REPORT OF THE WORKSHOP ON TRAWL SURVEY BASED MONITORING FISHERY SYSTEM IN THE MEDITERRANEAN

Rome, Italy, 26-28 March 2007

OPENING AND ARRANGEMENT OF THE MEETING

1. The Workshop on Trawl Survey Based Monitoring Fishery System in the Mediterranean was held in Rome, Italy, from 26 to 28 March 2007. It was attended by 76 participants (see list of participants in Appendix 2).

2. Ms Karlou-Riga, coordinator of SCSA and Chairperson of the workshop welcomed the participants and reviewed the justification of the meeting, the main topics of the agenda including the terms of reference for the workshop previously established by the Scientific Advisory Committee (SAC) and endorsed by the Commission.

3. Mr Bonzon, Executive Secretary of the General Fisheries Commission for the Mediterranean (GFCM), welcomed the participants and thanked all for their support to the GFCM intersessional activities. He also thanked the Italian Government for their kindness in hosting the workshop.

4. Mr Jacques Bertrand, Coordinator of the International Bottom Trawl Survey in the Mediterranean (MEDITS), moderated the meeting and Mr Lleonart and Mr Tserpes were nominated as rapporteurs for the 1st and 2nd session of the workshop respectively.

5. The agenda was adopted without changes. The agenda is attached as Appendix 1.

SESSION 1: STATUS OF KNOWLEDGE ON TRAWL SURVEY UNDERTAKEN IN THE GFCM AREA

6. The objective of this session was to update the status of knowledge regarding trawl survey activities to monitor fishery resources and ecosystems in the Mediterranean Sea. The information submitted by the participants according to standard forms is provided in Appendix 3).

Inventory of trawl surveys performed in the Mediterranean Sea.

- *Bottom trawl surveys*

7. Six presentations on trawl surveys were made as follow:

- Status of the international project “MEDITS” (by J. Bertrand).

  Abstract: The MEDITS survey (International bottom trawl survey in the Mediterranean is organized to monitor the demersal resources in the Mediterranean. It intends to produce relevant information to support the fishery policy by collecting abundance data and biological parameters of fish, crustaceans and cephalopods species. The hauls are positioned following a depth stratified sampling scheme with random drawing of the positions within each stratum. The hauls are made in the same position from year to year. The following depths are fixed in all areas as strata limits: 10 - 50 m, 50 - 100 m, 100 - 200 m, 200 - 500 m, 500 - 800 m. The protocols, including the specifications of the standard gear are described in an instruction manual. The series began in 1994 with one yearly survey. Ten Mediterranean countries are applying the Medits protocols (about 1100 hauls per year).

- The project GRUND (by G. Relini)

  Abstract: GRUND is an Italian trawl survey project which initiated in 1984-1985 in all Italian seas within the framework of Italian Law 41/1982 regarding multi-annual plans to improve fishery management and fish farming, a part of the funding was allocated to the assessment of fishery resources, mainly by direct methods.

  Fifteen Operative Units were divided into three separate groups until 1993 and operated within GFCM statistical sub-areas 37.1.3, 2.1, 2.2 following a stratified random sampling and transect system design.

  During the period 1994-95 two surveys per year: one in spring and the other in autumn were carried out over a total surface area of 209,372 km2 with 482 hauls per survey. The following ten target species were considered: Mullus barbatus (L.), Merluccius merluccius (L.), Phycis blennoides (Brunn.), Micromesistius poutassou (Risso), Nephrops norvegicus (L.), Aristaeomorpha folaicea (Risso), Aristeus antennatus (Risso), Parapenaeus longirostris (Lucas), Octopus vulgaris (Lam.) and Eledone cirrhosa (L.).

  Since 1996 the two GRUND surveys are concentrated in an autumn cruise combined with MEDITS (a single spring cruise) with a total of 1,085 hauls over a surface of 285,032 km2.

  Since 2002 GRUND is included in the Data Collection Programme (Regulation EC 1543) with seven Operative Units corresponding to GSA9, 10, 11, 16, 17, 18, 19 and 750 hauls for all Italian seas.

- FAO-Adriamed Bottom Trawl Survey and use of ATrlS (by Vrgoc N., Isajlovic I., Krstulovic Sifner S., Milone N., Massa F., Joksimovic A., Marceta B., Osmani K., Piccinetti C., Ungaro N.)

  Abstract: The FAO-AdriaMed Project (Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea) is a Regional Project conceived to contribute to the promotion of cooperative fishery management in the Adriatic Sea between the participating countries (Albania, Croatia, Italy, Slovenia and Montenegro). The Project has been operative since 1999. Among other activities of the project, annual Autumn-Winter bottom trawl surveys are held, covering the whole eastern Adriatic Sea. This survey is complementary (the same sampling period and methodology) to the GRUND survey held in the western Adriatic Sea. One of the main objectives of the Project is to develop a common basis to support international processes of fishery management. An important tool used to achieve this goal is ATrlS, a AdriaMed Trawl Surveys Information System. ATrlS is developed in the scope of the Project and it includes a database from bottom trawl surveys with a wide range of data types and a geo-referenced database with data stored directly within GIS.

- Trawl survey In Morocco

  Abstract: Bottom trawl surveys in the Moroccan Mediterranean. Tow surveys per year were carried out in the area in March and December. The sampling design consists of 55 hauls located in 5 bathymetric stratum: 0 - 50 m; 50 – 100 m; 100 – 200 m; 200 – 500 m; 500 – 800 m. Among others, the following species were analysed: *Boops boops*, *Nephrops norvegicus*, *Octopus vulgaris*, *Mullus barbatus*, *Merluccius merluccius*.

- Trawl survey in Greece

  Abstract: Trawl surveys were realized in a total of 12 “area-program” in several depths, ranges and seasons. They cover the period from 1983 to 2000.

- Trawl survey in Tunisia

  Abstract: The first trawl surveys (sporadic) started in 1925. The R/V Hannibal is used since 1999. The Tunisian sea is divided into three areas and five strata: 0 – 30, 30- 50, 50 – 100, 100 – 200 and > 200 m, and species are divided into three categories: target species (13), non-target species and trash.

- Other bottom surveys

8. Within this topic, a presentation was made by E.B. Morello, C. Froglia, E. Arneri: “Hydraulic dredge surveys for the assessment of clam resources (*Chamelea gallina*) in the

Maritime Districts of Ancona and San Benedetto del Tronto, central Adriatic Sea, Italy". The sampling was performed with commercial vessels using hydraulic dredges. The results are synoptic maps and frequency distributions.

Abstract: A large fleet of hydraulic dredgers has been targeting the clam *Chamelea gallina* in the Adriatic Sea for the past 30 years. The fishery has progressively reached a status of great economical importance for the fishing community. Following request of the Italian Ministry of Agriculture and Forestry, the clam resources in the entire Adriatic Sea have been assessed through hydraulic dredge surveys annually from 1984 to 2001. This presentation is aimed at summarising the methodologies adopted for such assessment in two Maritime Districts of the central Adriatic (Ancoan and S. Benedetto del Tronto) as well as the results obtained from 1984 to 2001.

Conclusions from the Session 1

- Within the discussion that developed, it was concluded that surveys performed in different GFCM GSAs have the same objectives and obtain similar results although they are not comparable since the methodology is not standard. It was stressed that there is a need to normalize and standardize trawl survey procedures and methods among all Mediterranean countries.
- It was noted that GFCM can play a paramount role on this issue. The development of standardized guidelines for trawl surveys was considered necessary. For this reason, the establishment of a common protocol by the GFCM is recommended.
- The establishment of a permanent working group to undertake this issue was discussed. The Permanent Working Group on Stock Assessment Methodology was mentioned, which could be used for these purposes.

SESSION 2. METHODOLOGIES FOR TRAWL SURVEY DATA USED TO ASSESS FISHERY RESOURCES AND THE ECOSYSTEM, INCLUDING THE USE OF THE BIOLOGICAL AND ECOLOGICAL INDICATORS

9. The presentations for this session were divided in four parts:

Survey methodology

10. Two presentations were made under this topic. The abstracts of the presentations are given below:

- A proposal for reducing haul time in the Mediterranean experimental bottom trawl surveys (by F. Bertolino, M.L. Bianchini, S. Gancitano, G.B. Giusto, G. Sinacori, S. Ragonese)

Abstract: Experimental bottom trawl surveys (EBTSs) must cope with the exigency of good estimates precision (i.e., many short hauls) and the need of gathering representative samples. Most Mediterranean EBTSs have adopted half to one hour effective haul bottom times (EHBT), which are set by adding a depth varying lag to the time at which the winch stop occurs. However, evidences have piled up outside the Mediterranean about the ability of the gear to yield representative biological samples even in short haul times, as a consequence of the interaction of different factors. From Minilog data gathered during an EBTS carried on in the Strait of Sicily (program Grund 2005), measured EHBT were compared by depth strata (shelf, upper and middle slope) with the corresponding nominal EHBT. Results indicate a not significant departure of measured and nominal EHBT, with different patterns among strata: measured EHBT was higher (+5 min), about the same (+1 min) and lower (2.5 min) in shelf, upper and middle slope respectively. Subsequently, hauls of the deepest stratum were split in 4 classes of increasing departure; notwithstanding departures of almost 15 min in some hauls, no substantial differences were appreciated in catch rates and LFD shapes, at least when considering the red shrimps (the most abundant target species). Even within the limits of the present study, it is suggested to consider the possibility of reducing, also for the Mediterranean EBTSs, the haul time to increase the precision of surveys.

- Rapido trawl surveys for stock assessment of Solea solea and other benthic resources in the northern and central Adriatic Sea – methodological aspects (SoleMon project) (By G. Fabi, O. Giovanardi, F. Grati, I. Isajlović, S. Raicevich, A. Santojanni, G. Scarcella, N. Vrgoc)

Inside the VI National Triennal Plan for Fisheries and Aquaculture the Italian Ministry for the Agricultural and Forestry Policies (MiPAF) - D.G. for Marine Fisheries and Aquaculture - funded a 3-year coordinated project entitled "Stock assessment of Solea solea in the northern and central Adriatic Sea and evaluation of the impact of the different fishing activities".

One of the main tasks of the project was to assess distribution and biomass of *S. solea* stock and to identify spawning areas of this species in the northern and central Adriatic Sea (GSA 17) through surveys at sea.

The project started in 2004. Initially, it involved only two Italian Units – CNR, Istituto di Scienze Marine (ISMAR) Ancona (Coordinator of the project), and Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare (ICRAM) Chioggia - and was limited to the Italian and international waters but, as it was focused on a stock which is shared between the western and eastern side of the northern and central Adriatic Sea, thanks to the support of AdriaMed Project, as concerns stock assessment of sole it was extended to the national Croatian waters involving the Institute of Oceanography and Fisheries (IOF), Split, Croatia.

Materials and Methods

Two surveys at sea per year (one in spring and the other in fall) were carried out in 2005 and 2006 in the area extending from Trieste to the Pomo Pit northern limit and from the Italian coast to the Croatian one, for a total trawlable area of 44,880 km2 at depths ranging from 5 to 1156 m.

A systematic design was adopted in the first survey year to get a detailed picture of the spatial distribution of sole. It included 67 sampling sites in spring and 62 in fall placed at 15 nm from each other along horizontal transects 15 nm apart, extending from the Italian to the Croatian coast.

One haul was carried out at each sampling site towing 4 "rapido" trawls at the same time at about 5.5 knots of speed. The hauls lasted from 5 to 30 minutes, depending on the bottom type.

Rapido trawl was chosen for its higher efficiency in capturing bottom fish in respect to otter trawl net. The gears were standardized between the Operative Units and had the following technical features: 3.5 m of width; 225 kg of weight; four 120-mm wide skids and 48-mm codend mesh size (stretched). The fixed mouth of the gear and the use of DST Logic Temperature and Depth Recorders allowed to know exactly the area explored by each rapido trawl.

The following data were recorded at each haul, separately for each rapido trawl:

- weight of the total catch;
- individual length, sex, gonadic maturity stage (five-point maturity scale by Holden and Raitt, 1974) and total weight of sole specimens;
- individual length and total weight of all the other commercial species;
- total weight of discards.

Based on the observed abundance and relative variance of S. solea and other commercially important bottom species which are efficiently caught by rapido trawl, a post-stratification was applied and 3 depth strata were identified: 0-30 m; 30-50 m, and >50 m. The area delimited by the Croatian islands, sampled from fall 2005, was considered as a further stratum (stratum 4). Consequently, a random stratified sampling was adopted for the definitive surveys to be carried out in 2006, including 42 hauls in spring and 67 in fall.

Data analysis was carried out using the data bank AdriaMed Trawl Information System (ATrIS; Gramolini et al., 2005). Total mortality rate (Z) of sole was estimated through the linearized length-converted catch curve method, using the von Bertalanffy growth parameters $L\infty = 42.11$, estimated by means of the relationship $L\infty = Lmax / 0.95$ (Froese and Binohlan, 2000), $k = 0.25$ estimated by inserting the $L\infty = 42.11$ into the average $\Phi' = 2.64$ (Pauly and Munro, 1984) obtained from 12 cases relative to the Mediterranean reported by web site Fishbase, and $t0 = -1.26$ computed inserting the mentioned estimates of $L\infty$ and k in von Bertalanffy equation along with some pairs of age and length values from Froglia and Giannetti (1985, 1986). M was estimated by means of the relationship $M = 1.5 k$ (Jensen, 1996).

Analysis of SoleMon data and comparison with similar investigations made at the same time and in the same area (MEDITSa and AdriaMed Trawl Survey) showed that rapido trawl is a more efficient tool for catching some benthic species than otter trawl (especially MEDITS net (GOC)). This is clearly visible for species as *Solea solea*, Lophius budegassa, and Pecten jacobaeus. Consequently, the logical conclusion is that rapiso trawl survey should be and additional tool for assessment of demersal resources.

Indicators

11. Nine presentations were made under this topic. The abstracts of the presentations are given below:

- Hake nurseries identification in the FAO-GSA 9 using a Bayesian geostatistical approach (By G. Ardizzone, F. Colloca, G. Iona Lasinio, V. Bartolino, L. Maiorano, P. Carpentieri, A. Abella, A. Mannini, C. Viva, S. De Ranieri, G. Relini.)

Abstract: Two time series of trawl survey data (GRUND project, 1985-2003, MEDITS project, 1996-2004) have been used to identify hake nurseries off the central-western coasts of Italy (FAO GFCM-GSA9). The study area covered the continental shelf and the upper and middle slope along the Ligurian and Tyrrhenian coasts. Density data of hake recruits, as mean number of individuals per squared kilometre (n km-2), has been computed considering only fish smaller than 14 cm in total length. A 2km x 2km estimation grid was built over the whole area (7290 cells). The mean and the covariance structure was modelled respectively as a first order spatial trend and assuming an exponential variogram. In the proposed Bayesian framework we adopted the estimated surface of MEDITS (carried in late spring-early summer) for every year as prior distribution for the estimation of GRUND (carried in autumn) for the same year. This provided a better use of the information contained in the data with improved estimations of recruits abundance and distribution. The proportion of significant estimated surface increased in the time series up to 80% for GRUND and 70% for MEDITS data. The Bayesian inference, respect to the classical kriging, which do not entirely accounts for uncertainty in the estimates, provides a way to incorporate parameter uncertainty in the prediction by treating the parameters as random variables and, integrating over the parameter space, and allows obtaining the predictive distribution of any quantity of interest (see for instance Diggle and Ribeiro, 2002). Furthermore, poorly sampled years do not need to be aggregated aiming at reducing the lack of spatial information, with a sensible advantage in the predictions of recruits spatial and temporal dynamics. In order to find hake juveniles hot spots (nurseries), different approaches have been used (e.g. G statistic, Kernel). Geostatistical aggregation curves have been used to describe the biomass-dependent spatial dynamic of hake recruits. Their spatial distribution was seasonally and yearly consistent and stable despite high temporal fluctuations in density.

- Real-time indexes of demersal resources status within the Mediterranean experimental bottom trawl survey context. (by M.L. Bianchini, G. Giusto, G.D. Nardone, G. Sinacori, S. Ragonese)

Abstract: Trawls surveys are elective instruments for assessing the demersal resources status; still, they represent a snapshot of the present situation, and risk therefore of being not representative, especially in highly variable situations, such as those of the Mediterranean fisheries. Analyses based on single surveys may produce misleading impressions of the actual status of the fishery, and induce to wrong management decisions; on the other hand, a complete and detailed assessment requires long delays, with outcomes mirroring an obsolete situation, and resulting in untimely actions. Aim of this note is to suggest a compromise, using a software package (SeaTrim) developed for the Mediterranean context: first, for each target species, a quick exploratory analysis of the most recent trawl data, followed by a retrospective exam extended over not more than the real exploited phase (max 2 4 years), and concluded with a geographical meta analysis; subsequently, the overall status of multispecies fisheries, like those typical of the Mediterranean, could be treated with simple sign tests on multiple arrays of indicators. A few examples of this approach, applied to some of the most important target species of the Strait of Sicily, are presented and commented, showing the behaviour of the pertinent actual data.

- Toward the establishment of length at age references for red mullet (*Mullus barbatus*) as a hint to support growth assessment in the Mediterranean geographical sub areas (GSA) (by M.L. Bianchini, S. Gancitano, S. Ragonese)

Abstract: Length at age (LAA) data represent a basic tool for the assessment of exploited fish stocks, their use requiring the identification of the "unit stock". In the present paper, a different scenario is proposed, consisting in: a) reconstructing the historical Mediterranean data within a common frame; b) looking for spatial trends related to easy to acquire covariates (such as surface seawater temperature); and c) figuring out reference LAA to be used as an overall benchmark for analyses inside the GSAs. This approach has been evaluated using the red mullet (*Mullus barbatus*), among the most investigated stock of the whole basin, as case study. Published and grey literature was browsed, to get direct and/or indirect LAA estimations, obtaining more than 50 Mediterranean cases. To set a

common baseline and maximize the use of partial information, a vBGF was fit to LAA data whenever possible. The vBGF parameters ($L\infty$ and K) vs. longitude/SST by sex were analyzed in order to figure out trends, checking their significance with parametric and non parametric tests; problems arose in the interpretation of old references and in the "circularities" of already elaborated values. Even if present results seem to confirm the existence of a W E gradient, this trend is confused by other variables related to the different sampling and methodologies employed; in fact, the bivariate scatterplots show not significant correlations in all cases, but the K SST relationship. Finally, an overall reference growth line was estimated by sex and its plausibility to the life traits of the species considered.

- Analysis of trawl survey time series from the Ligurian and Tyrrhenian Seas (by Ligas A., Baino R., Barone M., Belcari P., Belluscio A., Criscoli A., Mannini A., Relini G., Viva C.)

Abstract: The existence of common patterns in a set of time series of data of five demersal species (*Merluccius merluccius*, *Mullus barbatus*, *Eledone cirrhosa*, *Nephrops norvegicus* and *Parapenaeus longirostris*) was investigated in the FAO-GFCM Geographic SubArea 9, including the Ligurian Sea and the northern and central Tyrrhenian Sea. The time series of density and biomass data from the MEDITS and GRU.N.D. surveys, since 1994 to 2003, were analysed using the multivariate time series analysis routine MAFA (min/max autocorrelation factor analysis). The analyses were performed to compare the time series of each species among the four Operative Unit areas in which the SubArea 9 is divided. The results showed significant differences among the four areas: each species was significantly correlated with different trends in each Operative Unit area. These observations emphasize the importance of looking at smaller spatial scales (in terms of environmental variables, fishing effort, etc.) for a more accurate management of SubArea 9.

- Medits working group "Species assemblages and biodiversity" (By Gaertner JC, J.Bertrand, A. Kalianitotis, L. Gil de Sola, N. Ungaro, P. Vidoris, M. Murenu)

Abstract: The MEDITS working group untitled "Species assemblages and biodiversity" aims to pursue and enlarge the investigations previously made in the frame of the former MEDITS Working Group dedicated to "Demersal assemblages" (Medits 2002, final report). We intend to describe and quantify spatio-temporal patterns in community organization of demersal assemblages.

The main questions addressed in this working group are:

- Which descriptors of community appear to be the most relevant for both ecological analysis and fishery management purpose?

- What are the main distributional patterns exhibited by these descriptors in the northern Mediterranean Sea?

- Which descriptors do offer complementary information on community organization? (and then which descriptors are redundant ?)

- What are the consequences for management and conservation purposes?

- Which natural and anthropogenic factors may explain the observed patterns?

Organizational patterns of assemblages are analysed through different kinds of descriptors (e.g. species composition, species diversity, total abundance, etc.). Most of the research effort is devoted to investigations conducted at large-scale spatial pattern. Both ecological and methodological contributions are welcome.

- Analysis of the elasmobranches data collected in the frame of the MEDITS project and their potential use for stock assessment and management advice (by Serena F.)

Abstract: Data on the chondrichthyan species, collected in the frame of the European Union program MEDITS, have been analysed and reported in a scientific document as indices of abundance for standardised area (km2). This preliminary paper analyses the results of the trawl surveys carried out in the whole European Mediterranean area and it is aimed at producing a global overview of species distribution and abundance in this area. Some aspects of the population size structure are also analysed. Future work foresees the analysis of the historical trend of abundance of chondrichthyan fishes caught during all Medits campaigns and the use of simple indicators and models potentially useful for stock assessment.

- Distribution mapping of elasmobranch species in the Greek seas based on the MEDITS data (by Peristeraki P., Tserpes G., Politou C-Y., Kallianiotis A. and

Papaconstantinou C.)

Abstract: Abundance distribution maps by means of “natural neighbour” algorithm (Surfer 8) for six elasmobranch species from the Greek seas were developed using MEDITS surveys data from 1994-2005. Five of the species found more abundant in the S. Aegean Sea, while the most abundant species were *Raja clavata*, *Scyliorhinus canicula* and *Squalus acanthias*.

