ASSESSMENT AND MONITORING OF THE FISHERY RESOURCES AND ECOSYSTEMS IN THE STRAITS OF SICILY

MiPAAF

MedSudMed

GCP/RER/010/ITA

Report of the Workshop on Standardization of Trawl Surveys Protocol in the MedSudMed Project Area

Mazara del Vallo, Italy, 5-9 May 2003

MedSudMed Technical Documents No.4
GCP/RER/010/ITA/MSM-TD-04

Mazara del Vallo (Italy), December 2006

The conclusions and recommendations given in this and in other documents in the *Assessment and Monitoring of the Fishery Resources and Ecosystems in the Straits of Sicily* Project series are those considered appropriate at the time of preparation. They may be modified in the light of further knowledge gained in subsequent stages of the Project. The designations employed and the presentation of material in this publication do not imply the expression of any opinion on the part of FAO or MiPAF concerning the legal status of any country, territory, city or area, or concerning the determination of its frontiers or boundaries.

Preface

The Regional Project "Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily" (MedSudMed) is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Italian Ministry of Agriculture and Forestry Policies (MiPAF).

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

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

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GCP/RER/010/ITA Publications

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

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For bibliographic purposes this document
should be cited as follows:

MedSudMed. 2006. Report of the Workshop on Standardization of Trawl Surveys Protocol in the MedSudMed Project Area. GCP/RER/010/ITA/MSM-TD-04. *MedSudMed Technical Documents,* 4: 65 pp.

Preparation of this document

This document is the final version of the Report of the Workshop on Standardization of Trawl Surveys Protocol in the MedSudMed Project Area, organized by the FAO-MedSudMed Project (*Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily),* in Mazara del Vallo, Italy, from 5 to 9 May 2003.

Acknowledgements

The kind hospitality provided by the Consiglio Nazionale delle Ricerche-Istituto per l'Ambiente Marino Costiero (CNR-IAMC) is gratefully acknowledged. The assistance of Ray Griffiths and Daniela Massi in the technical editing of the document is acknowledged.

MedSudMed.
Report of the Workshop on Standardization of Trawl Surveys Protocol in the MedSudMed Project Area, Mazara del Vallo, Italy, 5-9 May 2003.
MedSudMed Technical Documents, No.4. GCP/RER/010/ITA/MSM-TD-04, Mazara del Vallo, 2006: 65 pp.

ABSTRACT

The Workshop on Standardization of Trawl Surveys Protocol in the MedSudMed Project Area was held in Mazara del Vallo from 5 to 9 May 2003. Research institutes of all four MedSudMed Countries (Italy, Malta, Tunisia and Libyan Arab Jamahiriya) were represented as well as the project staff. The objective of the seminar was to provide all available information on the existing procedures to carry out national and international trawl surveys, compare them and agree on future common methodological protocols. The technical contributions regarded four relevant topics: planning of activities at sea and fishing gears, processing of the catches and biological sampling, collecting biological information on target species, and data management and processing. On the basis of these themes three working groups were constituted, who discussed respectively: planning of activities at sea and fishing gear, collecting biological sampling and data management. In short period the participants agreed to maintain most of the current procedures used in collecting data within the national programs and adopt procedures to standardize selected data to be stored in a regional data base to be used for preliminary common analysis.

Table of Contents

Report of the Workshop on Standardization of Trawl Survey Protocols in the MedSudMed Project Area

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1. Background

The Workshop on Standardization of Trawl Surveys Protocol in the MedSudMed Project Area was held in Mazara del Vallo (Italy) from 5 to 9 May 2003 and was hosted by the Consiglio Nazionale delle Ricerche-Istituto per l'Ambiente Marino Costiero (CNR-IAMC)*. The Workshop was attended by 35 experts from all MedSudMed Project participating countries, as well as the Project staff (see list of participants in Annex A). The aim of the meeting was to compare and harmonize the sampling protocols used during the trawl surveys by the participating institutes (the Agenda, with the programme of the Workshop, is in Annex B). The expected output was a common protocol to be applied during experimental trawl surveys. However, when historical data series exist and no substantial change can be made in the protocols used in past surveys, the participants were invited to agree on methods to standardize the collected data.

The first part of the Workshop focused on the presentation of 10 technical papers (see the technical contributions in Annex D). On the basis of the terms of reference (see Annex C), four relevant topics were addressed: planning of activities at sea and fishing gears; processing of the catches and biological sampling; the collection of biological information on target species; and data management and processing. The experts presented the various methodological approaches used and the biological information currently collected under existing programmes.

The second part of the Workshop was dedicated to the discussions and the drawing up of an agreement on a common approach to collecting or standardizing data on demersal resources in the Straits of Sicily. Participants split into three thematic working groups (WG): (i) on "Planning of Activities at Sea and Fishing Gear", to discuss sampling period, sampling design, and fishing gears; (ii) on "Biological Sampling", focusing on the processing of the catch, fish handling, and the biological parameters that should be measured on board the fishing vessel and in the laboratory; and (iii) on "Data Management", to start working on the design of the trawl-survey data component of the MedSudMed Fishery and Ecosystem Information System (FEIS).

2. Planning of activities at sea and fishing gear

2.1. Study areas

The Working Group decided that the Geographical Sub-Areas (GSA**,** previously named Geographical Units and Management Units), defined under the General Fisheries Commission for the Mediterranean (GFCM) Protocol (Figure 1 and Table 1), would be adopted as the general geographical reference. The Project area currently includes six GSAs:

* Formerly Consiglio Nazionale delle Ricerche-Istituto di Ricerche sulle Risorse Marine e l'Ambente (CNR-IRMA)

- Northern Tunisia (GSA 12)
- Gulf of Hammamet (GSA 13)
- Gulf of Gabès (GSA 14)
- Malta Island (GSA 15)
- South of Sicily (GSA 16)
- Libya (GSA 21).

The WG agreed that, as far as demersal resources are concerned and in coherence with the subdivision currently used by the Libyan Marine Biology Research Centre (MBRC), only the western part of the GSA 21, up to Zwittina would be taken into consideration (Fig.1). Compared to the rest of Libyan coast, the eastern part of Libya is characterized by a narrow continental platform and bottoms where trawlable areas are difficult to locate.

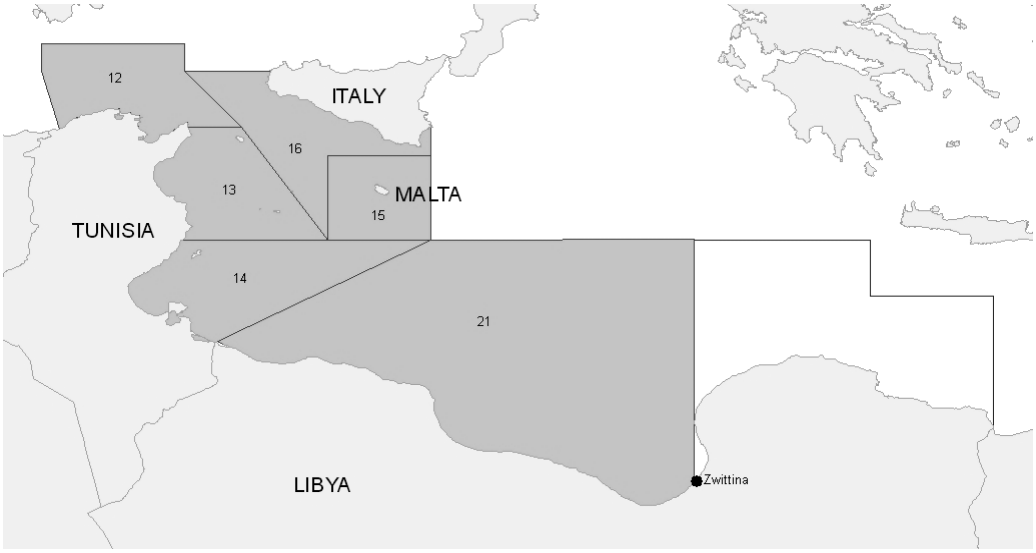


Figure 1. Project area to be considered when dealing with demersal resources.

Table 1. Surface (in km^2) and depth range of the areas to be covered in the MedSudMed common trawl-survey protocol. *n/a* = not available to the Workshop.

Geographical Sub-Areas - GFCM	Nominal Overall Area (km^2)	Depth Range (m) Explorable by Trawl Surveys	Trawlable Area (km^2)
GSA 12 (Northern Tunisia)	n/a	50–800	n/a
GSA 13 (Gulf of Hammamet)	n/a	50–600	n/a
GSA 14 (Gulf of Gabès)	n/a	30–300	n/a
GSA 15 (Malta)	23,583	10–800	n/a
GSA 16 (Southern Sicily)	34,645	10–800	32,798
GSA 21 (Libya)	n/a	25–400	n/a

2.2. Sampling periods and frequency

Each participant institution presented its foreseen calendar for the 2003 trawl surveys (Table 2). The sampling period extended from May to October. According to the calendar that was presented to the Workshop, the Project area should be covered in great part in June–July (except GSA 14 which would be sampled in May). Autumn surveys were also planned for GSA 15 and 16.

Table 2. Sampling periods of trawl surveys, by GSA.

GSA	Sampling period	Programmes
12	July	INSTM National survey
13	June	INSTM National survey
14	May	INSTM National survey
15	June–July September–October	MEDITS[1] GRUND[2]
16	June–July September–October	MEDITS[1] GRUND[2]
21	July	In cooperation with Spanish Government

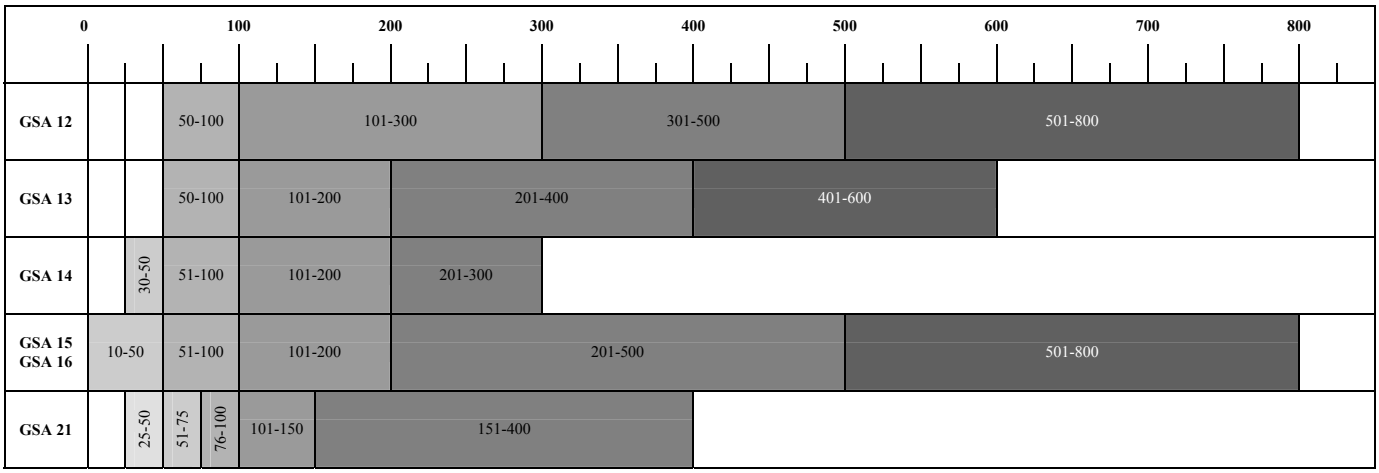
[1]MEDITS: Mediteranean International Trawl Survey
[2]GRUND: GRUppo Nazionale Risorse Demersali

As a general fact, most institutions perform one or two surveys per year, except MBRC which only does so occasionally and depending on the on-going cooperation agreements. As regards 2003, it was agreed to maintain this calendar. All information collected by the same method (protocol) should be analysed with a view to carrying out a joint trawl survey whenever possible. Such a joint trawl survey should be planned on the basis of the results obtained by a common data analysis, in order to identify a potentially "best" season to perform a common trawl survey at the Project level.

2.3. Sampling design currently used by the participating countries

The institutions bordering the Project area adopted a depth stratification of four or five layers, depending on the topography of the GSA. The stratification varies from one GSA to another, as shown in Table 3.

Table 3. Depth stratification, down to a depth of 800 m, used in the GSAs included in the Project area.



As regards the allocation of the hauls, a random extraction was performed by strata in GSA 12 to 14. In GSA 15, 16, and 21, the study area was divided into sampling squares of 3×3 nautical miles, which form the elementary sampling units. Hauls were allocated randomly to these squares, the number of hauls by depth stratum being made proportional to the stratum surface.

All institutions took into consideration trawlable and non trawlable bottoms in each stratum; unknown areas were conventionally considered as "trawlable" until they were explored and determined to be trawlable or not.

All institutions performed one haul per station. In GSA 12, 13, 14 and 21, the stations were planned first on geographical maps according to the depth and then the coordinates were transferred to the GPS device. In GSA 15 and 16, a 1:1 million-scale digital map was used (The IOC International Bathymetric Chart of the Mediterranean, IBCM, using the GEBCO software, 5th ed.); the location (GPS coordinates) of each haul and the expected depth were reported on a blank map and stored in electronic format.

All the institutions used a GIS software to estimate the strata surface. The selected hauls were normally maintained from one year to the next (MEDITS in GSA 15 and 16, commercially oriented surveys in GSA 12, 13, 14 and 21), re-selected after each survey (GSA 12, 13, 14 and 21) or according to a cycle (sampling design was changed every three years for GRUND surveys in GSA 15 and 16).

All participants agreed to maintain the current sampling frames for 2003 and to adopt a "post stratification" approach for the preparation of a selected and standardized data set to be processed jointly. Taking into account the natural (geomorphological and biocenotic) features and fisheries characteristics of the different areas, two approaches were suggested to combine the depth range of strata currently used by different GSA (see Table 3):

- a "general" approach combining current strata reported in new macrostrata; for example, Coastal Belt (CB) within the 0–50 m depth range, Shelf Edge (SE) in the depth range 50–200 m, Upper Slope (US) in the depth range 200–400/500 m, and Lower Slope (LS) in the depth range 400/500 down to 800 m
- a "specific" approach by species; for example, in the range 10–30 m down to 200 m for *Pagellus erythrinus***.**

2.4. Haul characteristics

• Number

In GSA 15 and 16**,** the overall number of hauls varied among the years and depended mainly on the allocated budget. For 2003, the total number of hauls foreseen for GSA 15 and 16 was about 120 (*GSA 15* = 44*; GSA 16* = 76) and 170 (*GSA 15* = 46*; GSA 16* =53 and 71 in the so-called area B, which includes "off-shore" portions of GSA 12, 13, 14 and 21) for the MEDITS and GRUND surveys, respectively.

In GSA 12, 13 and 14, the number of hauls was established by scientists on the basis of the results of the previous survey. Institut National des Sciences et Technologies de la Mer (INSTM) performed 175 hauls during the 2003 survey (50 in GSA 12, 50 in GSA 13 and 75 in GSA 14).

In GSA 21, the number of hauls was also established by the scientists. As an example, 220 hauls had been planned and explored by MBRC, with 141 hauls effectively trawled in the western part of GSA 21 during the 1995 survey.

The WG suggested that a statistical analysis could be made to compare the difference between the number of hauls performed in the specific survey and the theoretical number of hauls required to achieve a given level of precision for the abundance estimations (Biomass Index and Density Index).

• Coding

A consecutive number should be assigned to each haul corresponding to the order of execution, whether or not the haul is judged to be valid. Tunisia and Libya used only the GPS coordinates to characterize the position of each haul, whereas Italy and Malta added to the GPS coordinates a code identifying hauls carried out in the same elementary sampling unit.

The WG suggested the development of a standard code to enable the immediate identification of a MedSudMed haul. A possible way might be as follows: two digits for the GSA, one digit for the geographical sector, if any (otherwise, 0), and two digits for the macrostratum as previously defined (Coastal Belt, or CB, Shelf Edge, or SE, Upper Slope, or US, Lower Slope, or LS). For example, 21WCB would signify a haul performed in the coastal belt in the western part of GSA 21.

• Time of day

Hauls in GSA 15 and 16 were performed always during daylight and those for GSA 12, 13, 14 and 21 were normally performed in daylight. Night hauls were carried out in specific situations (for example in the Gulf of Gabès) or to estimate day–night variation in the availability or catchability of the resources (GSA 21). As concerns the definition of "daylight hours", there were slight differences among institutions: 1 hour before sunrise until 1 hour after sunset was adopted in GSA 15 and 16; from sunrise to sunset, in GSA 12, 13 and 14; and from 07:00 until sunset (solar time), in GSA 21. Whatever the definition and the time at which a haul was performed, all institutions used only "daylight" data to estimate stock density and abundance, except for the caramote prawn (*Penaeus kerathurus*) in GSA 12, 13, 14 and 21.

The WG advised maintenance of the separation between daylight and night-time hauls in the estimation of the abundance values. The WG also recommended performing night-time hauls to get information or check the available information on diel fluctuations in the catch for the MedSudMed target species.

• Vessel speed

All the institutions adopted a nominal standard trawling speed of 3 knots (based on GPS recording on board); the speed may have been lowered during trawling in deeper waters or when voluminous catches were being made. However, every effort was made to maintain the speed at a constant value. In GSA 12, 13 and 14, the speed was chosen on the basis of experience and knowledge of the prospected site and assigned to the haul as a mean speed value. In GSA 15 and 16 and within the GRUND Project, besides the effort to maintain the speed at a constant value, the speed assigned to the haul was taken as the average of the speed values recorded at the initial, middle and final positions of the vessel. As regards the MEDITS surveys, a univocal speed value was assigned to each haul by the software used for the input on the basis of geographical position at the start and at the end of the haul, assuming that the trawler maintained a straight track.

Although the differences in the methods used by the participating institutions to assign a univocal speed value to the hauls might influence the comparability of data, it was underlined that these procedures reflected the best adaptation to regional characteristics. Consequently, the WG advised maintaining the present pattern, although it was recommended to stay within the range of 2.5–3 knots. The participants discussed the possibility of performing experimental trials in order to assess the speed effect, if any.

