	Engraulis encrasicholus	Lab	70	117.6	117.4	1.23
National 2	2005	Pelagic trawl	5	Engraulis encrasicholus	Field	150	131.9	131.3	1.37
National 2	2005	Pelagic trawl	5	Engraulis encrasicholus	Lab	142	130.0	129.6	1.38
National 2	2005	Pelagic trawl	6	Engraulis encrasicholus	Field	150	133.9	132.9	1.25
National 2	2005	Pelagic trawl	6	Engraulis encrasicholus	Lab	151	130.2	129.6	1.32
National 2	2005	Pelagic trawl	7	Engraulis encrasicholus	Field	227	127.4	126.9	1.40
National 2	2005	Pelagic trawl	7	Engraulis encrasicholus	Lab	211	126.3	125.7	1.39
National 2	2005	Pelagic trawl	8	Engraulis encrasicholus	Field	200	129.3	129.1	1.20
National 2	2005	Pelagic trawl	8	Engraulis encrasicholus	Lab	195	128.8	128.4	1.47
National 2	2005	Pelagic trawl	9	Engraulis encrasicholus	Field	96	134.3	133.0	1.25
National 2	2005	Pelagic trawl	9	Engraulis encrasicholus	Lab	44	131.6	130.7	1.18
National 2	2005	Pelagic trawl	10	Engraulis encrasicholus	Field	150	129.7	129.4	1.57
National 2	2005	Pelagic trawl	10	Engraulis encrasicholus	Lab	150	126.1	125.5	1.29
National 2	2005	Pelagic trawl	11	Engraulis encrasicholus	Field	150	126.1	125.8	1.16
National 2	2005	Pelagic trawl	11	Engraulis encrasicholus	Lab	144	125.8	124.7	1.33
National 2	2005	Pelagic trawl	14	Engraulis encrasicholus	Field	150	124.3	123.4	2.55
National 2	2005	Pelagic trawl	14	Engraulis encrasicholus	Lab	148	121.1	120.8	1.25
National 2	2005	Pelagic trawl	15	Engraulis encrasicholus	Field	150	118.8	118.2	2.05
National 2	2005	Pelagic trawl	15	Engraulis encrasicholus	Lab	146	114.8	114.4	2.10
National 2	2005	Pelagic trawl	16	Engraulis encrasicholus	Field	150	124.0	123.0	1.64
National 2	2005	Pelagic trawl	16	Engraulis encrasicholus	Lab	208	126.3	125.7	1.33
National 2	2005	Pelagic trawl	17	Engraulis encrasicholus	Field	150	115.4	114.7	1.56
National 2	2005	Pelagic trawl	17	Engraulis encrasicholus	Lab	147	117.2	116.8	1.26
National 2	2005	Pelagic trawl	18	Engraulis encrasicholus	Field	100	112.6	112.2	1.92
National 2	2005	Pelagic trawl	18	Engraulis encrasicholus	Lab	99	108.7	108.4	1.77

Record: 1 of 46

Datasheet View

Example of Query output that estimates the geometric mean length per species and haul

Trawl & Biological Sampling - [locqry Traw: Length frequency per haul : Select Query]

Program	Cruise	Gear	Haul nu	Scientific name	Examin	Length class	Number of san	Number/h	Percent/hou	Average length (m	Variance of le
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	77.5	1	2.7	0.40%	78.0	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	82.5	1	2.7	0.40%	83.0	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	87.5	2	5.4	0.80%	88.0	0.0
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	92.5	2	5.4	0.80%	93.0	2.0
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	102.5	7	19.0	2.80%	102.4	0.9
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	107.5	7	19.0	2.80%	107.1	0.8
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	112.5	41	111.3	16.40%	112.2	1.5
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	117.5	44	119.4	17.60%	116.8	1.3
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	122.5	68	184.6	27.20%	121.7	1.4
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	127.5	33	89.6	13.20%	126.8	1.2
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	132.5	26	70.6	10.40%	131.5	1.7
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	137.5	10	27.1	4.00%	136.1	0.9
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Field	142.5	8	21.7	3.20%	142.0	2.0
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	82.5	1	2.7	0.40%	80.0	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	87.5	1	2.7	0.40%	88.0	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	92.5	1	2.7	0.40%	91.0	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	102.5	6	16.4	2.42%	102.3	1.8
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	107.5	8	21.9	3.23%	106.9	1.8
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	112.5	26	71.1	10.48%	112.2	2.0
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	117.5	62	169.7	25.00%	116.8	1.3
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	122.5	68	186.1	27.42%	121.9	1.3
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	127.5	37	101.2	14.92%	126.6	1.4
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	132.5	23	62.9	9.27%	132.1	1.1
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	137.5	11	30.1	4.44%	136.5	1.2
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	142.5	4	10.9	1.61%	143.3	0.2
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	112.5	1	3.6	0.67%	114.0	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	117.5	1	3.6	0.67%	117.0	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	122.5	17	60.5	11.33%	121.9	1.4
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	127.5	20	71.2	13.33%	127.0	1.1
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	132.5	37	131.7	24.67%	132.2	1.8
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	137.5	43	153.1	28.67%	137.0	1.1
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Field	142.5	20	71.2	13.33%	141.4	1.8

Record: 1 of 405

Datasheet View

Example of query output that estimates the length frequency per species and haul. Output is in Numbers/Hour

Trawl & Biological Sampling - [locqry Traw: Length frequency age per haul (Nr/hour) : Crosstab Query]

Program	Cruise	Gear	Haul numbe	Scientific name	Examination type	Length class (mm)	0	1	2	3
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	82.5	2.74			
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	87.5		2.74		
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	92.5			2.74	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	102.5		16.42		
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	107.5		21.89		
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	112.5		24.63		
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	117.5		30.10	13.68	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	122.5		10.95	30.10	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	127.5			30.10	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	132.5			41.05	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	137.5			27.36	
National 2	2005	Pelagic trawl	1	Engraulis encrasicholus	Lab	142.5			10.95	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	112.5		3.58		
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	117.5		25.09	3.58	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	122.5		17.92	10.75	3.58
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	127.5		10.75	50.17	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	132.5			78.85	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	137.5			25.09	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	142.5			39.42	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	147.5			3.58	
National 2	2005	Pelagic trawl	2	Engraulis encrasicholus	Lab	152.5				3.58
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	87.5		9.60		
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	97.5		9.60		
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	102.5		57.61		
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	107.5		86.41		
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	112.5		105.62		
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	117.5		124.82	9.60	
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	122.5		96.01	48.01	
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	127.5		48.01	57.61	
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	132.5		28.80	124.82	
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	137.5		28.80	67.21	
National 2	2005	Pelagic trawl	3	Engraulis encrasicholus	Lab	142.5		9.60	57.61	

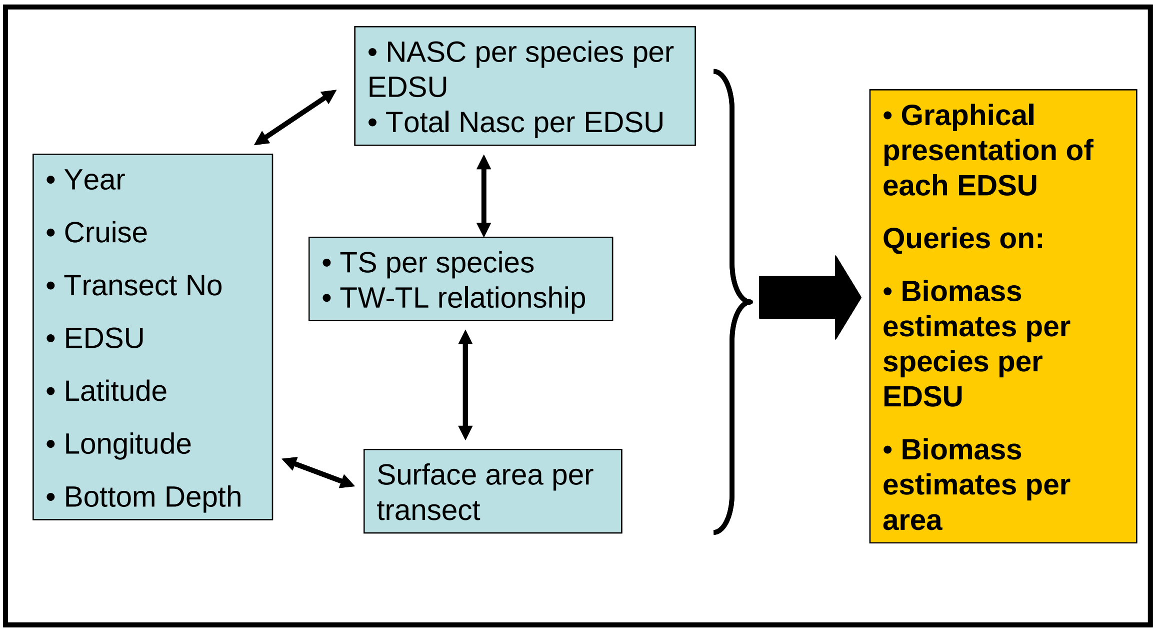
Record: 1 of 182

Datasheet View

Example of query output that estimates the length frequency per age class per species and haul. Output is in Numbers/Hour

Basic flow chart of the database fields:

Acoustic database



Environmental database

- Year
- Cruise
- Sampling Station
- Latitude
- Longitude
- Bottom Depth

Vertical profile of parameters per 1m
- Temperature
- Salinity
- Fluorescence
- Photosynthetic Active Radiation
- Density

- **Graphical presentation of the geographical position of each sampling station**
- **Graphical presentation of the vertical profiles of each parameter of the stations in a certain area**
- **Graphical presentation of the vertical profile of each parameter per station indicating the position of the Surface Mixed Layer and the Upper Mixed Layer**

Queries on:

- **Estimation of the Surface Mixed Layer and the Upper Mixed Layer per Station**
- **Estimates of mean value of each parameter per sampling station in the Surface Mixed Layer and the Upper Mixed Layer**

Haul data – Biological sampling

Haul general information

Cruise

Position

Date

Time (start, stop)

Duration (in time, length or both)

Average fishing speed

Net position in the water column (start, end)

Bottom depth (start, stop)

Haul biological data

Total catch by species

Subsample weight and number by species

Size, Weight, Age, Sex distribution per species in subsample (disaggregated data…)

- **Graphical presentation of the geographical position of each haul station**

Queries on:

- **% Catch Weight per species per hour**
- **% Catch Number per species per hour**
- **Estimation of the length distribution per haul or group of hauls per species**
- **Estimation of the length distribution (and associated variance) per haul or group of hauls per age group per species**
- **Estimation of the mean length (or geometric mean length, variance) per haul or group of hauls per species**

IFREMER

Acoustic Database

Table 1 - ESU

Label	*description*	*type*	*format*	*exemple*
SURVEY	*name*	*string*	xxxxxxxx	PELMED05
ESU	*ESU number*	*numerical*	nnnn	1
DATE	*Date*	*string*	yyyymmdd	20050716
TIME	*Time GMT*	*string*	hh:mm:ss	08:10:45
LATITUDE	*Decimal degree*	*numerical*	nn.nnnn (+/- ; N/S)	42.820633
LONGITUDE	*Decimal degree*	*numerical*	nn.nnnn (+/- ; E/W)	3.131211

Table 2 - sA

Label	*description*	*type*	*format*	*exemple*
SURVEY	*name*	*string*	xxxxxxxx	PELMED05
ESU	*identifier*	*numerical*	nnnn	1
Echo Type (n)	*Type of echogram*	*string*	xxx	sD2
SA (n)	*sA (Nautical area scattering coefficient) (m²/mille²) for echograms type n*	*numerical*	nnnn.nn	23.123

Table 3 - haul

Label	*description*	*type*	*format*	*exemple*	
SURVEY	*name*	*string*	xxxxxxxx	PELMED05	
NOSTA	*Haul N°*	*string*	xxxxx	M0032	*we can increase the letter for each year : for the vessel L'EUROPE, the letter is A in 1993, so the letter is M in 2005*
DATE	*Date*	*string*	yyyymmdd	20050428	
TIME	*Time GMT of shooting*	*string*	hh:mm:ss	08:10:45	
LATITUDE	*Mean position, Decimal degree*	*numerical*	nn.nnnn (+/- ; N/S)	42.820633	
LONGITUDE	*Mean position, Decimal degree*	*numerical*	nn.nnnn (+/- ; E/W)	3.131211	
DEPTH	*bottom depth (m)*	*numerical*	nnnn.n	123.4	