- Usefulness of the spatial indices to define the distribution pattern of key life stages: an application on the red mullet population in the south Tyrrhenian sea (by Spedicato M.T., M. Woillez, J. Rivoirard, P. Petitgas, P. Carbonara, G. Lembo)

Abstract: This study aims to explore the performance of the approach based on spatial indicators to characterise with quantitative metrics the spatial dynamics of red mullet life stages (recruits and adults), to identify areas where red mullet recruits are more concentrated, to establish relationships with the adult distribution and to detect the ability of spatial indicators to capture the stability of the spatial occupation of preferential areas across the years. Data are from the GRU.N.D. experimental trawl surveys. The methodological approach used in this study is based on the estimate of spatial indicators as developed within the EU Fisboat project. The results proved that many of the 9 examined spatial indicators and pairwise relationships, between indicators and abundance, enabled us to better understand the spatial distribution and interannual variability of the red mullet population life stages and the relationships between spatial distribution and abundance. In addition, we identified the geographical area (southwards,- along the Calabria coast) where recruits of red mullet resulted mainly distributed and we also verified that these locations are stable across years.

- Nursery areas of hake (*Merluccius merluccius*) and deep-water rose shrimp (*Parapenaeus longirostris*) in the Central Mediterranean Sea: perspectives for fishery management (by Carlucci R., D’Onghia G. Lembo G., Maiorano P., Marano C.A., Sion L., Spedicato M.T., Ungaro N.

Abstract: The spatial pattern of nursery areas of hake and deep-water rose shrimp was studied in Southern Adriatic and Northern Ionian Sea (Central Mediterranean) using geostatistical tools and data from trawl surveys time series conducted in the area. The analysed variables were: R (number of recruits/km2) and R/Tot (fraction of recruits on the total sampled population). The structural analysis showed a spatial pattern of both variables characterized by continuity at a small scale level. Predictions of nursery areas localization with probability of finding recruits at different threshold values were obtained through median indicator kriging. The main concentration of hake juveniles were estimated within 100-200 m depth along the Gargano peninsula and in the Otranto Channel, where the nursery of deep-water rose shrimp was mainly localised. A depth overlapping, between 100 and 200 m, was identified for hake and deep-water rose shrimp nurseries. Protection of these areas through limitations of fishing pressure is discussed.

The use of trawl survey data in the ICES region for assessment

12. One presentation was given under this topic. The whole document is reported in Appendix 4, while the abstract is given below.

- The use of trawl survey data in the ICES region for assessment purposes (by M. Armstrong)

Abstract: This presentation gives an overview of the use of trawl surveys in stock assessments carried out by the ICES scientific community. Aspects of survey design and survey standardisation/inter-vessel calibration are covered. The primary use for the surveys is to provide time-series data on abundance and distribution by size or age, and the main use is in the “tuning” of different types of sequential population analysis (SPA). Survey-only models are also widely used for providing fishery-independent trends in stock abundance, and for investigating the quality of the survey data. North Sea haddock is given as an example of both approaches. An important issue for many catch-based assessments is dealing with bias due to apparent trends in survey catchability. The trends may be due to problems with the fishery data, or to actual changes in catchability. Some assessments of European cod stocks use survey data to estimate unaccounted-for removals, for example due to misreported or discarded catch. Surveys are also widely used for providing data on biological parameters of stocks, and increasingly for providing information in support of ecosystem approaches to fishery management.

Linkage between trawl surveys and indirect assessment methods

13. Three presentations were given under this topic. The abstracts of the presentations are listed below:

- ALADYM (Age-Length Based Dynamic Model): a stochastic simulation tool to predict population dynamics and management scenarios using fishery-independent information (by Lembo G., S. Martino, A.J. Abella, F. Fiorentino and M.T. Spedicato)

Abstract: ALADYM (Age-Length Based Dynamic Model) is an age-length based simulation model designed to predict, through simulations, the consequences of management scenarios on a single population, in terms of different metrics and indicators. Removals are simulated on the basis of the total mortality rate modulated using selectivity pattern and a fishing activity coefficient. Aladym can work in absence of fishery-dependent data and is composed of two complementary tools: the quasi-deterministic dynamic tool defined as Aladym-r and the stochastic dynamic tool defined as Aladym-q. The latter adds to the same mathematical formulations of the former the capability to deal with the stochastic representation, modelling the uncertainty of estimates related to recruitment, growth and maturity through stochastic processes (user selected pdfs). This make the model more suitable for estimating the probability associated to predicted metrics, indicators and reference points. A case study on the red mullet population of the GSA 10 is discussed.

- Direct Survival Analisys: Its Application to Trawl Surveys (by Ferrandis, E.)

Abstract: The starting point is the correspondence between the concepts of Mortality, Survival and Lifetime Distribution. This is the corner stone of the possibilities that Survival Analysis Techniques open to Marine Population Dynamics.

The classical Marine Population Dynamics is based on deterministic models which try to estimate the mortality rates. In the present approach, the objective is to consider the stock and catch as stochastic processes whose distributions depend on the survival, to estimate the empirical survival function and built an adequate model for it.

Chiang (Chiang, 1960) and Ferrandis (Ferrandis, 2007) provide concrete different structured models for the stock evolution as a Markovian process.

The suitable approximation of these processes by means of Gaussian processes, can allow the application of the theoretical and computational multivariate Gaussian analysis to the probabilistic treatment of fisheries issues. As a consequence, the necessary "Catch Equation" appears as a stochastic integral with respect to the mentioned Markovian process of the stock. The solution of this catch equation is available when the mortalities are proportional. Hence, the use of the Cox (Cox, 1959) important body techniques of "Proportional Hazards". The assumption of these proportional mortalities leads in a natural way to build a survival model based on the Weibull distribution for the population lifetime. Finally, this Weibull survival model is elaborated in order to obtain some reference parameters useful for management purposes. We focus our work in two directions. Firstly, the adaptation to the proposed Weibull model of the main usual reference parameters has been elaborated. This is the case of the Biomass per Recruit and the Yield per Recruit that generate some of the important reference points used for management purposes, such as the FMSY, F0.1, Fmed. They also provide important and useful concepts as the Virgin Biomass or the Over exploitation Growth. On the other hand, we have analysed some indices broadly used in all population dynamics (including human populations) but marginally treated in fishery science. This is the case of Life Expectancy, Mean Residual Lifetime and Median Survival Time. These parameters are redundant with mortality rates in the classical exponential model, but are not so trivial in a more general framework.

As an example, the application of this approach to trawl survey data analysis is presented. The data must be structured in a "cohort and catch per unit effort concept". This material provides the estimation of the empirical conditional survival and to built an adequate model for the survival function. The considered model allows:

- The likelihood estimation of the survival parameters (hence of mortality)
- The analysis of the evolution of the stock in the period
- The use of reference parameters used in management adapted to the proposed models.
- The integration of commercial landing data as well as selectivity studies in order to improve the considered models and their applications.
- The comparison among different geographical areas (mainly neighbours) and cohorts along a period through their corresponding specific survivals.

- The use of robust parameters of general application in population dynamics such as the "Life Expectancy", as an integral of the survival.

- Application of a non-equilibrium surplus production model assessment using MEDITS data (by Tserpes G., Haralabous J. and Maravelias C.)

Abstract: Biomass and MSY estimates for the hake stocks in the Greek seas were obtained from a non-equilibrium surplus model approach utilizing CPUE time series derived from the MEDITS surveys and fishery production data. The model was developed in the freely available R-language and the results demonstrated the existence of fisheries over-exploitation.

- Permanent control of the state of trawl fisheries started in 1997 (By Djurovic M.)

Abstract: Estimated population dynamics parameters of important species: Pandora, *Pagellus erythrinus*, Red Mullet, *Mullus barbatus*, Hake, *Merluccius merluccius*, Pink shrimp, *Parapaeneus longirostris*. Estimated total biomass of economical important demersal resources on the shelf area (hake, red mullet, red pandora, squid, octopus, pink shrimp) was about 2 700 tons.. Estimated MSY of demersal resources was 600 tons per year. Estimated average catch per unit effort (CPUE) of demersal resources last four years was about 19.47 kg/h. In October 2004 and February 2007 in frame of FAO Adriamed Project has been performed AdriMed trawl survey (MEDITS protocol) in Montenegrin territorial and adjacent waters. In 1997 CPUE has fallen to 20 kg/h and for the last few years this value did not change. This indicates that some kind of the state of equilibrium was reached between fishing effort and resources.

Conclusions from the Session 2

14. The main conclusions from the discussion following the presentations are summarized below:

- It has been noted that analyses of time series data trends derived from surveys, other than of MEDITS, are also performed.
- Since the first MEDITS surveys covered only those species listed in the primary and secondary list of the sampling manual, it has been pointed out that the consistency of data should be checked when analyzing spatio-temporal variations for those species not included in any of the above-mentioned MEDITS lists.
- Assessment studies should be supported besides the MEDITS data with all the data available such as the fishing effort or commercial catch data.
- The use of trawl surveys data in tuning the application of analytical models for stock assessment was stressed.
- It was noted that in the Mediterranean region the data for defining nursery areas of hake already exist and this should be taken into account for recommending closed areas when needed.
- The experience achieved in the ICES region by the trawl surveys should encourage Mediterranean scientists to engage in common activities on assessment studies.

SESSION 3. APPLICATION TEST FOR SURPLUS PRODUCTION MODELS

15. The aim of this session was to test an application of surplus production models with the data brought by the participants. The application was made during the meeting with a tool at the participants' disposal. The methods and the information to be brought by the participants are described in a document made available on the GFCM website before the workshop. Mr Alvaro Abella was the moderator for this application test.

16. Mr Abella presented two approaches for the use of trawl surveys data in applying surplus production models. The abstract of his presentation is given below:

- The utilization of trawl surveys data for stock assessment purposes using two variants of surplus production models

Abstract: In this contribution two approaches based on surplus production models are presented. These approaches can be utilized for an assessment of the status of demersal stocks. Used data may proceed exclusively from trawl surveys. Necessary information regards size structure of the population at sea and an index of abundance. The first approach use spatial information of mortality rates and abundance indices proceeding from ecologically similar sub-areas which are exploited at different rates; in the second approach, couples of Z and a biomass index are used in order to fit a non-equilibrium production model approach and for the estimation of the parameters of the logistic population growth model.

Conclusions of the application test

17. Due to non proper elaboration of participants data, as initially had been requested by the application test moderator and also to some technical constraints beyond the moderator's control, the time left for the true analyses proved very limited to reach all the expected objectives. Thus, the participants experienced only one approach, that of equilibrium assumption. Since this exercise was qualified as very helpful, it was suggested to continue this work in the future.

GENERAL CONCLUSIONS FROM THE WORKSHOP

- The high attendance (76 participants) to the first GFCM workshop on trawl surveys reflected the interest of the scientific community to this topic.
- The existence of several survey data series in the Mediterranean was noted. Among them MEDITS is the most extended, including 10 countries. However AdriaMed, Grund or other surveys at local level should be also emphasized.
- The Workshop on Trawl Survey Based Monitoring System recognized the existence of many though different protocol trawl surveys operating in the area of Mediterranean. Besides the use of trawl surveys data to biological indicators and demographic population structure, various approaches were presented for the use of trawl surveys data in estimating the state of stocks, mainly by the application of surplus production models. The need for a common protocol for all member countries to follow was stressed, while the determination of certain approaches for stock assessment applied first locally then globally was considered a major task. Thus, the following recommendations were proposed:

  → Establishment of a permanent working group, under the GCFM/SAC umbrella, with the general objective to promote the use of the surveys data for stock assessment and management purposes[1] including for EAF needs. In particular this group shall:

[1] Parag. 74 of the ninth session of SAC report

- Identify the data requirements from the surveys at sea, examine any data deficiencies, look for research needs and finally search for appropriate ways in addressing them.
- Set a common framework for the harmonization of protocols and approaches, planning and quality control of demersal and pelagic surveys in the Mediterranean. The new GFCM protocol regarding trawl survey in particular should take into consideration the MEDITS experience.
- Facilitate data and information exchange.
- Perform analyses and interpretation of the data obtained from surveys at regional and GSA level, in connection with the Sub-Committee for Stock Assessment (SCSA)

The above draft terms of reference will be further elaborated during the next SCSA in order to be then forwarded to the forthcoming SAC session for adoption.

ADOPTION OF THE REPORT

18. The report was adopted on March 28, 2007.

Appendix 1

Agenda

1. Opening and arrangement of the meeting

2. Session 1: Status of knowledge on trawl survey undertaken in the GFCM area

- Inventory of trawl surveys performed in the Mediterranean Sea
  - Bottom trawl surveys
  - Other bottom surveys

- Conclusions/recommendations for the session 1

3. Session 2: Methodologies for trawl survey data used to assess fishery resources and the ecosystem, including the use of the biological and ecological indicators

- Survey methodology
- Indicators
- The use of trawl survey data in the ICES region for assessment.
- Linkage between trawl surveys and indirect assessment methods
- Conclusions/recommendations from the review of methodology

4. Session 3: Application test

- The utilization of trawl surveys data for stock assessment purposes using two variants of surplus production models
- Conclusions of the application test

5. Session 4: General conclusions

6. Adoption of the report

Terms of reference

- Inventory of methods used to carry out bottom surveys in the Mediterranean
- Pooling of concepts, methods and tools used to analyse trawl surveys data
- Elaboration of population and community indicators from standardized bottom surveys
- The use of trawl surveys data for the assessment and management of fishery resources and ecosystems

Appendix 2

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Appendix 3

INVENTORY OF BOTTOM TRAWL SURVEYS PERFORMED IN THE MEDITERRANEAN SEA

COUNTRY: Italy
GSA: GSA 17

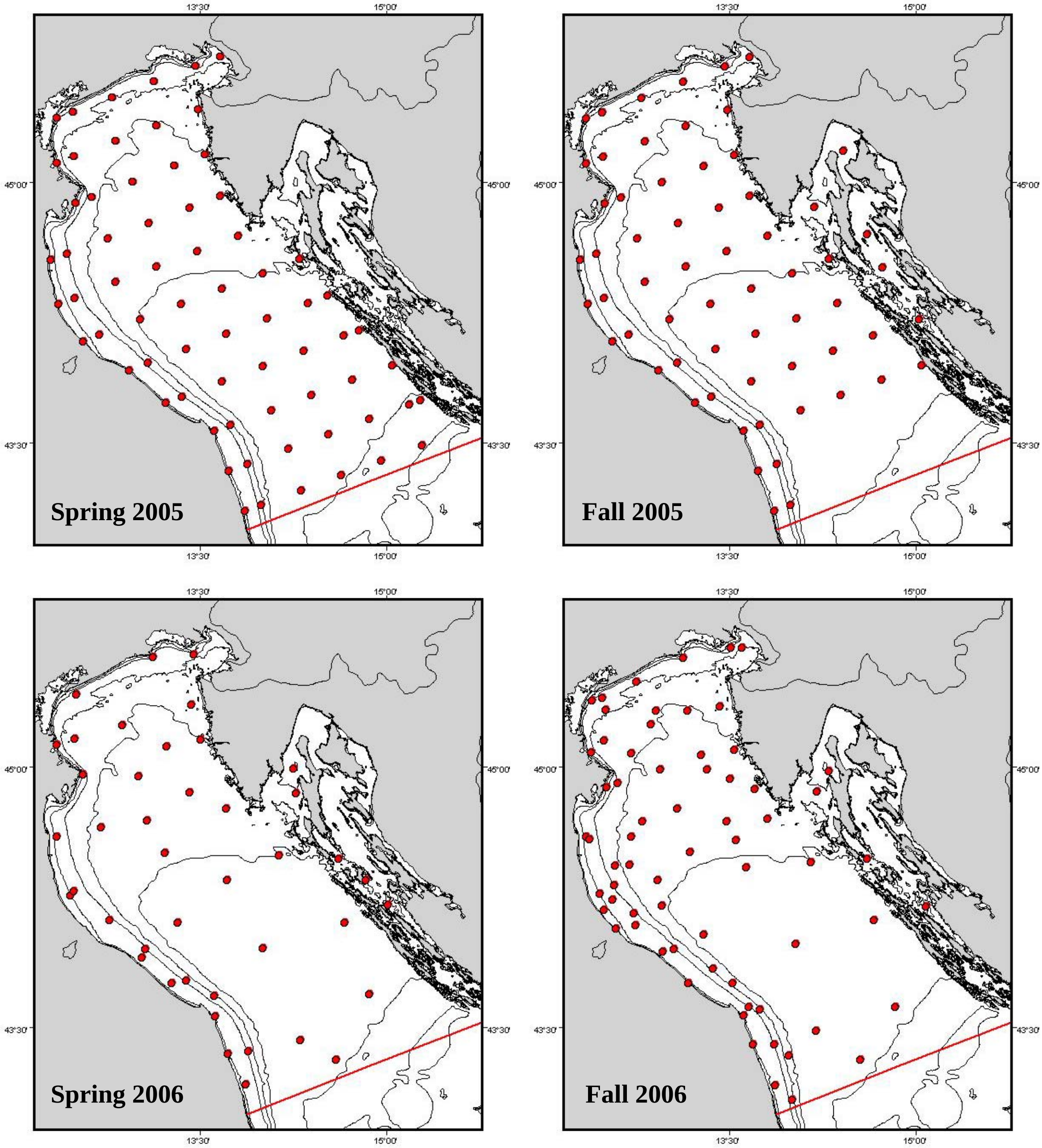
Overview of the survey

Survey title	*Stock assessment of Solea solea in the Central and Northern Adriatic Sea*	Survey code	*SOLEMON*

Country	*Italy - Croatia*	Institute in charge	*CNR-ISMAR Ancona (Italy)* *ICRAM Chioggia (Italy)* *IOF Split (Croatia)*
Area	GFCM GSA No 17	Period	*Spring 05, Fall 05, Spring 06, Fall 06*

Main objective	**General objectives of the survey. Types of information collected during the survey**
Complementary objective	*Stock assessment and spatial distribution of other benthic species, such as other flat fish (S. rhombus, P.maxima, C. linguatula, P. flesus, A. laterna, A. thori, etc.), Sepia officinalis, Chelidonichthys lucernus, Pecten jacobaeus, etc.*
Gear details	Rapido trawls made of an iron frame provided with 5. The rapido trawls were standardized between the Operative Units. They were 3.5 m wide, weighed 225 kg each one and had a 48-mm codend mesh size (stretched). The towing speed during surveys was 5.5 knots.
Area	*Central and Northern Adriatic Sea (southern limit: the northern limit of the Pomo Pit)* *Depht ranges:* - *spring 2005: 6.1(min) – 156.2 (max)* - *fall 2005: 4.6 (min) – 80.4 (max)* - *spring 2006: 5.8 (min) – 94.6 (max)* - *fall 2006: 6.8 (min) – 95.0 (max)*
Sampling design	*Spring 2005: systematic sampling (67 sampling stations)* *Fall 2005: systematic sampling (62 sampling stations)* *Spring 2006: random stratified* sampling (42 sampling stations)* *Fall 2006: random stratified* sampling (67 sampling stations)* ** = 4 strata were identified:1) 0-30 m depth; 2) 30-50 m; 3) >50 m; 4) channels among Croatians Islands.*
Species recorded	*- all fish, all cephalopods, crustaceans of commercial interest, Pecten jacobaeus, Aequipecten opercularis, Chlamys glabra,* *-subsamples of discard (species included in the subsamples were determined at the lowest taxonomic level)*
Data management	*Database AdriaMed Trawl Information System (ATrIS)*
Quality control	*The surveys were carried out simultaneously by two Operative Units (O.U. 1 operated from the northern limit of the Pomo Pit to the mouth of Po River and O.U. 2 at north of the mouth of Po River) using the same gears and the same towing speed (5.5 knots). A DST Logic Temperature and Depth Recorder collecting depth and temperature at 1- min. intervals was installed on each rapido trawl. Use of these recorders and fixed mouth of the gear allowed to know exactly the area explored by each rapido trawl.*

Position of hauls



Overview of the series

Period	Vessels O.U. 1 – O.U. 2	Type of vessel (R/V or C/V)	Gear	No. Tows planned	No. Valid hauls	Comments
23-05-05 / 02-06-05	Midway – E. Tanfa	C/V	Rapido trawls	68	67	4 rapido trawls towed at each haul
26-10-05 / 10-11-05	Midway – E. Tanfa	C/V	Rapido trawls	62	62	4 rapido trawls towed at each haul
14-16-06 / 24-06-06	Joacchì – E. Tanfa	C/V	Rapido trawls	42	42	4 rapido trawls towed at each haul
26-10-06 / 10-11-06	Joacchì – E. Tanfa	C/V	Rapido trawls	67	67	4 rapido trawls towed at each haul

COUNTRY: Italy

GSA: GSA 11

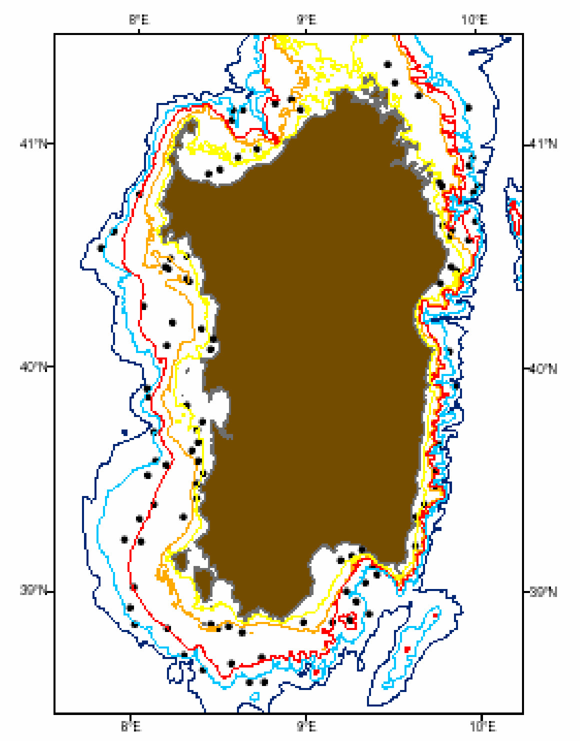
Overview of the survey

Survey title	*Mediterranean International Trawl Survey*	Survey code	*MEDITS*

Country	ITALY	Institute in charge	DBAE-UNICA
Area	GFCM GSA N 11o	Period	*Season of the survey*

Main objective	**General objectives of the survey. Types of information collected during the survey**
Complementary objective	*Possible additional work*
Gear details	Describe the gear. If possible, add a plan of the sampling gear and its rigging
Area	*Describe in detail the area, including minimum and maximum depth*
Sampling design	*Describe the number of hauls and the method used to select the sampling locations*
Species recorded	*Indicate the number and main groups of species recorded (e.g. all fish, crustaceans, etc.)*
Data management	*Describe the data storage method*
Quality control	*Indicate the types of quality control applied to the survey (on protocol application, gear design, data, etc.)*