• Duration

All institutions used the same criterion for the nominal haul time: from the winch stop until the beginning of warp retrieval. The duration of the haul varied from one region to another (Table 4).

Table 4. Haul duration in the GSAs included in the Project area. The differences in the durations between GRUND and MEDITS are shown for GSA 15 and 16

Area	Shelf		Slope
GSA 12, 13, 14	1 h		1½ h
GSA 21	½ h		1 h
GSA 15, 16	GRUND	1 h	1 h
	MEDITS	32 min (<50 m) 33 min (50–100 m) 34 min (100–120 m) 35 min (120-200m)	70 min

The WG suggested maintaining the current pattern. However, since a form of standardization was considered to be advisable, the WG agreed to adjust the nominal haul duration to a standard duration of 1 hour.

• Direction

All institutes performed hauls following a straight line; the orientation of each haul was chosen according to the sea conditions (for example, the currents), depth profile and cruise path (whenever possible towards the next haul). The WG advised maintaining the present pattern.

• Validity criteria

A minimum nominal haul time of 40 min was adopted under the GRUND programme for GSA 15 and 16; for the MEDITS survey, any haul shorter than the prefixed duration was considered to be not valid. For all institutions, haul validity was established subjectively by the chief scientist on board, on the basis of various criteria: anomalies in the overall performance, gear damage, presence of anomalous objects (such as iron drums, big stones, FAD anchor stones etc.). Invalid hauls specifications and catch composition were recorded in any case in GSA 15 and 16, whereas these null hauls were not considered in any of the other GSAs. Whenever necessary and possible, a new haul was chosen among the reserve ones, preferably in the same area/stratum. The WG advised maintaining the present pattern.

Regarding bulky human waste, the WG proposed considering these items and elaborating data with a view to developing a sort of "waste index" to be used eventually for mapping the impact on the sea floor of human activities.

• Warp length–depth ratio ("scope") in trawl surveys

Within MEDITS programme, the Italians and the Maltese used a prefixed ratio depending on **water** depth and warp length, whereas, within the GRUND programme, the ratio was chosen by the captain based on his own experience. GRUND empirical ratios, however, differed slightly from the predetermined MEDITS ratio. In Libya and in Tunisia, the ratio was also established by the captain on the basis of his own experience, bottom topography and warp diameter. The available data are shown in Table 5.

Table 5. Ratio between warp length (in metres) and the water depth (in metres) — the "scope" — adopted by MedSudMed countries during experimental trawl surveys.

Depth stratum (m)	**Warp (m) Italy and Malta**		**Warp (m) Libya**	**Warp (m) Tunisia**
	MEDITS	GRUND	Experimental trawl surveys	
<50 51-200 201-400/500 400/500-800	200–350 400–850 1000–1500 1600–2100	chosen by captain according to his experience	chosen by captain according to his experience	chosen by captain according to his experience

The WG advised including the length of warp paid out amongst the variables to be recorded for each haul.

• Sweep lengths

In GSA 12, 13 and 14, INSTM established sweep lengths for the GOV trawl (50 m), whereas, for the other trawl (shrimp trawl), the sweep length changed according to the water depth, from 50 (30–100 m depth stratum) to 100 m (>100 m depth). In GSA 15 and 16, CNR-IAMC and Malta Centre for Fisheries Sciences (MCFS) used different sweep lengths for the MEDITS gear: 100 m (on the shelf) and 150 m (on the slope), whereas the same value, 275 m, was maintained for the gear used during the GRUND surveys.

The WG advised maintaining the present pattern.

2.5 Available boats and navigational devices

A commercial stern trawler ("S. Anna") harboured in Mazara del Vallo is used by IAMC-CNR and MCFS in GSA 15 and 16. INSTM uses its own research vessel "Hannibal" and, so far, MBRC has conducted surveys on board the RV "Nour". The main characteristics of the vessels are reported in Table 6.

Table 6. Main characteristics and navigational devices of the vessels used in the MedSudMed Project area to perform trawl surveys.

Vessel	**RV "Hannibal"**	**RV "Nour"**	**CV "S. Anna"**
Year built	1998	1972	1981
Material	steel	steel	steel
Staff on board (crew/scientists)	20 (13/7)	21 (12/9)	12 (10/2)
Gross registered tonnage	192	599	197.6
Overall length (m)	34	49	32.3
Draught (m)	3.8	5.2	3.2
Beam(m)	7.4	10	7.2
Engine power	950 hp (708.4 kW)	690 hp (514.5 kW) each engine	1012 hp (754.6 kW)
Rpm	n/a	n/a	750
Reduction	yes	n/a	no
Variable pitch	yes	yes	no
Winch (two or four drums)	two (separate)	two	four
Winch capacity, m (warp diameter, mm)	2400 (18)	2×3000 (22)	3100 (14)
Net roller (m^3)	yes (3)	yes (?)	no
Autonomy at sea (days)	15	22	30
Movable gallows	no	no	no
Number cold-storage holds	1 (–40°C)	1 (–40°C)	2 (–40°C)
Number of fish-holds	1 (–5°C)	1 (–26°C); 1 (0°C)	2 (–25°C)
Video plotter	Furuno ?	?	Furuno GD-170
Colour echo-sounder	Furuno ?	yes	Furuno FCV-201
Number of echo-sounders	2 (Furuno)	2	2 (Furuno)
Sonar	1 Furuno	yes	no
Gps	Furuno	2	Furuno Navigator GPS-50
Radar	Furuno	2	Furuno FR-711
Automatic pilot	yes	yes	Skipper Pilot AP 103
Radio vhs	Furuno	yes	Furuno
Transceiver	Furuno	yes	Skanti TRP 6000

2.6 Plan and characteristics of the gear

Each institution used two types of bottom trawl. CNR-IAMC and MCFS used an *ad hoc* high-vertical-opening bottom trawl GOV *73:36/40* with steel boards (Morgere WH S) and a typical "Mazarese" commercial "tartana di banco" *(50/69)* with wooden doors (GRUND). The codends have the same mesh size (diamond; 20-mm opening).

INSTM performed its surveys with a shrimp bottom trawl (45/56; in GSA 14) and a high-vertical-opening bottom trawl (GOV: 42/55; in GSA 12, 13 and 14, from 50 to 800 m). Both trawls were fitted with the same type of doors (steel; Super V type), with the same dimensions and the same mesh size (diamond; 40-mm opening) in the codends.

In the framework of the Libfish Project, MBRC used two types of trawls:

- a high-vertical-opening bottom trawl (GOV: 36/47**)** over soft bottoms deeper than 100 m with codend mesh of 50 mm and an inside lining with a mesh size of 20 mm;

- an exploration bottom trawl (EXP:28/37) used between the coastline and 100 m depth over grounds where the chance of finding rough bottoms was high, with codend mesh size of 40 mm and an inside lining with a mesh size of 20 mm.

Both types of trawl had the same type of steel boards with the same dimensions.

2.7 Monitoring gear performance and swept-area estimation

The WG discussed the terminology that should be considered. Depending on the bottom depth and on the vertical distribution of the fish, the reaction of fish to an approaching trawler is a combination of vertical and horizontal movements. Consequently, when using trawl data, it is relevant to monitor the vertical and horizontal net opening, the so-called "trawl window" or "trawl mouth". The WG suggested adopting the following definitions:

- vertical net height or vertical net opening (VNO): "distance (in metres) between the centre of the baiting, chosen next to the centre of the headline, and the underlying ground rope when the trawl shows a stable bottom contact";
- horizontal net opening (HNO): "distance (in metres) between the beginning of the gear wings when the trawl shows a stable bottom contact".

In evaluating the catching performance of a bottom otter trawl, however, the so called "herding effect" should also be taken into consideration. Some species are herded towards the opening of the trawl (mainly by their avoidance and swimming capacity and their reaction to the sand cloud produced by the boards). The WG advised defining the boards spread as "otter board spread" (OBS), as follows: "the distance (in metres) between the doors when the trawl shows a stable bottom contact". Coming back to the trawls and the devices used by each country involved in the MedSudMed Project, the situation is reported in Tables 7 and 8.

Table 7. Measurements of trawl-net performance carried out in the MedSudMed countries

Parameter	MBRC	INSTM	CNR-IAMC and MCFS
Vertical net opening (VNO)	Indirect measurement	Direct measurements routinely gathered in selected hauls, by depth strata	Direct measurements during experimental trials, by depth strata
Horizontal net opening (HNO)	Indirect measurement	Indirect measurement on board of two distances, 1 m apart, between the warps	Direct measurement during experimental trials, by depth strata
Otter board spread" (OBS)	Indirect measurement	Indirect measurement on board of two distances, 1 m apart, between the warps	Direct measurements during experimental trials, by depth strata, carried out in the past
Devices and general remarks	Scanmar equipment available	Furuno net recorder (used for VNO measurement)	Scanmar equipment available

Table 8. Vertical and horizontal net openings (in metres) for the types of trawl net adopted by MedSudMed countries. NB: average values are presented for Libya (*).

Trawl type	Vertical net opening (VNO)	Horizontal net opening (HNO)
High-vertical-opening bottom trawl GOV 73:36/40 (MEDITS)	2.4–2.9	12–18
Mazarese traditional "tartana di banco" (50/69; GRUND)	0.9–1.1	20–28
Shrimp bottom trawl (45/56)	2–2.5	16–18
High-vertical-opening bottom trawl (GOV:42/55)	4.5–6	15–18
Exploration bottom trawl (EXP:28/37)	Not measured	14*
High-vertical-opening bottom trawl (GOV:36/47)	Not measured	18*

The WG advised using only the VNO and HNO to characterize the different trawl-net catching performances, taking into account the herding effect, if any, as a part of the sampling noise. The net mouth parameters fall within the ranges (in metres) shown in Table 8 where the variation depends on other haul specifications, such as water depth, trawling speed, "scope" etc.

Both parameters cover a wide range (Table 8), likely influencing the catch obtained in each haul, given the unknown variation in fish availability (i.e. the proportion of fish available to the trawl) and catchability (i.e., the fraction of the available fish which enter the gear). Consequently, if a Scanmar device is available, the WG recommended acoustically monitoring both vertical and horizontal net opening, although not in a systematic way, given the high cost of the equipment; in particular, trials on selected hauls, by depth strata, might prove a good way to derive an empirical model (by linking HNO to some other key parameter, such as warp length or depth) to be used to estimate the area swept in each haul. The details of such experiments might be fully discussed on the basis of an exploratory analysis of the data the moment they become available.

As concerns the possibility to introduce technical changes (for example, the ground-rope may be fitted with roller gear, or "bobbins", so that the trawl can be used on a stony sea bottom without being damaged, and so increase information on rough bottoms), the WG strongly discouraged such interventions both for reasons of consistency (for example, comparison with historical data) and of the high impact on benthic communities.

At this stage, whatever the method employed, the WG advised estimating the swept area for each haul by using: the actual distance covered from beginning to end of the haul, adjusting the actual duration of the haul to the nominal duration of 1 h", and taking into account the measured or estimated HNO."]. Hence, haul catch data would be standardized to 1 km^2, resulting in a biomass index (BI; kg/km^2) and a density index (DI; N/km^2) of local relative abundance.

3. Biological sampling

For biological sampling the trawl catch data were grouped into categories for which the sampling method and main measurements were discussed.

3.1. Species

The WG agreed that biological material caught during the experimental trawl surveys should be divided into three main categories: target species, non-target species, and trash. These categories should be processed at different levels of precision.

• Target species

The WG adopted a preliminary list of 13 target species (13) to be considered in the framework of the MedSudMed Project:

Bony Fishes	*Merluccius merluccius* *Mullus barbatus* *Pagellus erythrinus* *Mullus surmuletus* *Trachurus trachurus* *Helicolenus dactylopterus*
Cartilaginous Fishes	*Raja clavata*
Cephalopods	*Sepia officinalis* *Octopus vulgaris* *Eledone cirrhosa*
Crustaceans	*Parapenaeus longirostris* *Aristaeomorpha foliacea* *Nephrops norvegicus*

For all target species, basic information on their abundance in number and weight per haul should be collected. Furthermore, detailed biological information, such as individual length, weight, sex and maturation stage, should be always recorded for these species. In particular, the WG selected the following species for the first investigation under the MedSudMed Project: *Merluccius merluccius* and *Mullus barbatus.*

• Non-target species

The WG agreed that, for the "non-target species" (fishes, cephalopods and crustaceans), the information collected should be limited to the number and total weight per haul.

The WG agreed to collect more detailed information on the protected and endangered species caught during the trawl survey, as defined by international agreements. Moreover, considering the possible influence of global change on the distribution of species in the Mediterranean and the importance of the Straits of Sicily in the observation of bio-geographical variation in the area, the WG suggested that attention be paid to possible findings of exotic species that may be caught during the trawl survey.

• Trash

This category includes other invertebrates, algae, sea grass and biological debris caught by the haul. Only the total weight (in grams) of this category should be recorded. A sub-sample of the trash may be collected for laboratory analysis to obtain a rough indication of the biocoenoses trawled.

Moreover, the WG suggested that, when the case arises, information on anthropic wastes should be recorded.

3.2. Processing of the catch

The WG advised adopting different methods for the processing of the catch on board according to the size of the catch (small or large) and to the protocols currently used by the institutions.

• Small catch

No sub-sampling should be envisaged if the catch is small; the catch should be sorted directly into three categories:

- *Target species***:** all the catch should be taken to the laboratory for further processing, with the exception of individuals of the species *Raja clavata* which could be tagged in the framework of specific experiments
- *Non-target species*: the weight and number by species should be recorded directly on board
- *Trash*: the weight by phylum should be recorded directly on board; a fraction of the trash may be retained to obtain a rough indication of the biocenoses trawled.

• Large catch

Large catches should be sorted and processed following two procedures, as follows:

- *Target species*: the total catch should be sub-sampled by species and by size-class (stratified sub-sampling) in order to reconstruct the length-composition of the species in the catch; all sub-samples should be taken to the laboratory for further processing
- *Other categories*: the catch should be divided into non-target species and trash and randomly sub-sampled.

• Sub-sampling

The WG agreed that sub-samples should be taken only when the number of specimens was more than 100. Since the weight or volume of the individuals in the sub-sample has to be adjusted to the sample level (i.e. haul catch), the adjustment factor (ratio, in weight or volume, of the sub-sample to the sample) must be recorded.

3.3. Measurements: individual length and weight

The WG agreed that, in each sample or sub-sample, individual length and weight of the target species should be measured and recorded. Taking into account the measurements made by institutions operating in the area, the WG adopted the procedures described below.

• Length

The method of length measurement depends on the taxon. The length of fishes and cephalopods should be measured with ichthyometers, whereas calipers should be used for crustaceans, as follows:

- *For fishes*: total length (TL) should be measured to the nearest half inferior centimetre, from the tip of the snout to the end of the caudal fin
- *For cephalopods*: mantle length (ML) should be measured to the nearest half inferior centimetre, along the median line, passing between the eyes, to the apex of the mantle
- *For crustaceans*: carapace length (CL) should be measured to the nearest millimeter from the rearmost edge of the eye orbit to the median rear edge of the carapace.

• Weight
The individual body weight (BW) should be measured with analytical scales to the nearest 0.1 g in fish, cephalopods and crustaceans. If fish specimens are found to have swallowed large prey, the BW should be measured after emptying the stomach.

3.4. Other biological data

The WG suggested that further data should be taken only for target species, as follows:

• Sex identification
This should be done for each individual taken to the laboratory (for *Raja clavata*, sex should be determined on board). The WG suggested that each specimen be examined macroscopically and put into one of three categories: females, males, and indeterminate. In the case of hermaphrodites, the sexing should be based on the state of the gonads present.

- *Bony fishes and cephalopods*: specimens should be dissected to expose the internal body cavity to allow assessment of the shape and appearance of the gonads
- *Cartilaginous fishes*: males may be distinguished from females on the basis of the presence of external copulatory organs (pterygopods)
- *Decapod crustaceans*: the petasma (2^{nd} pleopods) and thelycum (4^{th} sternite) may be used, respectively, to distinguish males and females.

• Maturation stage
This should also be determined for each individual brought back to the laboratory. Concerning the maturation stages, the WG agreed that the universal scales presented during the Workshop should be adopted accordingly for each target species at subsequent specific seminars.

• Age (bony fish only)
At least two individuals (one male and one female) per size-class should be systematically taken in each haul. The hard structure used for age-determination (i.e. otoliths and/or scales) should be in accordance with procedures currently used in the participating institutions. However, the WG suggested that the MedSudMed Project organize a workshop on calibration of the two age-estimation techniques (length–age keys and back-calculation) used in the institutions participating in the Project.

• Gonad weight (except crustaceans)
At least two individuals (one male and one female) per size-class should be systematically taken from each haul. To calculate the gono-somatic index (GSI), the WG recommended using the eviscerated or total body weight according to the existing national procedures.

- *Bony fish*: gonad weight should be that of the well defined gonad
- *Cephalopods*: the gonad weight should include other reproductive organs (i.e testis, Needham's sac, spermatophoric complex, penis in males, nidamental, oviductal and accessory glands, ovary and oviducts in females).

• Diet composition

The WG agreed that the diet analyses were very important in the ecosystem approach to stock assessment; however, the lack of expertise in the Project area prevents the conduct of studies on this subject. Therefore, the WG suggested that extra-regional experts should be involved in any study that may be undertaken by the Project.

4. Data management

4.1. Objectives and general agreements

The Working Group on this theme focused on the construction of the "Trawl Survey Data Management Module" of the FEIS. The FEIS foresaw the development of a series of thematic data bases (national and regional). The ensemble of these thematic data bases will constitute the "Corporate data bank" of the FEIS.