Table 4 - catches

Label	*description*	*type*	*format*	*exemple*
SURVEY	*name*	*string*	xxxxxxxx	PELMED05
NOSTA	*Haul N°*	*string*	xxxxx	M0032
SPECIES	*latin name*	*string*	xxxxxxxxxxxx xxxxxxx	*Engraulis encrasilocus*
WEIGHT	*total catch (kg)*	*numerical*	nnnnn.nnn	525.32
NUMBER	*total number of individuals*	*numerical*	nnnnnnnnn	11054
MEAN LENGTH	*mean length (cm)*	*numerical*	nnn.nn	16.42

Table 5 - Species / echo type

Label	*description*	*type*	*format*	*exemple*
SURVEY	*name*	*string*	xxxxxxxx	PELMED05
Echo Type (n)	*Type of echogram*	*string*	xxx	sD2
SPECIES	*latin name*	*string*	xxxxxxxxxxxx xxxxxxx	*Engraulis encrasilocus*

Table 6 - Haul / echo type

Label	*description*	*type*	*format*	*exemple*
SURVEY	*name*	*string*	xxxxxxxx	PELMED05
ESU	*identifier*	*numerical*	nnnn	1
Echo Type (n)	*Type of echogram*	*string*	xxx	sD2
NOSTA	*Haul N°*	string	xxxxx	M0032

Table 7 - TS/length

Label	*description*	*type*	*format*	*exemple*	
SPECIES	*latin name*	*string*	xxxxxxxxxxxx xxxxxxxx	*Engraulis encrasilocus*	
CAC	*c coefficient of TS/length relationship*	numerical	nn.n	20	TS = **c** Log L(cm) - b
BAC	*b coefficient of TS/length relationship*	numerical	nn.nn	72.4	TS = c Log L(cm) - **b**

Table 8 - Weight/length

Label	*description*	*type*	*format*	*exemple*	
SURVEY	*name*	*string*	xxxxxxxx	PELMED05	
SPECIES	*latin name*	*string*	xxxxxxxxxxxx xxxxxxxx	*Engraulis encrasilocus*	
NOSTA	*Haul N°*	string	xxxxx	M0032	
AWL	*a coefficient of weight/length relationship*	numerical	n.nnnnnn	0.000235	W (g) = **a** L(cm) ^{n}
NWL	*n coefficient of weight/length relationship*	numerical	n.nnnnnn	3.12	W (g) = a L(cm) $^{\mathbf{n}}$

Table 9 - Length distribution

Label	*description*	*type*	*format*	*exemple*
SURVEY	*name*	*string*	xxxxxxxx	PELMED05
SPECIES	*latin name*	*string*	xxxxxxxxxx:	*Engraulis encrasilocus*
NOSTA	*Haul N°*	string	xxxxx	M0032
LENTH	*Length class*	numerical	nnn.n	12.5
NUMBER	*number*	numerical	nnnn	17

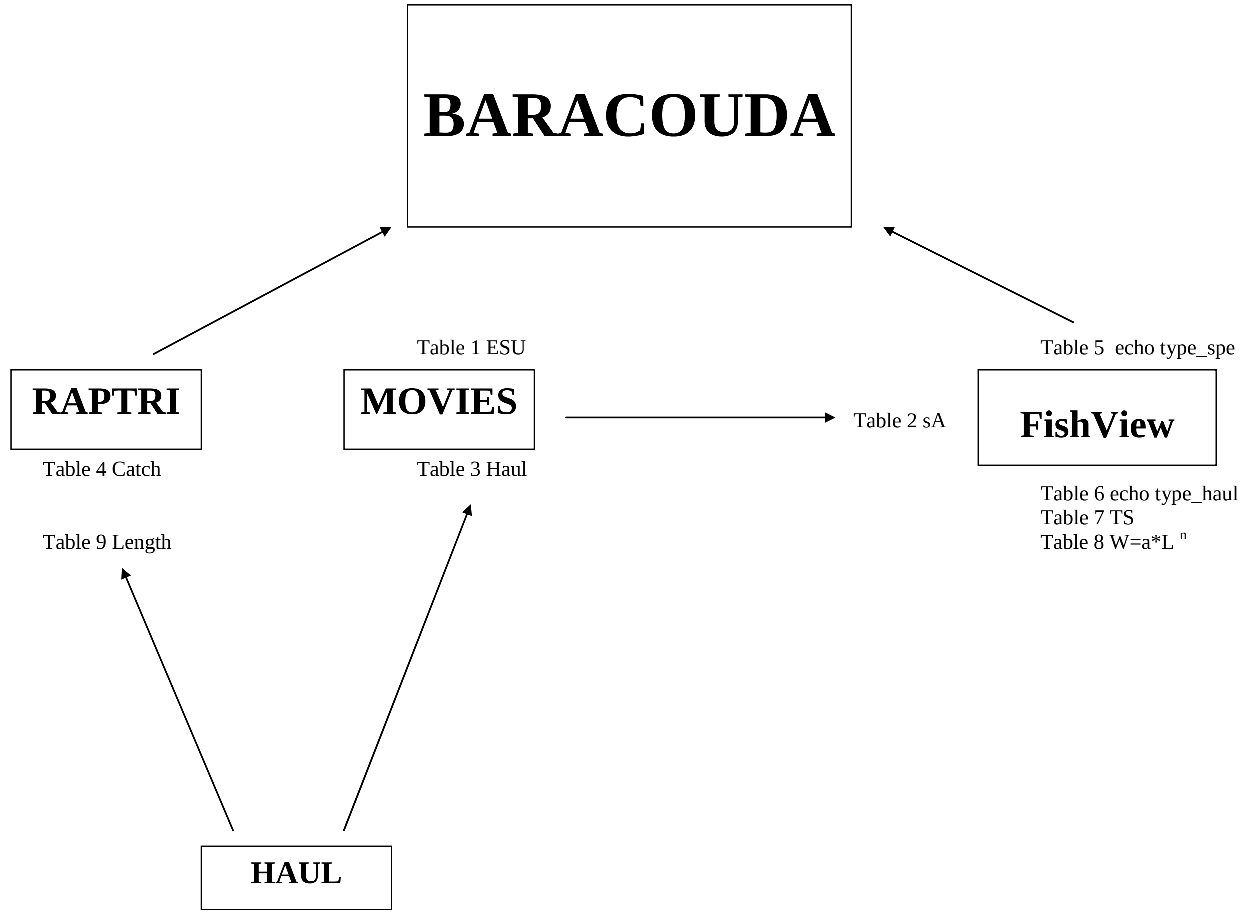
Table 10 - Age/Length key

Label	*description*	*type*	*format*	*exemple*	
SURVEY	*name*	*string*	xxxxxxxx	PELMED05	
SPECIES	*latin name*	*string*	xxxxxxxxxxx	*Engraulis encrasilocus*	
NOSTA	*Haul N°*	string	xxxxx	M0032	
LENTH	*Length clas*	numerical	nnn.n	12.5	
AGE	*age group*	numerical	nn	3	
PROPORTION	*proportion*	numerical	nn.nn	0.0324	*for 3.24%*

Table 11 - Catches / length distribution /Age-Length key

Label	*description*	*type*	*format*	*exemple*
SURVEY	*name*	*string*	xxxxxxxx	PELMED05
SPECIES	*latin name*	*string*	xxxxxxxxxxx	*Engraulis encrasilocus*
NOSTA	*Haul N° (for catches)*	string	xxxxx	M0032
NOSTAL	*Haul N° (for Length distribution)*	string	xxxxx	M0032
NOSTAGE	*Haul N° (for age/length key)*	string	xxxxx	M0015

Basic flow chart of the database fields:



IEO

General description of IEO database at present state

Type of Raw data:

1) **Acoustic data:** NASC values per EDSU per species, Total NASC values per EDSU, Geographic coordinates of EDSU, Echosounder Frequency and Bottom Depth.

2) Haul data: including general information of hauls, biological measurements data and net position.

3) Environmental data: CTD data, geographic coordinates of sampling stations, vertical profile of temperature and salinity.

File formats to be stored: *.xls

Time frame of the data included in the database:

1) Acoustic data period: 2003-2010; GSA: 06; 2003-2005:GSA 01

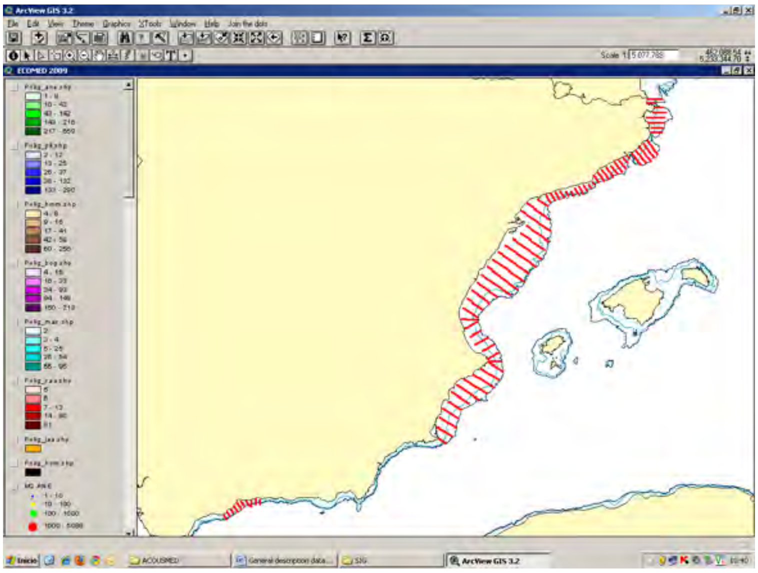
2) Haul data period: 2003-2010; GSA: 06; 2003-2005:GSA 01

3) Environmental data period: 2008-2010: GSA 06 and 01.

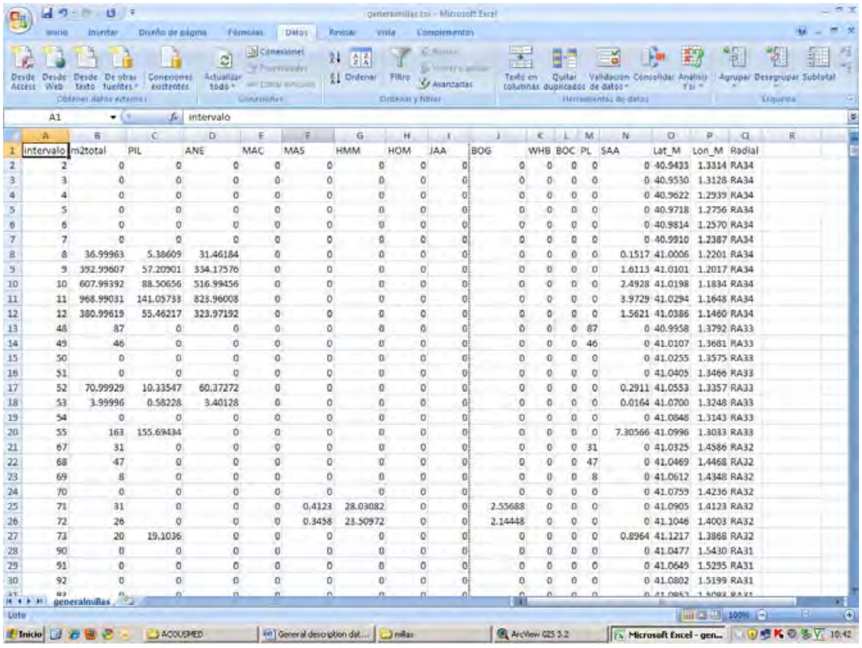
Structural software(s) for database:

Microsoft Excel (archiving)	ESRI Arcview (mapping)
Acoustic data	Acoustic data
Haul data	Haul data
Environmental data	Environmental data