Position of hauls (Medits 2006)



Overview of the series

Period	Vessel	Type of vessel (R/V or C/V)	Gear	No. Tows planned	No. Valid hauls	Comments
June-August 1994	Nuovo Splendore	C/V	GOC73	123	118	
May-July 1995	Nuovo Splendore	C/V	GOC73	123	107	
June-August 1996	Nuovo Splendore	C/V	GOC73	123	125	
June-August 1997	Nuovo Splendore	C/V	GOC73	123	126	
May-July 1998	Nuovo Splendore	C/V	GOC73	123	123	
May-July 1999	Nuovo Splendore	C/V	GOC73	123	123	
May-July 2000	Nuovo Splendore	C/V	GOC73	123	121	
June-July 2001	Nuovo Splendore	C/V	GOC73	123	122	
July-August 2002	Nuovo Splendore	C/V	GOC73	99	99	
June-July 2003	Nuovo Splendore II	C/V	GOC73	99	99	
June-July 2004	Gisella	C/V	GOC73	99	95	
June-July 2005	Gisella	C/V	GOC73	99	97	
June-July 2006	Gisella	C/V	GOC73	99	98	

COUNTRY: Morocco
GSA: 3

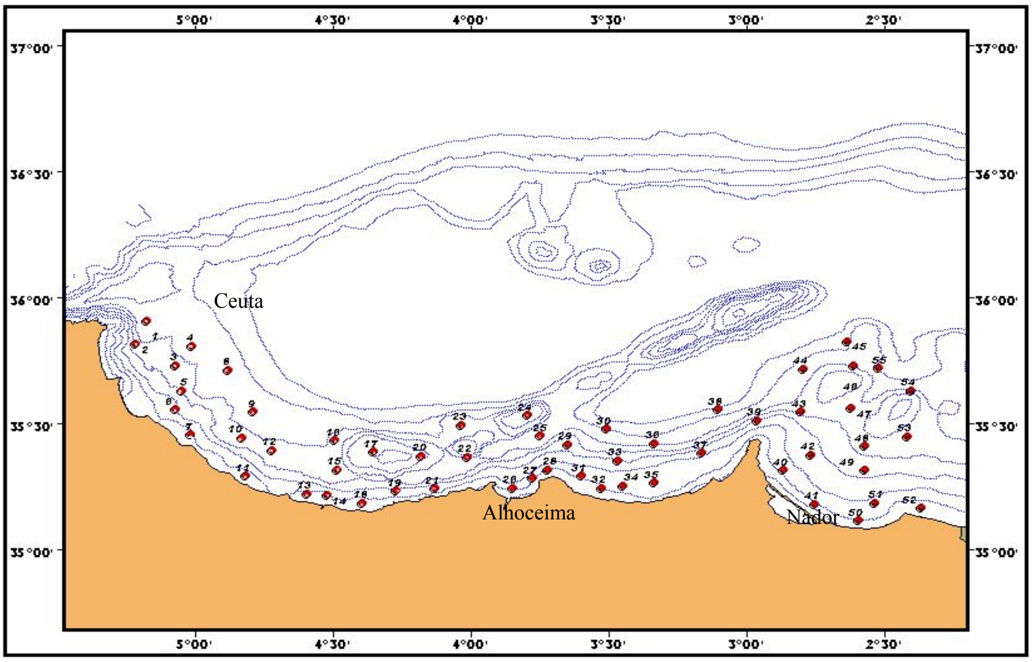
Survey title	Prospection par chalutage de fond des ressources demersales de la Méditerranée marocaine	**Survey code**	MED1206

Country	Maroc	**Institute in charge**	Institut National de Recherche Halieutique
Area	3	**Period**	Du 09/12/2006 au 16/12/2006

Main objective	Les objectifs de la campagne sont (i) l'estimation des indices d'abondance des principales ressources exploitées dans la région ; (ii) la détermination de la répartition spatiale de ces ressources ; (iii) l'étude des compositions démographiques et le suivi des paramètres biologiques pour les principales espèces. Pour chaque trait de chalut, des données techniques sont collectées comme les positions géographiques de filage et de virage, l'heure et la durée de pêche, le cap, la vitesse de chalutage, la longueur de câble largué, etc. La vitesse de chalutage est fixée à 3 nœuds. Les captures sont triées, pesées et comptées par espèce et par trait de chalut. Le comptage est soit total pour des captures faibles ou estimé à partir du poids de 50 individus quand les captures sont trop abondantes. Les mensurations en tailles sont prises au cm inférieur de la longueur totale pour les poissons. Pour les mollusques, c'est la longueur de manteau qui est prélevée au mm. La longueur céphalothoracique est prélevée pour la crevette rose.
Gear details	L'engin de pêche utilisé est un chalut du fond de conception locale dénommé le chalut à crevette dont la longueur totale est de 57 m et le cul est de 20 mm de maillage (voir shéma en annexe).
Area	La prospection par chalutage de fond a concerné la partie de la mer d'Alboran adjacente à la côte marocaine qui s'étend de Saidia à l'Est jusqu'à Ceuta à l'Ouest. Cette zone, étalée sur environ 512 km, présente un certain nombre d'irrégularités liées à la morphologie de la côte et à la bathymétrie. Les fonds sont à dominance vaseuse. Le long de la côte, l'aspect du plateau continental se modifie sensiblement. Il est plus étroit à l'Ouest d'Al Hoceima et relativement peu étendu à l'Est. En effet, à l'Ouest d'Al-Hoceima, l'isobathe de 300 m se trouve généralement à 6 miles de la côte. Au delà de cette profondeur, la pente a tendance à s'adoucir, la ligne de 800 m est située à 28 miles de la côtes. A l'Est d'Al-Hoceima,

	l'isobathe de 300 m se situe à 20 miles et la ligne de 800 m se trouve à 56 miles. Du fait de sa proximité du détroit de Gibraltar, cette zone est caractérisée par un hydrodynamisme particulier dû au contact avec les eaux de l'océan Atlantique : l'eau de la Méditerranée, chaude et salée, sort en profondeur, alors que l'eau de l'Atlantique, froide et moins salée, entre en surface. Lors de son parcours dans la mer d'Alboran, le jet d'eau Atlantique provoque deux tourbillons anticycloniques.
Sampling design	Au total, 53 stations de chalutage ont été réalisées de la côte (21 m) jusqu'à 675 m de profondeur. Les traits du chalut sont réalisés uniquement durant le jour pour une durée fixée à 30 min pour les stations situées dans des profondeurs qui sont inférieurs à 200 m et 1 heure pour les stations qui sont au delà de 200 m. Les prospections ont été réalisées par le navire de recherche de l'INRH « Charif Al Idrissi ». Elles ont été effectuées selon un réseau d'échantillonnage composé de 55 stations préalablement choisies et repérées au moyen d'un GPS différentiel à bord du bateau. Le choix des positions des stations de chalutage s'est fait aléatoirement pour chaque strate de profondeur.
Species recorded	Au total, 112 espèces ont été répertoriées durant cette campagne dont 83 poissons, 11 crustacés et 11 céphalopodes.
Data management	Au laboratoire humide, les données collectées sont enregistrées sur des fiches préparées spécialement pour cet usage. Ces données sont saisie, ultérieurement sur outil informatique sous format access.
Quality control	Une fois les données collectées sont saisie sur support informatique, une vérification se fait par une autre personne pour courriger les fautes evetuelle de saisie.

Position of hauls

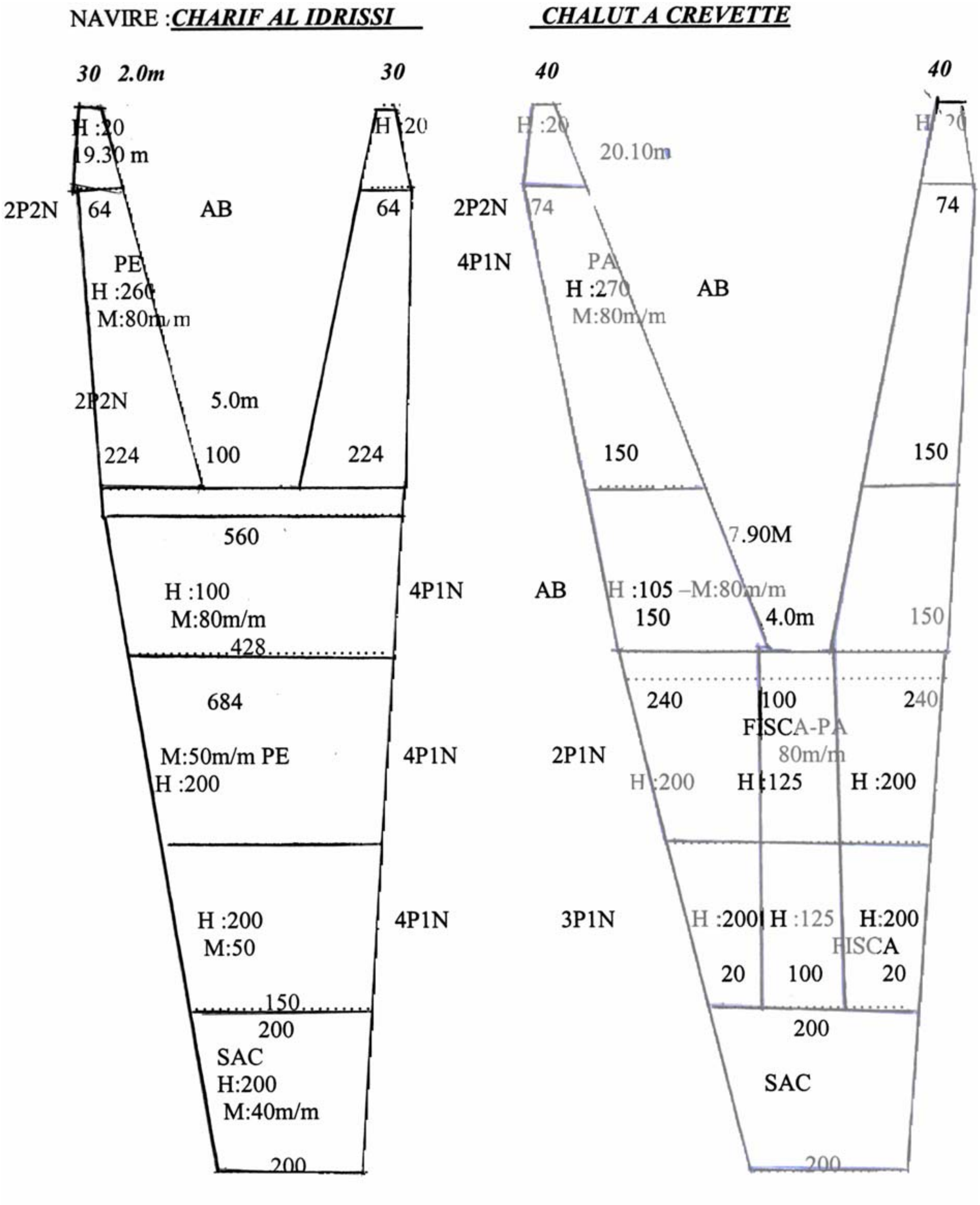


Réseau d'échantillonnage dans la zone comprise entre Saidia et Ceuta

Overview of the series

Period	Vessel	Type of vessel (R/V or C/V)	Gear	No. Tows planned	No. Valid hauls	Comments
Du 09/12/2006 au 16/12/2006	CHARIF ALIDRISSI	Navire de recherche	Chalut à crevette	55	53	Deux stations ont été annulées à cause de déchirures du chalut ou de l'envasement des panneaux.
Du 19/03/2006 au 29/03/2006	CHARIF ALIDRISSI	Navire de recherche	Chalut à crevette	55	53	Deux stations ont été annulées à cause de déchirures du chalut.

Annexe I : Schéma de Chalut à crevette

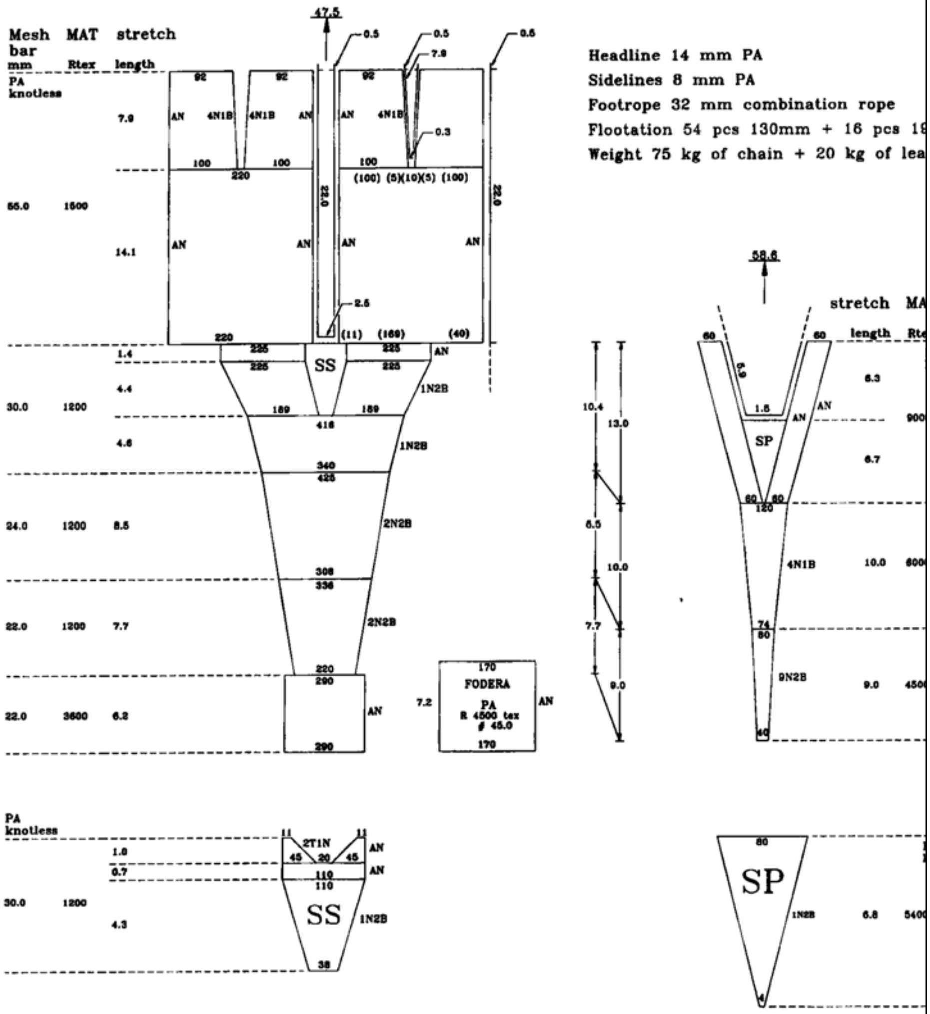


COUNTRY: Montenegro
GSA: GSA 18

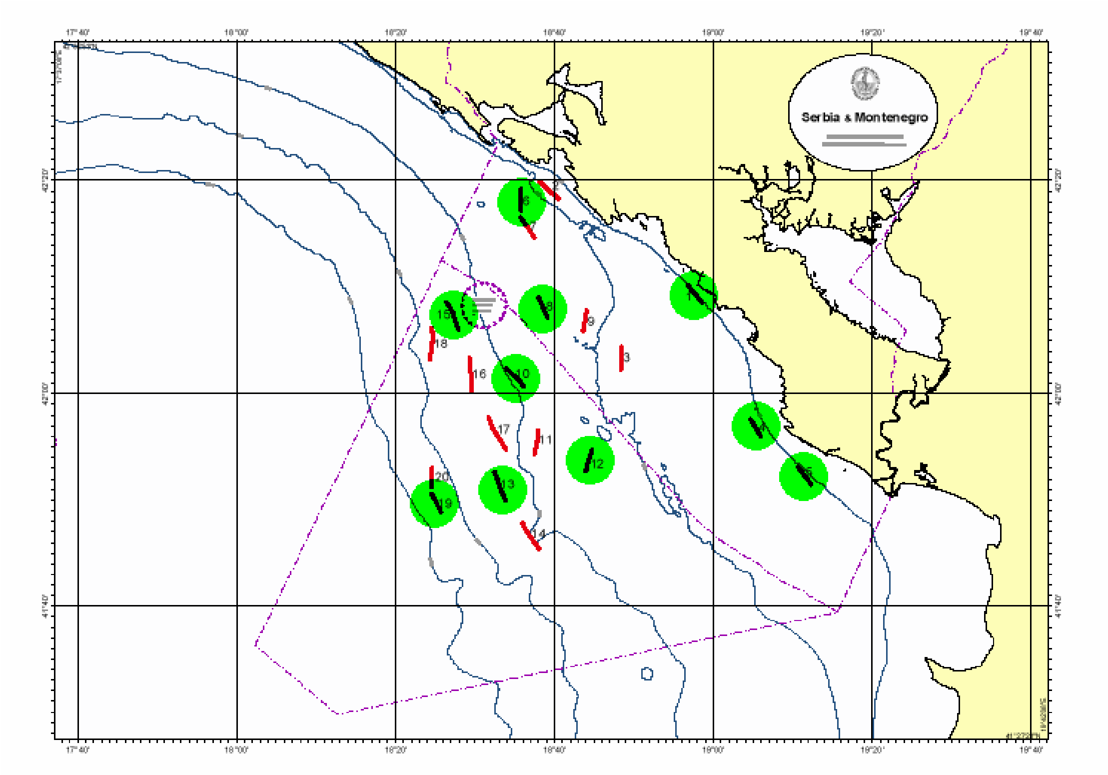
Survey title	*AdriaMed Montenegro Trawls Survey*	MONT	

Country	Montenegro	Institute in charge	Institute of Marine Biology-Kotor
Area	GFCM GSA 18	Period Feb.24-25.	*Winter 2007*

Main objective	**Monitoring of demersal resources. quantitative and qualitative data of relative and absolute target species abundance as well as with additional, biological indicators that might be utilized by fishery biologists, national administrations (managers) and finally fishermen for a better and successful national and regional policy to determine target species relative and absolute abundance in time and space and to each other their vulnerability to the sampling gear; where it was possible to establish approximations of the magnitude of important, or potentially important commercial species together with estimates of the physical yields that these resources might provide mankind; target species population dynamics parameters, such as: mortality rates and cod-end selection characteristics were analysed as well as biological properties, such as: gonads maturity stages, thus species spawning time and potential nursery grounds;**
Complementary objective	

<table>
<tr><td>Gear details</td><td>
</td></tr>
<tr><td>Area</td><td>Monenegrin territorial waters (2 173 km^2) and epicontinental waters (3 885 km^2),. Total surveyed area is 5 000 km^2</td></tr>
<tr><td>Sampling design</td><td>Sampling scheme on different strata with indications (within each area and depth stratum) of trawable surface area (km^2) with number of fixed stations in brackets.
<table>
<tr><td>10-50m</td><td>50-100m</td><td>100-200m</td><td>200-500m</td><td>500-800m</td><td>Total</td></tr>
<tr><td>280 km^2 (1)</td><td>1100 km^2 (2)</td><td>1700 km^2 (4)</td><td>1150km^2 (2)</td><td>770 km^2 (1)</td><td>5000 km^2(10)</td></tr>
</table></td></tr>
<tr><td>Species recorded</td><td>Data processing is still in progress</td></tr>
<tr><td>Data management</td><td>We used AdriaMed ATRiS software</td></tr>
<tr><td>Quality control</td><td></td></tr>
</table>

Position of hauls



Note: green coloure is valid hauls in 2007

Overview of the series.