The Working Group undertook the preparatory work to set up the first thematic data base (Trawl Survey Data) which should be further developed. The participants were requested to ascertain the situation regarding the Trawl Survey data management at the national level and to provide suggestions on the way data regionalization could be achieved. Specifically, the Working Group was requested to address the following questions:

- Should the Project (intended as the group of countries/institutions) use, and therefore develop, a unique data base to be distributed and used by all participating countries?

or

- Should each country/institution use, and/or develop, its own data base to manage national data, with an automatic data-transfer routine to generate a common data set for the regional system (the data-set structure agreed was based on the discussion arising from the Expert Consultation on the Spatial Distribution of Demersal Resources in the Straits of Sicily and the Influence of Environmental Factors and Fishery Characteristics held in Malta on 10-12 December 2002 and from the technical meeting on National Data and Information Aggregation Scheme held in Rome, Italy from 28 to 30 July 2003.

Participants agreed that the first proposal was the most direct and in line with the conceptual design. However, in applying that solution, some institutions (INSTM and CNR-IAMC, in particular) may loose the specificity and the peculiarities that a national system was intended to maximize. The Working Group agreed that, since Tunisia, Italy and Malta were already at an advanced stage in the development of their own Trawl Survey Data Base, it would be better to pursue the second proposal.

The Working Group took note of the argument and agreed the following:

- INSTM, CNR-IAMC and MCFS should go ahead with the finalization of their data base for the management of Trawl Survey data.
- The MedSudMed Project should take the initiative to develop a common data base comprising a minimum data set required as a regional interface between national systems and the FEIS.
- The project should also assist in the development of a "standard" national data base for the institutions that may not be in a position to develop or complete their own data base

- Each institution should ensure that all the data constituting the common data base of Trawl Survey Parameters be also present in its own data base
- Each institution should be requested to include in its data base the routines required for the automatic downloading of common data sets (as jointly agreed by the participating institutes) to the corporate data base.

4.2. The corporate data base

The Working Group advised developing the corporate data base in two versions: one with functions typical of a corporate system and one with data entry and data management functions built in as an additional module. The corporate system would be distributed to all the MedSudMed participating institutes and used for regional studies. It should assemble data from national trawl survey data-management systems and should:

- Foresee the dynamic incorporation of data
- Be open to and usable by all participants
- Perform joint institutional studies.

The version with a "national data entry and management module" should allow each country (or institution) to manage its own trawl survey data (even if these data are regionally standardized).

The Working Group acknowledged that INSTM, CNR-IAMC and MCFS had developed their national systems and supported the idea that the corporate system and the "standard" national system could be developed using INSTM or CNR-IAMC expertise (the same groups currently involved).

A preliminary diagram of the Trawl Survey Data Management Module is shown in Figure 2.

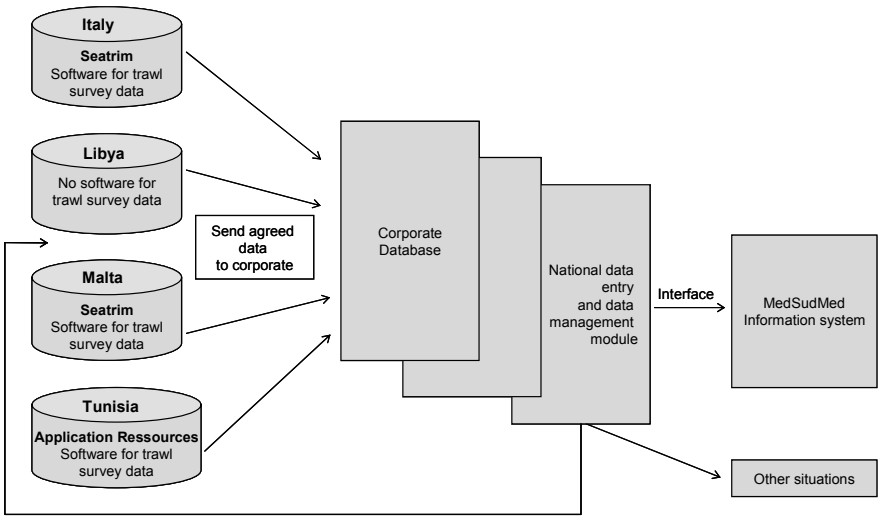


Figure 2. A preliminary diagram of the Trawl Survey Data Management Module in the MedSudMed Project.

The Working Group also decided that an "ad hoc group" should be created and that it was necessary to start working together as a team in the development of the MedSudMed data-archiving and management systems.

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Annex B: Agenda

Welcome from the local authorities

Background information on MedSudMed activities

Aim of the workshop

Presentation of the participants

Organization of the workshop

Planning of activities at sea and fishing gears

Processing of the catches – biological sampling

Biological information on target species

Data management and processing

Presentation and discussion of the protocol on the Planning of Activities at Sea and Fishing Gears

Presentation and discussion of the protocol on Processing of the Catches – Biological Sampling

Presentation and discussion of the protocol on the Biological Information on Target Species

Presentation and discussion of the protocol on the Data Management and Processing

Annex C: Terms of Reference

1. General information and purpose

The Workshop was organized at the request of the participants in the Expert Consultation on the Spatial Distribution of Demersal Resources in the Straits of Sicily and the Influence of Environmental Factors and Fishery Characteristics, held in Malta from 10 to 12 December 2002.

Some of the research institutions of the MedSudMed participating countries already participate in international and/or national programmes and conduct annual trawl surveys. Important geo-referenced data bases on abundance indices of several species have been produced and biological information gathered. In line with the priorities of the GFCM/SAC in providing information on shared stocks, MedSudMed Project activities concentrate on improving the knowledge of the spatial distribution and description of such stocks. The scope of this Workshop is to present existing national and international protocols, give all technical characteristics regarding material, methods, sampling design and data processing, compare them and agree on common methodology based on existing procedures.

2. Focus and issues to be addressed

As reported in the detailed programme (see Annex B) of this Workshop, the different research themes that should be addressed are:

- planning of activities at sea and fishing gear
- processing of the catches – biological sampling
- biological information on target species;
- proposals for further data sampling and measurements;
- data management and processing.

2.1. Planning of activities at sea and fishing gear

The protocol adopted by national programmes for the allocation of the hauls will be presented. This regards the sampling area, the equipment, the sampling design, and the fishing operations themselves. Details of the issues to be addressed in the presentations are indicated below:

a. study areas
b. sampling periods and frequency
c. sampling design presently used by the participating institutions: stratification criteria and spatial allocation of hauls to strata
d. haul characteristics (ordinal number, coding, time of day, vessel speed during haul, direction of haul, validity criteria etc.)
e. available vessels and navigational devices
f. plan and characteristics of the gear (setting and using the Scanmar equipment, if any, rigging, mesh, net design etc.).

2.2. Processing of the catches – biological sampling

This issue deals with the methods of processing the catches. General information will be given on the target and non-target species, as well as on trash, and on the methods of processing, preserving and measuring the samples. The following topics summarize the type of information that will be presented:

a. sub-sampling
b. target species
c. non target species
d. trash
e. grouping level of the above species
f. methods of basic measurement (for total length, carapace/mantle length etc.)
g. material preservation at sea and/or in laboratory
h. collection and preservation of otoliths (or other hard parts, such as vertebrae or scales).

2.3. Biological information on target species

This topic deals with more specific biological sampling procedures applied to the target species. It comprises more-detailed processing, such as organ identification and measurement, biological sampling and analysis. The characteristics listed below are those related to determination of sexual maturity:

a. sex-determination
b. macroscopic maturity evaluation
c. morphometric measurements (e.g. girth, pterygopod length, etc.)
d. organ weights (gonads, liver, nidamental glands etc.).

2.4. Proposal for further data sampling and measurements

According to the activities being implemented under the MedSudMed Project, and the needs and priorities identified during the Workshop by the institutions involved, further data sampling and measurements could be identified and discussed. The other data considered as relevant and necessary, regarding which an agreement on the protocol should be sought, are indicated below:

a. measurement of bottom-water temperature
b. egg and larva collection using bongo nets
c. dredging or grabbing of associated biocenoses
d. analysis of trash
e. tagging and mark–recapture studies
f. diet (stomach-content analysis).

2.5. Data management and processing

The structure of the data bases used in the different research institutions will be presented in order to give an idea of how the data are managed. Procedures used to input and control the

data in order to avoid erroneous information will also be presented. Participants will also mention which software they usually use for the exploratory analysis of the data, as well as the indices that are calculated and used for biomass estimation. Finally, when possible, examples of data representation can be given, in particular GIS outputs. Therefore, the matters that will be addressed are:

a. structure of the data base
b. input of the data and related quality-control
c. management of data
d. exploratory analyses
e. summary statistics
f. index of abundance in weight (Biomass Index, BI: kg/km^2) and number (Density Index, DI: N/km^2)
g. GIS representations.

3. Participation

The Workshop is open to technicians and researchers belonging to institutions and/or organizations of countries participating in the MedSudMed Project. Invitations will also be sent to national programme coordinators and to other regional Projects which might be interested in the subject matter.

4. Organization

The organization of the Workshop is detailed in the Agenda (Annex B). Each participating country (Tunisia, Malta, Libya, Italy) will present the status and aim of its fishery research, addressing each one of the points detailed below, in a brief document (2–3 pages following the Project's Guide for Authors) formatted according the guidelines enclosed. The protocol used for the different steps in bottom-trawl surveys will be presented in plenary session. Several working groups will meet in separate sessions to examine, and agree on a specific and detailed methodology for each of the subjects of concern. The working groups will present their consensual documents to the plenary session for further discussion and the meeting will approve the resulting common protocols. The report on the Workshop will be published as a Technical Document of the MedSudMed Project and will be available, for the relevant issues addressed, as an information paper for the GFCM's Scientific Advisory Committee (SAC) and the SAC sub-committees on Ecosystems and Marine Environment and on Stock Assessment.

The Workshop is scheduled from 5 to 9 May 2003. According to the planned activities, the seminar should last five days, and will be hosted by CNR-IAMC in Mazara del Vallo (Italy). The Workshop will be convened by FAO and all costs will be borne by the MedSud Med Project.

Technical Aspects of Experimental Demersal Trawl Surveys Carried out along the Coasts of Tunisia

R. M'Rabet*

Abstract

Before 1998, the experimental demersal trawl surveys were carried out by the old research vessel "Hannoun" (23-m length overall, 300-hp engine). The trawls used by this vessel were all bottom trawls with a small vertical mouth opening.

Since 1998, the National Institute of Marine Sciences and Technologies (INSTM) has had at its disposal a high-performance oceanographic research vessel (RV "Hannibal"), with a length overall of 34 m and a 950-hp engine.

The RV "Hannibal" is currently used by the Institute to promote marine research in Tunisia and in the Mediterranean Sea. It especially allows pelagic and benthic trawling to depths up to 800 m; it is equipped with scientific pelagic echo-sounders and conducts experiments on fishing techniques. It is also able to sample water, sediment and phytoplankton down to 4000 m depth and to measure salinity, temperature and other hydro-biological parameters.

During the demersal trawl surveys by the RV "Hannibal", two kinds of bottom trawl were used:

- The shrimp bottom trawl, essentially used in the southern region of Tunisia (Gulf of Gabès), to estimate the stock of caramote prawn, and in the northern region of Tunisia, to estimate the stock of deep-water pink shrimp. This trawl is made up of netting with a small mesh size (from 48 mm in the wings to 40 mm in the cod-end). The average vertical mouth opening is 2 m.
- The high-vertical-opening bottom trawl (GOV) used along the Tunisian coasts to estimate the stocks of demersal fishes and cephalopods. The meshes of this trawl are larger than those of the shrimp trawl (from 300 mm in the wings to 40 mm in the cod-end). The vertical opening is about 5.5 m.

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Sampling Methods Used in the Tunisian Experimental Trawl Survey for Demersal Species

O. Jarboui*

Abstract

Experimental trawl surveys, or direct methods, are one of the fundamental tools of stock assessment. In Tunisian waters, many surveys have been carried out, particularly those concerning the demersal resources. These experimental trawl surveys started in 1925 (Le Danois, 1925) and extended from the 1960s to the 1990s. Since the acquisition of the new research vessel "Hannibal", in 1998, the experimental surveys have been improving as a source of data for stock assessment. Indeed, the National Institute of Marine Sciences and Technologies (INSTM) considers the surveys as one of the main tools to acquire information on abundance and geographical distribution of national demersal resources.

To better evaluate and follow the spatio-temporal trends of abundances and distribution, INSTM programmes and carries out, annually, an experimental demersal trawl survey of all Tunisian waters.

In this paper we present the methodological approaches adopted by the Tunisian team and give some suggestions to improve data collection throughout trawl surveys in the light of our experience.

This could contribute to finalizing a common methodology and harmonizing its regional application, and which could be adopted by the different research teams participating in the MedSudMed Project in order to get comparable research results.

First of all, it is important to note that stations carried out by the RV "Hannibal" have been chosen generally adopting a stratified sampling design according to the depth. Depending on the prospected zones, different spatial strata can be identified: for example in the southern area we can delimit five strata (0–30 m; 30–50 m; 50–100 m; 100–200 m and below 200 m). The number of stations by stratum varies according to the fishing zones, but also according to the stratum surface.

During the trawl surveys, the main characteristics have been recorded on suitable report sheets. These characteristics concern particularly:

- Net: type, length of wings, lengths of warps, type of net
- Date: day, month, year
- Haul: ordinal number, direction, speed, geographical positions (longitude and latitude at the beginning and at the end of the haul, time at the beginning and at the end of the haul)
- Meteorological data: weather, sea state,sea-surface temperature
- Bottom: depth (at beginning and end of haul), nature of the bottom (if it is possible)

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The starting time of the haul coincides with the definitive stop of the arm and the end coincides with the beginning of the recovery of the fishing gear on board.

Generally, the haul lasts between 60 and 90 min. Differences in duration are due to the depth and the nature of the bottom. Bottom features are continuously monitored by the sounder and, in case of a dangerous bottom, the gear is immediately hauled out of the water.

For each haul, the commercial species in the catch are sorted, weighed and then analysed separately. The individual lengths are measured with an ichthyometer (0.5-cm precision), whereas weights (non eviscerated individuals) are determined with an electronic balance (50-g precision). All gathered information is recorded on ad hoc sheets. Representative samples of fishes, crustaceans, cephalopods and benthic invertebrates from the discarded fraction of each haul are collected and taken to the laboratory to evaluate number and weight.

Biological Sampling of Demersal Species Targeted by Tunisian Experimental Trawl Surveys

H. Missaoui* and O. Jarboui*

Abstract

According to official data, about fifty commercial marine species are captured by trawling in Tunisian waters. Target species are:

- Demersal fishes: *Pagellus erythrinus, Mullus barbatus, Merluccius merluccius, Solea aegyptiaca*, *Lithognathus mormyrus*, *Scorpaena* sp.
- Crustaceans: *Penaeus kerathurus, Parapenaeus longirostris*, *Aristaeomorpha foliacea, Plesionika* spp*., Aristaeus antennatus* and *Nephrops norvegicus*
- Cephalopods: *Sepia officinalis* and *Loligo vulgaris.*

As regards fish, the total length in centimetres is the commonly used measurement in biometry and to determine the length-composition of the catch. In many cases, however, the fork length rather the standard length is used. Generally, weight is taken in the laboratory and is expressed in grams. For crustaceans, the cephalo-thoracic length is measured in millimetres, although this measurement is converted to total length to meet administrative requirements. Finally, for cephalopods, the mantle length in centimetres is very often taken as the relevant morphometric parameter.

Fish maturation is assessed according to pre-established maturation scales. Fecundity is studied by gravimetric and volumetric methods. Spawning periods are identified by macroscopic observation of the state of the gonads, although, for some species, methods based on histology are also used.

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Methods Used to Determine the Spatial Distribution of Tunisian Demersal Resources: a GIS application

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Abstract

A long series of trawl-survey data has been assembled in the last few decades at the national and regional level. Adopting a standard methodology for archiving data in the Mediterranean countries has been a challenge, but it has allowed regional studies on shared stocks to be carried out.

The development of a standard data base, which takes into account the specificities of each region particularly with respect to the sampling methods, the target species, the processing of the catch, the biological sampling, the measurement methods (biological, physical, chemical and ecological parameters) and the analyses, will enhance the use of such a data base and encourage its adoption as a national data-archiving system.

The experimental-trawling demersal-resource data base, developed in the framework of COPEMED (FAO–Spain regional fishery co-operation project), is presented. Particular interest is attached to the data-base structure with respect to the sampling strategy already adopted during the Tunisian surveys. Moreover, the presentation gives particular attention to: the interface of this data base with the GIS (geographical information system) used to image the spatial distribution of the demersal resources; and to the available tools, including the summary statistics, the exploratory analyses and the geostatistical models for the spatial interpolation of data in the GIS system.

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Planning Trawl Surveys and Sampling at Sea: the IRMA Experience and Proposals

S. Ragonese*, S. Gancitano, P. Rizzo, C. Badalucco and D. Levi

Abstract

The experience acquired by CNR-IAMC in performing bottom trawl surveys to monitor demersal resources in the Strait of Sicily is briefly presented. Proposals for continuing this activity under the new Italian Fishing Plan and the MedSudMed Project are also discussed.

Introduction

The role of the experimental trawl surveys in collecting fishery-independent information on the standing stock, the biology and the state of exploitation state of bottom-dwelling populations has been widely recognized as useful in the Mediterranean context (Abelló *et al*., 2002). The proper statistical design and planning of sampling procedures at sea is a crucial step in performing such a complex activity. Trawl surveys, in fact, are very expensive and time-consuming and, consequently, it is necessary to find a compromise between scientific requirements, technical and logistic constraints, and available funds and human resources. This contribution aims at illustrating the IRMA proposals for future programmes, taking into account the experience that has been gained since the first experimental trawl survey carried out in 1985 (Levi *et al.,* 1998). It is worth recalling that CNR-IAMC has been carrying out bottom trawl surveys in the Strait of Sicily since 1985, using a traditional Italian commercial gear (GRUND project; Relini, 2000), and since 1994, using an *ad hoc* designed gear with a high vertical mouth opening (MEDITS project; Abelló *et al.*, 2002).