Graphic outputs (i.e. maps, charts):
Acoustic data

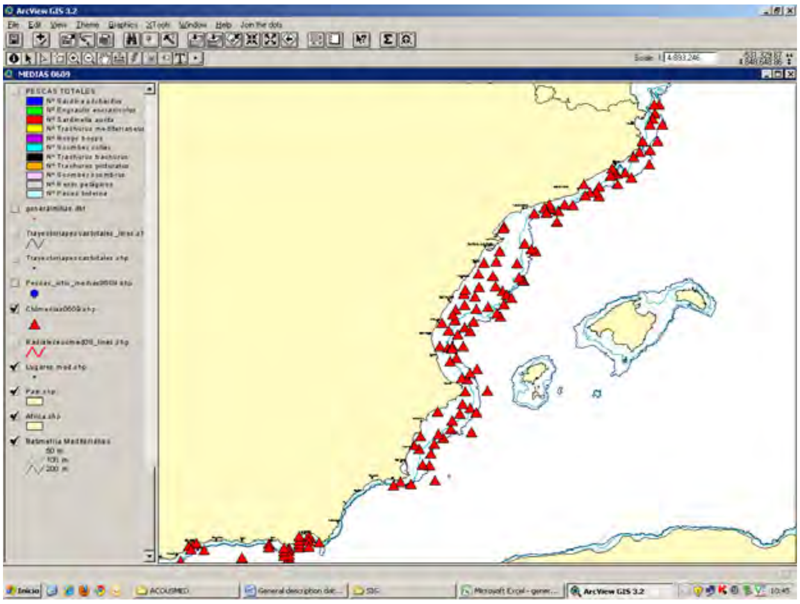


Position of transect, EDSU, NASC values per species



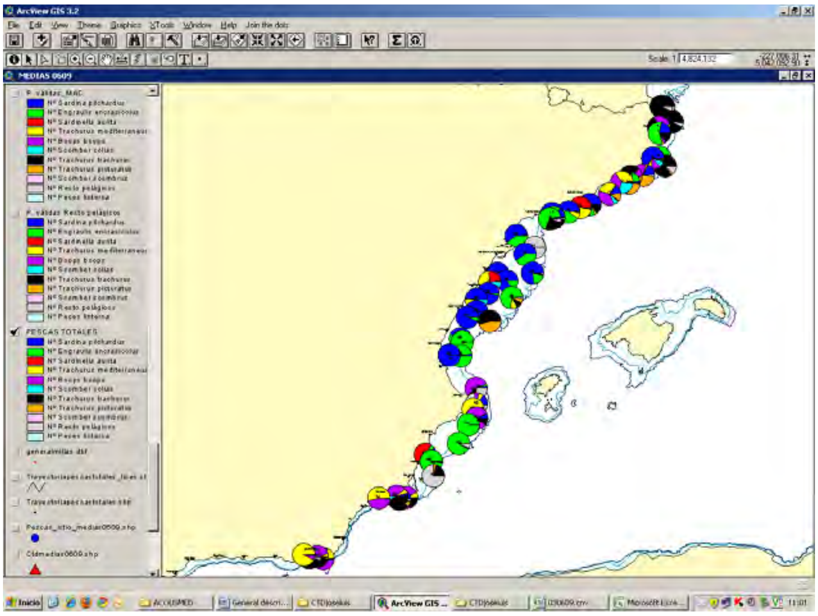
NASC values per species, EDSU and transect.

Environmental data

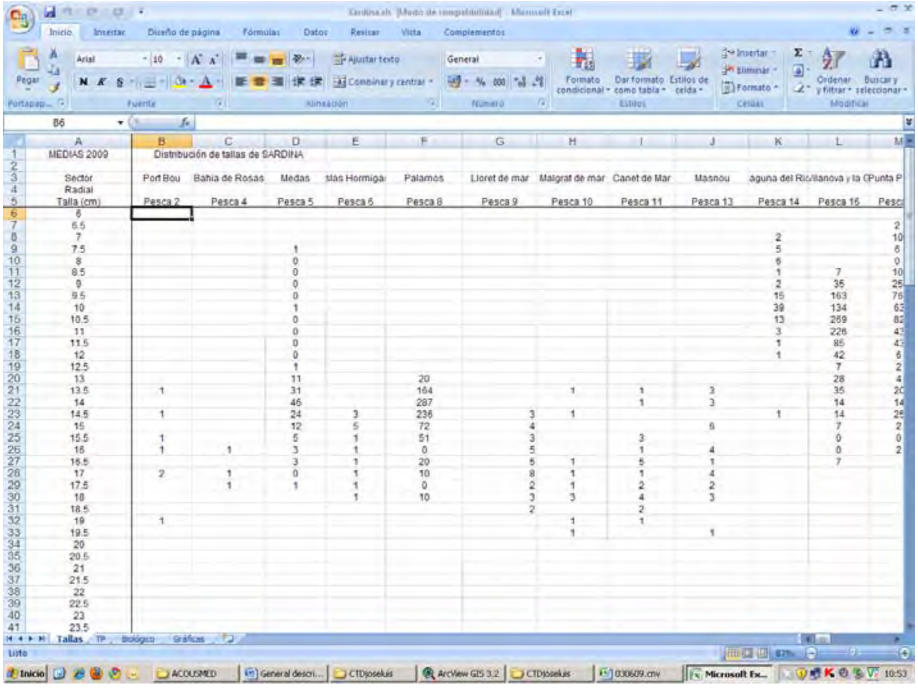


CTD station positions.

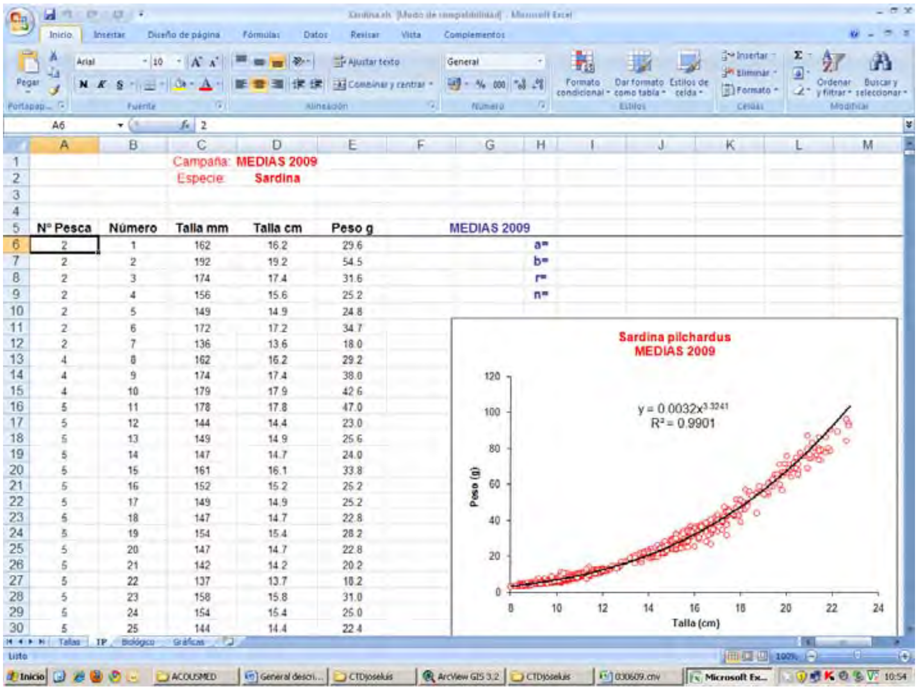
Haul data



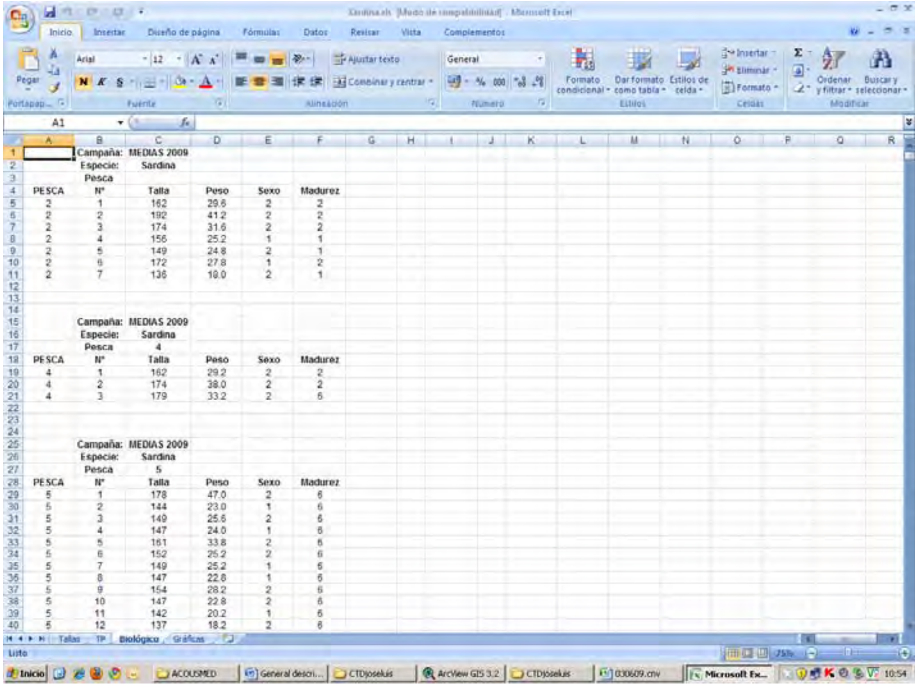
Position of pelagic trawls.



Length frequency distribution per fishing haul, per species.



Weight-length relation per species.



	Campaña:	MEDIAS 2009			
	Especie:	Sardina			
	Pesca				
PESCA	Nº	Talla	Peso	Sexo	Madurez
2	1	162	29.6	2	2
2	2	192	41.2	2	2
2	3	174	31.6	2	2
2	4	156	25.2	1	1
2	5	149	24.8	2	1
2	6	172	27.8	1	2
2	7	136	18.0	2	1

	Campaña:	MEDIAS 2009			
	Especie:	Sardina			
	Pesca	4			
PESCA	Nº	Talla	Peso	Sexo	Madurez
4	1	162	29.2	2	2
4	2	174	38.0	2	2
4	3	179	33.2	2	6

	Campaña:	MEDIAS 2009			
	Especie:	Sardina			
	Pesca	5			
PESCA	Nº	Talla	Peso	Sexo	Madurez
5	1	178	47.0	2	6
5	2	144	23.0	1	6
5	3	149	25.6	2	6
5	4	147	24.0	1	6
5	5	161	33.8	2	6
5	6	152	25.2	2	6
5	7	149	25.2	1	6
5	8	147	22.8	1	6
5	9	154	28.2	2	6
5	10	147	22.8	2	6
5	11	142	20.2	1	6
5	12	137	18.2	2	6

Biological data per species.

CNR-IAMC

The CNR-IAMC at Capo Granitola has a long time series of data regarding the acoustic evaluation of small pelagic resources.

During acoustic surveys three main categories of data are collected:

- Oceanography and Atmospheric main parameters
- Underwater acoustic
- Fish biology measurements and trawl positioning information data

Type of Raw data:

1. Acoustic data: Vessel geographic position, date, time, species density, Total NASC and NASC per species
2. Biological data: Length weight, sex, maturity and age
3. Trawl positioning: geographical positioning, date, time, opening distance from the bottom and from the vessel
4. Environmental data: temperature, conductivity, florescence, pressure, oxygen, etc.