Period	Vessel	Type of vessel (R/V or C/V)	Gear	No. Tows planned	No. Valid hauls	Comments
February 24-25 2007	Pasquale e Cristina	C/V	Tartana	20	10	

COUNTRY: Serbia and Montenegro

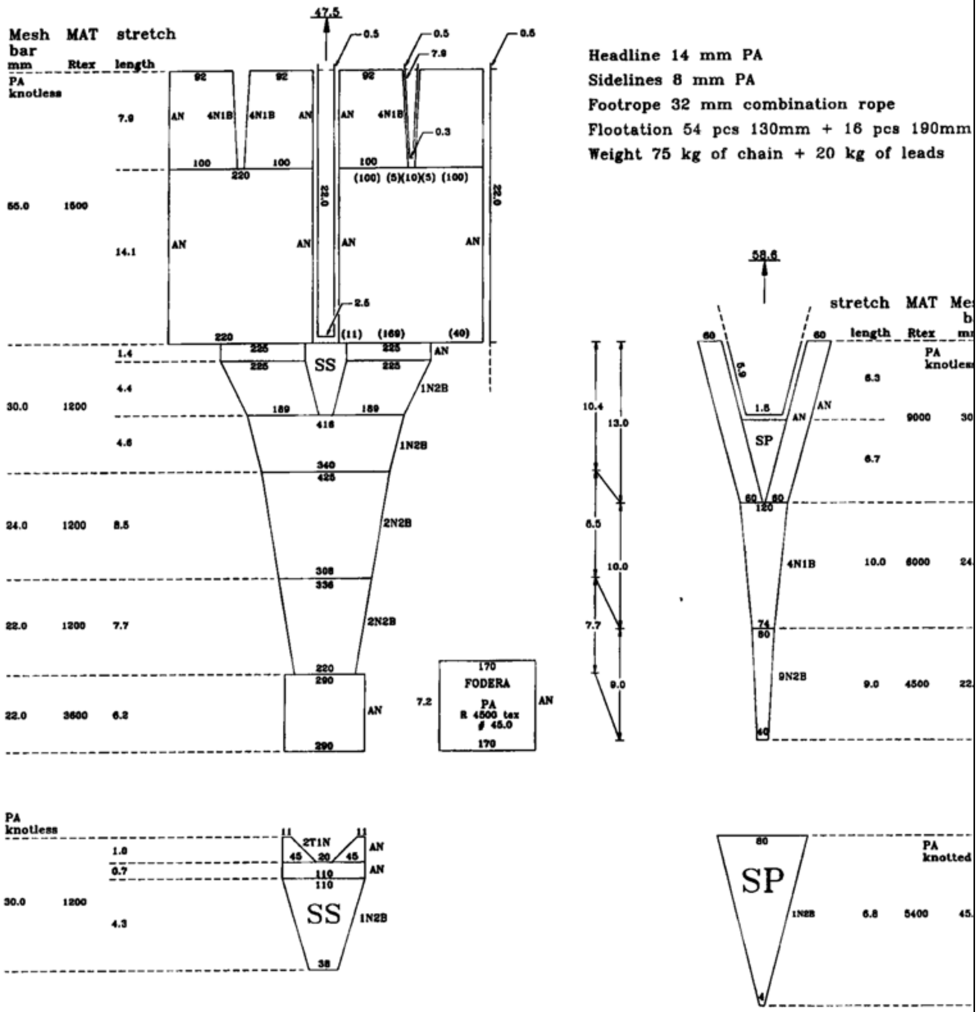
GSA: GSA 18

Overview of the survey

Survey title	*AdriaMed Serbia and Montenegro Trawls Survey*	SCG	

Country	Serbia and Montenegro	Institute in charge	Institute of Marine Biology-Kotor
Area	GFCM GSA 18	Period Oct.2-4.	*Autumn 2004*

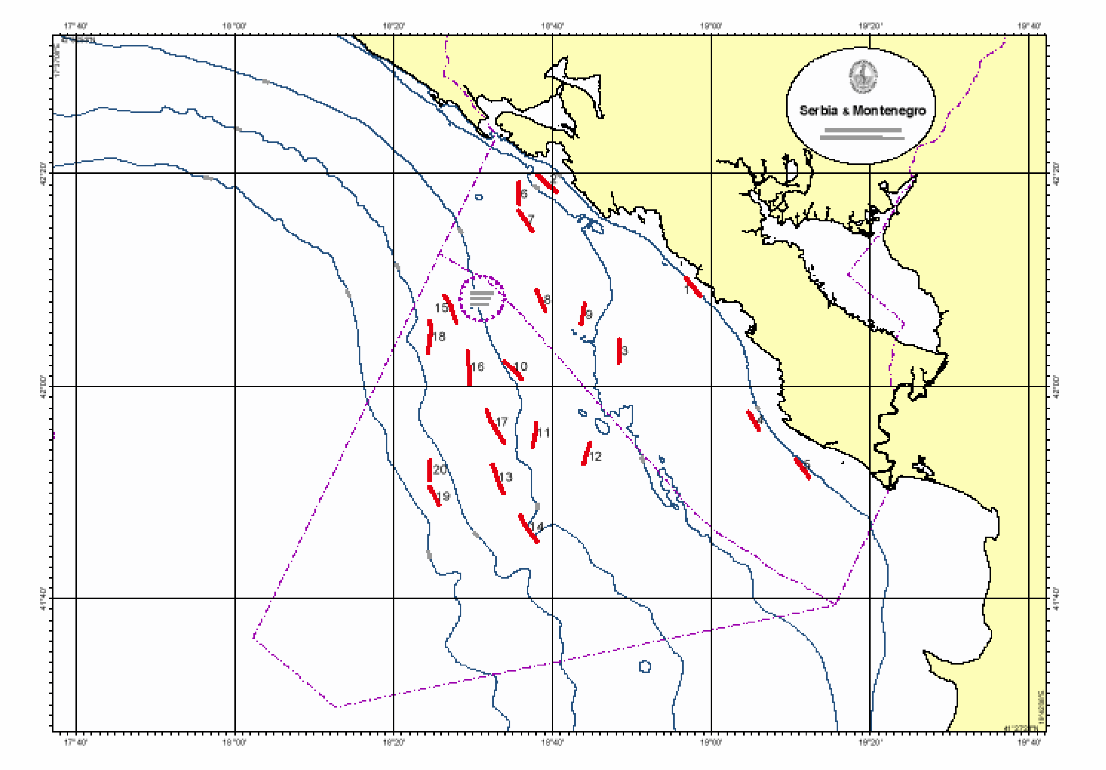
Main objective	**Monitoring of demersal resources. quantitative and qualitative data of relative and absolute target species abundance as well as with additional, biological indicators that might be utilized by fishery biologists, national administrations (managers) and finally fishermen for a better and successful national and regional policy to determine target species relative and absolute abundance in time and space and to each other their vulnerability to the sampling gear; where it was possible to establish approximations of the magnitude of important, or potentially important commercial species together with estimates of the physical yields that these resources might provide mankind; target species population dynamics parameters, such as: mortality rates and cod-end selection characteristics were analysed as well as biological properties, such as: gonads maturity stages, thus species spawning time and potential nursery grounds;**
Complementary objective	

<table>
<tr><td>Gear details</td><td>
</td></tr>
<tr><td>Area</td><td>Monenegrin territorial waters (2 173 km^2) and epicontinental waters (3 885 km^2),. Total surveyed area is 5 000 km^2</td></tr>
<tr><td>Sampling design</td><td>Sampling scheme on different strata with indications (within each area and depth stratum) of trawable surface area (km^2) with number of fixed stations in brackets.

<table>
<tr><td>10-50m</td><td>50-100m</td><td>100-200m</td><td>200-500m</td><td>500-800m</td><td>Total</td></tr>
<tr><td>280 (1)</td><td>1100 (4)</td><td>1700 (7)</td><td>1150 (6)</td><td>770 (2)</td><td>5000 (20)</td></tr>
</table></td></tr>
<tr><td>Species recorded</td><td>Total number of demersal, semi-demersal, and semi-pelagic species which belong to the groups A (Fish), B (Crustaceans) C (Cephalopods) D (Others marketable), collected during AdriaMed 2004 trawl survey was 113. Number of species from the group E (Others not marketable), mostly invertebrates was 47. Thus total number of species couth was 160.
Fish species prevailed with 76% of abundance, and 51.2% in density. Teleosts, 66 species made 65.6 % in abundance and 49.1% in density.
Elasmobranchia were represented with 17 species, with the percentages of abundance and density 12% and 2.1%, respectively.
Cephalopods, 20 species, were represented 11% in abundance and 17% in density.
Crustacea, 10 species, made 9.2% in abundance and 29.6% in density.</td></tr>
</table>

Data management	*We used AdriaMed ATRiS software*
Quality control	

Position of hauls



Overview of the series

Period	Vessel	Type of vessel (R/V or C/V)	Gear	No. Tows planned	No. Valid hauls	Comments
October 2-4 2004	**Pasquale e Cristina**	**C/V**	**Tartana**	**20**	**20**	

COUNTRY: Albania, Croatia, Cyprus, France, Greece, Italy, Malta, Montenegro, Morocco, Slovenia, Spain

GSA: GSAs 1, 3, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 22, 23, 25

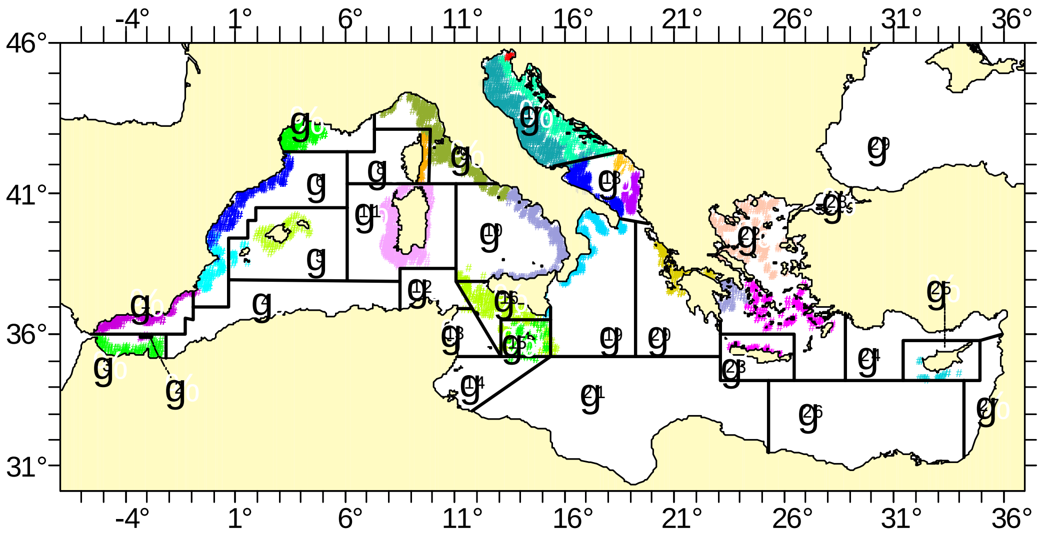
Overview of the survey

Survey title	*International bottom trawl survey in the Mediterranean*	Survey code	*MEDITS*

Country	Albania, Croatia, Cyprus, France, Greece, Italy, Malta, Montenegro, Morocco, Slovenia, Spain	Institute in charge	*Various*
Area	GFCM GSA Nos: 1, 3, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 22, 23, 25	Period	*centred on June (May to July)*

Main objective	***Monitoring of the demersal resources in the Mediterranean. Produce relevant data to support the fishery policy. Abundance indices of all the species of macrofauna collected (fish, crustaceans and cephalopods). Biological parameters for about 40 of these species.***
Complementary objective	
Gear details	The sampling gear is a bottom trawl made of four panels. The drawing of this trawl (IFREMER reference GOC 73) given in annex includes all the devices from the doors to the codend. This gear was calculated to be operated by a vessel with a towing power of at least 368 kW (500 ch) and 4.5 tons of bollard pull.
Area	*The survey is carried out in all the trawlable areas along the coasts of the partner countries, from 10 to 800 meters depth.*
Sampling design	The hauls are positioned following a depth stratified sampling scheme with random drawing of the positions within each stratum. The number of positions in each stratum is proportional to the surface of these strata. Except in the case of peculiar problems (damages noted in previous years, etc.), the hauls are made in the same position from year to year. The decision to make a haul in a given place should not be influenced by the presence of fish shoal eventually detected with the sounder or the sonar. *The following depths are fixed in all areas as strata limits : 10 - 50 m, 50 - 100 m, 100 - 200 m, 200 - 500 m, 500 - 800 m.*
Species recorded	*A census of all the fish, cephalopods and crustaceans caught during the surveys is taken. Since the beginning of the series 341 fish, 122 crustacean and 53 cephalopod species have been identified.*
Data management	*Standard formats are defined for the storage and to facilitate exchange of the data produced by the Medits surveys. The exchange files are in an ASCII format. Fifth files types are defined to store and exchange the data*: *Type A: Characteristics of each haul* *Type B: Catch of each haul in weight, number and number by sex* *Type C: Biological parameters for the species in the reference list (length, sex, maturity)* *Type D: Temperature data* *Type T: List of hauls by stratum*
Quality control	*A specific software has been developed (the Checkmed tool) for an automatic control of the coherence of the data.*

Position of hauls



In the map, the limits and numbers are those of the GFCM-GSAs. The coloured areas are those of the main Medits strata.

The designations used and the presentation of cartographic data imply no line as for the juridical status of the various areas neither as for the border lines between countries.

Overview of the series

To carry out the surveys since 1994, 14 fishing chartered vessels and 6 research vessels have been used, depending of the year and the area. Nevertheless, in any cases, the sampling equipment and the method used were the ones defined in the Medits protocols.

Year	Date Minimum	Date Maximum	Target No Tows	No Valid Hauls	Comments
1994	16/5/1994	22/8/1994	1061	914	Spain, France, Greece & Italy
1995	22/4/1995	28/7/1995	1061	947	Spain, France, Greece & Italy
1996	2/5/1996	3/8/1996	1154	1086	Addition of Albania, Croatia & Slovenia
1997	9/5/1997	14/8/1997	1154	1090	
1998	3/5/1998	28/7/1998	1154	1105	
1999	4/5/1999	14/10/1999	1217	1127	+ Morocco, No survey in Croatia
2000	2/5/2000	2/8/2000	1222	1166	+ Morocco, Addition of Malta
2001	26/4/2001	19/7/2001	1159	1126	Morocco not included
2002	11/5/2002	26/9/2002	1159	901	Morocco not included , No survey in Greece
2003	26/4/2003	18/9/2003	1159	1159	Morocco not included
2004	6/5/2004	11/8/2004	1159	1140	Morocco not included

ANNEX: The sampling gear used for the Medits surveys

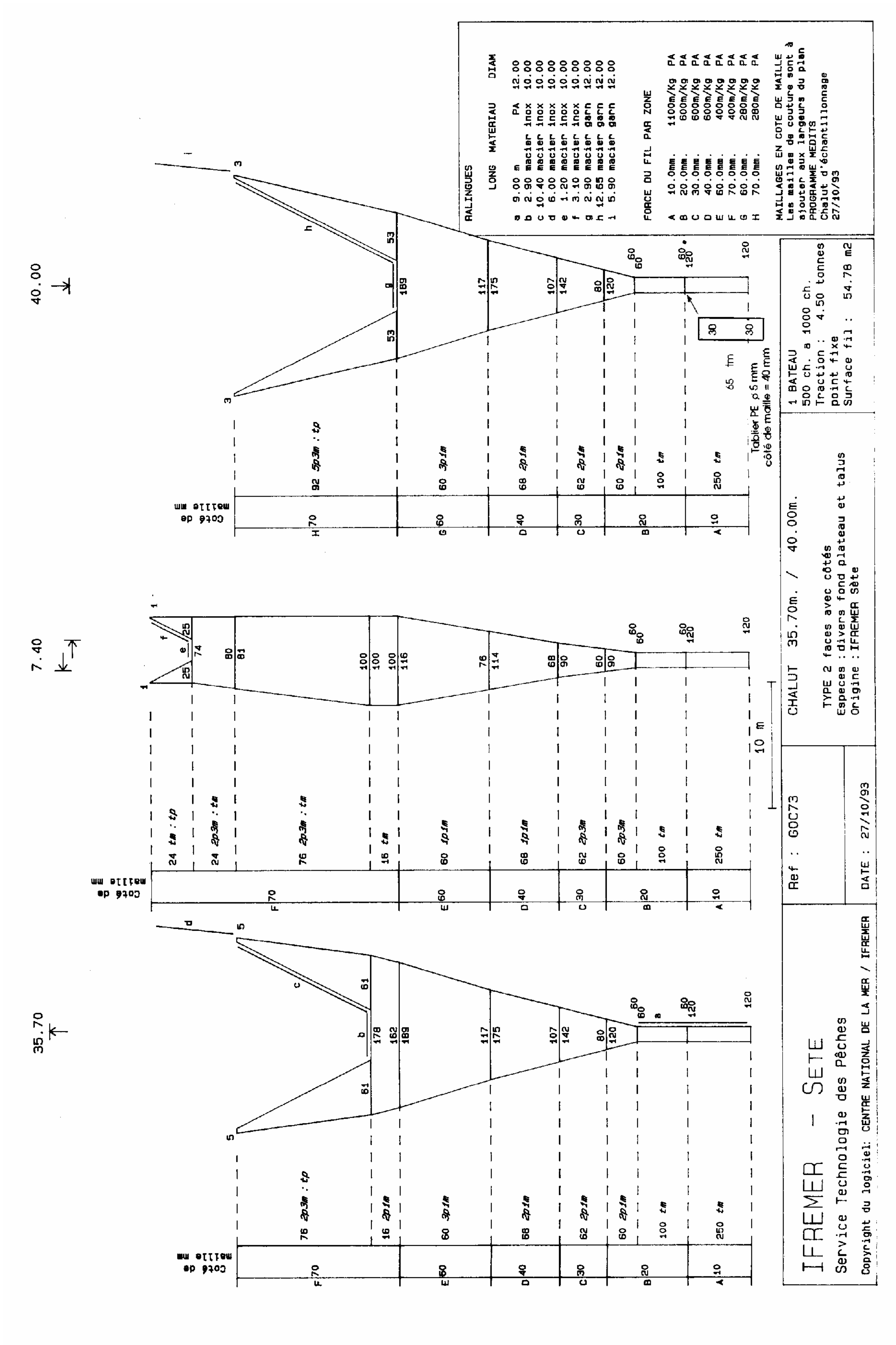


Fig. 1. Plan of the trawl GOC 73.

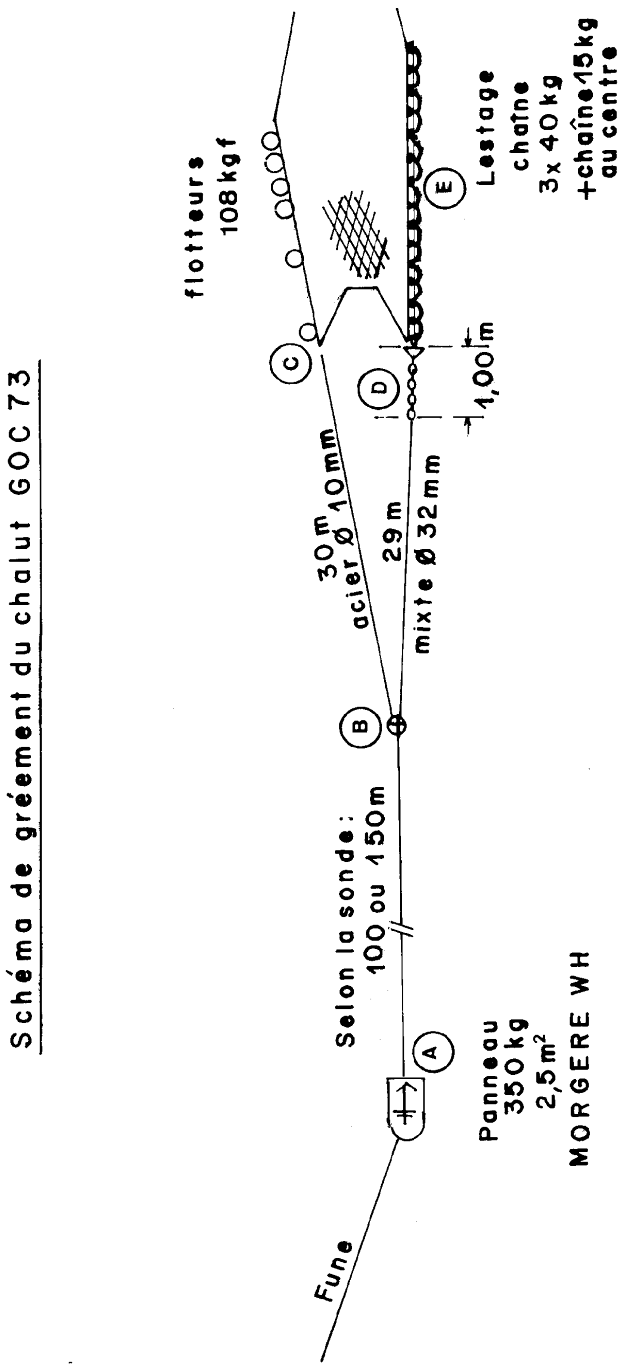


Fig. 2. Diagram of the rigging.

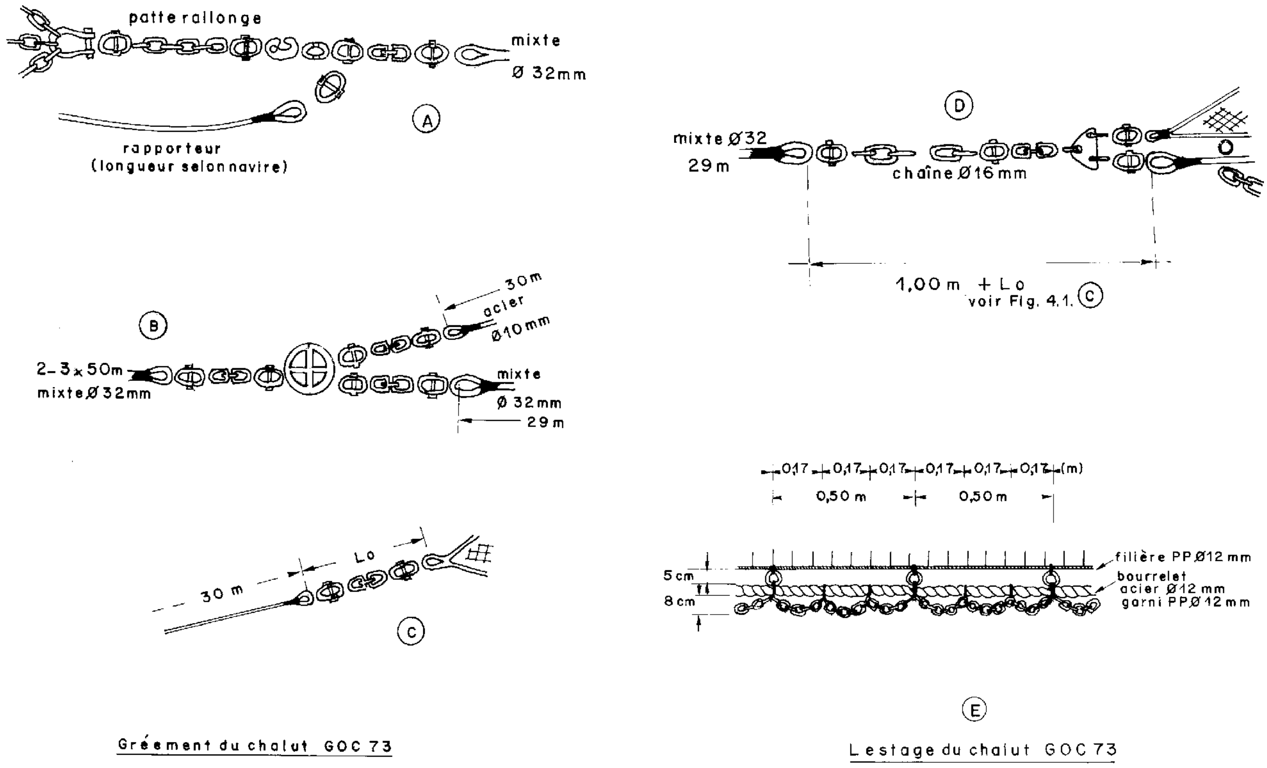
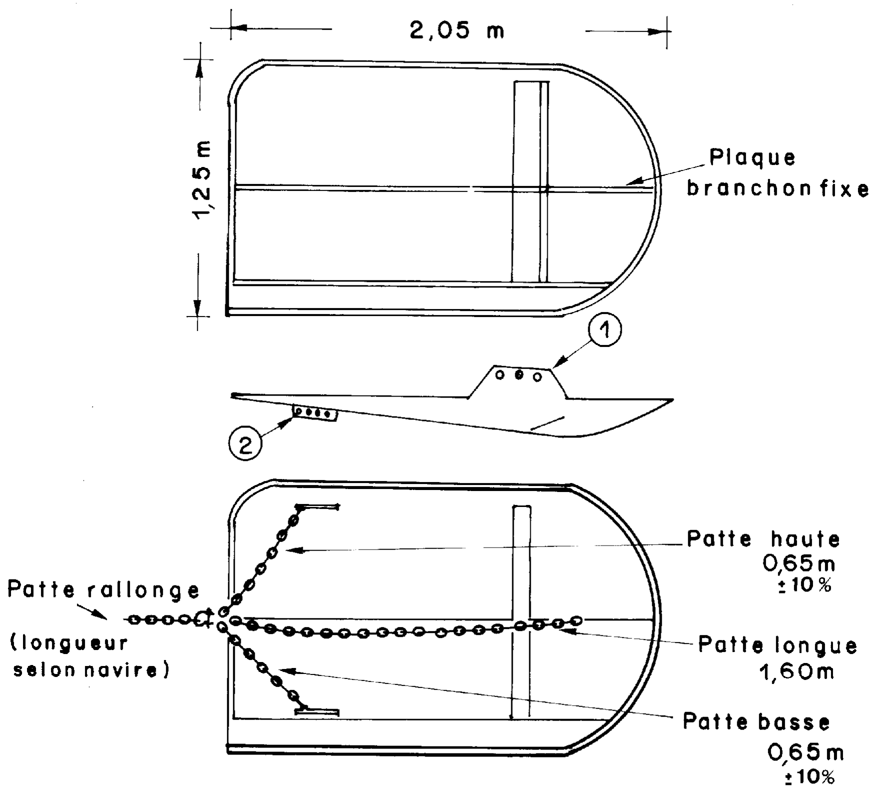


Fig. 3. Various details of the rigging.