Materials and methods

Study area

Different parts of the Strait of Sicily (*sensu lato*) have been traditionally explored by IRMA: the waters inside (A) and outside (B) the midline and the Sicilian and Maltese Exclusive Fishing Zones (MEFZ) within the GRUND and MEDITS programmes, respectively (Figure 1). Since 2002, the Geographical Sub-Areas (GSA, formerly Management Units, MU) adopted by the GFCM have been adopted as experimental trawl-survey areas; in particular, the GSAs 15 and 16 were covered by a joint Italian and Maltese team during the MEDITS 2002. GSA 15 includes the Maltese Exclusive Fishery Zone and a part of the eastern bottoms of the Strait of Sicily, whereas the GSA 16 covers the western bottoms; for both these GSAs, the outermost boundary is represented by the midline, and the overall surface is about 58,228 km^2 (23,583 and 34,645 km^2 for GSA 15 and 16, respectively).

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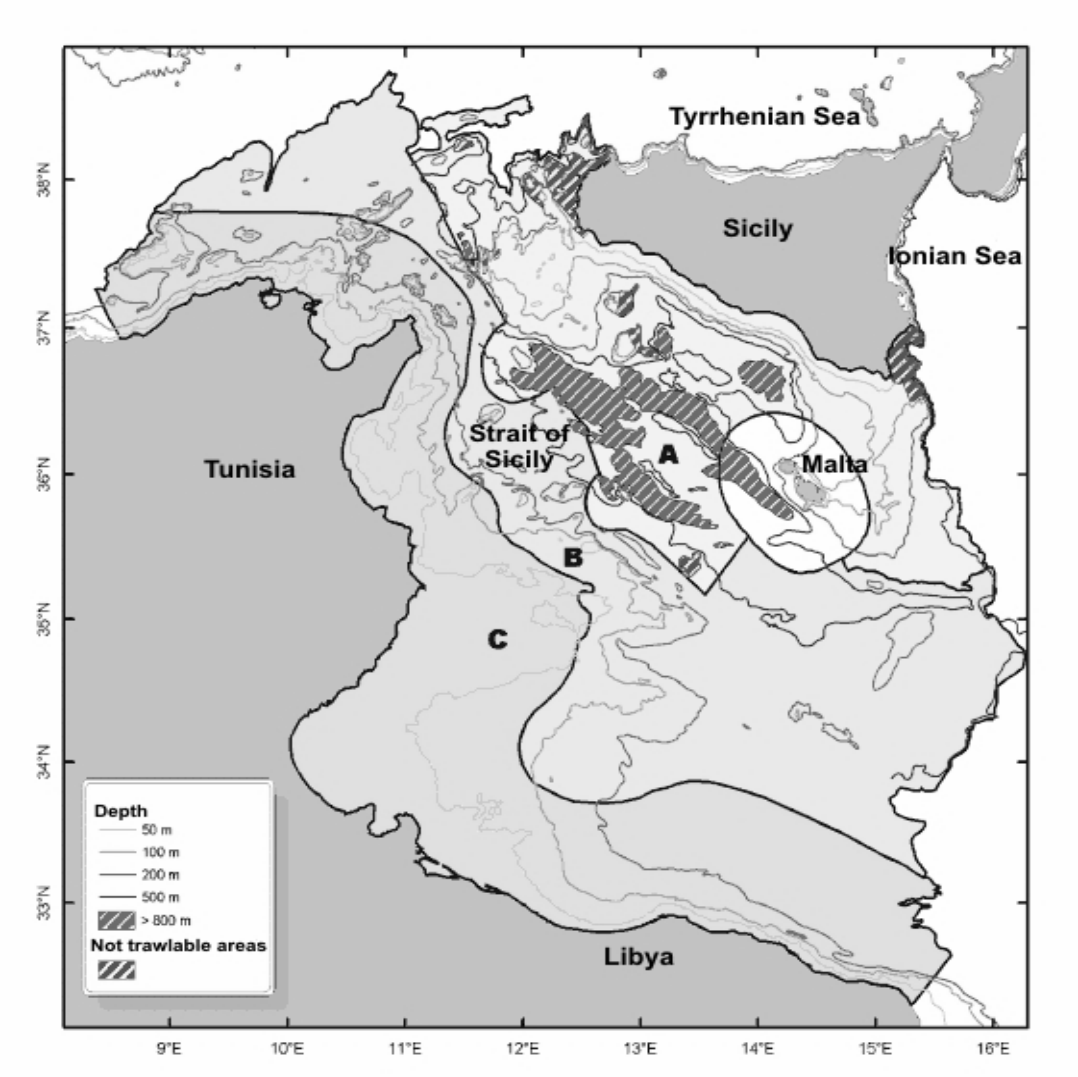

Figure 1. Subdivisions of the Strait of Sicily (*sensu lato*) traditionally explored by CNR-IAMC within MEDITS (zone A) and GRUND (zones A and B) experimental bottom trawl surveys. Zone C is not investigated by CNR-IAMC trawl surveys.

Stratification and strata limits

A depth-stratified sampling design has been adopted since the first GRUND survey, although depth limits were subsequently changed slightly. At present, five depth strata (in metres) are defined within both GRUND and MEDITS: stratum A (10–50 m, covering 161 km^2 in GSA 15 and 3,031 km^2 in GSA 16); stratum B (51–100 m, covering 2,044 and 5,827 km^2, likewise); stratum C (101–200 m, covering 6,069 and 5,681 km^2); stratum D (201–500 m, covering 6,195 and 10,646 km^2); and stratum E (501–800 m, covering 9,114 and 9,460 km^2). Each stratum overlies trawlable and non-trawlable bottoms; unknown areas are conventionally considered as "trawlable" until evidence to the contrary is obtained during the survey.

Sampling stations/hauls and allocation

The sampling stations/hauls (only one haul is normally carried out at each station) are randomly allocated within the strata, with the number of hauls being proportional to the surface of sea bed covered by each stratum. A 1:1-million-scale digital map (The IOC

International Bathymetric Chart of the Mediterranean, IBCM, using the GEBCO software, 5th ed.) was used in conjunction with a GIS to estimate the sea-bed surface under each stratum. Hauls are selected randomly on the basis of a grid of points (separated by a distance of 3 nautical miles). The location and expected depth and the GPS coordinates of each haul are recorded on a map and stored in electronic format on board. The positions of the hauls thus selected are maintained (in MEDITS) or may be re-selected after each survey cycle (every 3 years in GRUND).

Haul identification and execution

A sequential number is assigned to each haul in order of execution, regardless of whether or not the operation proves to be valid. Valid hauls are those carried out between 1 h after dawn and 1 h before sunset. The nominal (solar) haul time (nHT) is 1 h (under GRUND and for slope hauls under MEDITS) and half an hour on the continental shelf (under MEDITS). The nHT is set from the time the winch stops (GRUND), adding a lag-time, variable with depth (MEDITS), to the beginning of warp retrieval; GRUND and MEDITS 1-h hauls that actually last less than 40 min are considered non-valid. The direction of the haul is chosen according to sea conditions and the local bottom topography, and, whenever possible, towards the point of departure of the next haul; the vessel speed during a haul is maintained at about 3 knots (but reduced to 2.2–2.5 knots in deep water). Beyond the duration of 40 min, haul validity is judged by the chief scientist on the basis of subjective criteria (anomalies in the performance, gear breakage, anomalous catch, such as the presence of waste in the codend). Invalid haul specifications and catch composition are recorded in any case and a new haul is chosen among those pre-determined, preferably in the same area/strata. The overall number of hauls varies from one year to another, depending on the availability of funds; in 2002, when the investigated area was limited to the GSA 15 and GSA 16, 120 valid hauls were carried out during the MEDITS survey, and only 65 in the GRUND survey.

Vessel, gear and equipment

Sampling at sea has been conducted always with the same vessel since 1985: a commercial stern trawler ("S. Anna") harboured in Mazara del Vallo (built in 1981; 32.2 m, length overall, 197.1 GRT, powered with an engine of 736 kW (1,012 hp), 750 revolutions per minute, maximum,, colour echo sounder, and 2,300 m of trawl warp). She can berth up to 12 persons (crew and scientific staff). Two types of bottom trawl have been used: the *ad hoc* GOC 73 (MEDITS) and the traditional "Mazarese" commercial "*tartana di banco*" (GRUND). The two gears mainly differ in the vertical opening of the mouth: 2.4–2.9 m (MEDITS) and 0.6–1.3 m (GRUND), whereas the codends mount the same mesh size (diamond; 20 mm, stretched). Furthermore, wood and iron trawl boards are used in the GRUND and the MEDITS gear, respectively. The area swept in each haul is computed according to the trawling speed, haul duration and horizontal net opening (HNO; estimated by using a model). Recently, Scanmar equipment was bought by IRMA to determine a direct link between trawling depth and the corresponding HNO. Since 1999, the bottom water temperature is recorded routinely with a specific device (minilog) fixed to the floatline of the gear.

Discussion

Other designs (systematic, simple, transects, etc.) and methods of allocating survey effort (optimal, Neymann, two-phase etc.) have been explored and proposed for the bottom trawl surveys (Gunderson, 1993). The design in use, however, remains the most "flexible" and adaptable choice, although a reduction in the number of strata would be welcomed.

Survey periodicity and time of the year are two other important issues; it would be advisable to perform at least seasonal surveys (with the same vessel/equipment) to measure the periodicity of the biological phenomena (as already done during the first survey cycle; 1985–1988). At present, surveys are conducted during spring (MEDITS) and late summer (GRUND) when most of the target species show peaks of biological activity (recruitment, growth, sexual maturity, etc.).

Concerning the choice of the proper sampling gear, it is always better to adopt a commercial-oriented gear. The mesh size in the codend should be set according to the minimum size usually used by fishermen (notwithstanding the existing legal dispositions in this respect), even if that might produce some biases in the catching of big and more active swimming fish.

Diel variations in the availability of many species should be investigated by *ad hoc* studies, since a proper continuous sampling activity is not ordinarily feasible.

The most relevant controversy is related to the variable performance of the bottom trawls by depth. Recent experiments (Bertrand *et al*., 2002) confirmed that the gear towed in deep water requires more time to stabilize. Some authors suggest that the nominal haul time should be increased in order to guarantee the limits placed on haul duration (50 min to 1 h), but this would imply a reduction in the number of hauls per day, and consequently an increase in the cost of survey that may be unbearable. On the contrary, other authors (Godo *et al.,* 1990), on the basis of the auto-correlation in the samples taken from the same haul, recommend increasing the number of hauls by reducing the nominal haul duration. Besides the opportunity to perform specific trials to highlight the influence of haul duration on the catch of the specific gear, a possible compromise would be to maintain the nominal haul duration in order to compare the previous data and to correct the bias by introducing a weighting factor (nominal/effective time) when the data collected in the different depth strata are merged for the purpose of analysis.

Whatever the general protocol adopted, it is fundamental to maintain it unchanged at least for a given time interval (in our case, 5–10 yr) in order to ensure the consistency of the data. Although expensive and imprecise, gear standardization and intercalibration should be foreseen when technical or logistic constraints require a change in vessel/equipment and/or protocol.

Conclusions

Although any experiment at sea includes sampling noise and biases, trawl data collected within both national (GRUND) and international (MEDITS) programmes represent a precious and consistent source of information for the assessment of spatial patterns, abundance and dynamics of exploited demersal resources. The relevance of these surveys is enhanced by the difficulty in collecting, on a regular basis, representative biological data from the highly diversified and scattered commercial fleets in the Mediterranean Sea.

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Processing Trawl Survey Catch for Stock Assessment Purposes: Some Proposals for the MedSudMed Project on the Basis of Existing Programmes

F. Fiorentino*, E. Gancitano, G.B. Giusto and G. Sinacori

Abstract

Procedures for the processing of data collected during trawl surveys carried out by CNR-IAMC are presented. These procedures combine protocols of Italian (GRUND, CAMPBIOL) and European (MEDITS) research programmes on the demersal resources in the Strait of Sicily and can be considered as a contribution to the discussion on an international coordinated system for the monitoring of demersal resources in the area covered by the FAO MedSudMed Project.

Introduction

Trawl surveys are mainly aimed at gathering information on abundance and age composition of populations at sea (Gunderson, 1993). In the Strait of Sicily, they represent the main source of information on stocks exploited by distant-water trawlers (Levi and Andreoli, 1998). The catch processing is the fundamental step to obtain data necessary to know the species-composition and their spatial distribution. Furthermore, detailed information on sex, length- and age-composition of the target species is a prerequisite for an effective stock assessment of the main demersal resources.

This paper reports the procedures for processing data collected during the trawl surveys carried out by CNR-IAMC in the Strait of Sicily in the most recent years. These procedures combine the protocols of Italian (GRUND, Anon., 1996; CAMPBIOL, Anon., 2002) and European (MEDITS, 1998) research programmes on demersal resources. The procedures reported in this paper, together with those used by other concerned institutions of the countries involved in the MedSudMed Project, should stimulate discussion on the implementation of coordinated trawl survey programmes to assess the demersal resources at the regional level in the Strait of Sicily.

Onboard processing

When the catch is on the deck, after the net has been checked to certify the haul validity, a photo is taken with a digital camera. Each shot reports date, trawl survey code, number of the haul and stratum. Specimens remarkable for their size or for their rarity are photographed individually.

Thereafter, the catch is processed according to the following procedure:

1. remove all large specimens, regardless of the species
2. remove all bulky non-living materials (e.g. rocks, car tyres)

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3. sort the catch by categories:
   - *target species* – bony and cartilaginous fishes, cephalopods, and decapod crustaceans
   - *non-target species* – bony and cartilaginous fishes, cephalopods, and decapod crustaceans
   - *other biological material (trash)* – other invertebrates, algae, sea grass, and biological debris
   - human wastes.

Depending on the size of the haul, target species and/or other categories may be sub-sampled. In order to allow a good reconstruction of the length-composition of the target species when different length groups are present, the catch by species may be first of all divided into fractions homogeneous by size. Secondly, samples are randomly extracted from these fractions (two-stage random sampling) (Fig. 1).

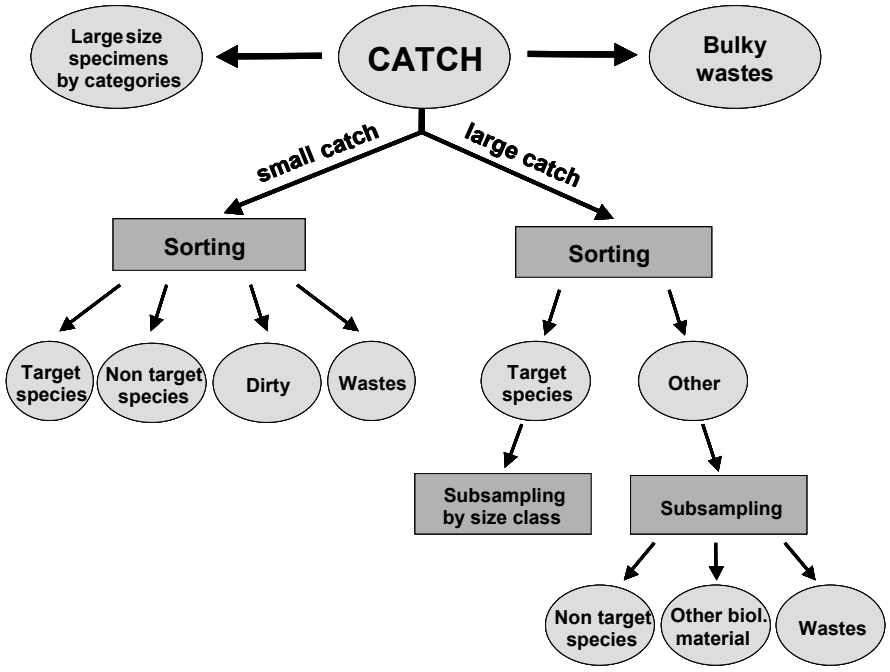

Figure 1. Flow chart showing procedures for processing catches (sorting and sub-sampling)

All the specimens of the target species are processed in the laboratory, with the exception of the big individuals of *Raja clavata*.

After sorting, specimens are stored in wooden or plastic boxes with a label reporting the code of the haul and survey. These boxes are sealed in polyethylene bags and immediately deep-frozen (–40°C). After 24 h, samples are placed in cardboard boxes and stored at –18°C.

The number of individuals and total weight in grams are recorded on board for non-target species. Samples of non-target species may be preserved for further study, within the framework of specific research programmes.

Trash and human wastes are weighed. Samples of trash can be preserved for laboratory analysis in order to gain a rough idea of benthic organisms.

Regardless of the category the sample corresponds to, weight is always measured on board with a steelyard.

Target species

At present, different lists of target species are available, depending on the different programmes:

GRUND (8 bony fishes, 5 cartilaginous fishes, 3 crustaceans, 3 cephalopods)
MEDITS (23 bony fishes, 3 cartilaginous fishes, 4 crustaceans, 6 cephalopods)
CAMPBIOL (11 bony fishes, 2 cartilaginous fishes, 4 crustaceans, 4 cephalopods)

Detailed lists of target species by programme are given in Table 1 (species common to all programmes are in boldface). The existing lists should be combined by the following criteria to choose the MedSudMed list of target species:

- importance for the demersal fisheries in the Strait of Sicily and the Mediterranean
- easiness of routine identification
- vulnerability to fishing pressure
- presence of time-consistent information in the institutions'data bases.

Taking into account the new Italian Fishing Plan and the information stored in the IRMA data base, the following 23 target species are proposed as target species within the framework of the MedSudMed Project (last column in Table 1):

13 bony fishes – *Helicolenus dactylopterus, Lepidorhombus boscii, Merluccius merluccius, Mullus barbatus, M. surmuletus, Pagellus erythrinus, Peristedion cataphractum, Phycis blennoides, Lophius piscatorius, L. budegassa, Trachurus mediterraneus, T. trachurus*
2 cartilaginous fishes – *Raja clavata, R. miraletus*
4 decapod crustaceans – *Aristaeomorpha foliacea, Aristeus antennatus, Nephrops norvegicus, Parapenaeus longirostris*
4 cephalopods – *Eledone cirrhosa, E. moschata, Loligo vulgaris, Sepia officinalis.*

Table 1. Target species adopted by the GRUND, CAMPBIOL and MEDITS trawl-survey programmes, with the target species proposed for the MedSudMed Project. The species boldfaced are common to all four programmes.