Time frame of the data included in the database:

1. Summer survey (1998, 2000, 2002, 2003, 2005, 2006, 2007,2008,2009,2010)
2. Autumnal survey (1999, 2000, 2001, 2004, 2005)

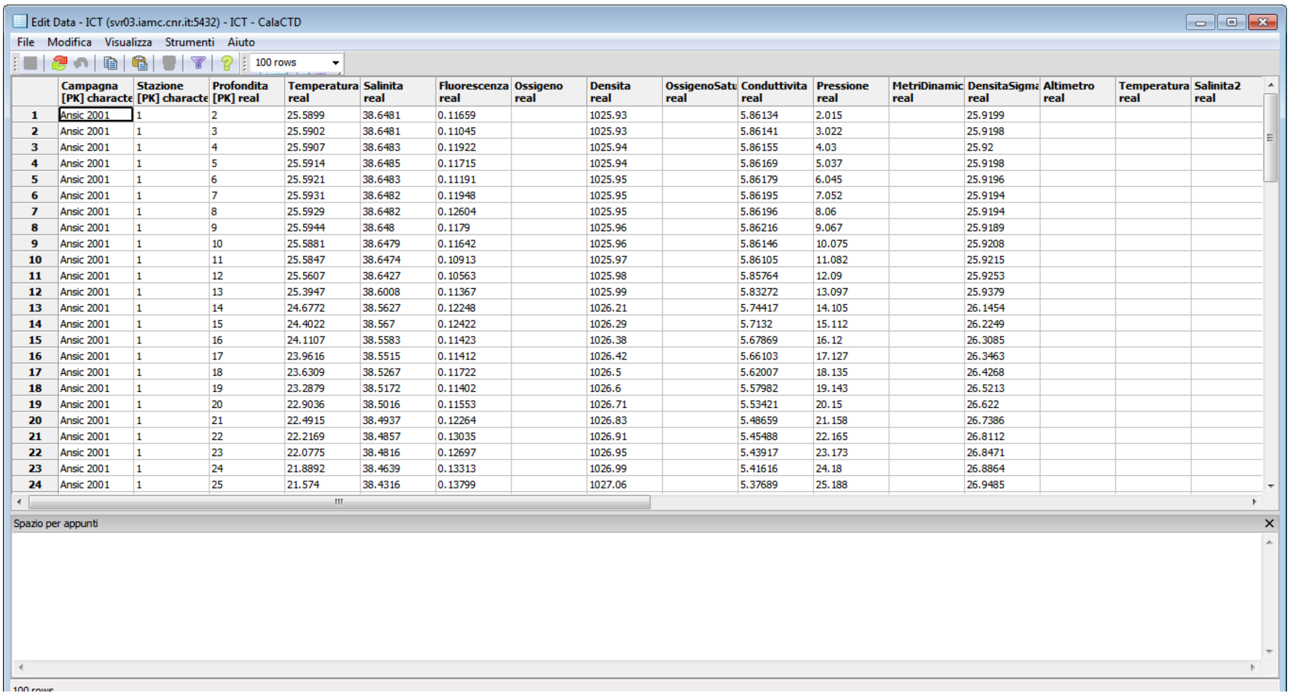
The investigated areas are:

1. Strait of Sicily Italian waters
2. Strait of Sicily Maltese waters
3. Tyrrhenian sea (2009)
4. Strait of Sicily Libyan waters (2008 and 2010)

The GIS database was improved by means of the dbms “Postgres” which was integrated with the geographical information by means of the PostGIS software. The database structure is made of several tables with different datasets, joined together by means of some data field as the name of the survey or the trawl id. The tables and links are illustrated in the following figure.

Graphic outputs (i.e. maps, charts):

Environmental data


Edit Data - ICT (svr03.iamc.cnr.it:5432) - ICT - CalaCTD

File Modifica Visualizza Strumenti Aiuto

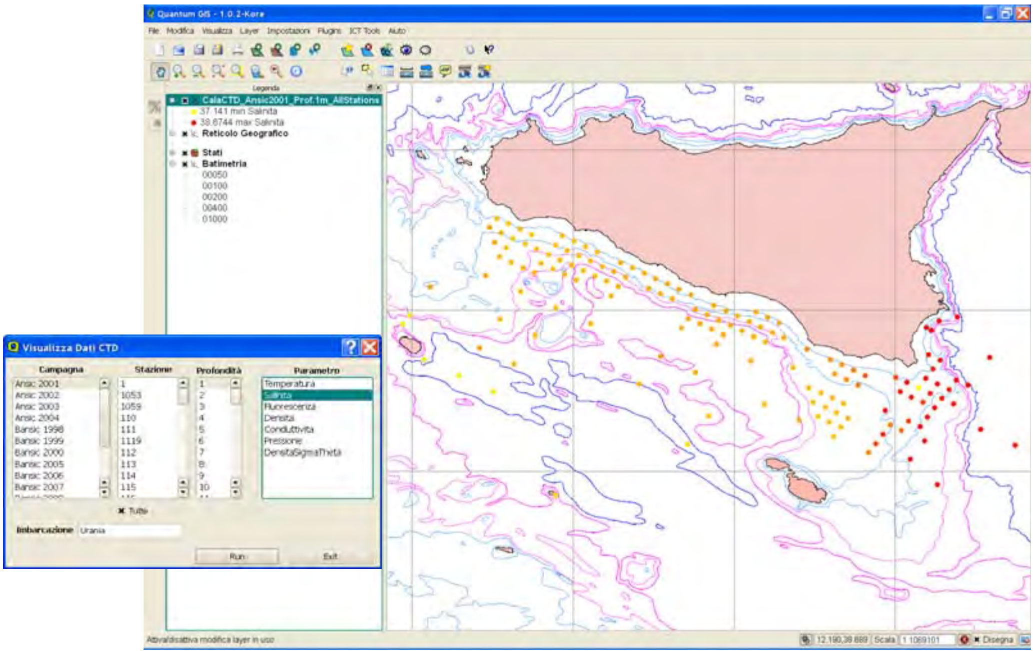
100 rows

	Campagna [PK] characte	Stazione [PK] characte	Profondita [PK] real	Temperatura real	Salinita real	Fluorescenza real	Ossigeno real	Densita real	OssigenoSatu real	Conduttivita real	Pressione real	MetriDinamic real	DensitaSigma real	Altimetro real	Temperatura real	Salinita2 real
1	Ansic 2001	1	2	25.5899	38.6481	0.11659		1025.93		5.86134	2.015		25.9199			
2	Ansic 2001	1	3	25.5902	38.6481	0.11045		1025.93		5.86141	3.022		25.9198			
3	Ansic 2001	1	4	25.5907	38.6483	0.11922		1025.94		5.86155	4.03		25.92			
4	Ansic 2001	1	5	25.5914	38.6485	0.11715		1025.94		5.86169	5.037		25.9198			
5	Ansic 2001	1	6	25.5921	38.6483	0.11191		1025.95		5.86179	6.045		25.9196			
6	Ansic 2001	1	7	25.5931	38.6482	0.11948		1025.95		5.86195	7.052		25.9194			
7	Ansic 2001	1	8	25.5929	38.6482	0.12604		1025.95		5.86196	8.06		25.9194			
8	Ansic 2001	1	9	25.5944	38.648	0.1179		1025.96		5.86216	9.067		25.9189			
9	Ansic 2001	1	10	25.5881	38.6479	0.11642		1025.96		5.86146	10.075		25.9208			
10	Ansic 2001	1	11	25.5847	38.6474	0.10913		1025.97		5.86105	11.082		25.9215			
11	Ansic 2001	1	12	25.5607	38.6427	0.10563		1025.98		5.85764	12.09		25.9253			
12	Ansic 2001	1	13	25.3947	38.6008	0.11367		1025.99		5.83272	13.097		25.9379			
13	Ansic 2001	1	14	24.6772	38.5627	0.12248		1026.21		5.74417	14.105		26.1454			
14	Ansic 2001	1	15	24.4022	38.567	0.12422		1026.29		5.7132	15.112		26.2249			
15	Ansic 2001	1	16	24.1107	38.5583	0.11423		1026.38		5.67869	16.12		26.3085			
16	Ansic 2001	1	17	23.9616	38.5515	0.11412		1026.42		5.66103	17.127		26.3463			
17	Ansic 2001	1	18	23.6309	38.5267	0.11722		1026.5		5.62007	18.135		26.4268			
18	Ansic 2001	1	19	23.2879	38.5172	0.11402		1026.6		5.57982	19.143		26.5213			
19	Ansic 2001	1	20	22.9036	38.5016	0.11553		1026.71		5.53421	20.15		26.622			
20	Ansic 2001	1	21	22.4915	38.4937	0.12264		1026.83		5.48659	21.158		26.7386			
21	Ansic 2001	1	22	22.2169	38.4857	0.13035		1026.91		5.45488	22.165		26.8112			
22	Ansic 2001	1	23	22.0775	38.4816	0.12697		1026.95		5.43917	23.173		26.8471			
23	Ansic 2001	1	24	21.8892	38.4639	0.13313		1026.99		5.41616	24.18		26.8864			
24	Ansic 2001	1	25	21.574	38.4316	0.13799		1027.06		5.37689	25.188		26.9485			

Spazio per appunti

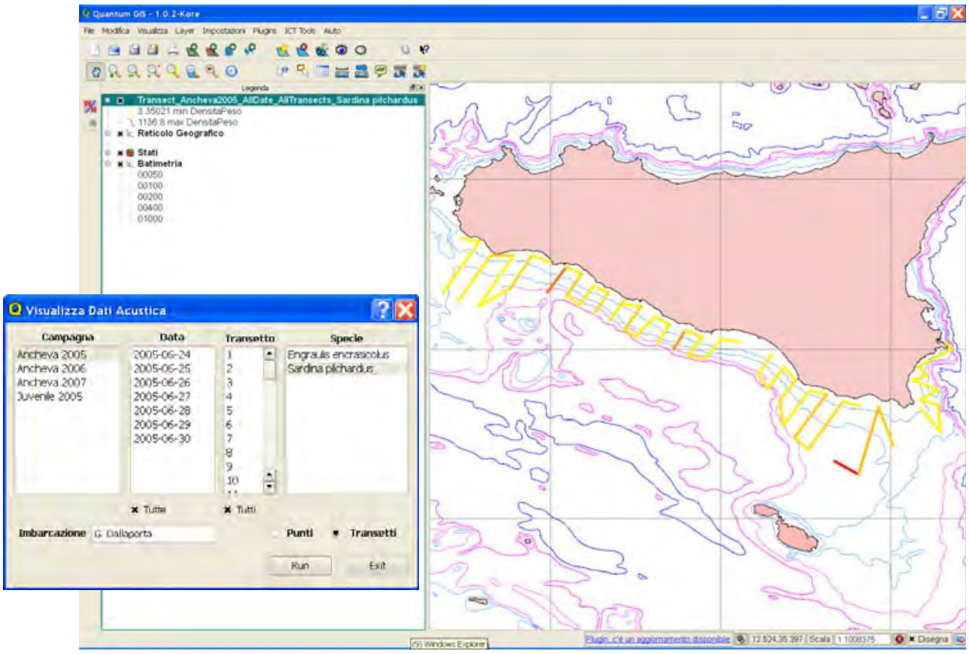
Environmental data

The analysis tools of the system (available by the menu Data Analysis) shows the data on a geo-referenced map with information selected from database, allowing comparison among species and environmental features spatial distribution.



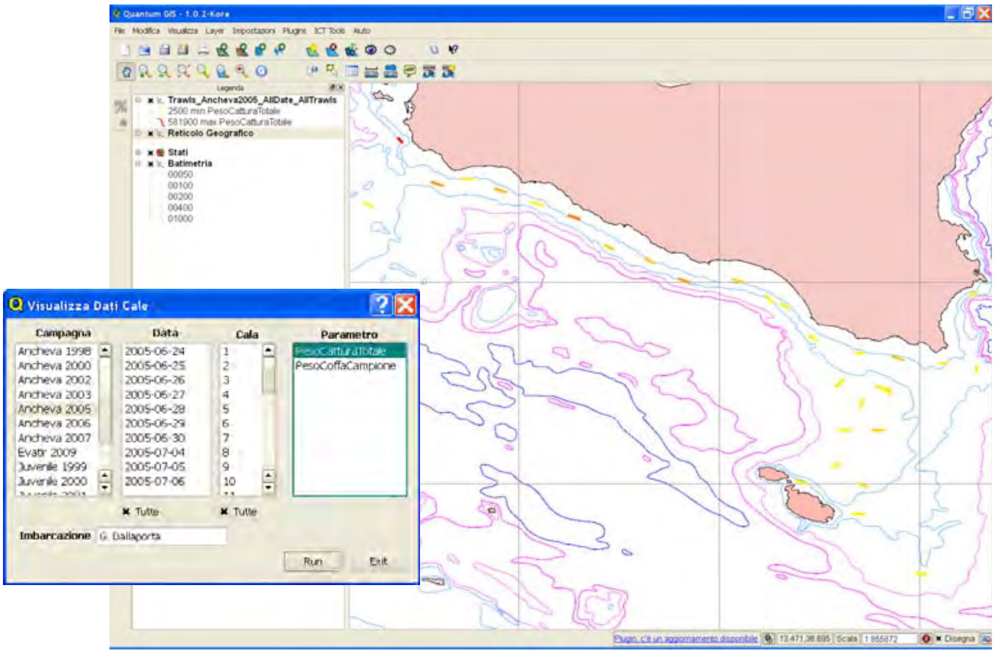
CTD data geographical representation: i.e. salinity at surface values