(2,6 m² ; 350 kg)



Les longueurs des pattes sont indiquées
manilles non comprises

Fig. 4. Drawing of a door Morgère WHS (8).

COUNTRY: Cyprus

GSA: GSA 25

Overview of the survey

Survey title	International bottom trawl surveys in the Mediterranean	Survey code	MEDITS

Country	Cyprus	Institute in charge	Department of Fisheries and Marine Research
Area	*GFCM GSA No 25*	Period	June (May – July)

Main objective	**Evaluation of demersal fish stock abundance. Biological data collected: total weight, total number, length, maturity stage. Basic environmental data are also collected.**
Complementary objective	
Gear details	*Bottom trawl (IFREMER reference GOC 73 (Details on sampling gear and rigging included in the Instructions manual – MEDITS survey – version 4)*
Area	The survey area covers the territorial waters of Cyprus. Based on the Medits manual, hauls are conducted in depths from 10 – 800m, in five depth strata: 10-50m, 50-100m, 100-200m, 200-500m and 500-800m. In Cyprus particularly, hauls are conducted in depths from about 20-615m.
Sampling design	26 hauls are conducted. The sampling locations have been selected proportionally to the surface that covers each of the five depth strata, in combination with the suitability of the seabed topography.
Species recorded	All species are recorded (number, total weight, length distribution), while additional data on maturity are recorded for 38 target species (including fish, crustaceans and cephalopods).
Data management	Data are stored in the Medits Data Management System (MDMS), a common tool at the disposal of the Medits partners.
Quality control	Quality of biological data: The common Medits methodology, which includes a common maturity scale, is used. Sampling gear: The same vessel and sampling gear have been used so far for carrying out the Cyprus Medits survey. Raw data quality control: Data checks are performed when data are inserted in the MDMS base, for ensuring the validity of the data.

Position of hauls

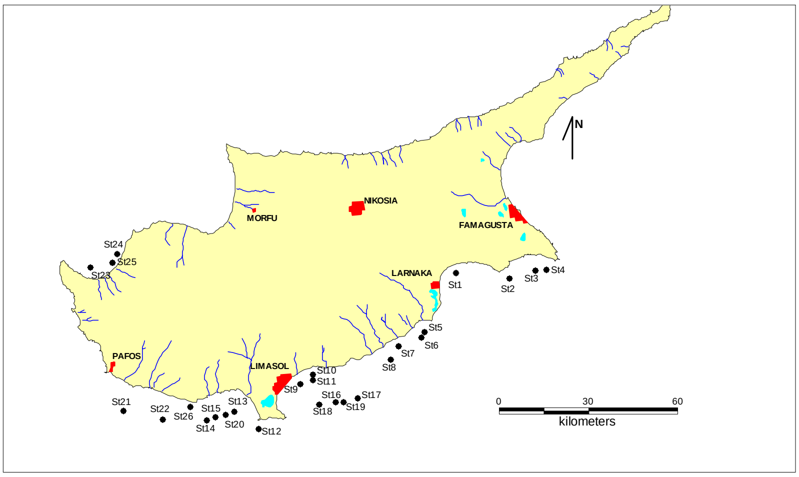


Fig:Sampling stations distribution of the Cyprus Medits survey.

Overview of the series

Period	Vessel	Type of vessel (R/V or C/V)	Gear	No. Tows planned	No. Valid hauls	Comments
1/8/05 - 11/8/05	EVA	C/V	Bottom trawl GOC73	25	25	
22/6/06 – 3/7/06	EVA	C/V	Bottom trawl GOC73	26	26	

Appendix 4

The use of trawl survey data in the ICES region for assessment purposes

Mike Armstrong
Centre for Environment, Fisheries and Aquaculture Science (Cefas), UK

Abstract

This Working Document and associated presentation gives an overview of the use of trawl surveys in stock assessments carried out by the ICES scientific community. Aspects of survey design and survey standardisation/inter-vessel calibration are covered. The primary use for the surveys is to provide time-series data on abundance and distribution by size or age, and the main use is in the "tuning" of different types of sequential population analysis (SPA). Survey-only models are also widely used for providing fishery-independent trends in stock abundance, and for investigating the quality of the survey data. North Sea haddock is given as an example of both approaches. An important issue for many catch-based assessments is dealing with bias due to apparent trends in survey catchability. The trends may be due to problems with the fishery data, or to actual changes in catchability. Some assessments of European cod stocks use survey data to estimate unaccounted-for removals, for example due to misreported or discarded catch. Surveys are also widely used for providing data on biological parameters of stocks, and increasingly for providing information in support of ecosystem approaches to fishery management.

Contact details: Mike Armstrong, Cefas Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR330HT, UK. mike.armstrong@cefas.co.uk Tel +44 (0)1502 524362

Overview of the extent of trawl surveys used in ICES assessments, including in relation to commercial cpue data

The use of survey data in the assessments of stocks assessed by ICES in the NE Atlantic is inevitably going to differ from the approaches that are possible for many Mediterranean stocks, due to the almost universal use of age-based rather than length-based assessments. However, there are many aspects of the design, coordination and implementation of the surveys that are relevant to the Mediterranean situation.

The great majority of assessments carried out by ICES Working Groups involve sequential population analysis (SPA) of fishery catch-at-age data, and require auxiliary information to estimate population numbers and fishing mortality for recent years. Up until the 1980s, ad-hoc VPA tuning procedures such as the Laurec-Shepherd and Hybrid methods were commonly used at ICES, with strong emphasis on the use of fishery data on catch and effort. Fishery data provided CPUE trends for all fully-selected age classes, whereas surveys were considered useful mainly for recruiting year classes not well represented in the fishery.

Over time, the ability of many commercial CPUE series to provide unbiased trends in abundance became questioned, due to problems of inaccurate catch reporting, changes in fleet structure and vessel efficiency, and changes in fisher's behaviour in relation to abundance and legislation. ICES Working Groups began to make greater use of survey data over a broader range of age classes and to reduce the use of commercial CPUE data. For example, in the 1990s, the assessment of North Sea cod was assessed using up to nine commercial CPUE fleets, 2-3 surveys with data for cod up to 5 or 6 years of age, and 2-3 surveys with data only for young cod. This continued after the introduction in 1993 of Extended Survivors Analysis (XSA; Shepherd 1991) to provide a more robust method of calibrating VPA population estimates against abundance indices. In 2000, all the commercial CPUE series except one were removed from the assessment due to concerns over the reliability of the data, and since 2001, the assessment has used only the IBTS or component national groundfish surveys.

The most recent reports of the major ICES stock assessment working groups, covering the North Sea, Baltic, Barents Sea, Iceland, Faroes, Greenland, Northern Shelf and Southern Shelf, indicate that 55 or more different research surveys are currently used for tuning the assessments. These are predominantly bottom trawl surveys but also include beam trawl, acoustic, egg, larval and pre-recruit surveys, and one fixed-net survey.

Out of 72 fish stocks with an assessment of stock trends given by ACFM in 2006, 39 of the assessments were tuned or carried out using only survey data, 5 used commercial CPUE data only, and 28 used a mixture of both. Many deep-water and elasmobranch stocks are data-poor and do not have analytical assessments. Survey data are sparse for the deepwater stocks and the larger elasmobranch species.

Where fishery and survey CPUE are used together for tuning an age-based assessment, it is often the case that the surveys carry most weight at the youngest age classes, whilst commercial fishery CPUE fits the VPA population trends better at the older age classes. This is partly due to noisier survey data for older age classes where survey catch rates are very low, but also due to correlations arising from fishery CPUE fleets that contribute substantially to the catch at age matrix and may also suffer the same problems of misreporting etc.

Surveys used by ICES Working Groups

ICES places great emphasis on the international coordination of surveys. Areas such as the North Sea and Western Waters are very large, and it is expensive for a single country to achieve full spatial coverage with the desired sampling intensity. Involvement of several countries spreads the costs, brings a wider range of expertise to bear, but also brings issues of standardisation, inter-calibration of vessels and gears, data exchange, quality control and data management.

The most extensive surveys used by ICES are the International Bottom Trawl Surveys (IBTS). The North Sea IBTS started off in 1961 as a herring survey, then its use extended to demersal stocks in the 1970s with an associated expansion of range. The surveys became internationally coordinated through ICES in 1965. Initially a single quarter-1 survey, the IBTS increased to four quarterly surveys per year in 1991-96, but was subsequently reduced to Q1&Q3 only. Figure 1 shows how the trawl stations for the North Sea IBTS are allocated between countries. Since 1994, the IBTS WG has also assumed responsibility for coordinating surveys in western and southern waters (Fig. 2). The history of the IBTS is given in more detail in the IBTS manual (IBTSWG 2006).

The ICES coordinated surveys usually started off with national surveys using quite different fishing gears and methods. Over time these have become more standardised, and all North Sea surveys within IBTS now use the GOV (Grande Overture Verticale) trawl, a high-headline (4-5m) otter trawl. The western and southern surveys use a greater variety of gear variants and survey designs, although participating countries have where possible adopted a version of the GOV trawl. There has however been much discussion within IBTS to develop a new “standard” trawl more suitable for the wide variety of fishing conditions encountered.

Other major international survey programmes within ICES include the Baltic International Trawl Surveys (WGBIFS, 2006 and earlier) and the Barents Sea trawl surveys. A series of beam-trawl surveys in the North Sea and western waters is coordinated by the ICES

International Beam Trawl Survey Working Group (WGBEAM). In addition to the ICES-coordinated surveys, a number of countries also carry out national surveys using different types of fishing gear to the IBTS surveys.

Material available from ICES on trawl survey design and analysis

ICES Working Groups, Study Groups, Workshops and Conference Proceedings are a rich source of material and current thinking on all aspects of fish survey design, analysis and use in stock assessment and habitat/ecosystem studies. The annual meetings of the ICES IBTSWG primarily address the coordination of existing international surveys and management of the data. However, much useful information is contained in the IBTSWG reports on aspects of trawl gear surveillance, survey standardisation, and intercalibration of vessels and gears.

The ICES Fishing Technology Committee (FTC) oversees the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) and the Working Group on Fisheries Acoustic Science and Technology (WGFAST). Recent reports of both WGs are available on the ICES website. The WGFTFB reports cover some aspects of survey technology, but increasingly appears to deal with commercial fishery issues such as technical conservation measures and descriptions of fleets and fishing activities.

In 2003, a review of the FTC led to the formation of the Workshop on Survey Analysis and Design (WKSAD) which met in 2004 and 2005. The reports of these Workshops provide extremely valuable summaries of current thinking on a wide range of survey design and analysis issues. Finally, a Study Group on Survey Trawl Standardisation (SGSTS) was established in 2005, having evolved from the SGSTG (Study Group on Survey Trawl Gear for the IBTS Western and Southern Areas).

A general overview of the topics covered by ICES in recent years, and some highlights, are given below. Refer to reports on the ICES website for more information.

Design of ICES surveys

The different trawl surveys used in ICES assessments have different designs, sometimes for historical reasons. The IBTS surveys of the North Sea have always been designed using ICES rectangles as the basis for stratification (Fig. 1). The IBTS Manual for this area (ICES IBTSWG, 2006) specifies the number of half-hour tows per rectangle per participating country. A database of clear tows is available; each country chooses semi-randomly from available tows, with the proviso that no two tows are less than 10 miles apart, or less than 1 day apart within a rectangle. In practice, some countries (e.g. England) use fixed-position stations with implications for variance estimation.

Some other surveys have more elaborate stratification schemes based on depth bands and habitat types, with additional subdivisions by (e.g.) ICES subdivisions. An example is the French Evhoe survey in the Celtic Sea (Fig. 3), and the international Baltic International Trawl Survey (WGBIFS, 2006). Allocation of hauls to strata in the BITS is based on a weighted combination of each stratum's area and mean stock size of cod (5-year running mean of age groups 1+ in spring), the weighting factors being 0.6 for area and 0.4 for stock size.

ICES surveys also differ in the extent to which trawl stations are randomised within strata, whether the strata be ICES rectangles or depth/habitat related. Partial randomisation, by placing a few tows at random within each of many small strata (e.g. ICES rectangles) has the benefit of avoiding large gaps that can occur with more tows in larger strata. This is the approach (theoretically) adopted in the North Sea IBTS. The BITS uses a randomised design with depth-related strata, with tows selected each year from a tows database. Other stratified random surveys based on larger (depth related) strata rather than small rectangles include the Faroes Plateau trawl surveys in spring and summer, the Icelandic cod surveys and the Greenland cod surveys (ICES NWWG, 2006).

Some surveys use a more-or-less fixed station design, in which the same positions are fished each survey. This is more common in European surveys than in North American and Canadian surveys which tend to be stratified random. Fixed-station designs are more common in the IBTS regions with extensive areas of untrawlable ground where there may be few known tow tracks. They may often have a pseudo-random initial design, according to the availability of clear tows. In such cases, some fish species (e.g. cod) may be more associated with the rough seabed, and catches on the finer sediments may reflect changes in fish behaviour affecting movement away from the preferred habitat.

Statistical aspects of survey design and analysis

Survey design

The WKSAD meeting in 2004 provided a wide ranging overview of methods for design and analysis of surveys taking into account the statistical properties of catch-rate data, as well as a summary of the design basis for the main North Atlantic surveys. The use of simulations to investigate a range of design-based and model-based estimation procedures for random, random-stratified and systematic surveys was investigated. The outcomes of existing studies confirmed that –

- In the presence of positive local autocorrelation, a more precise estimate of the population mean will be obtained by stratified random sampling, or systematic sampling with random starting point (as in North Sea herring acoustic survey), than by simple random sampling;
- Stratified random sampling will often be preferable if getting a good estimate of precision is required;
- Geostatistical estimators, or random sampling with many strata but only two samples per stratum, gave the smallest 90% confidence intervals.

The 2005 WKSAD meeting carried out further simulation studies using data generated by a geostatistical simulation model. Two simulated data sets were generated with high and low levels of spatial autocorrelation. Meeting participants were invited to apply different survey designs within specified operational constraints, without knowing the underlying properties of the simulated populations. These included 8 systematic designs, 7 stratified random designs and 4 other designs. The results confirmed the advantage of more systematic designs in the presence of more spatial autocorrelation, but also showed that when autocorrelation is low, random designs can perform better when using route optimisation algorithms that allow more trawl samples to be taken than in a (non-optimised) systematic survey.

On the basis of the different simulation studies, WKSAD (2005) produced a valuable "decision tree" to assist in designing new surveys (Fig. 4). The WKSAD (2005) report contains a valuable Working Document by Cadigan ("Confidence intervals for trawlable abundance from random stratified bottom-trawl surveys") that includes the effects of random selection of sites as well as the random fish capture process at a site (conventional "design-based” methods consider only the former).

Use of covariates

Many variables affect the ability of trawl surveys to give catch rates proportional to fish abundance at and near each trawl site. These can cause interannual variability in abundance indices with greater measurement error than implied by within-survey estimates of precision. These divide into variables related to gear deployment (e.g. door spread and headline height), and those such as weather conditions, tidal state, time of day, sea temperature, depth, sediment type etc.) whose direct effect can only be altered by changing when and where tows take place, by post-stratifying the survey to give homogeneous tows with respect to the variable, or by modelling the response over the full survey area using GAMs or similar models. Numerous studies have examined relationships between covariates and survey catch rates. The WKSAD meeting in 2004 reviewed a number of these, and the 2005 meeting gave an example of a GAM-based approach applied to Bay of Biscay groundfish where survey design and wind conditions explained about half the interannual variation in survey density estimates. For one species, an originally strongly fluctuating trend became a smooth increasing trend when covariates were included.

The IBTSWG (2003) meeting reviewed the EU-funded project MIQES: “Use of multivariate data for improving the quality of survey-based stock estimation in the North Sea” (1998-2000). This project demonstrated significant diel effects on catch rate of cod aged 2+ and herring, and for haddock in Quarter 1, as well as significant vessel effects. Another EU project “FINE” (“Survey based abundance indices that account for fine spatial scale information for North Sea stocks”. 1999-2002) involved high-intensity trawling in a number of ICES rectangles in different parts of the North Sea. Sampling at this scale allowed an examination of the implications of diurnal or semidiurnal variations in vertical migration on survey catch rates, and highlighted the implication of non-random distribution of trawl timing with respect to time of day.

A wide range of papers on variables affecting surveys was presented at Theme session K of the ICES Annual Science Conference in 2000, and these are reviewed in the 2001 report of the ICES IBTS Working group.

Effects of altering tow duration

Reducing the tow duration in bottom trawl surveys has the benefit of allowing more tows per day which can either improve precision (more tows overall) or reduce costs (same number of tows but less sea time). Other benefits can accrue in reducing the need to subsample large hauls, provide more time between hauls for working up samples, and avoiding gear saturation effects. The critical issues for short tows are potential non-linearity between tow duration and catch rate for different species and sizes of fish, and the greater impact of catches made as the net is settling at the start of the tow and after the haul commences.

The WKSAD meeting in 2005 provided a very useful review by Michael Pennington on effects of tow duration on precision, and the Workshop recommended that survey planners should be encouraged to examine the possibility of reducing tow duration by carrying out suitable experiments. If it can be demonstrated that reducing tow duration has the expected effect of increasing precision, then the tow duration should be reduced and the extra time allocated to obtaining more samples.

Results of several studies reviewed by WKSAD (2005) showed that the coefficient of variation of catch rates did not vary with tow duration, except possibly for species with very low catch rates. For ocean pout on the George's Bank, optimum tow length for maximum precision was around 10-15 minutes, allowing 30% more tows by reducing tow length from 30 to 10 minutes. Comparative towing in the Bering Sea also showed no significant difference in length compositions for a range of species taken in 30-min and 15-min tows.

An example of a comparative tow exercise to examine effects of tow duration was given in a Working Document to WKSAD(2005) by Wieland and Storr-Paulsen ("Effect of tow duration on catch rates and mean length of Northern shrimp (Pandalus borealis) and Greenland halibut (*Reinhardtius hippoglossoides*) in the Greenland Bottom Trawl Survey, 1999-2004"). Tows in this survey had been progressively reduced from 60 mins down to a mixture of 30min and 15min tows, and an analysis of the effect of reducing all tows to 15mins was needed. A GLM approach where log (CPUE + 1) was modelled as a linear response to stratum, year, depth and tow duration, or to log (mean CPUE) and tow duration, indicated no significant effect of tow duration on catch rates or maximum size of shrimp or halibut.

The WKSAD (2005) also presented results from an experiment to determine the catch rate of trawls during the periods before and after the official haul duration, and the potential for a "surprise" effect noted in some camera studies. This was done by carrying out "zero-duration" tows – i.e. where the net was retrieved as soon as it had settled adequately on the seabed at the official start of the tow. The study indicated that for less mobile species such as sole, the catch before and after the nominal haul duration may be proportional to tow duration during these brief periods, whereas for highly mobile species such as hake, the initial surprise effect may be more important, casting doubts on swept-area based abundance indices for such species. A significant surprise effect at the start of a tow could imply that surveys with many short tows of equal duration would perform better than having fewer longer tows that in some areas have to be reduced in duration for various operational reasons.

Estimating biological parameters

WKSAD(2005) examined the statistical basis for estimating biological parameters, treating the samples from individual tows as cluster samples. It was demonstrated that effective sample size to determine parameters such as length composition can be much smaller than the number of samples taken. This implies the need for more but smaller independent samples (another benefit of short tows). Spatial mapping and interpolating of biological parameters on acoustic surveys is also examined in the WKSAD report.

Practical aspects of survey design and implementation: IBTSWG and SGSTS

Trawl surveillance

Trawl standardisation and inter-calibration of vessels and gears is a major topic addressed by IBTSWG and by SGSTS and its predecessor the SGSTG. Each national survey is expected to fully implement the strict protocols to ensure that their trawl gear fishes as consistently as possible, and to monitor trawl performance using suitable sensors. Good trawl surveillance data can clearly indicate the effects of changes in vessel or gear construction and deployment. The ICES SGSTS gives an example of the change in vessel by Cefas (Lowestoft) from the *Cirolana* to the *Endeavour* (Fig. 5) showing a significant increase in door spread and reduction in headline height of the GOV trawl when towed by the more powerful *Endeavour*.