Categories	Species	GRUND	CAMPBIOL	MEDITS	MedSudMed
Bony fishes	*Aspitrigla cuculus*			X	
	Citharus linguatula			X	
	Eutrigla gurnardus		X	X	
	Helicolenus dactylopterus	X		X	**X**
	Lepidorhombus boschi	X		X	**X**
	Lophius budegassa		X	X	**X**
	Lophius piscatorius		X	X	**X**
	Merluccius merluccius	X	X	X	**X**
	Micromesistius poutassou			X	
	Mullus barbatus	X	X	X	**X**
	Mullus surmuletus	X	X	X	**X**
	Pagellus acarne			X	
	Pagellus bogaraveo			X	
	Pagellus erythrinus	X	X	X	**X**
	Peristedion cataphractum	X			**X**
	Phycis blennoides	X		X	**X**
	Sparus pagrus			X	
	Solea vulgaris		X	X	
	Spicara flexuosa			X	
	Trachurus mediterraneus		X	X	**X**
	Trachurus trachurus		X	X	**X**
	Trigla lucerna		X		
	Trisopterus minutus capelanus			X	
	Zeus faber			X	
Cartilaginous fishes	*Galeus melastomus*	X			
	Mustelus mustelus	X			
	Raja clavata	X	X	X	**X**
	Raja miraletus		X		**X**
	Scyliorhinus canicula	X			
Crustaceans	***Aristaeomorpha foliacea***	X	X	X	**X**
	Aristeus antennatus		X	X	**X**
	Nephrops norvegicus	X	X	X	**X**
	Parapenaeus longirostris	X	X	X	**X**
Cephalopods	***Eledone cirrhosa***	X	X	X	**X**
	Eledone moschata	X	X	X	**X**
	Illex coindetii	X		X	
	Loligo vulgaris		X	X	**X**
	Octopus vulgaris			X	
	Sepia officinalis		X	X	**X**

Laboratory processing

At the end of the trawl survey, the frozen material is stored at the research institution. Before processing, specimens are defrosted overnight at room temperature. Each specimen is measured and weighed. Sex is identified and the macroscopic maturitation stage and gonad weight are recorded. This last parameter is not considered for the crustaceans (see detailed procedure in Gristina *et al.*, in the present MedSudMed Technical Document).

Morphometric measurements

In each sample or sub-sample of target species, length and weight are measured for the following categories of organism:

- Fishes – total length (TL) is measured to the nearest half inferior centimetre from the tip of the snout to the end of the caudal fin
- Cephalopods – mantle length (ML) is measured in millimetres along the median line, passing between the eyes, to the apex of the mantle;
- Crustaceans – carapace length (CL) is measured in millimetres from the rear edge of the eye orbit to the rearmost median edge of the carapace.

The length of fishes and cephalopods is measured with ichthyometers, whereas calipers are used for crustaceans. Specimens whose length is not measurable are considered as "broken".

The body weight (BW), measured with analytical scales, is expressed in grams rounded to the nearest 0.1 g in cephalopods and to the nearest 0.01 g in crustaceans. The BW of fish able to swallow large prey is measured after emptying the stomach.

Nephrops norvegicus, which have lost their chelae during and after the haul, are weighed without chelae; the weight is then converted to total body weight using an *ad hoc* relationship.

Hard structures

Hard structures to be used for age estimation are taken from adequate sub-samples of each haul. Sub-samples are selected in order to cover uniformly the length-range present in the catch. For each haul, the hard structures of at least two specimens, by sex and for each size-class are removed: first rays of dorsal fin (*illicia*) for *Lophius* sp. and otoliths (sagittae) for the other teleosts. Once removed, the hard structures are washed with water and subsequently preserved dry in small containers, with the indication of survey, haul and specimen code.

Otoliths are read *in toto*, except for very small and very large specimens. In these cases, otoliths are processed in order to obtain thin section. The procedure allows the identification of daily rings in juveniles and annual marks in the oldest fraction of the population. Conversely, the dorsal fin rays of angler fish are always read in thin section.

Discussion

The procedures reported in this paper derive from three programmes: the GRUND programme (Relini, 2000), started in 1985 and funded by the Italian Government; the MEDITS programme (Bertrand *et al.,* 2000) supported by the European Commission and started in 1994; and the CAMPBIOL programme, started in 2002 within the framework of the Italian Programme on fishery data, which was added to the GRUND and MEDITS trawl surveys, with the main objective being to study length- and age-composition of landings. Since the above-mentioned programmes originated in different times and contexts, data were collected according to different protocols. The procedures reported in this paper represent the effort made by CNR-IAMC to unify the method of processing catch data. Although data collected within the three programmes are processed following a standardized approach, information is generally given according to the different formats foreseen by each programme (GRUND, MEDITS and CAMPBIOL). Considering the advantage to each country to maintain consistency in time-series of data, the opposite solution could be chosen for the FAO MedSudMed Project; namely, an exchange format could be decided to allow common analyses of selected data sets. Starting from data collected in the national programmes, these analyses could represent a first step in building up coordinated trawl-survey programmes to assess the demersal resources at the regional level.

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Biological Information on Target Species: Sex-Determination, Maturation Stages and Gravimetric Indexes

M. Gristina*, G. Morizzo, G. Bono and S. Ragonese

Abstract

Procedures for collecting data and information on the reproductive biology of target species taken during trawl surveys implemented in the framework of the new Italian Fishing Plan and the FAO MedSudMed Project is proposed. These procedures cover sampling, sex-determination, analysis of gravimetric indexes, and the identification of the maturation stage of individual organisms. The maturation stage is assessed through a macroscopic examination of the reproductive system and a synoptic scale is presented for bony and cartilaginous fishes, crustaceans and cephalopods.

Introduction

Analysing the reproductive biology is a crucial step in assessing the dynamics of any exploited populations (stocks). In fishery science, in particular, the monitoring of gonad development and cyclic changes in the maturation stages is normally used to determine the maturity ogive by age and size, the size at onset of reproduction ("first maturity"), the spawning period and areas. This information is essential both for further assessments (for example, estimation of spawning stocks) and for setting management regulations, such as "minimum catchable size" or "area/seasonal closure".

Materials and methods

Sampling

For each haul and target species, all specimens (or a sub-sample thereof in the event of a large catch) are collected. Sub-samples are gathered for special processing, such as histological analysis.

It is preferable to manipulate the samples when fresh (for measurement or for extraction of gonad samples and conservation), directly on board. Conversely, the material is deep-frozen (–40°C) for 24 h and subsequently stored (–18°C) on board, and later defrosted (overnight) and processed in the laboratory.

One female and one male (where foreseen) are picked from each haul catch by the following size-classes (in millimeters): <10, 10–20, >20 for bony and cartilaginous fishes (total length; TL), cephalopods (mantle length; ML) and crustacean decapods (carapace length; CL).

Sex-determination

Each sampled specimen is classified macroscopically (i.e. by naked eye) into one of three categories: Females (F; 1), Males (M; 2), and Indeterminate (I; 3). In case of hermaphrodites,

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the sex is assigned on the basis of the predominant gonad. Unsexed specimens (U; 4) should be employed to characterize specimens for which the assignation of sex was not possible for various reasons (for example, whole specimen measured at the market). Particularly:

Bony fishes – Specimens are dissected in order to expose the internal body cavity and appreciate the shape and appearance of the gonads.

Cartilaginous fishes – Males are distinguished from females on the basis of the external presence of copulatory organs (pterygopods).

Crustacean decapods – The petasma (2nd pleopod) and thelycum (4th sternite) indicate males and females, respectively.

Cephalopods – Specimens are dissected in order to expose the internal body cavity and appreciate the shape and appearance of the gonads.

Maturation stages

The number of maturation stages on macroscopic keys varies from two (immature–mature) to more than fourteen. For monitoring surveys, four or five (4/5) stages (including "0" for the Indeterminate, as previously defined) can be considered acceptable. Two kinds of maturity scale can be considered: "universal" and "specific". In the "universal" type, the most frequently adopted scales are:

Bony fishes: 5/8-stage scale for partial/total spawners, respectively (Holden and Raitt, 1974).

Cartilaginous fishes: 4-stages for females and 3-stages for males, based on the degree of development of the pterygopods, gonads, ducts and shell glands.

Crustaceans decapods: 3/4-stage scale for females (Froglia, 1984; Ragonese, 1985), based on the colour of the gonads and the shape and the degree of development of the ovary lobes; a 3-stage scale for males (Ragonese, 1985) based on the petasma structure, rostrum length and the presence/absence of spermatic masses inside the seminal pockets (*ampullae*).

Cephalopods: 5/6-stage scale for females (Mangold, 1963; Lipinsky, 1979) and for both sexes of the Teuthoidea; 4- and 3-stage scales for the Octopoda (Ragonese, 1985) based on the appearance of the gonads, presence/absence of spermatophores in the Needham's sac (males) or inside the mantle (residuals; females), modification of the *hectocotylus* and the "relative" dimension (and appearance; "smooth" surface) of the eggs.

As concerns future planning, a general 4/5-stage scale (including "0") is proposed herein for each category (maturation stage) of organisms (Table 1). In particular:

Bony fishes: 5-stage scale (0 and from 1 to 4) based mainly on the relative volume of the gonads.

Cartilaginous fishes: 4-stage scale (0 and from 1 to 3) based mainly on the presence of embryos and on the egg dimensions (females), and on the pterygopods (males).

Crustacean decapods: 5-stage scale (0 and from 1 to 4) based on the appearance of ovary lobes (females), and 4-stage scale (0 and from 1 to 3) based mainly on the degree of fusion of

the petasma, presence/absence of the spermatic masses on seminal *ampullae* and the dimension of the rostrum (males).

Cephalopods: 5-stage scale (0 and from 1 to 4) based mainly on the degree of development of the reproductive apparatus, the dimension of the eggs and the presence of spermatozoa. Some particular attention should be given to assessing the gonad colour in most crustacean decapods (for red shrimps, for example, it is necessary to cut the dorsal part of the carapace and expose the tissue).

Gravimetric indexes

The gonad weight (GW) will be determined in sub-samples of females (to the nearest 0.1 g, for bony and cartilaginous fishes, and 0.01 g, for cephalopods and crustacean decapods), and expressed as a proportion of the "whole" body weight (BW) by computing the gonosomatic index (GSI=GW/BW). In bony fishes, the GW refers only to the well defined and predominant gonad. On the contrary, in cartilaginous fishes and cephalopods, the GW includes other reproductive organs. For the cephalopods, in particular, the GW includes the weight of the testis, Needham's sac, the spermatophoric complex and penis (in males), and nidamental and oviducal glands, accessory glands, ovary and oviducts (in females). Some particular remarks concern the determination of GW in shrimps. The extraction of such a structured ovary is very difficult, especially in small and immature females, and in any case is not routinely feasible; GSI should be determined using a sub-sample. Furthermore, the eggs extruded onto the pleopods (as is the case of the Norway lobster) are normally not included in the GW.

Other parameters

The mating condition (i.e. absence, 0, or presence, 1, of spermatophores on the thelycum) and the berried condition (absence, 0, or presence, 1, of the eggs among the pleopods) in crustacean decapods should be recorded on a separate field in the reporting form to help both in the sex-determination and in describing more precisely the reproduction status.

Table 1. Universal maturity stages by sex.

Sex	Maturity stages					Remarks
	0 Virginal	1 Immature	2 Maturing or resting	3 Mature	4 Post-spawning	
F	Impossible to determine sex by naked eye. Gonads small and translucid, almost transparent. Sex is indeterminate.	Pinkish and translucent ovary occupies about one-third of length of body cavity. Ova not visible to naked eye.	Pinkish and translucent ovary occupies about one-half of length of body cavity. Ova not visible to naked eye.	Orange-pink ovary occupies from two-thirds to full length of body cavity. Under light pressure, large transparent, ripe ova are expelled.	Ovary is shrunken to about one-half of length of body cavity. Ovary may contain remnants of darkened ova. Dormant state.	MEDITS: 4-point scale GRUND: 5-8-point scale CAMPBIOL 5-point scale
M		Whitish testis occupies about one- third of length of body cavity.	Whitish testis more or less symmetrical occupying about one-half of length of body cavity.	Whitish-creamy soft testis occupies from two-thirds to full length of body cavity. Under light pressure sperm is expelled.	Bloodshot and flabby testis is shrunken to about one-half of length of body cavity. Dormant state.	
F	Impossible to determine sex by naked eye. Sex is indeterminate.	Ovary is barely discernible, with small isodiametric eggs. Oviducts contain no eggs.	White eggs are visible in the ovary. The distal parts of oviducts (uterus) are well developed but contain no eggs.	The uterus has a sack shape and contains eggs or embryos.		GRUND: 3-point scale CAMPBIOL 3-point scale
M		Pterygopods are small and flaccid and do not reach the posterior edge of the pelvic fin.	Pterygopods are larger, and not ossified. They extend to the posterior edge of the pelvic fin.	Pterygopods extend well beyond the posterior edge of the pelvic fin and their internal structure is hard and ossified.		
F	Impossible to determine sex by naked eye. Sex is indeterminate.	Traslucid and stringy ovary, anterior and lateral lobes are poorly developed. No spermatophores on thelycum.	Ovary in the process of development. The colouring begins to be evident.	Ovary much developed, occupying all the dorsal portion. Colouring is more intense. The anterior and lateral lobes are much developed. Oocytes well visible.	Stage "Berried" for *Nephrops norvegicus:* presence of eggs on pleopods.	MEDITS: 3-point *Nephrops* scale GRUND: 3/4-point scale for female 2 point scale for males CAMPBIOL 4/5-point scale for females 2/3 point scale for males
M		Petasma is not much visible, and there are spermatic masses on seminal ampullae. Long rostrum.	Petasma appears visible and nearly or completly joined, but there are no spermatic masses in seminal ampullae. Long or intermediate rostrum.	The petasma is perfectly visible and completly joined; spermatic masses in seminal ampullae. Small rostrum.		
F	Impossible to determine sex by naked eye. Sex is indeterminate.	Small and translucid nidamental glands (NG). Stringy and translucid ovary. Eggs are very small.	Larger and opaque NG. Accessory nidamental glands (ANG) reddish coloured. Ovary with small eggs but visible to naked eye.	Very large reddish ANG and white- cream coloured NG. Bulky ovary and oviducts with many medium and big eggs. Presence of spermatophores in the mantle indicates that mating occurred.	Flaccid and less bulky NG. Smaller ovary with not many mature eggs. Oviducts contain many eggs in degenerative phase.	MEDITS: 3-point scale GRUND: 3-point scale CAMPBIOL 3-point scale On females it is important to measure the dimensions of the eggs (See specific tables in CAMPBIOL and GRUND).
M		Small and translucid testis. Spermatophoric complex (SC) not much visible. No spermatophores on Needham's sac. Deferens ducts with no spermatozoids. Starting differentiation of hectocotylus.	Larger whitish testis. Bright white SC. No or not many spermatophores on Needham's sac. Deferens ducts with spermatozoids. Hectocotylus is clearly recognizable.	Opaque big testis. Spermatophores on Needham's sac and penis. Deferens ducts are full of spermatozoa.	Long but thin testis. SC with many membranous corpuscles. No spermatophores.	

Discussion

Setting discrete categories and defining discrete reference points for continuous biological processes, such as the sexual maturation and reproduction of marine organisms, are a matter of convention. A wide variety of time- and space-scales, definitions of terms, and methods, both qualitative and quantitative, are found in the relevant technical literature and are determined by the context and the goals of different studies. In planning the routine collection of "maturity" data in a multipurpose seasonal bottom trawl survey with limited resources, however, a compromise must be found between the scientific requirements and the practical possibilities. The present proposal is incomplete and in some parts inadequate, but might allow the acquisition of information suitable for most of the available assessment procedures. The lacking measurements were, however, considered and are summarized here below.

Sex-determination

In crustacean decapods, the observation and description of the "male organ" were not considered, because the organ is too small for a macroscopic evaluation. In cephalopods, the presence/absence and development evaluation of the hectocotylus, the male arm modified for spermatophore transfer during mating, could help both in sex-determination (maturing and mature specimens) and in evaluating the adulthood condition, but the technique is prone to error and is time-consuming.

Maturation stages

The macroscopic determination of the maturation stage of a marine organism is a powerful tool for routinely monitoring the "maturation schedules" of marine organisms; whatever the scale (of the stages relevant to a given species) chosen, it is important to remember that the maturation stage assigned to a given specimen is relative to its adulthood condition. An "adult" shrimp (i.e. a shrimp that has spawned at least once) caught and analysed macroscopically in a period different from its reproductive season can, in fact, have a resting (or spent) gonad that is similar in appearance to that of a juvenile shrimp. The number of stages and their definition must, consequently, be determined in such a way as to minimize the risk of misclassification, a problem which makes the fitting of the maturation ogive at full maturity problematic. Furthermore, specific histological study remains the only way to validate the adopted macroscopic stages, whether universal or specific.

Gravimetric indexes

An estimation of the energy investment in gonad tissue, even if only rough by means of the computaion of the GSI, could be a useful tool, not only for the interpretation of the macroscopic data, but also for the establishment of the relationships between GSI and the life-cycle (for example, the link with the natural mortality, at least in bony fishes). In this context, somatic weight (SW; i.e. body weight excluding all the viscera) might have been a better alternative to body weight (BW) itself, but only the BW was considered, for practical reasons.

Other parameters

In planning trawl surveys (Bianchini *et al.,* in the present Technical Document), many other morphological and gravimetric measurements might have been considered. As examples of the morphological measurements, the most attractive would be the length of the right propodite of Norway lobster males (to figure out the transition between the juvenile and adult condition), or the length of the nidamental gland in cephalopods. As concerns gravimetric measurements, the hepato-somatic index (HSI=100LW/BW, where LW denotes the weight of

the liver) could be a precious piece of integrative information, especially for female cartilaginous fishes, since this index is often "in phase" with the corresponding GSI. Also with respect to the cartilaginous fishes, important information (especially as an aid in discriminating sub-populations) could be obtained by measuring and weighing the egg capsules and the embryos inside them.