Acoustic data

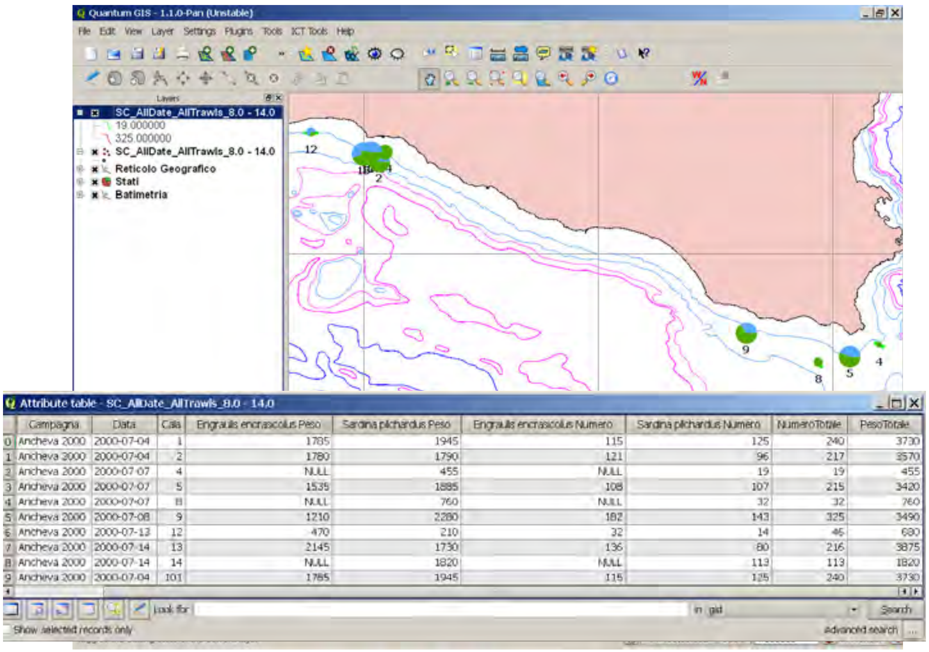


Acoustic transects done during the survey: i.e. NASC for species

Haul data

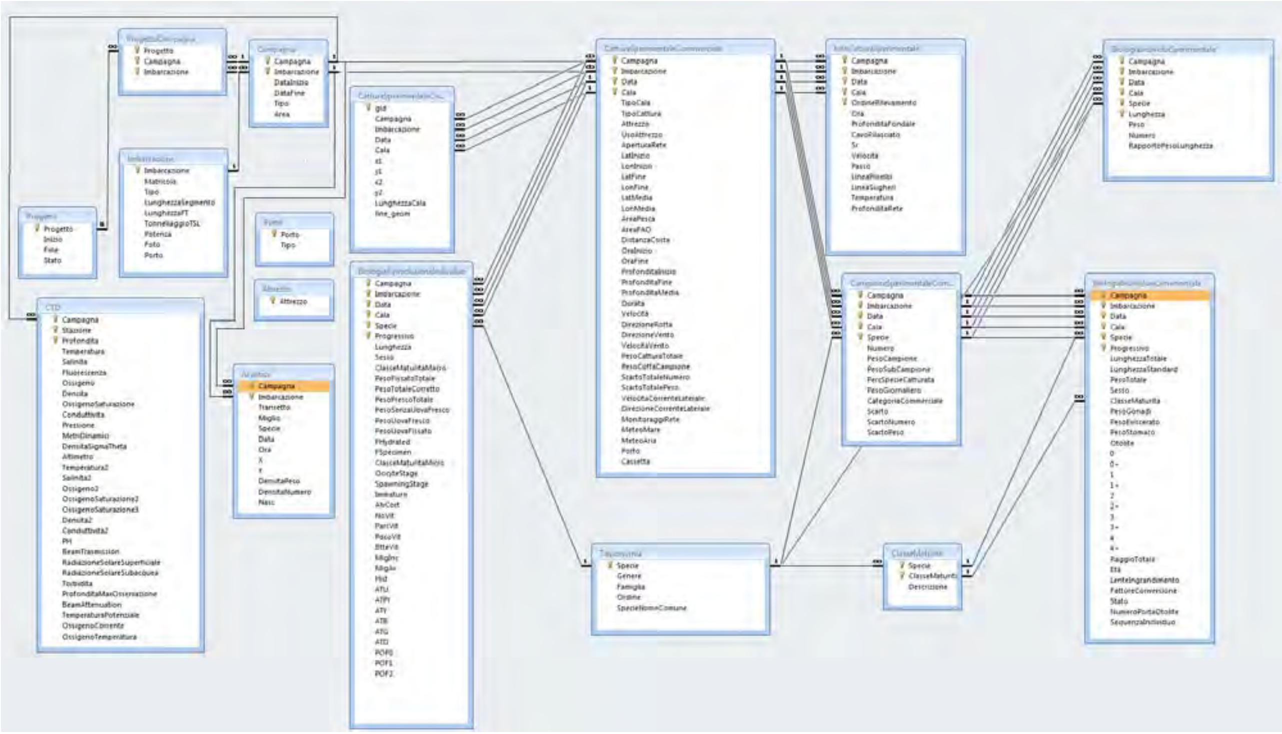


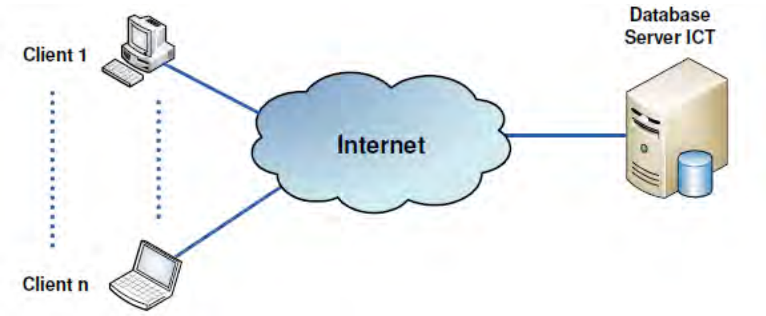
Haul data representation: i.e. geographical position and total amount of catch



The catch composition for each haul could be showed by means of pie chart graphic geo-referenced

Basic flow chart of the database fields:





The system has as primary aim to allow the access to archived data and their geographical representation. There is access also via Internet. The several clients are operative under Windows system only if the open source software "QuantumGIS is installed. There are transect data and Geographic positioning representation tools.

4.4.3 Overall Discussion, Conclusions, Difficulties encountered, Recommendations

Based on the review of the existing acoustic databases among partners/surveys in the Mediterranean and the workshops/discussions held within the project, the following fields for input/processes/queries are proposed to be incorporated in an operational Common Database for Acoustics (Figs. 4.4.1 to 4.4.7) and to be included in MEDIAS protocol.

Specifically, the major fields discussed and agreed within the four workshops/meetings held within the project are associated to:

1. input information related to export data from acoustic software (Figs. 4.4.2 & 4.4.3),
2. input information related to biological sampling and environmental data sampling (Figs 4.4.4 & 4.4.5)
3. queries-calculations to fulfil DCF requirements (Fig. 4.4.6)
4. queries-calculations to facilitate abundance/biomass estimates (Fig. 4.4.6)
5. echosounder calibration report (Fig. 4.4.7)
6. data input validation and control checks
7. up to date demands related to surveys and the Ecosystem Approach to Fisheries (Figs. 4.4.5 & 4.4.6)

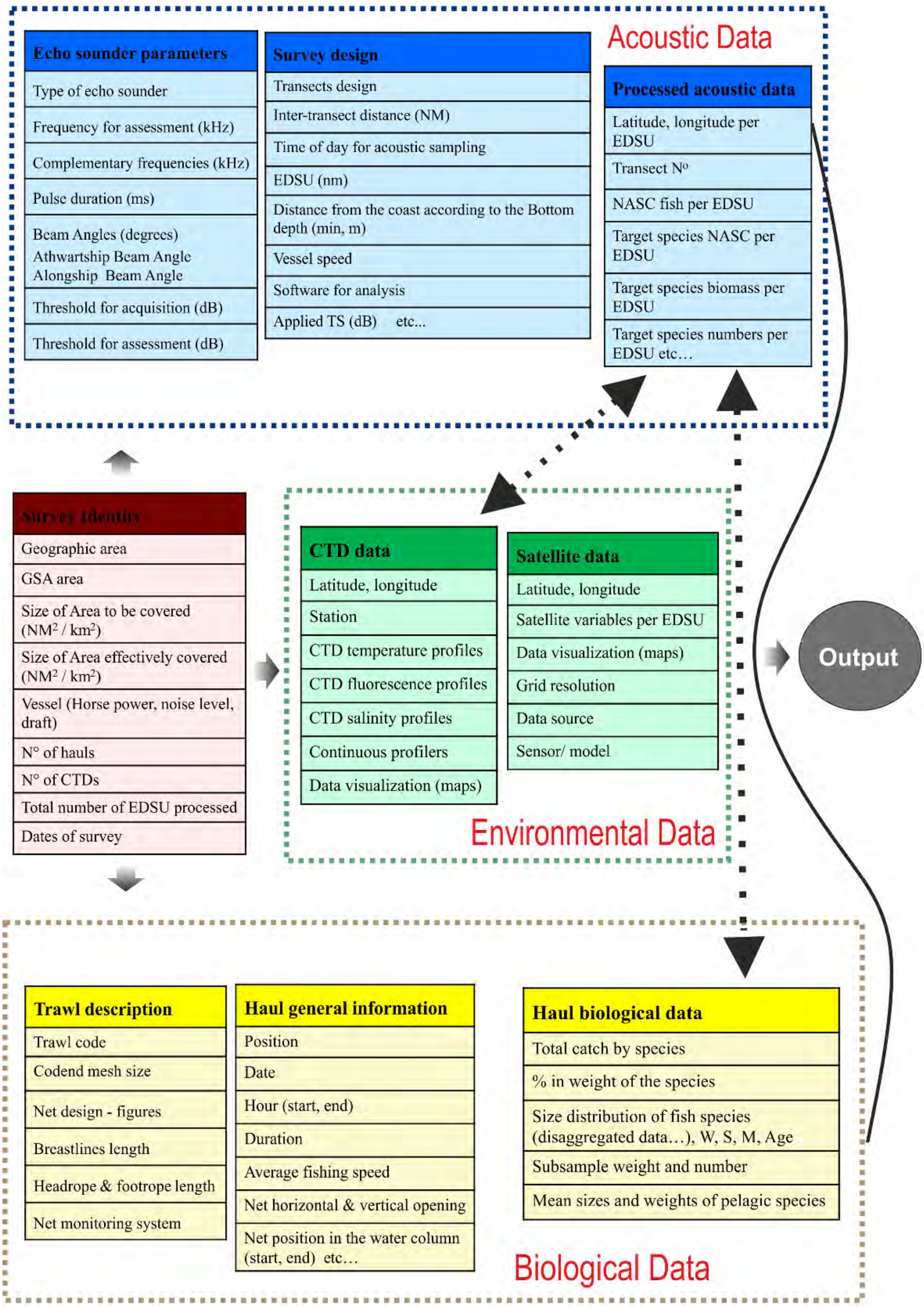


Figure 4.4.1. General outline of a database for acoustic surveys.

Analytical info per database field are presented below.

Survey Identity
Geographic area
GSA area
Size of Area to be covered (NM^2 / km^2)
Size of Area effectively covered (NM^2 / km^2)
Vessel (Horse power, noise level, draft)
N° of hauls
N° of CTDs
Total number of EDSU processed
Dates of survey

Figure 4.4.2. Fields associated with the typical input info about the survey

Acoustic Data

Echo sounder parameters
Type of echo sounder
Frequency for assessment (kHz)
Complementary frequencies (kHz)
Pulse duration (ms)
Beam Angles (degrees) Athwartship Beam Angle Alongship Beam Angle
Threshold for acquisition (dB)
Threshold for assessment (dB)

Survey design
Transects design
Inter-transect distance (NM)
Time of day for acoustic sampling
EDSU (nm)
Distance from the coast according to the Bottom depth (min, m)
Echo sounding depth (min, m)
Echo sounding depth (max, m) recording.
Vessel speed
Software for analysis
File format
Applied TS (dB)

Processed acoustic data
Latitude, longitude per EDSU
Transect N°
NASC fish per EDSU
Target species (i.e. anchovy, sardine) NASC per EDSU
Target species biomass per EDSU
Target species numbers per EDSU
Echogram figures especially related to hauls

Figure 4.4.3. Fields associated with input info on Acoustic Data

Specific routines that are useful for a database dealing with acoustic survey data are outlined below.