The 2005 and 2006 SGSTS reports devote considerable space to issues of trawl surveillance including the types of sensor that are available, the deployment, testing and calibration of sensors to measure net parameters such as door and wing spread, vertical opening and bottom contact, and the screening and interpretation of data from the sensors. Advice is also given on the use and deployment of other sensors such as warp measurements, door angle, net speed, net offset and catch size, which are considered useful for understanding causes of variability in catch and for Quality Assurance purposes. Methods for analysing factors affecting within-haul variations in net geometry are reviewed in the 2006 SGSTS report. The effect of depth on gear performance in the Q4 western IBTS was evaluated by the IBTSWG in 2001, and it was noted that this has implications for survey indices should the distribution of a fish species shift with respect to depth.

The 2006 SGSTS meeting also considered in some detail the difficult issue of when to accept a tow as "invalid" due for example to gear damage, towing protocol violation, oversized catches (e.g. jellyfish) causing gear saturation, etc. Such decisions are often subjective and vary between individuals. The SGSTS commented that overly-strict rejection of tows due to marginal net damage can bias results towards areas with smooth seabed and underestimate species associated with rougher ground, whereas the opposite can lead to underestimation of relative abundance of species.

Intercalibration of vessels and gears

This subject is covered at great lengths by the IBTSWG and by SGSTS and STSTG. The IBTSWG in 2001 and 2002 reviews the EU contract 98/057 "IPROST" (International programme of Standardized Bottom Trawl Surveys off Northwestern Europe). This was a project dealing with inter-calibration of surveys in western waters. It provided a statistical method for vessel intercalibration that requires relatively few tows and can be carried out at different times and in different areas. Intercalibration exercises compare species abundance and richness using t-tests, Mann Whitney U-tests and principal components analysis. Catch rates by length class from comparative tows can be compared using models analogous to the methods for analysis of gear selectivity trials.

The issue of intercalibration is also dealt with by WKSAD (2004&2005). The 2004 report summarises results of seven different intercalibration exercises and lessons learned from them. A few examples are given below:

1. Baltic Surveys: Calibration of new survey trawl with older gear. This used sequential tows along the same track, with different ordering of tows. It demonstrated the disturbance effect of the first tow, and the need for an experimental design to estimate the disturbance effect.

2. Intercalibration of a new Icelandic RV with Japanese-built trawlers used for the Icelandic trawl survey. Paired tows by the two vessels were carried out along the same track, 1.5h apart. Paired tows using the same vessel/gear were used to calculate the disturbance effect. GLM with log-link and different variance functions was used to analyse the results. Disturbance factors indicated 10-30% higher catch rates in the first tow compared to the second tow.

3. The Alaska dept. of Fish and Game and National Marine Fisheries Service carry out groundfish surveys using gears with very different fishing characteristics, particularly headline height and ground gear. Paired tows showed that the calibration factor for Walleye Pollack can change both spatially and seasonally due to variations in behaviour of the fish.

4. A different approach was proposed by Cotter (2001) to correct for the change from a small Granton bottom trawl to the larger GOV trawl in the English groundfish surveys in 1992. A catch-curve model were used to estimate species- and age-related offsets due to change in fishing gear. This was, however, used only as a temporary measure until the survey series

could be treated as separate.

Some examples of comparative trawling exercises are also given in the IBTSWG reports in 2004 and 2005. For further information on methods of survey gear calibration, see Lewy *et al.* (2004).

The 2006 SGSTS meeting provided advice on intercalibration of gears and vessels, based on material and examples provided by SGSTS (2005) and WKSAD (2004). The question of when to calibrate changes was broken down to cases of:

- Minor improvements designed to allow better compliance with agreed standards (advice: do not calibrate). This can include minor changes to components when they are no longer available with the same specifications as before, or introduction of better trawl surveillance equipment such as bottom contact sensors.
- Modest changes or departures from agreed standards that will have some effect on net performance, but whose effects are individually hard to estimate (advice: save all changes up and introduce in a single tranche, or introduce stepwise to allow comparison).
- Major changes in gear or standards that depart significantly from the previous ones (advice: calibrate).

The SGSTS (2006) also examined the main approaches to calibration including comparative fishing trials, modelling approaches, and gradual incorporation of gear changes to a survey. It also advised that poor calibration may be worse than no calibration at all, and provides guidelines for good practice for calibration studies. The SG advises that, before investing in an intercalibration exercise, careful consideration should be given to the prior expectation of the magnitude of change in catchability, the ability to deal with multivariate estimation of different factors for different sizes and species of fish; and the required precision of the calibration (as evaluated using simulations of the stock assessment process).

Computation of abundance indices

Abundance indices from IBTS and most other ICES surveys are mostly computed as standardised catches per unit tow duration. The calculation of abundance indices as numbers per area swept is less common. One example is the Norwegian Bottom Trawl Surveys in the Barents Sea (ICES Arctic Working Group, 2006). The ability of swept-area estimates to provide absolute estimates of abundance is very much dependent upon factors such as vertical distribution of fish and fish behaviour (ship and trawl avoidance).

Norwegian scientists have been active in the use of acoustics to study fish behaviour in relation to trawls (e.g. Godø 1999), and a recent initiative to use commercial and research trawlers to obtain a swept-area estimate of anglerfish biomass off Scotland (Reid *et al.* in press) has involved underwater video records to examine fish behaviour in contact with trawl doors and bridles etc. The IFREMER-coordinated EU project “SURVEYTRAWL” in 2003 focused on the design of a trawl that can deliver quantitative estimates of fish density with minimal herding of fish. Following from this project, IMR in Norway initiated the “Norwegian Trawl” project to develop a quantitative bottom trawl (see IBTSWG reports in 2004 – 2006 and SGSTS 2005, 2006 for overview of progress).

The procedures for generating abundance indices from IBTS-coordinated surveys are described in the report of the EU contract EVARES (Beare *et al.* 2003). The indices for the

North Sea IBTS surveys are obtained by averaging standardised catch-rates across tows within each ICES rectangle. ALKs are also formed for each rectangle or (if < 25 fish), from nearby rectangles, with procedures for filling missing length classes in the ALK. Different "standard areas" are defined by species, for averaging of the rectangle mean catch rates by age class. Individual countries may use different approaches for their own surveys when used on their own – for example the English Q3 GFS uses seven subdivisions of the North Sea known as roundfish areas (RFA) as survey strata rather than the component ICES rectangles. In this case, the age-length keys are compiled and applied by RFA, and the indices at age are then averaged over RFAs using the number of ICES rectangles per RFA as weighting factors.

Some form of weighted arithmetic mean is the most common approach to calculating abundance indices in ICES surveys. Model-based estimates are also used where appropriate. For example, the delta-lognormal distribution is used with a GLM to calculate abundance indices for separate sexes of spurdogfish (*Squalus acanthias*) taken in the Scottish groundfish surveys, due to the extremely patchy catch rates and the necessity to model presence/absence separately from abundance where present (WGEF, 2006).

How the survey data are used by ICES

About 60% of the assessments currently carried out at ICES use Extended Survivors Analysis (XSA) as the primary method. Around 10% of the assessments are trends given from analysis of surveys on their own. The remaining 30% comprise a mixture of other SPA techniques including Adapt, TSA and separable models such as ICA. There is only one example of a surplus production model (Aspic: NOAA Toolbox), applied to anglerfish in Iberian waters:

Primary assessment Model	No. stocks
XSA	44
Adapt	3
Time series Analysis	2
ICA	5
Other separable models	4
Other statistical catch at age models	3
Catch-Survey Analysis	1
Bayesian Biomass Based Model	1
Aspic	1
Length-based models	1
Survey only	7

Up to the 1980s, age-based assessments of ICES stocks were "tuned" mainly with commercial fishery CPUE data, with survey data being used mainly to provide information on recruitment. Concerns over the quality of commercial fishery data, and in some cases divergent abundance trends between different commercial and research survey series, has led to a progressive reduction in the use of fishery CPUE data. In 2006, more than half of the assessments used by ACFM for advice were based on survey-only tuning or trends from surveys without the use of fishery data:

The current XSA software can only use age-based survey indices. The need to include age-aggregated indices in some assessments, particularly herring and mackerel for which larval or egg surveys are carried out, led to the development of a version of Separable VPA able to be tuned using both age based and age-aggregated indices. This method, Integrated Catch at age Analysis (ICA; Patterson, 1997), separates fishing mortality into a year effect and an age effect specified for one or two recent periods of years. Parameters are estimated by minimising an objective function specifying the residual errors between catchability-adjusted survey indices and model estimates (errors considered log-normal), and between observed catches at age and model estimates of catches at age, according to user-specified weighting values for each component of the objective function.

A number of other full age-based assessment models are applied to stocks according to specific needs or availability of expertise. These include seasonal XSA models for short lived species such as sandeels (WGNSSK, 2006), Time Series Analysis (Gudmundsson, 1994) applied to gadoids to the west of Scotland (WGNSDS, 2006), a number of versions of the Adapt formulation (cod in the Irish Sea, North Sea and Faroes: WGNSDS, WGNSSK,NWWG 2006), and a number of other models (AMCI; SAD: used for horse mackerel and sardine by WGMHM (2006), and AD-Cam used for Icelandic gadoids by NWWG (2006)). Due to the importance of predator-prey interactions in the NE Arctic, the AFWG (2006) also runs the GADGET (Begley and Howell, 2004) model for cod and redfish. Although the Multispecies VPA for the North Sea is updated at intervals, it is not used as a formal assessment tool for annual management advice.

Partially age-structured models have not been widely used for NE Atlantic or Arctic stocks. The method Catch-Survey Analysis (Mesnil, 2003), in which catch and survey data are divided into recruits and “the rest”, is used for North Sea sprat (HAWG, 2006). There are some problems with the application to sprat due to violation of some model assumptions, including constant relative selectivity of the two age groups.

Do conventional catch-at-age models make the most efficient use of survey data?

The use of survey data in stock assessments was reviewed extensively in the EU project EVARES (Evaluation of Research Surveys in Relation to Management Advice; Fish/2001/02-Lot 1; Beare *et al*. 2003). The review indicated that most surveys used by ICES were able to track populations over time, with relative standard errors of 10-30% for the age classes used in the assessments. Assessment results for the most recent years, and short term forecasts, were more sensitive to recent survey data.

The WKSAD (2004) meeting also reviewed briefly the use of survey data in stock assessment, and highlighted the often good consistency between survey indices and VPA estimates for the converged part of the VPA but divergent trends for more recent years. Since recent VPA estimates are revised, but survey indices stay the same, this implied that the information content of surveys was not being efficiently used for the critical recent period. Often the VPA revisions are consistently in one direction, the problem of “retrospective bias”. The WKSAD (2004) report promotes an idea more recently published by Pennington and Nakken (2006) that population trends used for management advice should be based principally on survey data that have been calibrated against VPA population estimates for cohorts that are no longer in the catch. A retrospective analysis using Northeast Arctic cod data showed more precise estimates for the recent period using this approach.

Versions of the Pennington approach are currently adopted for a number of European gadoid stocks for which longer term trends in apparent survey catchability are given by conventional models despite strict protocols for survey standardisation. Such changes could occur in response to progressive changes in the vulnerability of fish to capture due to other factors, but may also reflect an effect of changing amounts of unaccounted for removals due to discarding, misreporting, natural deaths or movements into neighbouring areas. Evidence for incomplete fishery catch data during periods of TAC reductions lends support to this as an important factor.

Two procedures have been adopted for cod in the North Sea, Irish Sea and West of Scotland to deal with the bias. The first involves the use of Time Series Analysis of data for the Scottish stock, in which survey data are calibrated with fishery catch at age during an earlier period when catchability was effectively constant, and the model extended into subsequent years using only the survey data (WGNSDS 2006). A second method (B-Adapt; Darby, 2004) is a variant of the Adapt model formulation in which all the available fishery data are included but a bias factor for fishery catches is calculated for a recent period of years. This method is used for cod in the Irish and North Seas (WGNSDS and WGNSSK 2006). The bias factor is calculated by adjusting the annual total catch tonnage in the relevant period until the assumption of constant survey catchability is met as closely as possible.

The B-Adapt model for Irish Sea cod gives total removals figures for 2000 onwards that are close to independent estimates of total landings based on sampling schemes rather than vessel logbook data (Fig. 6). The independent estimates were used in the B-Adapt assessment up to 1999, but official data were used for subsequent years due to an absence of independent estimates for some years. Fig. 6 shows that not accounting for potential biases in catches since 2000 due to misreporting, causes major retrospective bias in F-estimates. Allowing B-Adapt to estimate the bias to give constant survey catchability (on average) results in a removal of the retrospective bias leaving random residuals.

Survey-only assessment methods

Raw survey data

The most parsimonious use of a survey to describe trends in stock biomass and/or year-class strength is the trend given by the raw data, without any form of smoothing or modelling other than has been applied to generate the "raw" indices (e.g. through use of geostatistical models, GLMs or GAMs). Simulation models have shown that design-based estimators such as stratified means will differ from model-based estimators such as GAMs mainly in the estimation of error variance, rather than the overall mean. In a time-series context, year-effects also occur in trawl survey indices, due to factors such as weather conditions, unintended changes in gear rigging, or changes in fish behaviour. These act to inflate the overall variance within a time-series of indices as well as to introduce autocorrelated errors across age classes. Additional error may be introduced through deficiencies in age-length keys or errors in ageing.

The great majority of ICES surveys provide age-based data, and the quality of the data can be quickly screened by examining the internal consistency in tracking year classes over time. Examples are given later in the section on North Sea haddock.

Survey-only models

Simple catch-curves do not make full use of the information content of the surveys if there are year or age effects, common to all year classes, that can be estimated through simultaneous analysis of all the data. Simple catch curves are also not useful for year classes that have only been surveyed for a few years. If there is temporal stability in the catchability at age for a stock in a particular survey, this permits the use of a separable model in which "mortality" (i.e. ratios Ln $(N_{a+1,y+1} / N_{a,y})$) can be separated into an age effect and a year effect.

The simplest approach is given by Shepherd and Nicholson (1991), involving a multiplicative model with three factors: year, age and year class. This approach explicitly incorporates the form of error distribution but requires the imposition of a trend in the year effect (e.g. based on fishing effort) to provide a unique solution. This approach can be used with fishery catch or survey data, and is currently used by the NWWG (2006) to screen fishery age composition data.

The model SURBA (Survey Based Assessment), derived from an analysis of survey data given by Cook (1997, 2004), is used widely by ICES Working Groups to provide model-based estimates of recruitment, SSB and total mortality (Needle, 2004). In essence:

$Z_{a,y} = s_a \,.\, Z_y$

where s_a and f_y are the age and year effects in total mortality.

Abundance is modelled as:

$N_{a,y} = N_{a0,\, y-a+a0}$ exp (-Z')

where $N_{a0,\, y-a+a0}$ is the number of fish at the recruitment age (a_0) in the same yearclass and Z' is the cumulative total mortality from age a_0 to age a in the year class.

Parameters are estimated by minimising the sums of squared differences between observed and modelled abundance indices. Smoothing options are provided. The current version of the model allows simultaneous analysis of multiple surveys (may not have been fully simulation tested yet).

Experience with applying SURBA to a variety of survey data within the ICES Northern Shelf and North Sea WGs has shown that, if survey selectivity has remained more or less constant over time, the model provides smoother and more realistic biomass and recruitment trends than given by the error-prone raw data. However, the method cannot give unbiased estimates of Z for all ages without auxiliary information to estimate the pattern of catchability at age. The ICES Working Group on the Assessment of Northern Shelf Demersal stocks has for some stocks used mean catchability at age from an appropriate converged part of a catch at age assessment such as XSA to define the catchabilities in SURBA, to allow a direct comparison of absolute values with XSA. However, survey catch-curves also reflect age-dependent natural mortality and emigration effects not modelled in XSA for these stocks. .

There are methodological difficulties in estimating trends in Z for the recent years using SURBA. Longer-term trends in the steepness of the catch curves may indicate trends in Z, but there is generally insufficient information to estimate Z for the most recent years. Hence, SURBA currently uses an assumption that the year effect in Z in the final year is equal to the average for the preceeding three years. Catchability at the oldest age is also assumed the same as for the next youngest age.

The SURBA software provides limited diagnostic plots to help interpret the model fit. Users can manually alter the catchability at age to "straighten" out the fitted catch curves at the youngest ages as described above – however including partially selected younger age groups (which may also be subject to more variable selectivity and mortality) may actually degrade the overall model fit.

Increasing interest in the use of survey-only methods for assessment and management led to the establishment of the current EU FP6 contract FISBOAT (Fisheries Independent Survey Based Operational Assessment Tools; 2004-07), coordinated by IFREMER. This project aims to evaluate how these methods perform in producing advice within defined management criteria, such as determining the optimum level of harvesting, to study the sensitivity of the methods in anticipating changes in population biology and survey performance, and to compare, through case studies, test results and the corresponding management advice with historical records and actual events in specified fisheries. A paper by Pomarede *et al*. (2006) provides an example application from FISBOAT for herring stocks.

There is an increasing interest in the use of suites of indicators for assessing the status of stocks and ecosystems (Rochet *et al*. 2005). Surveys can provide a range of metrics related to size and age composition, community size-spectra, spatial distribution, fish condition, size/age at maturity, species diversity etc. that may contribute to integrated assessments using indicators.

Other uses of survey data by ICES

Fish surveys offer a unique platform for collecting a wide range of data on oceanography, biota and habitats across large sea areas. The data on trawl catches also are a rich source of information for use in ecosystem studies. The EU contract EVARES (Beare et al. 2003) provides a useful listing of non stock assessment uses (plus references) for the bottom trawl surveys that are reviewed, including collection of biological data to meet EC Data Collection Regulation targets, abundances of non-commercial species, spatial distribution data, stomach content analyses, hydrography, genetics studies, ecological studies, contaminant studies, climate studies, acoustics studies and other uses.

A major issue with the use of surveys for other purposes is the quality control of data and consistency of standards over time. For example, quality control of species identification is an important current topic with IBTS, and photographic identification guides are being compiled. Investigations of historical North Sea IBTS data revealed that 20 species pairs (~ 30% of species in the North Sea database) may be affected by identification errors, reducing the usefulness of the IBTS data base for diversity studies (Daan, 2001).

North Sea haddock: an example of the use of surveys in an ICES assessment

Haddock (*Melanogrammus aeglefinus*) is an important demersal gadoid species taken in trawl fisheries in the North Sea. The IBTS trawl surveys show that the distribution is mainly in the northern North Sea (Fig. 7). Both juveniles and adults are widespread across the northern North Sea. The stock is characterised by pulses of very strong recruitment. The 1999 year class was one of the strongest on record. Such strong year classes result in substantial discarding, exacerbated by slow growth in the strong year class and subsequent year classes subject to density dependence at high overall stock size.

The stock is assessed by the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and the Skagerrak (WGNSSK), and the reader is referred to recent reports of the WG on the ICES website for further details not covered here. The assessment is fully age structured, using Extended Survivors Analysis tuned with the IBTS Q1 international survey and the separate English and Scottish groundfish Quarter 3 surveys (rather than the international Q3 survey to which these surveys contribute). The Scottish and English surveys are each divided into two separate historical series due to a change from Granton trawl to GOV trawl in 1992 in the English survey and from RV Scotia II to RV Scotia III in the Scottish survey in 1998. This was considered a better option than using single series with calibration factors.

The IBTS Q1 and ScGFS survey series both had data from 2006 available to the WGNSSK meeting in 2006. As XSA cannot handle survey data after the last year with fishery catch data, the IBTSQ1 survey series was treated as if it took place at the end of the previous year. The ages and years in the data file were shifted back accordingly. The benefits of having the extra survey were considered to outweigh the loss of data for tuning the older ages due to the back-shift in age.

Unfortunately, the IBTS data had been supplied with a 6+ group, which could not be used in XSA. This resulted in the survey tuning only the age groups 0 – 4. As the current stock biomass was dominated by the 1999 year class, information on this year class in the last two surveys (2005 and 2006) was lost, a serious problem. The ICES WG also discarded data on 6-year-olds from the English and Scottish surveys, because survey data at this age was considered too noisy, even though this removed data on the 1999 year class in 2005. Furthermore, the 2006 Scottish survey could not be used in XSA, losing a further piece of information on the 1999 year class. Unfortunately, the recent discarded data on the 1999 year class indicated a sharp decline in biomass, and may have been influential in the assessment had it been possible to include all the data.

The haddock stock has a wide dynamic range of population size, and the three surveys are able to accurately track year classes. Simple plots of log $N_{a,y}$ vs log $N_{a-1,y-1}$ and plotting of time series of indices by age, stacked by year class, show good internal consistency of the surveys (Figs 8 & 10). The usefulness of this approach (used extensively in the EVARES project) is shown by an example of a survey that has poor internal consistency (Irish Sea whiting; Fig. 9). The three North Sea surveys also show quite good between-survey correlation (Fig. 11).

Inspection of catch curves by cohort shows fairly smooth decline in numbers at age (with some exceptions) and low selectivity of the youngest age class causing a hook in many of the curves (Fig. 12). The catch curves suggest that their slopes may provide useful information on trends in total mortality (Z). The Z estimates decline from >1.0 yr^{-1} in the 1980s to 0.5-1.0 in recent years (Fig. 13). The final XSA assessment tuned using the three surveys shows a similar pattern of decline in Z (mean F+M over ages 2-5), following the trend from the IBTSQ1 and Scottish surveys more closely than the trend from the English GFS (Fig. 13). The XSA indicates a steeper decline in Z in the last few year classes than indicated by the surveys.

An application of SURBA to analyse all the data from each survey series leads to similar general results to those given by analysis of the raw survey data. The example for IBTSQ1 (Fig. 14; survey data not back-shifted) includes retrospective analysis which shows the effect of setting Z in the terminal year as an average of the previous three years. Note that the SSB index from SURBA doesn't include the 6+ group, and hence under-estimates SSB in 2005 and 2006 when the 1999 year-class is in the plus-group (a drawback of the software version used for this analysis).

Having ascertained that the survey data contain coherent data on the stock abundance and year-class dynamics, the next step is to use each survey in turn to tune an XSA run, with F-shrinkage reduced to negligible amounts. All three surveys produce an assessment showing a sharp decline in F in recent years (Fig. 15), probably associated with a large increase in biomass of the 1999 year class together with measures such as increased mesh size since 2000 and reductions in fleet size of UK vessels which are the main fleets targeting haddock. The IBTSQ1 survey produces the largest decline in F estimates with correspondingly larger SSB estimates (Fig. 15), possibly related to the reduced information on recent abundance of the 1999 year class. None of the survey series indicate longer-term trends in catchability.