As a matter of fact, many measurable body parts (for example, the hectocotylus length and testis diameter indexes in cephalopod males) could be relevant either to the assessment of the maturation pattern of an exploited population or to their implications for determining, for example, maximum girth in fish. Whatever the protocol adopted, however, it must be maintained unchanged until experimental evidence disproves its validity.

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Information that Could Be Obtained from Ancillary Activities during Trawl Surveys

M.L. Bianchini, G. Andreoli, G. Morizzo and S. Ragonese*

Abstract

Ancillary activities could be carried out during the routine operations of a trawl survey; while, in general, the information is marginal to the principal aim of the research, it comes at almost no extra cost. Among the many possibilities, such as the measurement of physical-chemical parameters, simplified echosounding, checking of discards, utilization of other fishing gear, study of the bottom biocenoses, qualitative collection of eggs and larvae, improved evaluation of maturity, diet analysis, parasitology, ecotoxicology, the most rewarding potential seems to lie in mark-recapture experiments.

Introduction

Scientific trawl surveys, aimed at assessing abundance and evaluating the population parameters of fishery resources, are highly demanding in monetary terms, mainly because of the high cost of vessel time. Two approaches are possible to lower the cost of the information gathered during the surveys: reduce the sample size, or increase the amount of "information items" collected in a fixed-cost campaign. Since a sound experimental design is already conceived to eliminate redundancies and excessive data collection, only the second approach proposed is feasible. Besides, while many more data can be obtained with only a small increase in "hard" costs, their production for eventual users may require long (and costly) additional hours for handling and processing.

As a working definition, an "ancillary" activity is something that is not routinely considered part of the traditional "stock assessment" procedure, or something "ordinary" but which is carried out in more detail than usual; in fact, something ancillary during the trawl surveys may be considered essential in other scientific circumstances.

The amount, quality and synergic effects of the "extra" knowledge must justify the increase in hard costs, laboratory use and personnel time; of course, the collection of ancillary information should not interfere with the "normal" activities of the trawl survey.

There are ancillary activities which can be carried out on board the experimental trawl-survey vessel, in the “dead” times between hauls, and others which may be conducted on preserved samples in laboratory conditions, between fishing campaigns. Broadly speaking, contemporary catch-and-effort surveys may be ancillary to the offshore activities, and genetic analyses could be employed to discriminate stocks.

Measurement of physical (and chemical) parameters

Bottom-water temperature is now routinely registered with miniloggers during the Italian and European trawl surveys; if deemed necessary, other oceanographic parameters could be easily measured with multisensor probes to discriminate among water types. Even though bottom-water

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temperature is cheap and easy to measure, a few recent studies have failed to show a correlation of this particular parameter with the state of the biological resources, at least at the local scale.

Echosounding

Stock assessment with echo-locating devices is above the practical possibilities of a classical trawl survey; nevertheless, a simple correlation between the catch and the integrated output of an echo sounder may produce interesting results. An in-and-out use of hydroacoustics would not interfere with the fishing operation, and a good-quality research echo sounder is now an affordable investment.

Mark-recapture

Tagging and subsequently recapturing animals could be the most rewarding of the feasible ancillary activities; if the time lapse after the release is sufficient, recaptured specimens will provide information on migration and short-range movements, on actual growth, on true abundances, even on mortalities (though in special cases only). Many situations do influence the outcomes of a mark–recapture experiment, among which, the species biology, the behaviour of tagged animals, the amount of tagging effort, the intensity of fishing, the fishermen's attitudes in reporting. Without considering special (and expensive) tags, such as storage tags, radio tags, active and passive sounders, transponders and so on, or out-of-fashion ones (Petersen disks, opercular clips, rubber-banding, batch marking, etc.), three kinds of individual tags could easily be utilized: magnetic microwires, freeze branding, "spaghetti tags" (a.k.a. T-bars, streamers, Floy tags). Regarding tagging during trawl surveys, recaptures would probably come from commercial fishing; therefore, only the easy-to-read type of tag (“spaghetti tags”) could be employed.

Many models exist, but in essence the "spaghetti tag" consists of a plastic tubing, carrying a unique code and information for the casual retriever (this information usually comprises the name of the "owner" of the experiment, phone numbers to call, rewards, etc.), with a short anchoring line; this line is inserted intramuscularly (and in general, dorsally) with the help of a tagging gun. With some practice, and using medium-sized animals, it is possible to tag a few hundreds animal per hour, without anesthesia or complicated care.

First, fishermen of the southern Sicilian fishing fleets will be informed of the programme, directly and by the posting of notices, and offered a consistent reward (worth the extra care and handling required) for recovered tags.

Sturdy fish, such as dogfishes and skates, more able to tolerate the stress of a survey trawl, will be sorted out from the catch as soon as possible, and put into a water tank; after rapid classification, sexing, measuring and tagging, the animals will be released on the same spot. To enhance the chances of recovery, at least a few hundred fish must be released in each campaign.

Even a few recaptures will provide qualitative, but still useful, insight into growth and movement; more recaptures will allow a quantitative assessment and an idea of migratory patterns. Moreover, specimens recovered by the research vessels will provide information on the absolute abundance of the species.

Providing that the recovery rate is interestingly large, more species may be tagged, because this kind of high-quality information will be well worth the extra effort and money for this ancillary activity.

Discards

Fishermen discard part of their catch for different reasons, with a very subjective and variable attitude. Nevertheless, discards are "dead fish", whose death must be attributed to the overall fishing mortality (F), and not to the natural mortality (M). Estimating the amount and quality of the discards is important for any study based on landings. A real, true evaluation of discards, valid for the entire fishery, requires an *ad hoc* programme, but in the meantime the research team carrying out a trawl survey could ask the fishermen to sort the catch as they would do in a commercial fishing operation, and make a preliminary assessment of the rejects in terms of weight, number and species composition.

Other fishing gear

Trawling is only a part of the fishing effort, and in some instances targets only a particular component/fraction of the resources; in theory, it will be of great importance for a real stock assessment to fish also with different gears, such as trammel and gill nets, bottom longlines or baited traps. On the other hand, the interference with the ordinary work would be maximal if these other techniques were utilized on the same vessel; maybe the only non-disruptive activity is nocturnal jigging (for cephalopods).

Biocenoses

The catch from trawling is composed mainly of animals permanently linked to the sea , either real bottom-dwellers (the so-called benthos) or species living entirely close to the sea bottom (the so-called demersal species) or living there occasionally (e.g. for spawning), the so-called dermerso-pelagic species. The knowledge of the sea-bottom biocenoses is therefore essential in understanding the ecology of fishes of commercial interest. The collection of non-commercial benthic invertebrates may proceed by dredging or grabbing samples of the sediments; both procedures are disruptive of the daily routine of the trawl survey, especially when the sampling occurs at greater depths. In any event, grabbing seems an easier way to proceed. Only a van Veen grab (0.1 m^2), a steel cable and a power winch are needed as hardware, but this activity requires both onboard and laboratory time; to be of value, the taxonomical classification must reach at least the genus level. Besides the biological study, the grab sample should provide information on the bottom sediments.

Collection of eggs and larvae

Non-quantitative, non-depth-related samples are easy to collect, creating only a minimal interference with the at-sea activities; to be "ancillary", the study must be limited to the teleost component of the zooplankton. Using a Bongo 40 net (less than 0.25 m^2 mouth opening), the amount of material to be subsequently classified (at least to family level) in the laboratory should be minimal; however, this activity requires qualified personnel, trained in taxonomy. For simple classification purposes, the ichthyoplankton can be preserved in formaldehyde; liquid nitrogen should be used if counting daily rings in the otoliths is required.

Another approach to collect swimming fish larvae and early juveniles is to attract them into a sort of trap "baited" with chemicals and/or with lights (night fishing); the fishing vessel, when near the coast or over the fishing banks, can drop a few traps at night, and take them back in early morning.

This activity is aimed at finding nursery areas, relating them to the oceanography and larval migrations and establishing spawning periods.

Maturity

Besides the routine sexing and macroscopic assessment of maturation stages, microscopic analyses of the gonads and gonado-somatic indexes can be performed on a few species of greater interest, using a focused sub-sampling. This study will be useful in validating the existing macroscopic maturity scales, in creating new and better ones, and in measuring relative and absolute fecundity.

Diet

In-depth studies of the trophic web to which the commercial species belong are generally outside the expertise of fishery biologists; still, even a qualitative knowledge the ecology of foraging and of the fish prey may be worth the effort of examining and classifying, in the laboratory, the stomach content of at least the most important commercial species. The seasonality of the samples must be considered, given that presence of certain species may represent the result of an active search for prey or just of a temporal/geographical abundance of the prey item. This kind of ancillary research could produce very useful results, especially if carried out in association with studies on the bottom biocenoses.

Parasitology

Since some parasitologists are actively seeking fish samples from deep fishing grounds, and/or for sharks, to conduct studies on parasitic flatworms, it should be easy to deep-freeze whole specimens or specific organs, for further studies.

Ecotoxicology

Considering the role of certain long-lived animals in the trophic web and their capacity for biomagnification, samples of their flesh could be analysed for heavy metals, pesticides, PCBs and other contaminants, using biomarkers (such as the cytochrome P_{450}-A1, metallothionein, ALA-D) and/or the DNA-adduct techniques. These analyses, however, require specific equipment and skilled staff.

Data Processing and Management at IRMA: Overview and On-going Activities

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Abstract

This note describes the main features of the Software for the Exploratory Analysis of Trawling Information in the Mediterranean (SeaTrim) which is currently under development at CNR-IAMC. It is an advanced software designed for the handling of data collected during experimental bottom trawl surveys. Its main component provides a flow of integrated routines to accomplish the exploratory analysis of the data, both globally and spatially oriented. SeaTrim outputs range from abundance indexes to biological features, such as length–frequency structure, sex-ratio, maturation stages, size at maturity. The software is designed to import any existing data base by converting it to a standardized format, and to provide a consistent modular architecture that can be tuned for regional data-management needs.

In view of the establishment of harmonized data-collection protocols and common analytical procedures within the framework of the FAO MedSudMed Regional Project (MedSudMed, 2003), the package may provide an excellent tool for easy data handling and exploratory analysis, especially on the shared stocks.

Introduction

CNR-IAMC has been carrying out bottom trawl surveys in the Strait of Sicily since 1985, using a traditional Italian commercial gear (GRUND project; Relini, 2000), and since 1994, using an *ad hoc* designed gear with high vertical opening (MEDITS project; Anon., 2000; Abelló *et al*., 2002). At present, the MEDITS historical data-series comprises nine consecutive spring surveys, whereas the GRUND series consists of 26 campaigns. This latter series is discontinuous in time, however (surveys were not performed in some years), and presents a seasonal heterogeneity (only the autumn season was regularly covered).

Since 1984, researchers at IRMA have been devoting much effort to improving the quality and timeliness of survey data collection, processing and analysis. Over the years, different software tools have been designed for, and applied to, the data and information management, often under the pressure of rapid technological advances. To date, however, there is neither a unique data base nor a common analytical environment to serve the demand of the different scientific programmes. Moreover, what has become increasingly important in recent years, and will become even more crucial in the future, is putting emphasis on the possibility to share data, analytical methods and assessment of results with other scientific communities in the framework of joint projects. This process includes applying harmonized codes to different data bases to increase the amount, the uses and hence the value of the data collected. Foreseeing these priorities, scientists of CNR-IAMC are now developing a new comprehensive computerized data base for the analysis of data from bottom trawl surveys. The package, called SeaTrim (Software for the Exploratory Analysis of Trawling Information in the Mediterranean), provides a standard data-base structure as well as the possibility to import or customize regional data bases. In both cases, procedures for the input and validation of the data are available. Starting from raw catch and biological (length measurements, etc.) data, a set

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of integrated routines performs exploratory analysis and estimates biological and population dynamics parameters. Basic cartographic functions are also provided to allow a geographical representation of the population features. Preliminary analysis and results provided by SeaTrim can be used under other software (FISAT, ArcView, etc.) to accomplish the assessment of the demersal stocks.

In this note, after a brief overview of the data-management systems currently used at CNR-IAMC, the architecture and the main components of SeaTrim will be described.

Overview of existing software packages

TrawlBase

TrawlBase was developed in the early 1990s (Garofalo *et al.,* 1991; 1993) and was the first PC-based data-base management system of the GRUND programme. It was designed to manage three different types of data files (Figure 1): (a) haul files; (b) catch files; (c) species files. The "haul file" is structured to contain all the technical and operational information regarding the execution of the haul, such as geographical coordinates, duration, speed and depth. The "catch file" is designed to record the total number and weight of each species caught. Finally, the "species file" contains the biological parameters of the target species. The analytical capabilities of the system are limited to the calculation of the abundance indices, by species, both in weight (kg/km^2) and number (N/km^2).

New Trawl

The package called "New Trawl" was developed to improve the management of the data in the GRUND data base. Its purpose is to provide routines both for checking the data quality-controlling and producing a number of predefined outputs. In other words, it allows a quick look at the data and a preliminary exploratory analysis.

In particular, the software allows the automatic drawing of the graphs and the export (on Excel spreadsheets) of the following results of analysis:

- number and weight per haul
- abundance indices per haul
- maturation stages
- length-distribution by maturation stage
- number of specimens by sex
- sex ratio by size
- length–weight relationship.

Moreover, routines have been developed for exporting the data to the FISAT package according to the length–frequency (LFQ) and catch-probability (PBT) formats.

Finally, the software provides statistical and summarization routines which allow an assessment of the consistency of the data in the data base.

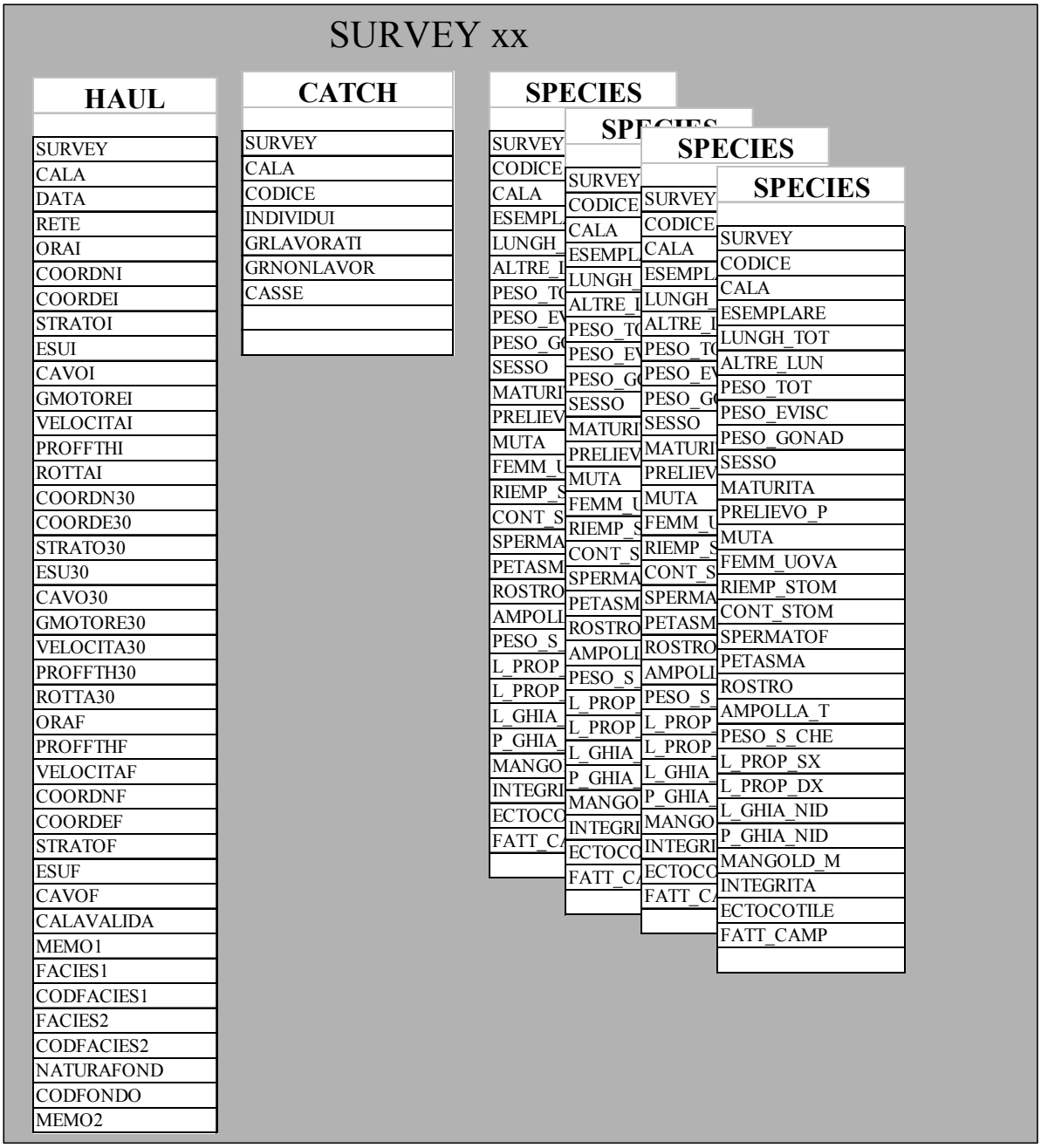

Figure 1. File structure of TrawlBase

MEDITS data base

The MEDITS Programme does not have its own data-base management system. It requires data to be recorded according to three standard exchange formats (text TA, TB, TC files; Anon., 2001), including normalized coding (Table 1) of: (a) characteristics of each haul; (b) total catch per haul; (c) biological parameters of the samples.

Observations on the target species comprise the count of individuals, length–frequency distribution, sex (including sexual maturation stage) and total weight. For all the other species of commercial interest (fishes, crustaceans and molluscs), the total number and total weight are recorded for each haul.

Two specific software tools have been developed to manage the data. The first one, CheckMed (Souplet, 1996a), has been written to allow an automatic checking of the data, the other one, IndMed (Souplet, 1996b), performs simple standard analyses of the data. These analyses include the production of biomass and abundance indices (in kg/km² and in N°/km²), as well as length–frequency distribution for each of the reference species and each of the depth strata.