1. Sub-area creation: query that allows the selection of a sub-area along with the underlined acoustic data (i.e. referring to whole transects or parts of transects) and the respective hauls based on certain criteria (e.g. depth, etc.), possibly through a GIS software that will be linked to the database
2. Calculation of NASC average values and standard error in a sub-area
3. Merge haul information in a sub-area: calculation of the mean size by species and the percentage in terms of weight and number of the species composition
4. Biomass estimation per species in a sub-area: using the average NASC value per species and composition information from hauls or through direct allocation of NASC to species if otherwise

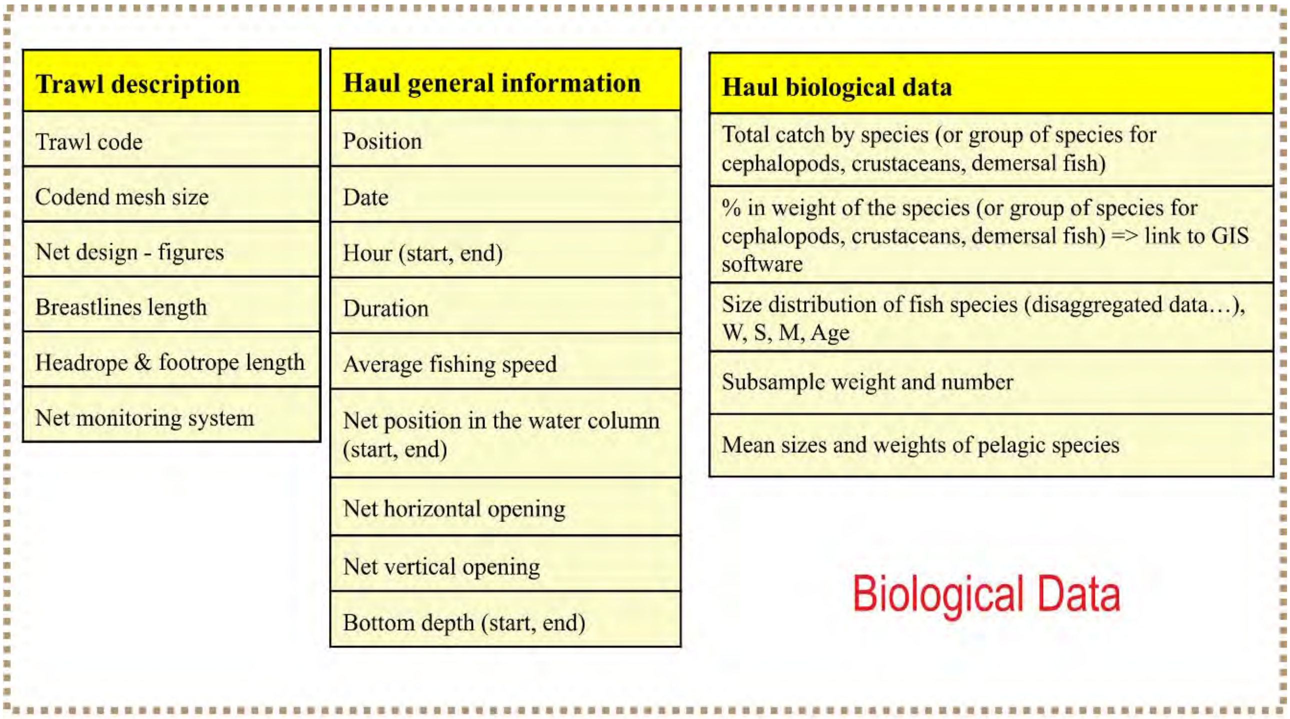


Figure 4.4.4. Fields associated with input info on Biological Data related to acoustic surveys

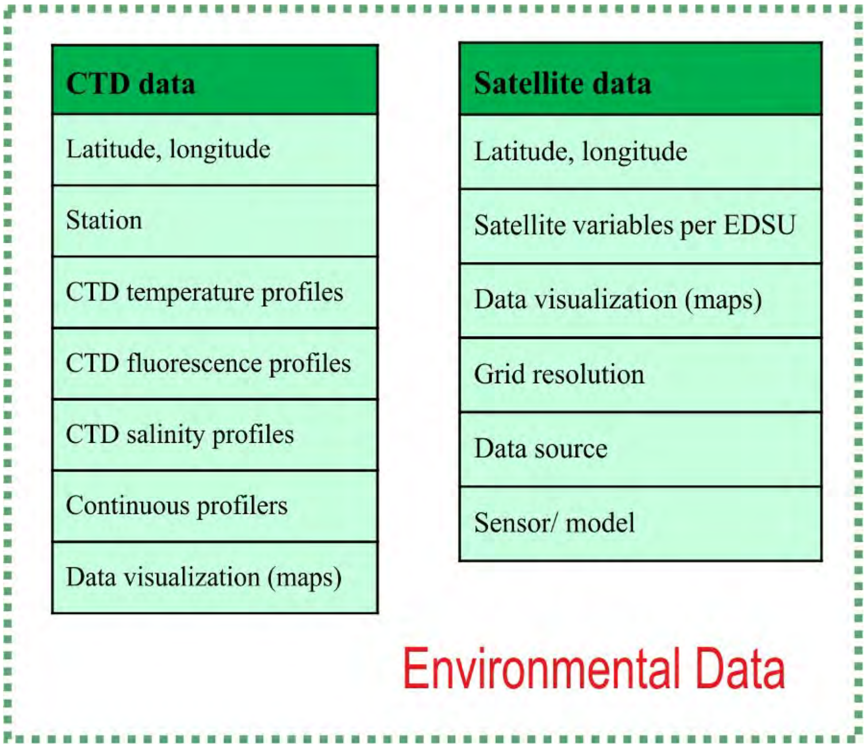


Figure 4.4.5. Fields associated with input info on Environmental Data related to acoustic surveys

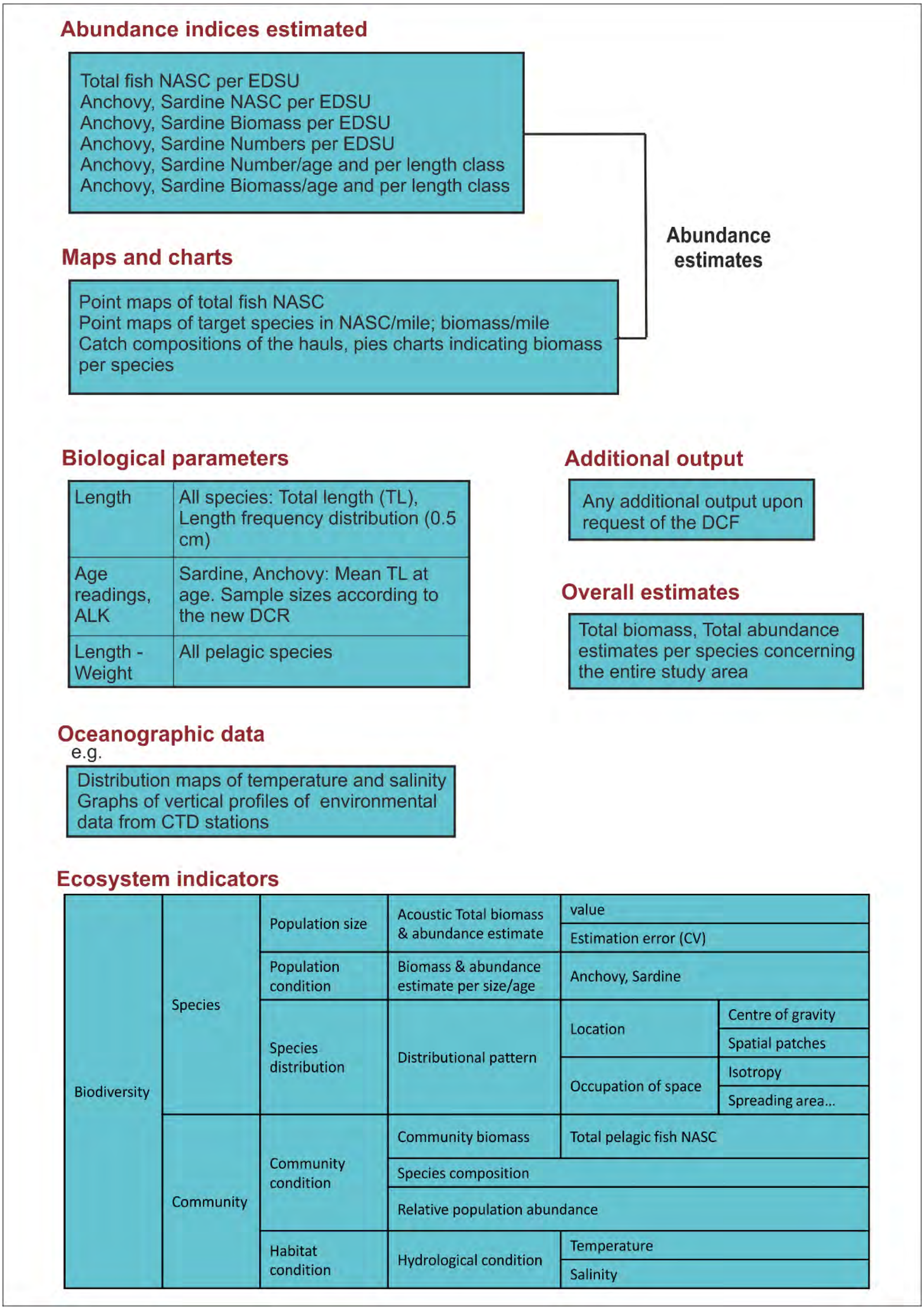


Figure 4.4.6. Fields associated with potential acoustic database output.

Calibration report

Frequency (kHz)	*	**Speed of sound (ms^{-1})**	*
Echosounder type	*	**TS of sphere (dB)**	*
Transducer serial no.	*	**Pulse duration (s)**	*
Vessel	C	**Equivalent 2-way beam angle (dB)**	*
Date	*	**Default Sv transducer gain**	*
Place	C	**Iteration no.**	C
Latitude	C	**Time**	*
Longitude	C	**Range to sphere (m)**	*
Bottom depth (m)	C	**Ping rate**	C
Temperature (ºC) at sphere depth	C	**Calibrated Sv transducer gain**	*
Salinity (psu) at sphere depth	C	**Time (GMT)**	*

***.- Data you can find in the EK60 report sheet.**

Improve/update the above report with fields from EK60 report sheet? Sa correction, RMS etc..

Figure 4.4.7. Database Fields related to electroacoustic calibration report.

Data Validation

Data validation in a database generally presents two control levels.

A) **Before data input** into the database, at the database planning level:

- Routines to block «Improper» data input in the database through the creation of specific table fields provided with value confirmations
- Indices in the tables block data for duplicates input
- Connections set among database input tables prevent the incomplete information input

B) **During data input** into the database

- Define a series of tables with codes related to parameters archived in the tables
- Use of specific data check routines while importing data through files or manually

These routines could also be used for data already included in the database

Parameter coding

Some examples of codes for an acoustic survey database are suggested.

- Coding for research vessels used for surveys
- Coding for geographical areas covered with surveys
- Coding for echosounders used during surveys
- Coding for frequencies used
- Coding for strata to subdivide the water column (if required)
- Coding for aggregation patterns of fish
- Coding for schools shapes
- Coding for geometrical measures of schools
- Coding for species
- Coding for parameters measured through CTD

Data input and relative checks

Few examples of data checks for an acoustic survey database are given below:

- Automatic creation of nautical mile progressive number
- Check on echosounder type and frequencies in use
- Check on minimum and maximum depth of strata used
- Check on minimum and maximum size of single individuals per species
- Check on minimum and maximum weight of an individual per species

The possibility for the database to store raw acoustic data in HAC (acronym for *H*ydro*AC*oustics) format should also be considered and foreseen. HAC is a standard data format for raw and edited hydroacoustic data and is used as the common format for exchanging fisheries acoustics data and for comparing processing algorithms. HAC allows easy exchange of data between research groups using different hardware and software. The HAC format is used by the principal hardware and software developers (e.g. SIMRAD, Myriax, IFREMER and DFO),and it is possible to exchange and analyze raw data independent of platform sampled (ICES, 2003). However, in this case the needs for extended storage capacity of the system to support the respective database should be foreseen.