All the survey data were retained for the final XSA run. Figure 16 shows that the SSB trends from the final XSA match the trends in SSB from the raw survey data (including the IBTSQ1 6+ gp) except for the recent period of growth and decline of the 1999 year class. Most importantly, the three surveys provide strong evidence that SSB in 2005 and 2006 has declined much faster than indicated by the XSA. This may again be a consequence of omitting potentially influential recent survey indices for the 1999 year class from the assessment model. The historical performance of the assessment by successive Working Groups has been relatively good (Fig. 17), but has mostly been over years with less dynamic changes in the stock and the fishery.

The conclusion from the North Sea haddock example is that surveys and fishery data can provide useful information on stock trends and fishing mortality when the stock is relatively stable, but extreme dynamics such as the appearance of very strong year classes can be difficult to handle in fishery-based models. The haddock example also emphasizes the need to make the most efficient use of all the available survey data that are considered reliable, which was not possible in this case because of the constraints of adopting a model (XSA) that could not handle all the available survey data after the last year with catches, and inclusion of important survey data in a plus-group that could not be included in the tuning procedure.

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WGBIFS (2005&2006): Report of the ICES Working Group on Baltic International Fish Surveys. ICES CM 2006/LRC:07; CM 2005/G:08

WKSAD (2004 & 2005). Report of the Workshop on Survey Design and Analysis. ICES CM 2005/B07; CM 2004/B:07.

SGSTS (2005 & 2006). Report of the ICES Study Group on Survey Trawl Standardisation. ICES CM 2005/B:02; CM 2006/FTC:05.

References: ICES stock assessment WG and SG reports

All references: see www.ices.dk
AFWG: ICES Arctic Fish Working Group
HAWG: ICES Herring Assessment Working Group for the Area North of 62°N
NWWG: ICES Northwestern Waters Working Group
WGMHM: ICES Working Group on the assessment of mackerel, horse mackerel, sardine and anchovy.
WGHMM. ICES Working Group on the assessment of stocks of hake, monk and megrim.
WGNSDS: ICES Working Group on the Assessment of Northern Shelf Demersal Stocks
WGNSSK: ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak.
WGEF: ICES Working group on Elasmobranch Fish

Some useful ICES Annual Science Conference Theme sessions:

1997 Session W: The catching performance of fishing gears used in surveys
1997 Session Y: Synthesis and critical evaluation or research surveys.
1998: Session J. Variation in the pattern of fish aggregation: measurement and analysis
1999: Session J: Application of acoustic techniques to bottom trawl surveys
2000: Session K: Incorporation of external factors in marine resource surveys
2001: session T: Use and information content of ecosystem metrics and reference points
2003: Session N: Size dependency in marine and freshwater ecosystems
2005: Session L. Spatial dimension of ecosystem structure and dynamics
2006: Session P. Integrated assessment in support of regional seas ecosystem advice

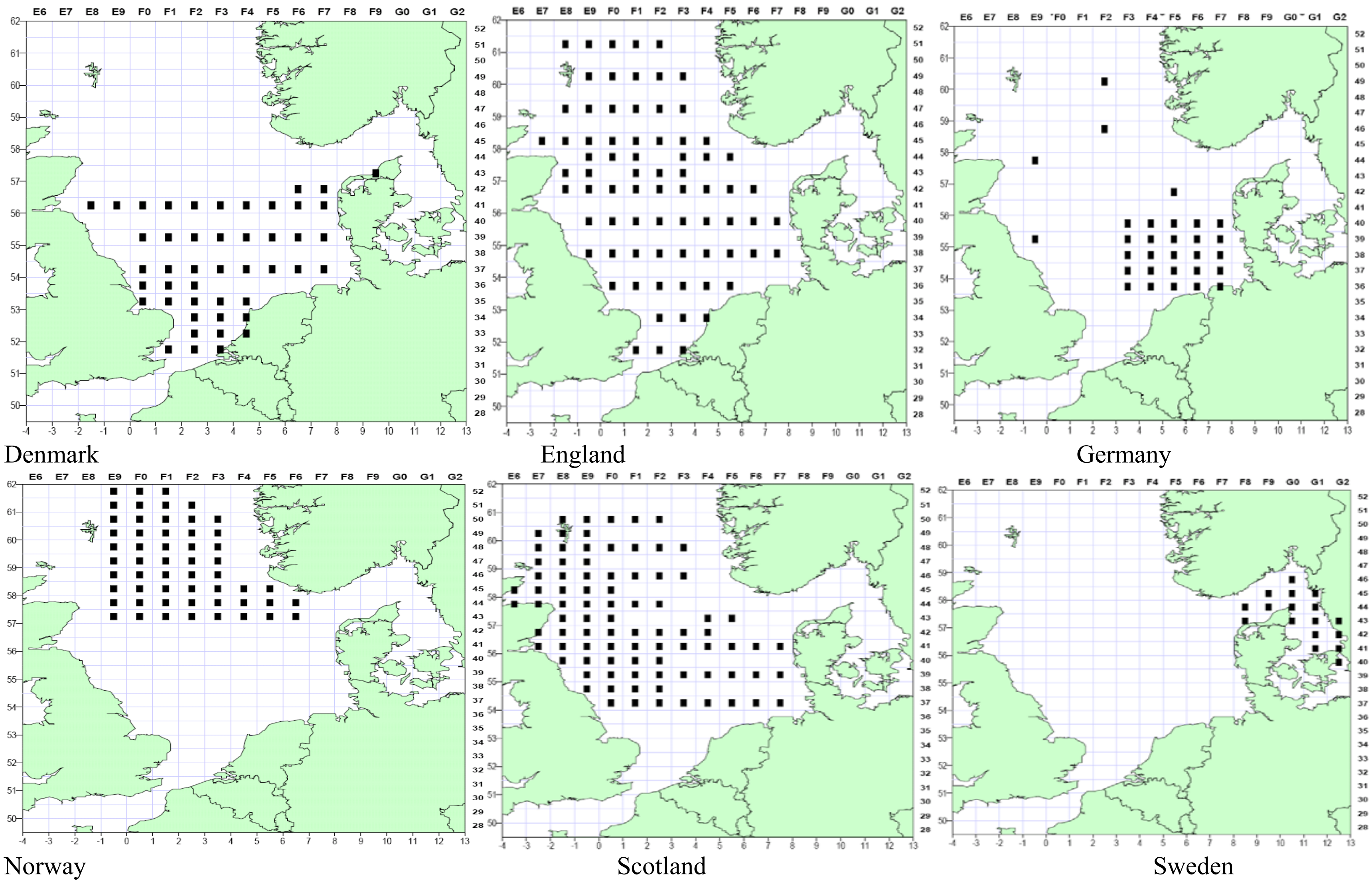


Fig. 1. Allocation of IBTS survey effort by country.

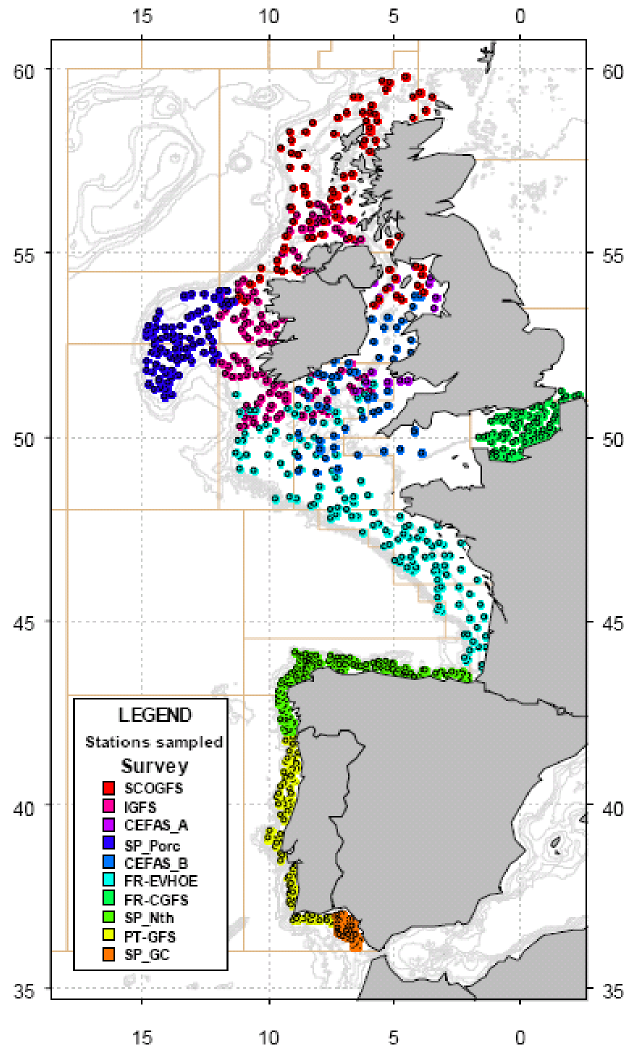


Fig. 2. Station positions of the IBTS surveys in the western and southern area in autumn/winter 2005

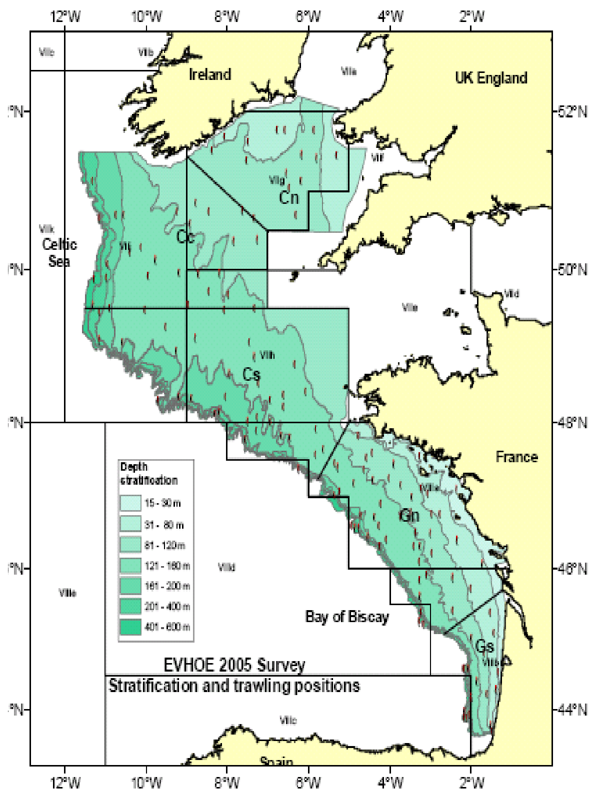


Fig. 3. Stratification of French Evhoe survey by depth and zone

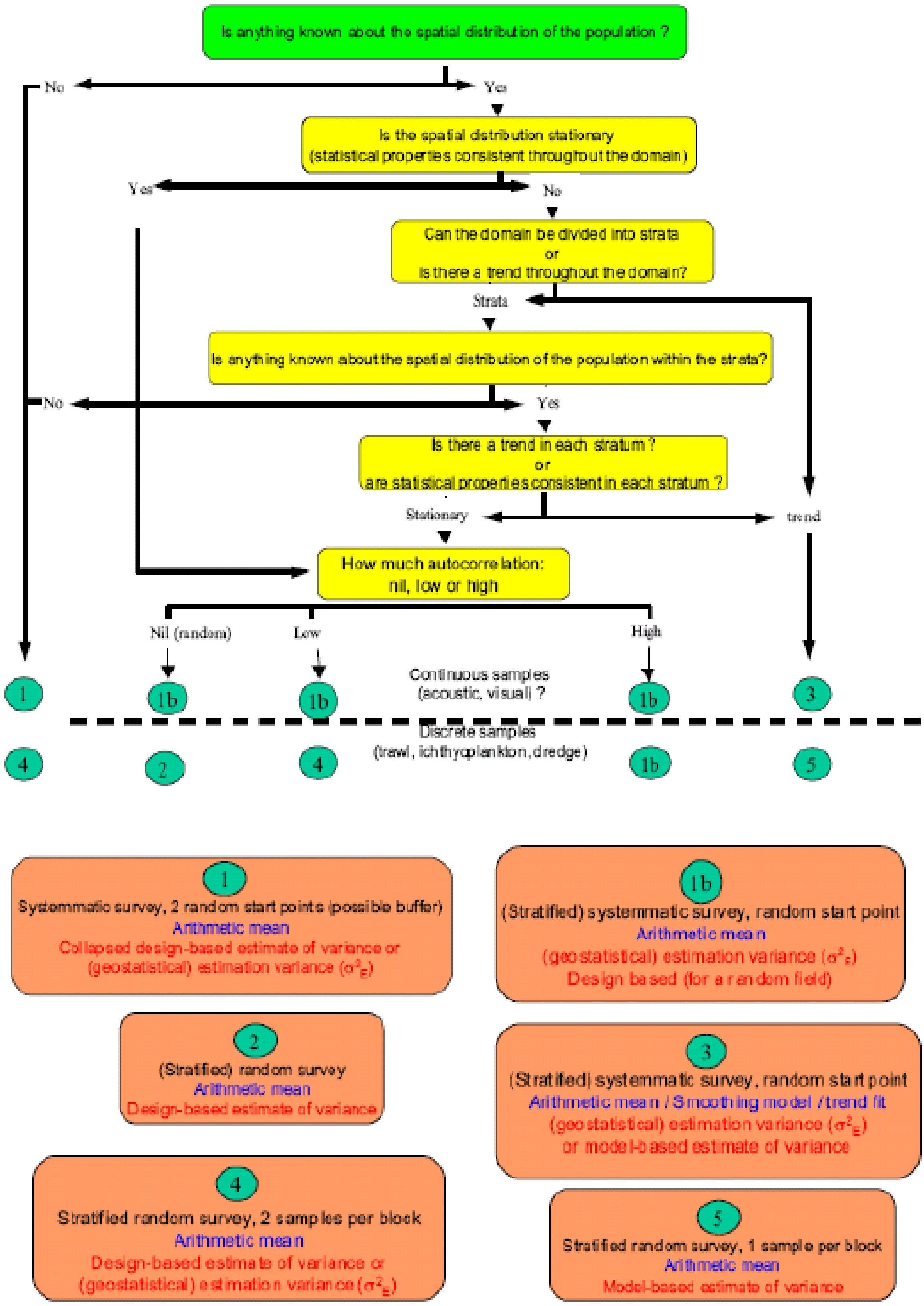


Figure 8.2.1: A decision tree for designing a survey in marine resource.

Fig. 4. A decision tree for designing a survey of a marine resource (from WKSAD 2005)

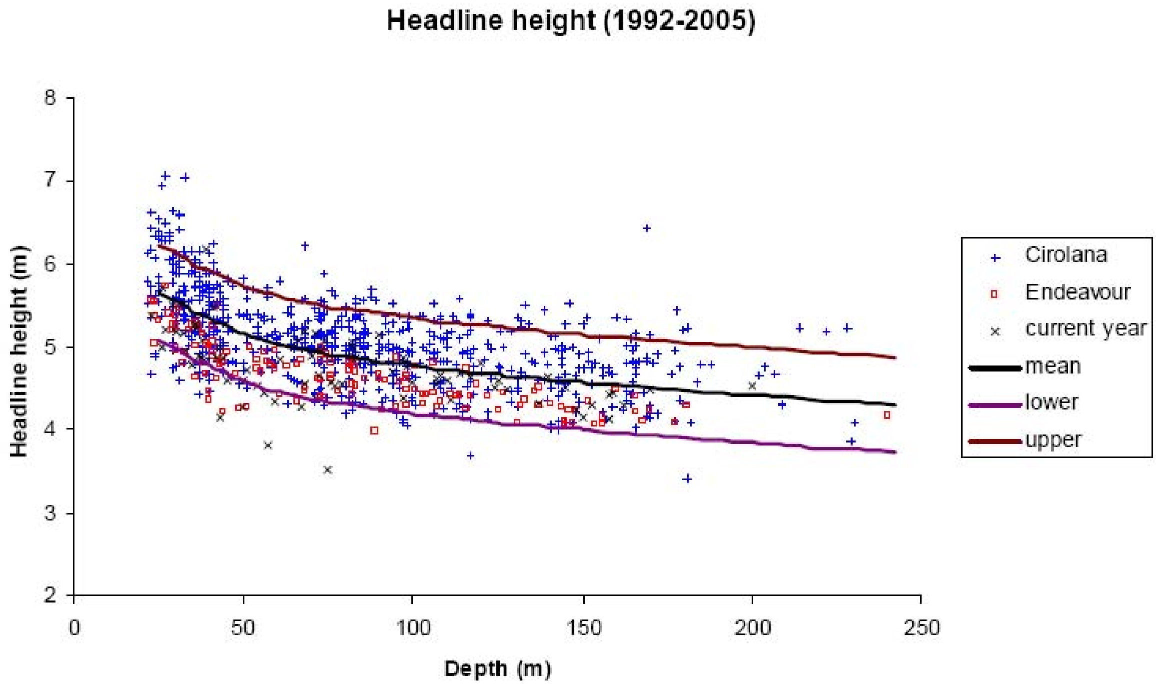


Figure 2.3.5.1: Headline height to depth ratio, from Scanmar units.

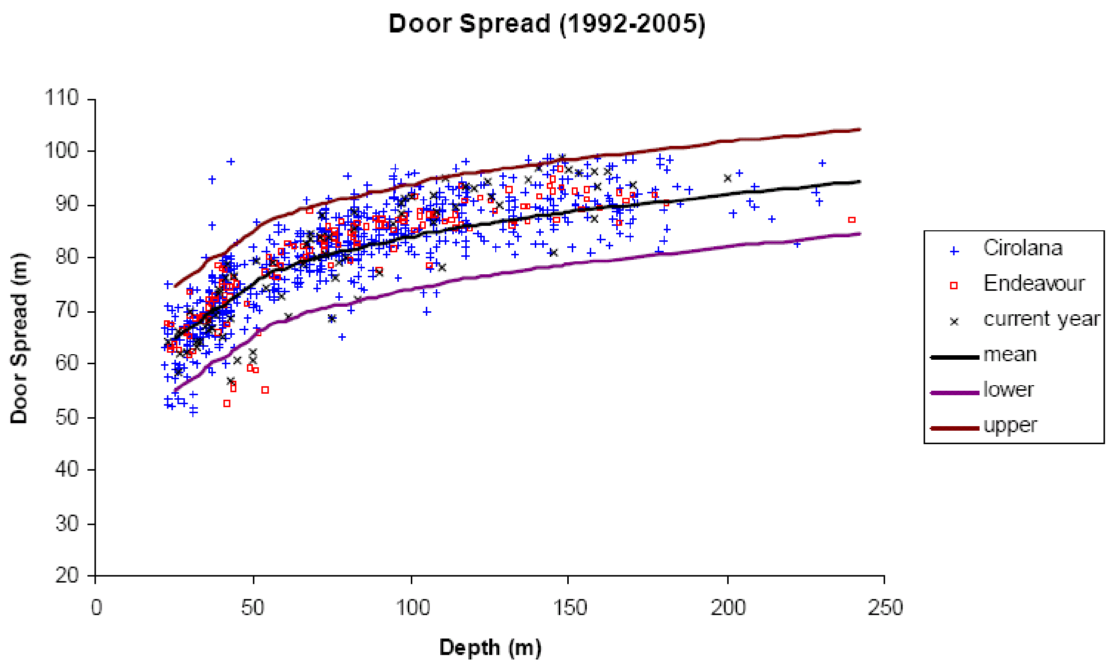
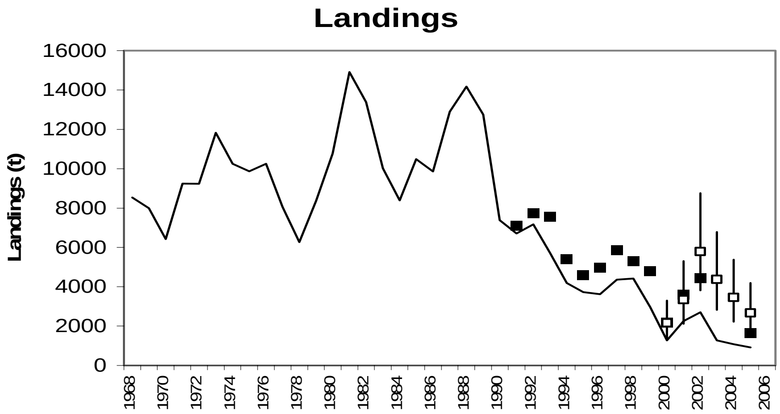


Fig. 5. Scanmar measurements of headline height and door spread as a function of depth of tows carried out on the Cefas RV *Cirolana* and its replacement vessel the more powerful RV *Endeavour*. The mean, upper and lower curves represent IBTS tolerance levels for the standard GOV trawl.