SeaTrim

SeaTrim is a software for the management and standard preliminary analysis of trawl survey data. The package originates from the experience gained during the SAMED experiment (Stock Assessment in the Mediterranean; SAMED, 2002). Based on MEDITS data, scientists of the different countries involved worked together to study the abundance, biological features and age-structure of the most important target species; the scientists also performed equilibrium and non-equilibrium assessments. Indeed, the SeaTrim software has the potentiality to work on a standardized data base (the international MEDITS format has been selected as the reference) and be also employed with flexibility to export data sets for estimating the age-structure of the main demersal resources and for developing predictive capability aimed at the management of the fishery resources.

The architecture of SeaTrim, synthesized in the flow chart in Figure 2, comprises four different parts:

- data acquisition
- project definition
- elaborations supporting the analysis
- utility functions

Data acquisition – Besides the acquisition of data by importing text-format files (TA, TB, TC, standard MEDITS), which are supposedly error-free, it is also possible to create a new data base, with four information fields: survey, haul, catch data and laboratory measurements. The fields' only requirement is to be compatible with the structure of SeaTrim analytical procedures.

Data acquisition is an interactive process, following the successful completion of a series of formal checks; these checks, besides the formal aspects, produce reports and graphs which should be employed to verify the correctness of the data directly inputted into SeaTrim.

Having validated the data, an *ad hoc* data base is created for the specific survey; there is no limit to the number of these data bases (a.k.a. "sources"); in this way, a single analytical package allows the management of many different choices which may arise from the various interests of the research teams.

Project definition – The management of the projects is centered on a data base of reference, holding information on: data-base sources (with filtering options); geographical units; target species; macrostrata of interest. Moreover, an outfit data base stores pre-defined geographical areas, their coordinates and the proportion of each depth stratum; the user may define his/her own study area, for *ad hoc* projects.

Elaborations supporting the analysis – Every time a project is chosen, SeaTrim creates (following the previous definitions) an *ad hoc* processing data base which, together with a technical "query"-operating system, allows analyses of, and export procedures for: raw haul and catch data; text TA,

TB, TC files (standard format for data exchange); Excel files of the detailed exploratory analyses performed using SeaTrim "Job" procedures.

The exploratory analysis, in particular, comprises nine "Jobs":

- Job.0 – Descriptive features of the geographical units encompassed by the project
- Job.1 – Spatial distribution
- Job.2 – Abundance
- Job.3 – Length structures as box plots
- Job.4 – Sex ratio
- Job.5 – Maturity stages and size at sexual maturity
- Job.6 – Length-structure stability
- Job.7 – Length–frequency distributions
- Job.8 – Young of the year.

Side-lined functions - Among the outfit functions, the most relevant ones are: the utilities to assign a unique code to each haul; and the users' management of the data sets.

SeaTrim has been designed to operate both in a computer network and on a single desktop. The operative system is Windows 98 or succeeding versions, whereas the data bases are structured in the MDB (Access 97) format, although the application does not require the corresponding software. As a matter of fact, also Excel was employed in SeaTrim, but to manage the outputs (as *.xls files) and as a shuttle for the quick transfer of data. Consequently, it is necessary to install the corresponding Microsoft programme (Excel).

Table 1. MEDITS data-exchange formats (ASCII).

Haul characteristics (file TA)	**Catch per haul (file TB)**	**Biological parameters (file TC)**
Country	Country	Country
Vessel	Vessel	Vessel
Gear	Year	Year
Rigging	Haul number	Haul number
Doors	Codend closing device	Codend closing device
Year	Part of the codend	Part of the codend
Month	Faunistic category	Faunistic category
Day	Species code (Rubbish)	Species code (Rubbish)
Haul number	Total weight in the haul	Length-class code
Codend closing device	Total number in the haul	Fraction weight
Shooting time	Females (number)	Sub-sample weight
Shooting quadrant	Males (number)	Sex
Shooting latitude	Unsexed (number)	Number of measured individuals
Shooting longitude		Length-class
Shooting depth		Maturation stage
Haul time		Number of individuals in that class
Haul quadrant		
Haul latitude		
Haul longitude		
Haul depth		
Haul duration		
Validity code		
Course (rectilinear or not)		
Species reporting code		
Distance		
Vertical opening		
Wing opening		
Bridle length		
Warp length		
Warp diameter		
Hydrological station number		
Observations		

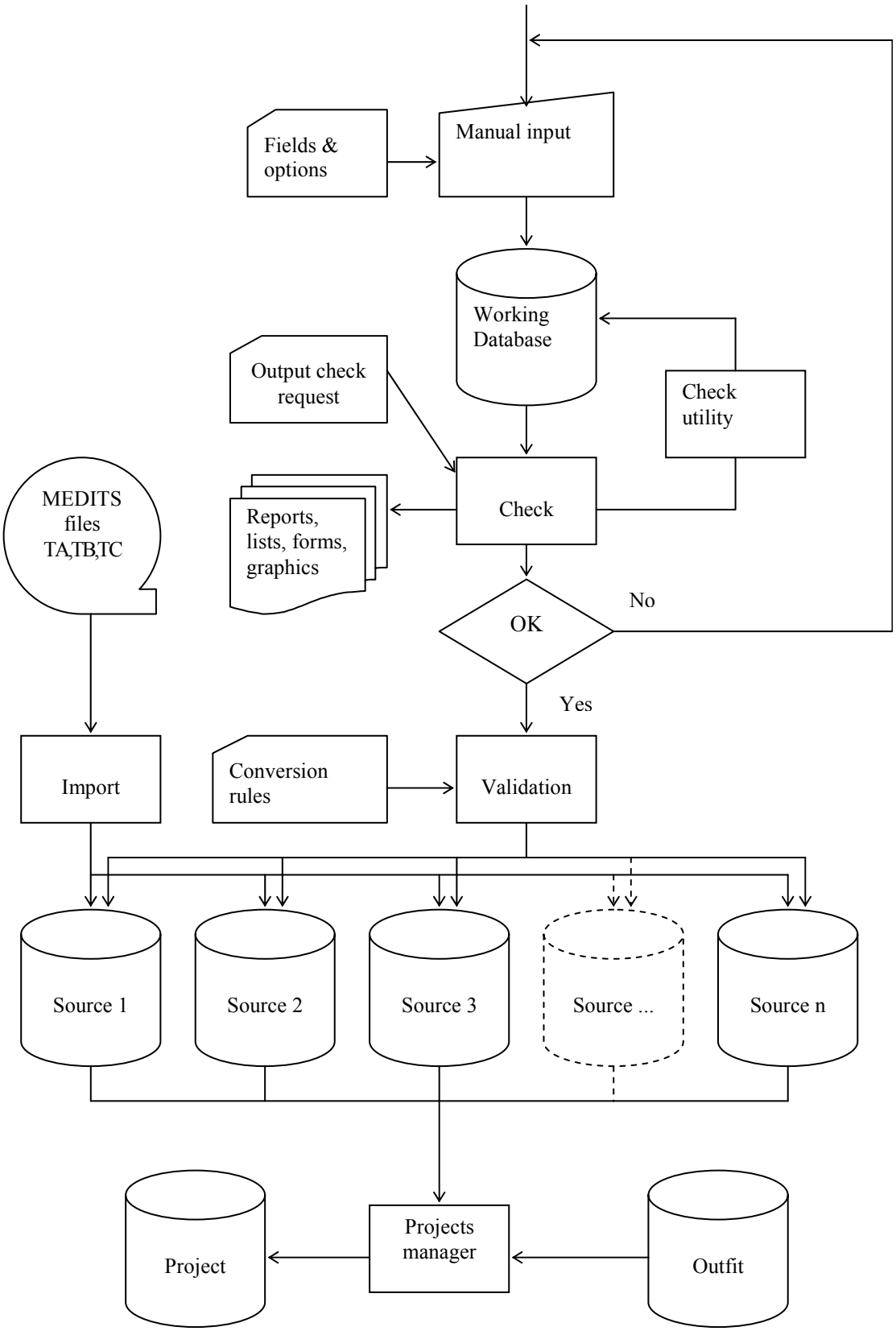

Figure 2. Flow chart representation of the **SeaTrim** software

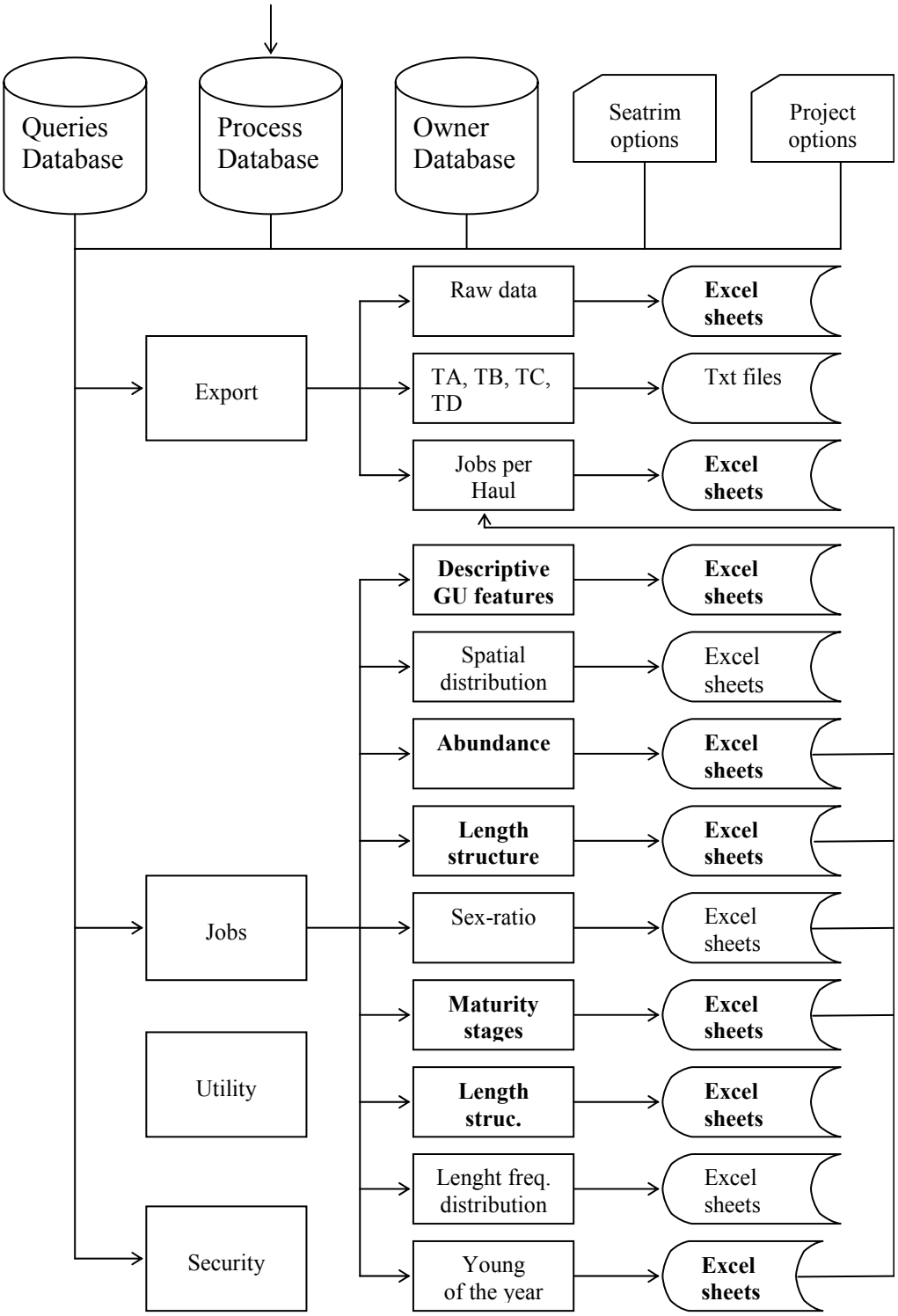

Figure 2 (continued). Flow chart representation of the **SeaTrim** software

Conclusions

Today, the concerned research communities have a growing need for collaboration and the sharing of information and data to carry out common research projects. This process includes applying harmonized codes to the data bases to allow easier summarization and use of data across all partner jurisdictions.

We believe that the development and use of SeaTrim could contribute to the promotion of scientific cooperation among research institutions involved in the assessment and monitoring of the fisheries resources through experimental trawl surveys. By standardizing and validating the storage and exploratory analysis of data, SeaTrim is expected to: increase the value and quality of the data collected; provide easy and timely access to information by a wider range of users; and increase the amount and uses of the data collected. In addition, it will reduce the labour and cost involved in storing, managing and analysing the data. Ultimately, by keeping the data in a standard format, the potential for wide data exchange and improved scientific communication is being exploited.

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Sampling Trawls Used for Demersal Resource Assessment in the Mediterranean

I. Leonori*, S. Palladino and G. Cosimi

Abstract

In the Mediterranean several scientific bottom trawl surveys have been conducted for many years in an attempt to assess the demersal fishery resources. In Italy, in particular, two projects have been carried out every year: a national survey (GRUND) and an international survey (MEDITS). Different fishing gears are used as sampling trawls: the GRUND's teams use the local Italian commercial trawls; the MEDITS teams use only one particular kind of standardized trawl. Fiorentini *et al.* (1999a) assessed the efficiency of the MEDITS sampling trawl relative to that of a typical Italian commercial trawl. The study results showed that the MEDITS trawl was the less efficient for benthic species, and the more efficient for the pelagic species. A new research project, financed by MIPAF, is being carried out by the fishing technology team of ISMAR-CNR-Ancona (formerly, IRPEM) to develop a standardized sampler trawl for Mediterranean benthic and demersal resources. The preliminary results have shown a good performance of the sampler prototype. The next trials will be carried out in order to test the sampler trawl on different fishing grounds and at the greatest depths.

Introduction

Trawling has a long tradition in the Mediterranean where bottom species constitute a considerable fraction of the landings; therefore several scientific bottom trawl surveys have been conducted for many years to attempt to assess the demersal resources in this area (Relini and Piccinetti 1996; Bertrand *et al*. 1997).

In Italy, in 1985, a national survey programme (GRUND), covering the whole Italian coast, was started (Relini and Piccinetti 1996) and is still in progress. It has been carried out by 11 teams, each of them using a trawl that is typically employed in their respective local fishing area. Although these trawls are similar in design, since they all derive from the original commercial Italian trawl (Cosimi *et al.* 2001), they are not identical. The fishing technology team of Ancona (Fiorentini and Cosimi 1981; Fiorentini *et al.* 1994; 1998; 1999b) has studied the performance and geometry of these trawls. Recently, for all GRUND trawls, a standardized cod-end, with a stretched-mesh size of 20 mm (Leonori *et al.* 2003), has been introduced into the sampling protocol (same depths, fishing periods, etc.).

Since 1994, the Mediterranean International Trawl Survey (MEDITS) programme (Bertrand *et al.* 1997) has been carried out yearly in the Mediterranean to assess the benthic and demersal resources along the coasts of the western and northern part of the basin. The sampling protocol (Anon. 1998; 1999) required the same standardized gear to be used throughout the study by all teams. The sampling trawl (Dremière *et al.* 1999) was designed by the IFREMER (Sète) fishery technologists, based on specifications provided by the biologists involved in the programme.

An IFREMER, ISMAR-CNR-Ancona (formerly IRPEM), fishing technology team has been associated with the programme since its beginning and monitors the MEDITS trawl efficiency and

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performance (Dremière et al. 1999; Fiorentini et al. 1996; 1999a; Bertrand et al. 2002). The efficiency of sampling trawls has been extensively studied. Comparative fishing trials with different trawls or gear arrangements have been described by several authors (Ehrich et al. 1994; Engås et al. 1988; Engås et al. 1989; Sissenwine et al. 1978; Walsh et al. 1984; Wilderbuer et al. 1998).
As In the work "Efficiency of the bottom trawl used for the Mediterranean International Trawl Survey" (Fiorentini *et al.* 1999a), the catch efficiency of the MEDITS sampling trawl was assessed by comparing the catch data with those obtained with a typical Italian commercial trawl.

Catch data were converted into abundance per swept area before comparing the trawls. For each haul, the numbers and weight of each species were converted into number and kilograms per km² based on horizontal net opening (measured by the Scanmar system), vessel speed (measured by the vessel's Doppler Log) and tow duration.

The catch data analysis showed that the MEDITS trawl was less efficient than the commercial Italian trawl, for benthic species, and more efficient, for pelagic and semi-pelagic species.

These results were confirmed by most MEDITS programme teams (Baino 1998; Bertrand *et al,* 1997), too. The comparison was performed on ten fish species, one crustacean and four molluscs, all on the MEDITS main list of reference target species. The MEDITS trawl was significantly less efficient in terms of both weight and numbers of individuals fished, for hake (*Merluccius merluccius*), common sole (*Solea vulgaris*) and Norway lobster (*Nephrops norvegicus*). A highly significant difference in favour of the commercial trawl was found in the weight, but not the numbers, of common pandora (*Pagellus erythrinus*). The differences in catch efficiency between the two trawl nets were negligible with respect to the red mullet (*Mullus barbatus*), whereas the MEDITS trawl was significantly more efficient for the numbers of Atlantic horse mackerel (*Trachurus trachurus*). Regarding the size of individuals caught, the catch efficiency of the MEDITS trawl was especially low for small size-classes of *N. norvegicus* (Dremière *et al.* 1999).

The different bottom contact of the two trawls accounts for their different benthic-species efficiency. The Italian trawls are characterized by close bottom contact: not only the footrope but also the whole lower panel is towed in close contact with the sea bed. This difference is a result of their different designs. The Italian-trawl body consists of two asymmetric panels, the upper panel is larger and shorter than the lower one; the lower panel has a greater amount of slack (20–30%) to maximize bottom contact. The MEDITS trawl (Dremière *et al.* 1999) consists of two panels and sides, symmetrical in pairs. It has been observed that the lower panel, just above the footrope, rises completely from the sea bed, and nor does the footrope stay in close contact with the sea bottom (Dremière *et al.* 1999). By contrast this trawl has a higher vertical opening (2.4–2.9 m) than that of most Mediterranean commercial trawls.