It should be clarified that acoustic data present many peculiarities compared to other types of survey data that is reflected to the associated database. Raw acoustic data are extremely big in terms of size and require a specialized software for analysis and viewing. Echogram scrutinization and allocation of echo in terms of pelagic trawl catch is a prerequisite. The common output of acoustic surveys is echo abundance per EDSU (Elementary Sampling Unit) expressed as NASC or s_A cannot be considered as raw data opposed to the case of the “raw catch data” of the respective trawl surveys. Thus, an effective common database for different acoustic surveys practically should store and use “processed” data not “raw acoustic” data. Moreover, the ability to re-analyze acoustic data under different terms (e.g. different TS, different acquisition threshold, plankton filtering) consists a frequent need. Thus, the dynamic aspect of such a database becomes essential, because data update and revision of past surveys results is quite common. Applied queries related to this analysis can be a very useful tool to produce abundance indices and other output related to DCF needs, and should be foreseen in such a database.

However, the abovementioned characteristics impair the need towards a common format database that operates locally at the different Institutes, being more effective and flexible in terms of storage capacity, computer power, queries update and data re-analysis. Operating a common database in a specific server through web access could be useful mainly in terms of data storage, but less effective in terms of data processing. Moreover, it would cost a lot more in terms of hardware, computer power demanding server and maintenance.

A common format database operating locally would also be more flexible and advantageous in terms of the following:

- Ensure a faster way to load and retrieve data
- Maintain data accuracy and completeness
- Reduce data input errors assuring better control
- Develop GIS tools to produce maps that represent raw data and results (connecting the database to a GIS software)
- Facilitate the development of new queries and analysis procedures
- Acoustic estimates at specific areas can be associated with echogram images in order to facilitate *ad hoc* data re-analysis

Moreover, the link of such a database with acoustic processing software like the Myriax Echoview or Movies should be considered. In addition, the establishment of an e-forum would allow questions to be posed and promote the exchange of database queries and routines updates. Such an e-forum would be useful to be associated with a web page supporting the MEDIAS surveys and facilitating the dissemination of knowledge between all MEDIAS partners, ICES and Mediterranean scientists, EU and non EU parties.

4.5 References

Azzali M., Cosimi G. and Luna M., 1997. La biomassa, la struttura delle aggregazioni e la distribuzione geografica delle popolazioni di acciughe e sardine nel Basso Adriatico, stimate con metodologia acustica. Rapporto finale al Ministero delle Politiche Agricole e Forestali. Direzione Pesca. Eds. C.N.R.-I.R.Pe.M. 57 pp.

Barange M., Hampton I. and Soule M., 1996. Empirical determination of in situ target strengths of three loosely aggregated pelagic fish species. ICES Journal of Marine Science 53(2):225-232

Clarke K.R. and Warwick R.M., 1994. Change in marine communities: an approach to statistical analysis and interpretation. Natural Environment Research Council, UK.

Doray M., Berger L., Coail J.Y., Vacherot J.P., Bavouzet G. and Petitgas P., 2011. *In-situ* measurements of the individual acoustic backscatter of European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina Pilchardus*), with concurrent optical identification. ICES C.M. 2011/F:07.

Doray M., Mahevas S. and Trenkel V.M., 2010. Estimating gear efficiency in a combined acoustic and trawl survey, with reference to the spatial distribution of demersal fish. – ICES Journal of Marine Science, 67: 668–676.

Foote K.G., 1979. On representing the length dependence of acoustic target strengths of fish. *J. Fish. Res. Board. Can.* 36: 1490-1496.Foote K.G., 1987. Fish target strengths for use in echo integrator surveys. J. Acoust. Soc. Am., 82: pp. 981–987.

Fréon P. and Misund O.E., 1999. Dynamics of Pelagic Fish Distribution and Behavior: Effects on Fisheries and Stock Assessment, Vol, Oxford.

Giannoulaki M, Machias A. and Tsimenides N., 1999. Ambient luminance and vertical migration of the sardine *Sardina pilchardus*. Mar Ecol Prog Ser 178:29-38.

Coombs R.F. & Cordue P.L., 1995. Evolution of a stock assessment tool: acoustic surveys of spawning hoki *(Macruronus novaezealandiae)* off the west coast of the South Island, New Zealand, 1985-91. *New Zealand Journal of Marine and Freshwater Research,* 29: 175-194.

Guttierez M. and MacLennan D., 1998. Preliminary results of determination of in situ target strength of main pelagic species: Cruise of RV Humboldt 9803–05 from Tumbes to Tacna. Inf. Inst. Mar. Peru, 135: pp. 16–19.

Henderson M.J., 2005. The influence of orientation on the target strength of Pacific hake (Merluccius productus). MSc thesis, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA.

Henderson M.J. and Horne J.K., 2007. Comparison of *in situ, ex situ,* and backscatter model estimates of Pacific hake (*Merluccius productus*) target strength. *Can J. Fish. Aquat. Sci.* 64: 1781-1794.

ICES, 1983. Report of the Planning Group on ICES Coordinated Herring and Sprat Acoustic Surveys. ICES Document CM 1983/H:12.

ICES 1998. Report of the Planning Group for Acoustic Surveys in ICES Subareas VIII and IX. ICES Document CM 1998/G: 2. 17 pp.

ICES, 2003. Report of the Planning Group on the HAC Data Exchange Format. ICES Document CM 2003/B: 03. 23 pp.

ICES, 2005. Report on the Planning Group for herring surveys. ICES Document CM 2005/G: 04. 226 pp.

ICES, 2006. Report on the Planning Group for herring surveys. ICES Document CM 2005/LRC: 04. 239 pp.

ICES, 2008. Report of the Working Group on Acoustic and Egg Surveys for Sardine and An-chovy in ICES Areas VIII and IX (WGACEGG). 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17.

Iglesias M, Carrera P, Muino R, 2003. Spatio-temporal patterns and morphological characterisation of multispecies pelagic fish schools in the North-Western Mediterranean Sea. Aquatic Living Resources 16:541-548.

Jech J.M., Foote K.G., Chu D. and Hufnagle L.C.Jr., 2005. Comparing two 38-kHz scientific echosounders. *ICES Journal of Marine Science*, 62: 1168-1179.Jolly G.M. and Hampton I., 1990. A stratified random transect design for acoustic surveys of fish stocks. Canadian Journal of Fisheries and Aquatic Sciences, 47: 1282–1291.

Jolly G.M. and Hampton I., 1990. A stratified random transect design for acoustic surveys of fish stocks. *Canadian Journal of Fisheries and Aquatic Science*, 47: 1282–1291.

Kang D., Cho S., Lee C., Myoung J.G. and Na J., 2009. Ex situ target-strength measurements of Japanese anchovy (*Engraulis japonicus*) in the coastal Northwest Pacific. ICES Journal of Marine Science, 66: pp. 1219–1224.

Karakassis I, Smith C.J. and Eleftheriou A., 1996. Performance of neutral model analysis in a spatio-temporal series of macrobenthic replicates. Mar Ecol Prog Ser 137:173–179.

Kasatkina S., 2009. The influence of uncertainty in target strength on abundance indices based on acoustic surveys: examples of the Baltic Sea herring and sprat. ICES Journal of Marine Science, 66: 1404–1409.

Machias A. and Tsimenides N., 1996. Anatomical and physiological factors affecting the swim-bladder cross-section of the sardine *Sardina pilchardus,* Can. J. Fish. Aquat. Sci. 53(2): 280–287.

MacLennan D., Fernandes P., and Dalen J., 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES Journal of Marine Science, 59: 365–369.

MacLennan D.N. and Menz A., 1996. Interpretation of *in situ* target-strength data. *ICES Journal of Marine Science,* 53: 233–236.Massé J., 1996. Acoustic observations in the Bay of Biscay: Schooling, vertical distribution, species assemblages and behavior. Scientia Marina 60 (Suppl. 2): 227-234.

Massé J., 1996 Acoustic observations in the Bay of Biscay: Schooling, vertical distribution, species assemblages and behavior. *Scientia Marina*, 60 (Supl. 2): 227-234.

O'Driscoll R.L., Gautier S. and Devine J.A., 2009. Acoustic estimates of mesopelagic fish: as clear as day and night? ICES Journal of Marine Science, 66: 1310–1317.

Ona E, 1990. Physiological factors causing natural variations in acoustic target strength of fish. Journal of the Marine Biological Association of the UK, 70: 107-127.

Peltonen H. and Balk H., 2005. The acoustic target strength of herring (*Clupea harengus* L.) in the northern Baltic Sea. *ICES Journal of Marine Science*, 62: 803-808.Sawada K., Takahashi H., Abe K., Ichii T., Watanabe K. and Takao Y., 2009. Target-strength, length, and tilt-angle measurements of Pacific saury (*Cololabis saira*) and Japanese anchovy (*Engraulis japonicus*) using an acoustic-optical system. ICES Journal of Marine Science, 66: pp. 1212–1218.

Simmonds E.J. and MacLennan D.N., 2005. Fisheries acoustics: theory and practice. Blackwell Publishing, 437 pp.

Soule M., Hampton I. and Barange M., 1996. Potential improvements to current methods of recognizing single targets with a split-beam echo-sounder. *ICES Journal of Marine Science*, 53: 237–243.Stefanescu C., Rucabado J. and Lloris D., 1992. Depth-size trends in western Mediterranean demersal deep-sea fishes. Mar Ecol Prog Ser 81: 205-213.

Stefanescu, C., Rucabado, J. & Lloris, D., 1992. Depth-size trends in western Mediterranean demersal deep-sea fishes. *Marine Ecology Progress Series*, 81: 205-213.

Szczucka J., 2000. Acoustically measured, diurnal vertical migration of fish and zooplankton in the Baltic Sea – seasonal variations. Oceanologia 42: 15–17.

Torgersen T. and Kaartvedt S., 2001. *In situ* swimming behavior of individual mesopelagic fish studied by split-beam echo target tracking. *ICES Journal of Marine Science*, 58: 346–354.

Tsagarakis K., Pyrounaki M. M., Giannoulaki M., Somarakis S., Machias A. 2012. Variability in positional, energetic and morphometric descriptors of European anchovy *Engraulis encrasicolus* schools related to patterns of diurnal vertical migration. Marine Ecology Progress Series, Vol. 446: 243–258.

Wilson M.T., Brodeur R.D. and Hinckley S., 1996. Distribution and abundance of age-0 walleye pollock, *Theragra chalcogramma*, in the western Gulf of Alaska during September 1990. NOAA AFSC Tech Rep 126: 11-24.

Woodhead P.M.J., 1966. The behavior of fish in relation to light in the sea. Oceanogr. Mar. Biol. Ann. Rev. 4, 337-403.

Zar J.H., 1984. Biostatistical analysis. Prentice-Hall, Englewood-Cliffs, NJ.

Zhao X., Wang Y. and Dai F., 2008. Depth-dependent target strength of anchovy (Engraulis japonicus) measured in situ. ICES Journal of Marine Science, 65: pp. 882–888.

Zwolinski J., Morais A., Marques V., Stratoudakis Y. and Fernandes P.G., 2007. Diel variation in the vertical distribution and schooling behavior of sardine (*Sardina pilchardus*) off Portugal. ICES Journal of Marine Science 64: 963-972.