The problems of determining the efficiency of a sampler trawl net, such as the MEDITS trawl, on the Mediterranean bottoms, have lead most of the GRUND scientists to look for a new one-of-a-kind standardized sampler trawl, to be employed by all the survey teams in the Italian national programme. Within GRUND, a research project has been developed to plan a standardized sampler trawl for Mediterranean benthic and demersal resources, which are typically multispecific in their depth assemblages. The MIPAF project "Development of a standardized sampler trawl for demersal resource assessment" has been carried out by the fishing technology team of Ancona since 2000 and is still in progress.

Materials and methods

The prototype STDB (Figure 1) of a standardized sampler trawl is based on the technological characteristics of the commercial trawls used in many Italian trawl fisheries, in accordance with the various requests of the scientific teams that wanted to employ it in their surveys. The main sampler specifications were: (i) ability to work in all the areas and at all the depths envisaged by the programme; (ii) lowest possible selectivity, so as to obtain good descriptions of the populations sampled and (iii) ability to sample efficiently a great variety of species. This last feature is important, since even though few species, mainly benthic, account for a considerable proportion of the value of the fish landings, the great species diversity found in the Mediterranean requires careful fishery management. The netting in the cod-end has a stretched-mesh size of 20 mm. The final part of each of its wings is split in two; this results in a slightly higher vertical opening and, consequently, improves the catches of demersal species. Although the final part of its wings is split in two, unlike most of the other GRUND trawls, it is similar in design to the trawls used for the Italian programme. Moreover, the mouth-opening sizes of the sampler trawl are a compromise based on the openings of all the trawls used by the Italian teams for the GRUND programme. To study the performance of the new sampler trawl, several sea trials (haul duration: 1 h) were undertaken with the CNR research vessel "Dallaporta" which is equipped for scientific trawling experiments. All trips were carried out in the central Adriatic Sea at different depths, from 10 m down to 250 m. An underwater monitoring system was used to measure the trawl performance and geometry; it shows changes in vertical and horizontal net openings, in the spread of the trawl doors, and many others technological parameters. On the first trip, in September 2001, a first prototype of the standardized net was tested and some improvements were made to it. On the second trip, in May 2002, the catch efficiency of the sampler trawl STDB developed was compared to a typical Italian commercial trawl (Figure 2). The trawls were alternated daily, so that both nets were tested on the same fishing ground and at the same depth.

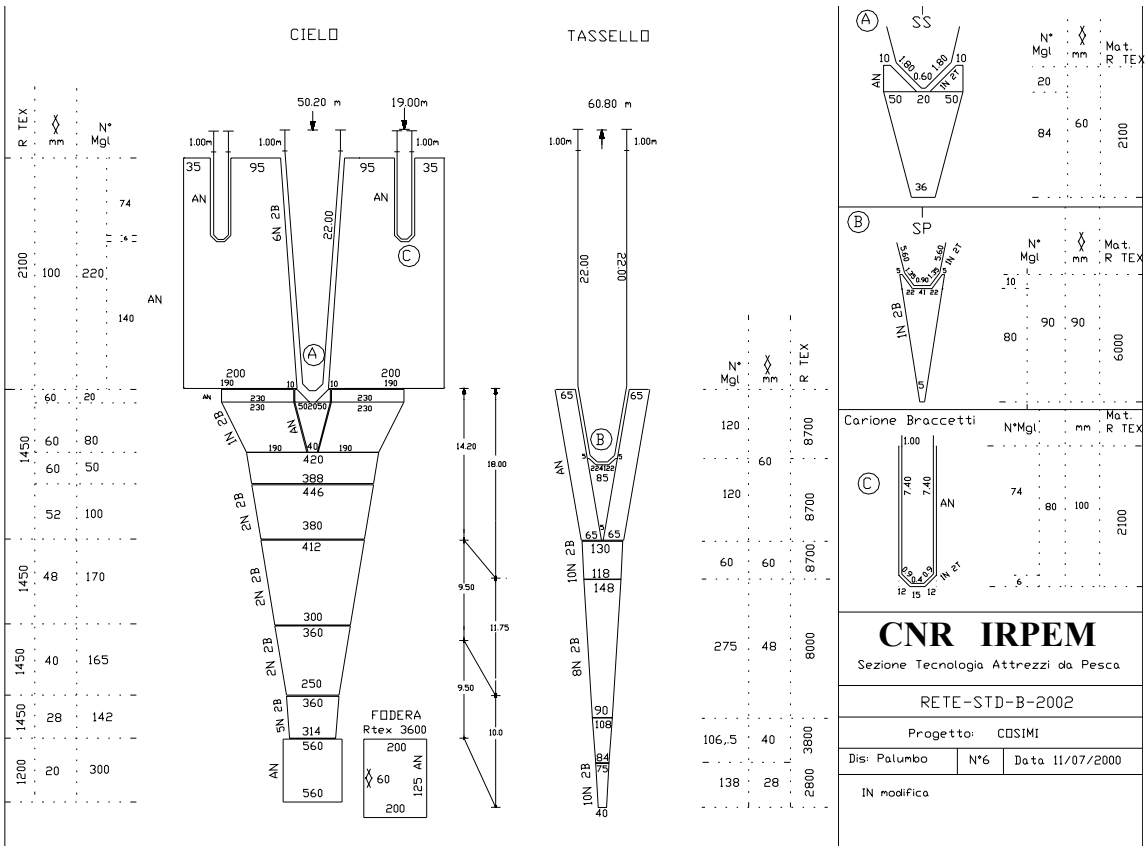

Figure 1. Design of the new standardized STDB sampler trawl.

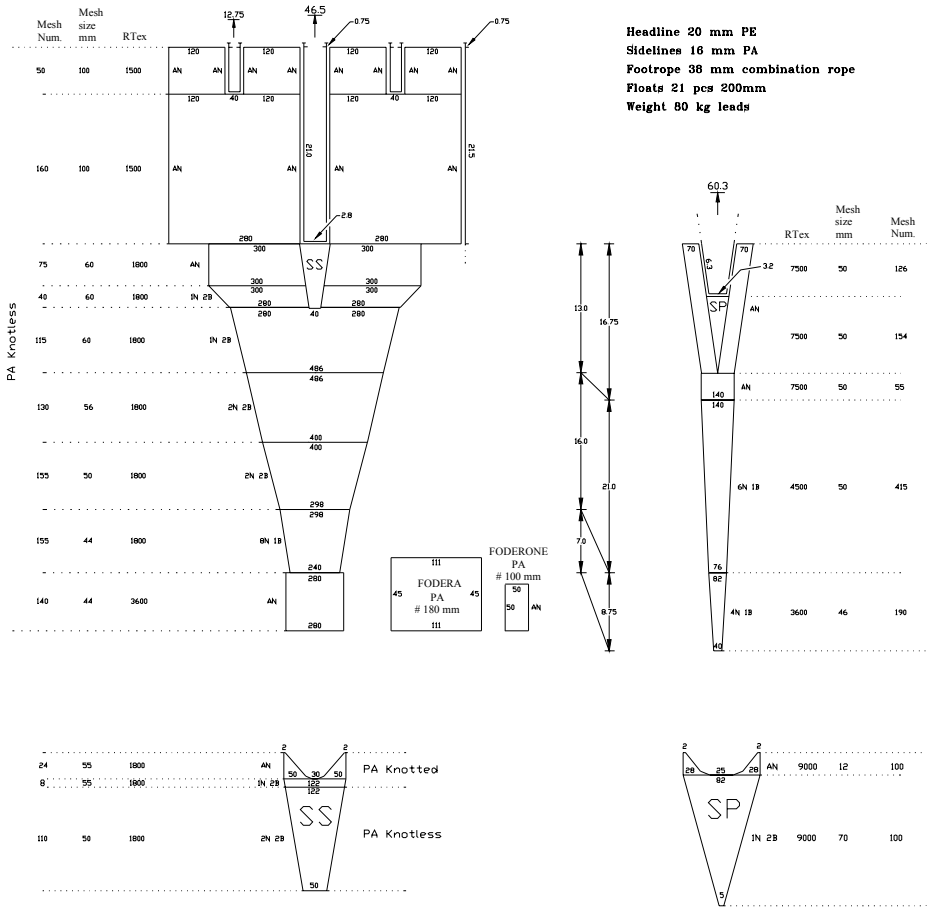

Figure 2. Design of the Italian commercial trawl employed for comparison with the STDB trawl (Figure 1).

Preliminary results

The sea-trial results showed a good performance of the STDB sampler trawl in terms of the key geometrical parameters during the hauls (Table 1) and the net's good stability under different fishing conditions.

The main species caught on the second trip are reported in Table 2. Catch data were converted into abundance per swept area before comparing the trawls. The mean size of the species caught with STDB was slightly smaller than that for the commercial trawl, except for *Merlangius merlangius*. It is an expected result, bearing in mind the difference in the cod-end mesh size between the sampler trawl and the commercial trawl. The mean size–frequency distributions of some economically important species, hake for example, are similar in both trawls with a larger range for the STDB than for the commercial trawl. For each GRUND target species, a catch efficiency coefficient (STDB/Comm) was computed (Figure 3) as the ratio of the mean catch of the STDB trawl to that of the commercial trawl, both in number of individuals and in weight per km^2.

Table 1. Main technological parameters monitored during the hauls carried out with the STDB and commercial trawls.

Haul	Date	Trawl Type	Shooting Time	Bottom Depth [m]	Warp Length [m]	Sweep Length [m]	Vessel Speed [knt]	Shaft Power [HP]	Warp Loads [kg]	Horizontal Net Opening [m]	Vertical Net Opening [m]	Door Spread [m]
4	21/05/02	STDB	09:23	30.5	300	100	3.12	261.5	2,769	18.50	1.56	71.26
5			11:22	30.5			3.13	252.1	2,844	18.41	1.58	69.57
6	21/05/02	Comm.	15:23	31.5	300	100	3.23	232.5	2,706	17.34	1.51	74.28
7			17:19	30.5			3.13	230.3	2,785	17.93	1.47	78.80
8	22/05/02		08:47	31.5			3.15	248.2	2,925	19.66	1.39	82.99
9			11:08	32.0			3.21	244.1	2,864	18.21	1.31	84.12
10	22/05/02	STDB	15:10	31.0	300	100	3.17	231.0	2,697	18.37	1.62	69.97
11			17:33	31.0			3.10	216.2	2,587	18.52	1.62	70.02
12	23/05/02	STDB	08:38	50.0	400	100	3.04	259.2	2,666	20.21	1.53	93.94
13			10:49	50.0			2.96	269.2	2,610	18.60	1.55	69.29
14	23/05/02	Comm.	15:03	50.5	400	100	3.14	295.4	2,904	19.19	1.24	104.10
15			17:07	50.5			3.16	308.2	3,025	20.15	1.15	103.05
16	25/05/02	STDB	08:52	74.0	400	100	3.11	270.8	3,033	20.78	1.43	81.43
17			10:52	74.0			3.07	274.6	3,083	21.02	1.42	80.44
18	25/05/02	Comm.	15:10	74.0	400	100	3.27	273.9	3,081	19.80	1.15	82.03
19			17:07	74.0			3.18	255.7	2,804	19.76	1.19	82.02
20	27/05/02		09:02	74.0			3.15	272.7	2,927	19.91	1.17	111.49
21			10:59	74.0			3.19	271.7	2,956	18.53	1.11	80.95
22	27/05/02	STDB	14:47	74.0	400	100	3.14	259.0	2,912	21.32	1.39	81.84
23			16:49	74.0			3.11	262.9	2,938	21.08	1.43	80.95
24	30/05/02	STDB	07:33	209.0	800	150	3.18	279.6	3,159	22.43	1.23	104.35
25			09:56	215.0			3.12	275.9	3,175	22.20	1.27	100.56
26			15:02	216.5			3.19	280.6	3,289	22.94	1.09	107.94
29	31/05/02	Comm.	08:13	215.0	800	150	3.16	279.7	3,109	21.17	1.12	107.59
30			10:28	216.0			3.11	270.5	3,109	21.22	1.18	104.13

Table 2. Comparison of the results for the main species caught in the central Adriatic Sea: mean size (in centimeters, of individuals); percentage presence in the hauls; geometric mean and coefficient of variation (*CV*) of number and weight per km^2, Student's *t* test results (to compare the catch efficiency on the species) and the coefficient of efficiency. *G*: GRUND target species. *Boldface type*: species very important economically in the central Adriatic (the size–frequency distribution was taken into account only for these species).

Species	Size		Presence		N/km^2						kg/km^2					
	STDB	Comm.	STDB	Comm.	STDB Mean	STDB CV	Comm. Mean	Comm. CV	*t* test (P≤0.05)	Coeff. STDB/Com	STDB Mean	STDB CV	Comm. Mean	Comm. CV	*t* test (P≤0.05)	Coeff. STDB/Com
	(cm)	(cm)														
Gobius niger (G)	-	-	54%	50%	6,6	99%	4,3	110%	0,64	1,55	0,4	123%	0,4	120%	0,90	1,08
Lophius spp. (G)	-	-	54%	67%	5,4	100%	6,7	84%	0,80	0,81	0,9	131%	0,5	131%	0,42	1,77
Merlangius merlangus	9,7	9,4	77%	83%	117,4	60%	100,2	55%	0,89	1,17	2,6	80%	2,0	92%	0,64	1,33
Merluccius merluccius **(G)**	11,8	16,3	100%	100%	824,2	18%	484,8	10%	0,18	1,70	35,0	21%	29,2	13%	0,48	1,20
Micromesistius potassou	13,6	14,5	23%	17%	3,9	190%	2,6	234%	0,81	1,49	1,0	190%	0,9	234%	0,90	1,17
Mullus barbatus **(G)**	13,4	13,7	54%	50%	7,5	111%	8,2	112%	0,94	0,91	0,9	165%	1,1	124%	0,84	0,86
Pagellus erythrinus (G)	-	-	54%	50%	3,6	98%	2,7	109%	0,71	1,35	0,2	122%	0,2	137%	0,56	1,40
Trisopterus minutus capelanus **(G)**	6,5	6,8	100%	92%	358,0	27%	140,1	54%	0,29	2,56	2,0	90%	1,9	111%	0,95	1,05
Eledone moschata (G)	-	-	62%	25%	8,3	92%	2,0	195%	0,19	4,18	1,7	134%	1,0	223%	0,58	1,77
Loligo vulgaris (G)	-	-	15%	25%	0,5	247%	0,8	181%	0,52	0,62	0,1	249%	0,1	183%	0,85	0,84
Sepia officinalis (G)	-	-	54%	67%	8,2	98%	6,7	79%	0,13	1,23	0,2	164%	0,1	93%	0,22	2,69
	(mm)	(mm)														
Nephrops norvegicus **(G)**	26,2	28,8	62%	58%	41,3	90%	31,6	98%	0,85	1,30	4,6	87%	4,2	99%	0,91	1,09
Squilla mantis (G)	-	-	46%	50%	6,7	115%	8,8	110%	0,80	0,76	0,7	130%	0,8	119%	0,79	0,84

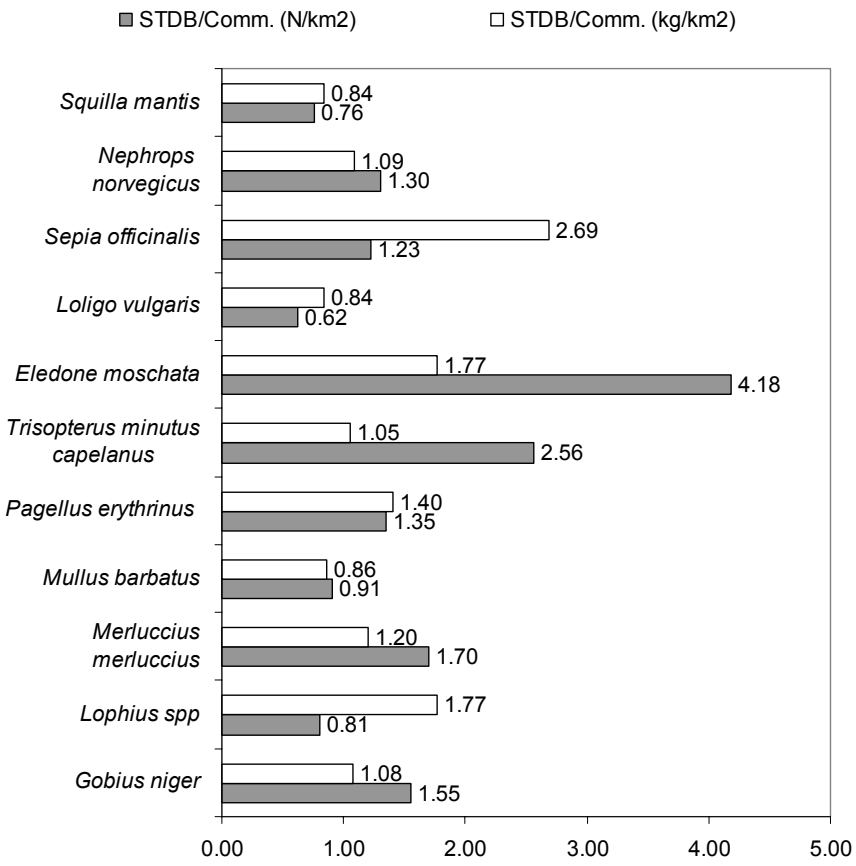

Figure 3. Coefficient of efficiency (ratio between the catches in numbers and weight per km² by the STDB and the commercial trawl) for the main GRUND target species.

Discussion and conclusion

Until now the STDB net has given a good performance in the central Adriatic Sea compared to the commercial net. In general, the STDB catches were higher than those of the commercial trawl. In terms of the mean size–frequency distributions of some economically important species, the STDB was similar to the commercial trawl and thus a good sampler of a wide range of sizes from the sampled stock. In the coming months this sampler trawl will be tested in the southern Adriatic and in the Tyrrhenian Sea, in order to assess its performance on different fishing grounds and at the greatest depths.

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