Annex 1

Agenda of the Meetings

Kick off Meeting of AcousMed project
Capo Granitola, Sicily (Italy)
23-24 March 2010

Tuesday 23 March
9:30 Welcome of the Participants, adoption of the agenda
9:40 Outline, Coordination, Reporting by Marianna Giannoulaki (HCMR)

10:00 **WP2: Optimization of Survey design**
WP2.1 Review of Survey Design (Lead Participant HCMR)
WP2.2 Geostatistical analysis (Lead Participant IFREMER)
Brief presentation of the WP objectives, deliverables, required information, suggested approach possible time framework for work based on the proposal (input from Pierre Petitgas, presentation by Marianna Giannoulaki)
10:45 Brief presentation of the data available from Spanish waters, comments and suggestions on the followed approach by Magdalena Iglesias
11:00 Coffee Break
11:15 Brief presentation of the data available from the Gulf of Lions by Jean-Louis Bigot
11:30 Brief presentation of the data available from the Strait of Sicily, comments and suggestions on the followed approach by Sergey Goncharov
11:45 Brief presentation of the data available from the Adriatic Sea, comments and suggestions on the followed approach by Iole Leonori - Andrea De Felice
12:00 Brief presentation of the data available from the Aegean Sea, comments and suggestions on the followed approach by Marianna Giannoulaki – Athanassios Machias
12:15 Discussion on the organization of the work, agreement on the time framework for work until next meeting
12:45 Discussion on technical issues, planning and organization of work by case study
13:00 Lunch Break
14:30 Continue the discussion, working on the data depending on time availability, finalizing the protocol for work. Set a working group with participants from each area

15:15 **WP3: Harmonization and optimization of the acoustic methodology**
Outline of the whole WP objectives, required information and deliverables by Marianna Giannoulaki (HCMR)

15:30 **WP3.1 Target strength equations for anchovy and sardine** ***(Lead participant IEO)***
Brief presentation of the WP objectives, deliverables, required information, suggested approach, possible time framework for work based on the proposal by Magdalena Iglesias.
15:45 Brief presentation of the data available from Spanish waters by Magdalena Iglesias
16:00 Brief presentation of the data available from the Gulf of Lions by Jean-Louis Bigot
16:15 Brief presentation of the data available from the Strait of Sicily, comments and suggestions on the followed approach by Angelo Bonanno
16:30 Coffee Break
16:45 Brief presentation of the data available from the Adriatic Sea, comments and suggestions on the followed approach by Iole Leonori - Andrea De Felice
17:00 Brief presentation of the data available from the Aegean Sea, comments and suggestions on the followed approach by Marianna Giannoulaki – Athanassios Machias
17:15 Discussion on the organization of the work, agreement on the time framework for work until next meeting. Set a working group with participants from each area
18:30 Closing

Wednesday 24 March
9:00 **WP3.2 Acoustic sampling** ***(Lead participant CNR-IAMC)***

Brief presentation of the WP objectives, deliverables, required information, suggested approach, possible time framework for work based on the proposal by Angelo Bonanno
9:15 Brief presentation of the data available from Spanish waters by Magdalena Iglesias
9:30 Brief presentation of the data available from the Gulf of Lions by Jean-Louis Bigot
9:45 Brief presentation of the data available from the Strait of Sicily, comments and suggestions on the followed approach by Angelo Bonanno
10:00 Brief presentation of the data available from the Adriatic Sea, comments and suggestions on the followed approach by Iole Leonori - Andrea De Felice
10:15 Brief presentation of the data available from the Aegean Sea, comments and suggestions on the followed approach by Marianna Giannoulaki – Athanassios Machias
10:30 Discussion on the organization of the work, agreement on the time framework for work until next meeting. Set a working group with participants from each area
11:00 Coffee Break
11:15 Continue Discussion on WP3.1

11:45 **WP3.3 Biological sampling *(Lead participant HCMR)***
Brief presentation of the WP objectives, deliverables, required information, suggested approach, possible time framework for work based on the proposal by Athanassios Machias
12:00 Brief presentation of the data available from Spanish waters by Magdalena Iglesias
12:15 Brief presentation of the data available from the Gulf of Lions by Jean-Louis Bigot
12:30 Brief presentation of the data available from the Strait of Sicily, comments and suggestions on the followed approach by Gualtiero Basilone
12:45 Brief presentation of the data available from the Adriatic Sea, comments and suggestions on the followed approach by Iole Leonori - Andrea De Felice
13:00 Lunch Break
14:30 Brief presentation of the data available from the Aegean Sea, comments and suggestions on the followed approach by Marianna Giannoulaki – Athanassios Machias
14:45 Discussion on the organization of the work, agreement on the time framework for work until next meeting. Set a working group with participants from each area

16:00 **WP3.4 Common format on acoustic data *(Lead participant CNR-ISMAR)***
Brief presentation of the WP objectives, deliverables, required information, suggested approach, possible time framework for work based on the proposal
by Iole Leonori – Andrea De Felice
16:15 Brief presentation of the database used in Spanish Surveys by Magdalena Iglesias
16:30 Brief presentation of the database used in the Gulf of Lions by Jean-Louis Bigot
16:45 Brief presentation of the database used in the Strait of Sicily, comments and suggestions on the followed approach by Angelo Bonanno
17:00 Coffee break
17:15 Brief presentation of the database used in the Aegean Sea, comments and suggestions on the followed approach by Athanassios Machias-Marianna Giannoulaki
17:30 Discussion on the organization of the work, agreement on the time framework for work until next meeting. Set a working group with participants from each area
18:30 Closing

Joint AcousMed project/ICES WGACEGG Workshop on Geostatistics (WKACUGEO)
Palma de Mallorca (Spain)
20-21 November 2010

Saturday 20 November

9:00 Opening, adaption of agenda, House-keeping and support arrangements
Presentation of surveys in each area
9:15 Spanish Mediterranean waters (IEO, Pilar Tugores, Magdalena Iglesias)
9:30 Gulf of Lions (IFREMER, Jean Louis Bigot)
9:45 Strait of Sicily (CNR IAMC, Angelo Bonanno, Marco Barra)
10:00 Adriatic Sea (CNR ISMAR, Andrea DeFelice, Fabio Campanella)
10:15 Aegean Sea (HCMR, Marianna Giannoulaki)
10:30 Gulf of Cadiz (spring IEO, Fernando Ramos)
10:45 Bay of Biscay (spring IFREMER, Mathieu Doray)
11:00 Coffee Break
11:15 Atlantic Spanish waters & Cantabrian Sea (spring IEO, Magdalena Iglesias)
11:30 Atlantic – Bay of Biscay (autumn AZTI, Guillermo Boyra)
11:45 Atlantic -Western English Channel- CEFAS (spring, Jeroen Van Der Kooij)
12:00 Opportunistic acoustic surveys of Tasmanian west coast blue grenadier using commercial fishing vessels (CSIRO, Tim Ryan)
12:15 Precision of acoustic surveys and geostatistics (Pierre Petitgas)
12:45 Discussion on technical issues, planning and organization of work by case study
13:00 Lunch Break
14:00 Practical Session: Geostatistical applications on case studies
16:00 Coffee Break
16:15 Geostatistical applications on case studies
18:00 Wrap up of the day work, Closing

Sunday 21 November

9:00 Geostatistical applications on case studies
11:00 Coffee Break
11:15 Geostatistical applications on case studies
12:00 Definition of a common format for reporting Case Studies
13:00 Lunch Break
Evaluation of case studies: presentation of results, problems, solutions
14:00 Spanish Mediterranean waters
14:20 Gulf of Lions
14:40 Strait of Sicily
15:00 Adriatic Sea
15:20 Aegean Sea
15:40 Atlantic IEO (spring)
16:00 Coffee Break
16:20 Altantic IFREMER (spring)
16:40 Atlantic CEFAS (spring)
17:00 Altantic AZTI (autumn)
17:20 Tasmania CSIRO
17:40 Suggestions for future work and analysis, format of report
18:30 Closing

2nd Meeting of the AcousMed project
Palma de Mallorca (Spain)
22-24 November 2010

Monday 22 November
WP3.1 Target Strength estimation
9:00 Presentation of the protocol agreed in the first AcousMed meeting (Magdalena Iglesias)
9:15 Relative presentation from the WGACEGG
9:30 Presentations on the data available from each area, the progress of the work, difficulties encountered
11:00 Coffee Break
11:30 Discussion and suggestions for further work with the data
13:00 Lunch Break
14:00 Practical Session: applications on case studies
16:00 Coffee Break
16:30 Practical Session: applications on case studies
18:00 Closing

Tuesday 23 November
WP3.3 Day-Night Biological sampling
9:00 Presentation of the protocol agreed in the first AcousMed meeting (Athanassios Machias)
9:15 Presentations on the data available from each area, the progress of the work, difficulties encountered
11:00 Coffee Break
11:30 Discussion and suggestions for further work with the data
13:00 Lunch Break

WP3.2 Day-Night Acoustic sampling
14:00 Presentation of the protocol agreed in the first AcousMed meeting (Angelo Bonanno)
14:15 Presentations on the data available from each area, the progress of the work, difficulties encountered
16:30 Coffee Break
17:00 Discussion and suggestions for further work with the data
18:00 Closing

Wednesday 24 November
WP3.4 Common Database
9:00 Presentation of the protocol agreed in the first AcousMed meeting (Andrea De Felice)
9:15 Discussion on the submission of a future project for a common database and the ToRs
10:00 Discussion related to issues referring to MEDIAS protocol
11:00 Closing

Final Meeting of the AcousMed project
Iraklion, Crete (Greece)
13-16 December 2011

Tuesday 13 December
WP2. Survey Design
9:00-9:15 Welcome, Adaption of agenda
9:15-9:30 Brief overview of the project
9:30-9:45 Presentation of the objectives and the deliverables of the WP (Pierre Petitgas, Marianna Giannoulaki)
9:45-10:15 Presentation of the common R-script on geostatistics (Marco Barra)
10:15-13:00 Presentation of the work done on indicator variograms in each area (by each partner)
10:15-11:00 Spanish Mediterranean surveys (Magdalena Iglesias, Pilar Tugores)
11:30-11:45 French surveys (Pierre Petitgas by Skype)
11:45-12:00 Strait of Sicily surveys (Marco Barra, Angelo Bonanno)
12:00-12:15 Adriatic Sea surveys (Claudio Vasapollo, Andrea De Felice)
12:15-13:00 Aegean Sea surveys (Marianna Giannoulaki)
14:00-18:00 Working on data by case study area if necessary. Discussion and suggestions for deliverables, timeframe of the final report. Planning for joined publication.

Wednesday 14 December
WP3.1 Target strength estimation
9:00-9:15 Presentation of the protocol agreed, the progress of work by the interim AcousMed meeting (Magdalena Igelsias)
9:15-11:00 Presentations on the data available from each area, the progress of the work related to deliverables, difficulties encountered (by each partner)
9:15-9:30 Spanish Mediterranean surveys (Magdalena Iglesias, Pilar Tugores)
9:30-9:45 French surveys (Mathieu Doray, Jean Luis Bigot)
9:45-10:00 Strait of Sicily surveys (Angelo Bonanno)
10:00-10:15 Adriatic Sea surveys (Andrea De Felice, Iole Leonori)
10:15-10:30 Aegean Sea surveys (Athanassios Machias, Maria Myrto Pirounaki)
10:30-12:00 Working on data in a pooled basis
12:00-14:00 Continue working on data
17:00-18:00 Discussion and suggestions to finalize the work, deliverables, timeframe for final report

Thursday 15 December
WP3.3 Day-Night Biological sampling
9:00-9:30 Presentation of the protocol agreed, the progress of work by the interim AcousMed meeting (Athanassios Machias)
9:30-11:00 Discussion on the progress of the work related to deliverables, difficulties encountered, common publication currently in progress, timeframe for final report

WP3.2. Day-Night Acoustic sampling
11:30-11:45 Presentation of the protocol agreed, progress of work by the interim AcousMed meeting (Angelo Bonanno)
11:45-14:30 Presentations on the data available from each area, the progress of the work related to deliverables, difficulties encountered (by each partner)
11:45-12:00 Spanish Mediterranean surveys (Magdalena Iglesias, Pilar Tugores)
12:00-12:15 Strait of Sicily surveys (Angelo Bonanno, Gualtiero Basilone)

12:30-12:45 Adriatic Sea surveys (Andrea De Felice, Iole Leonori)
12:45-13:00 Aegean Sea surveys (Marianna Giannoulaki, Maria Myrto Pirounaki
14:00-8:00 Working on data if necessary. Discussion on deliverables and timeframe for final report

Friday 16 December
WP3.4 Common Database
9:00-9:30 Presentation of the work progress of work, difficulties encountered (Andrea De Felice)
9:30-11:00 Discussion on the submission of a future project for a common database and the ToRs, related on issues related to the MEDIAS protocol, deliverables of WP3.4 and framework for the final report
11:30-13:00 Discussion on issues related to acoustic surveys in the Mediterranean:

- a possible joined meeting with ICES WGACEGG in 2012
- Ecosystem indicators from acoustic surveys and the possibility to fill the ICES WKCATDAT files. Short presentation from Magdalena Iglesias on the related results from the recent WGACEGG meeting
- The intercalibration study in the Mediterranean

14:00 Overall discussion, deliverables overview of the work to be included in the final report (Marianna Giannoulaki)

Coffee break: 11:00 and 16:00
Lunch break: 13:00-14:00

Annex 2

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AcousMed Kick off Meeting
CNR-IAMC Capo Granitola (Sicily)
23-24 March 2010

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WKACUGEO
IEO Palma de Mallorca (Spain)
20-21 November 2010

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AcousMed 2nd Meeting
IEO Palma de Mallorca (Spain)
22-24 November 2010

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AcousMed Final Meeting
Iraklion, Crete (Greece)
13-16 December 2011

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