(a) Landings



(b) Trends in fishing mortality

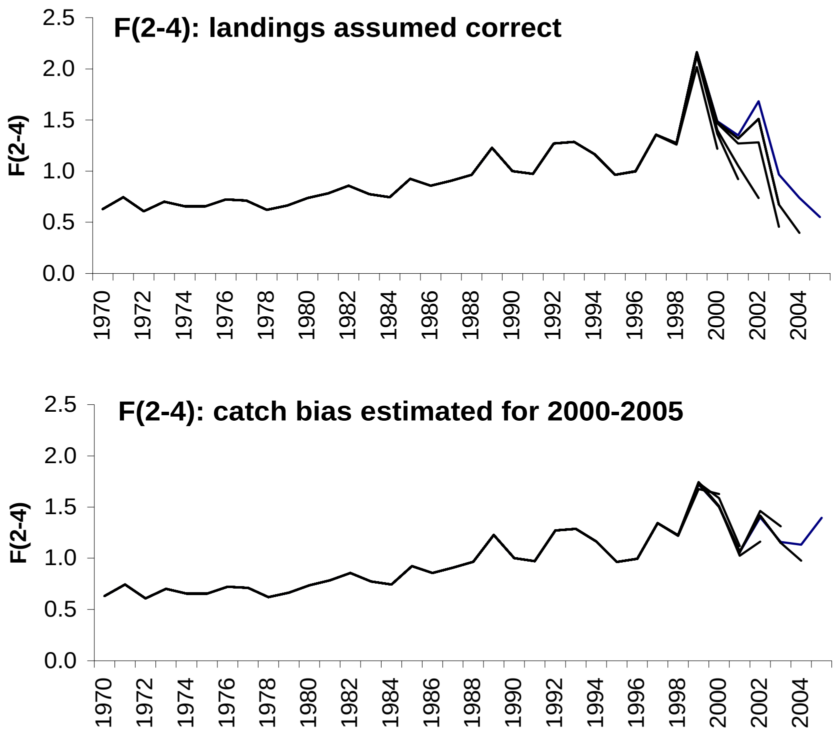


Fig. 6. Irish Sea cod assessment. (a) shows the time series of official landings (solid line), WG estimates of total landings based on a sampling scheme (solid squares) and estimates of total removals and 95% confidence intervals from B-Adapt run using WG landings estimates to 1999 and official landings from 2000 onwards. (b) retrospective trends in F-estimates when no bias is estimated for 2000 onwards (top plot) and when bias is estimated using B-Adapt (bottom plot)

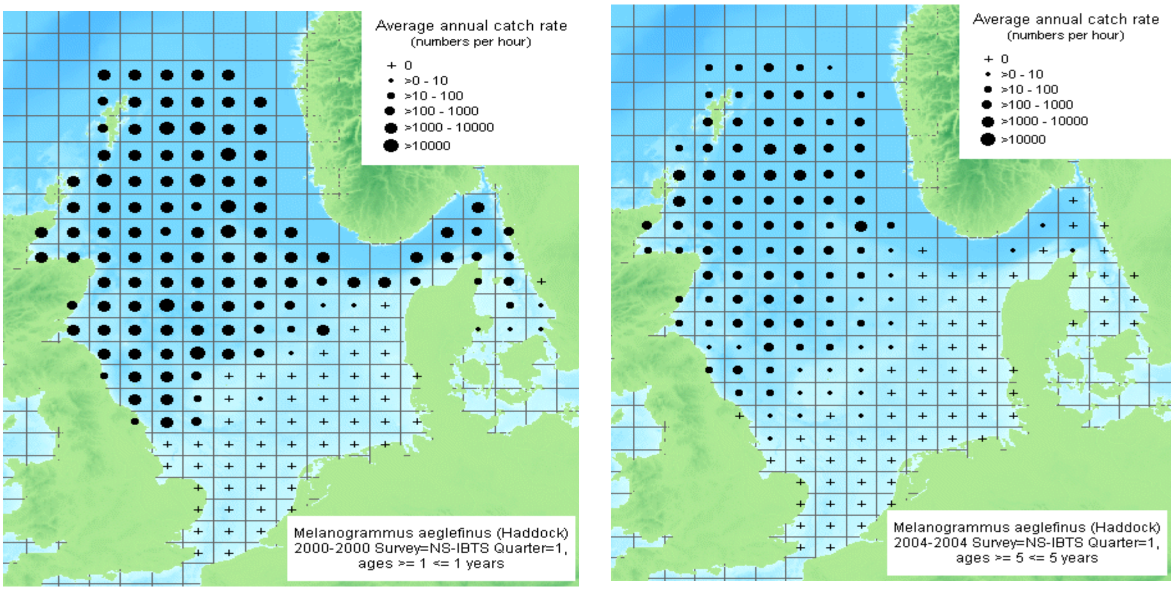


Fig. 7. Density distribution of 1-year-old and 5-year-old haddock from the strong 1999 year class, as given by catch rates of the IBTS Quarter 1 survey. (from ICES FishMap: www.ices.dk)

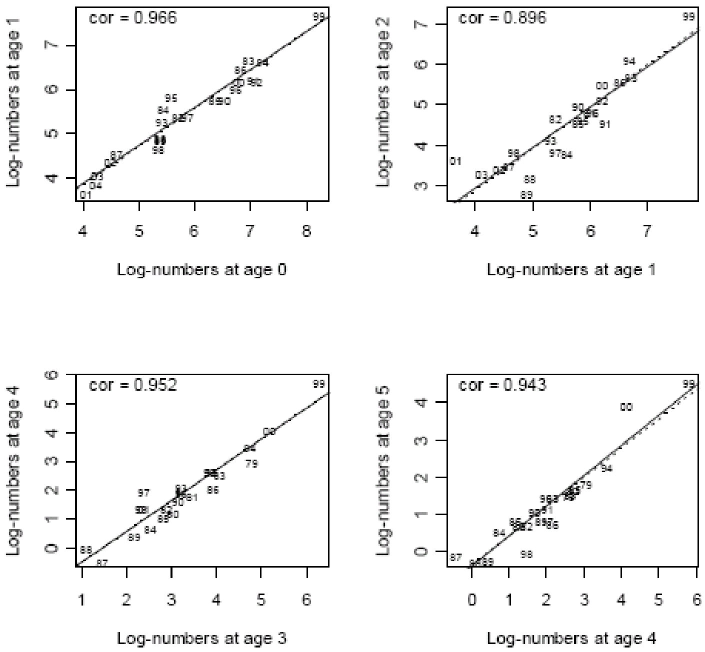


Fig. 8. Haddock in the North Sea and Skagerrak: Within-survey correlations for IBTS Q1 (back-shifted: note that age 5 is a plus-group) for the period 1982-2005. Individual points are given by cohort.

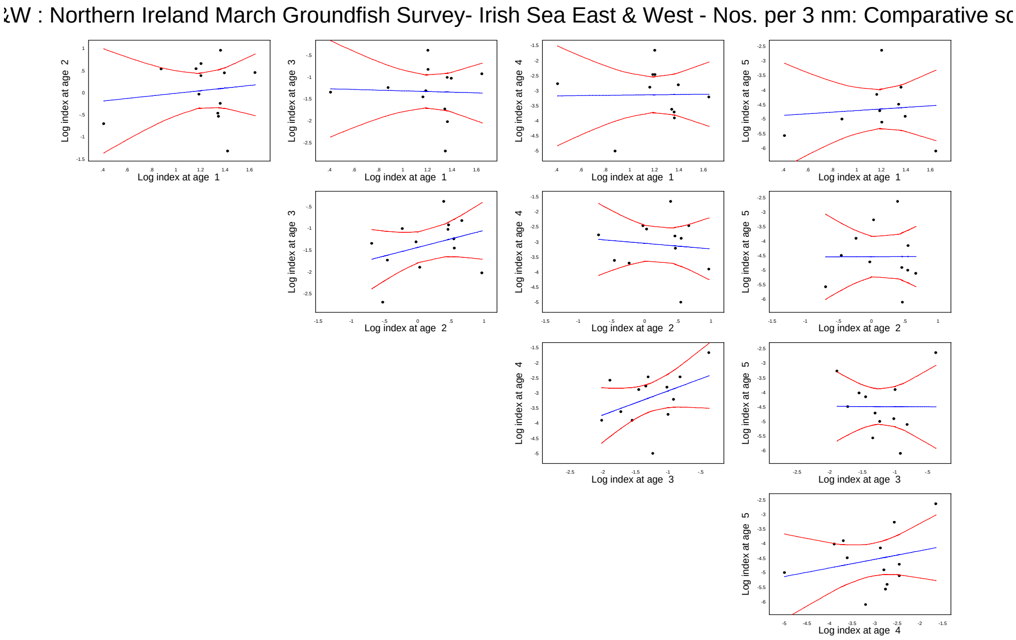


Fig. 9. Within-survey correlations for Irish Sea whiting in the: NI-GFS (March) Q1 groundfish survey. Regression lines and confidence intervals for the regression are shown.

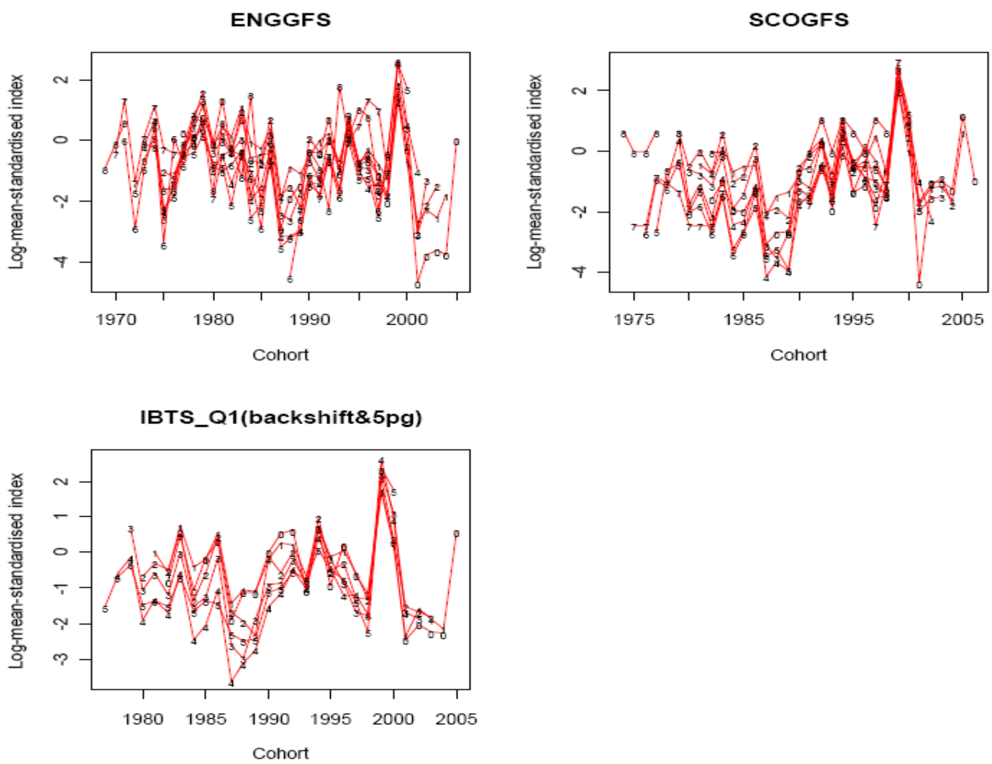


Fig. 10. North Sea haddock: Log mean-standardised abundance indices by cohort for each of the three surveys used in the assessment.

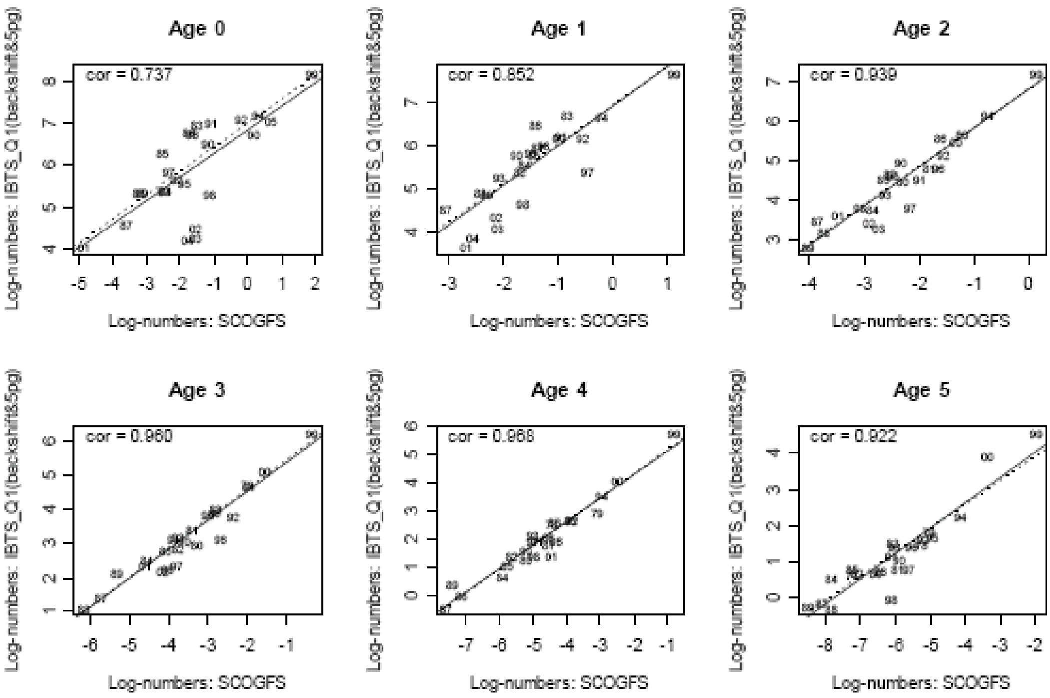


Fig. 11. North Sea haddock: Correlations between abundance indices at age in the ScoGFS and IBTSQ1 surveys

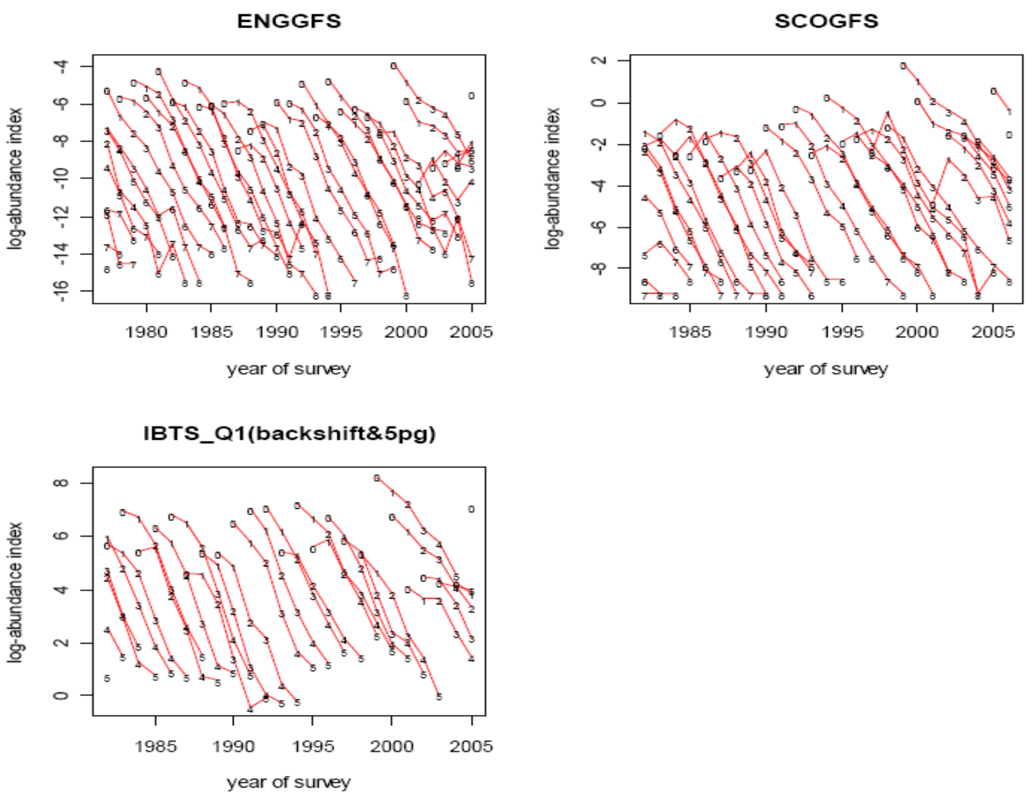


Fig. 12. North Sea haddock : Catch curves by cohort for the three surveys used in the assessment.

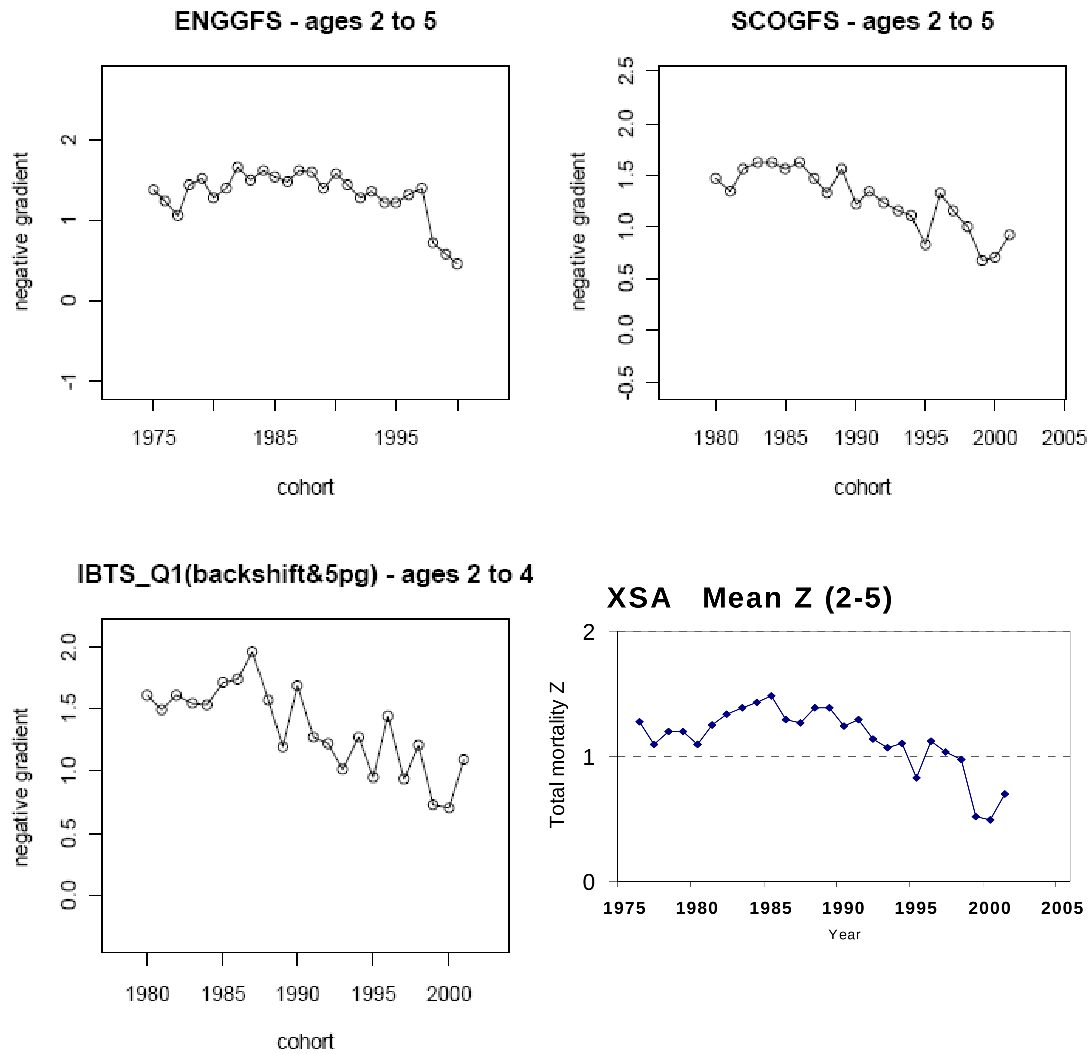


Fig. 13. North sea haddock : Negative gradients of log-abundance per cohort for each of the three surveys for the age-ranges specified for each survey (i.e. indices of total mortality Z). The bottom right-hand plot gives comparable values from the final XSA assessment as average total mortality (M+F) for ages 2-5 by cohort.

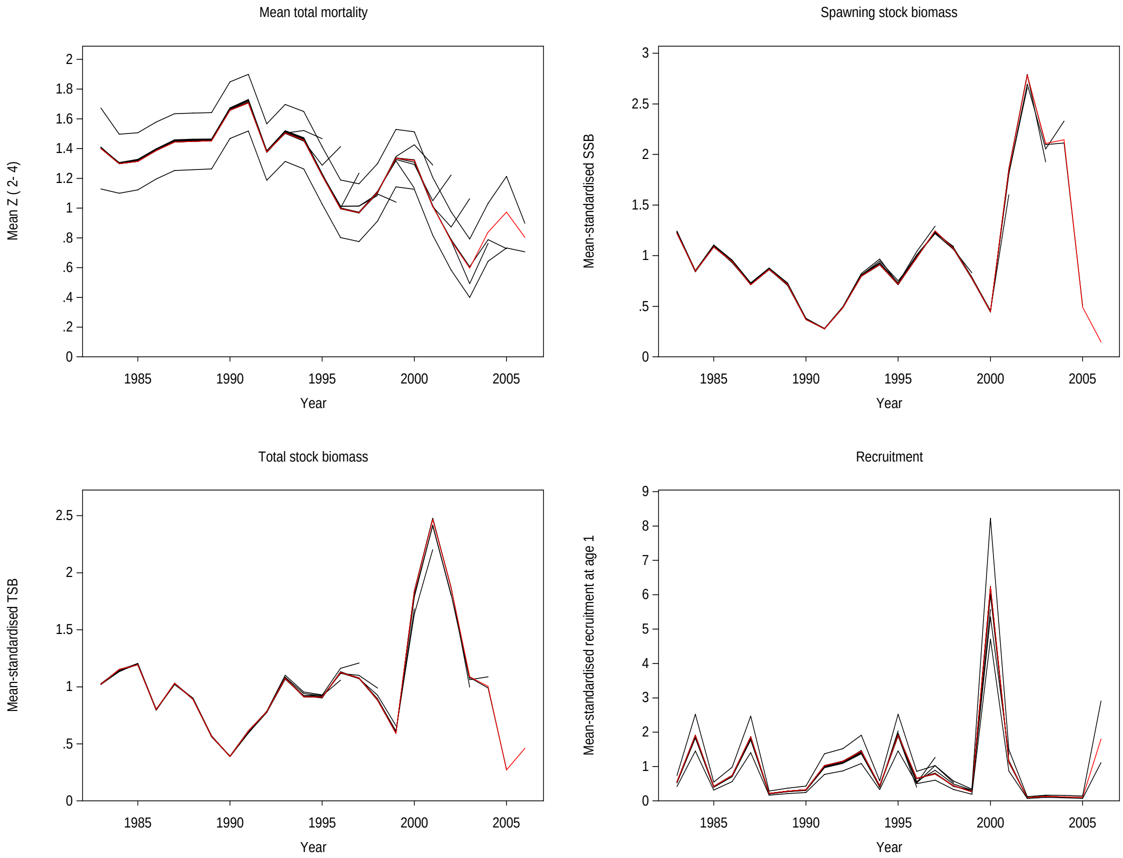


Fig. 14. North Sea haddock : retrospective analyses of the ICES IBTSQ1 survey data using the survey-only model SURBA (note: 6+ group not included in analysis – hence SSB in 2005&2006 is underestimated due to exclusion of data from strong 1999 year class).

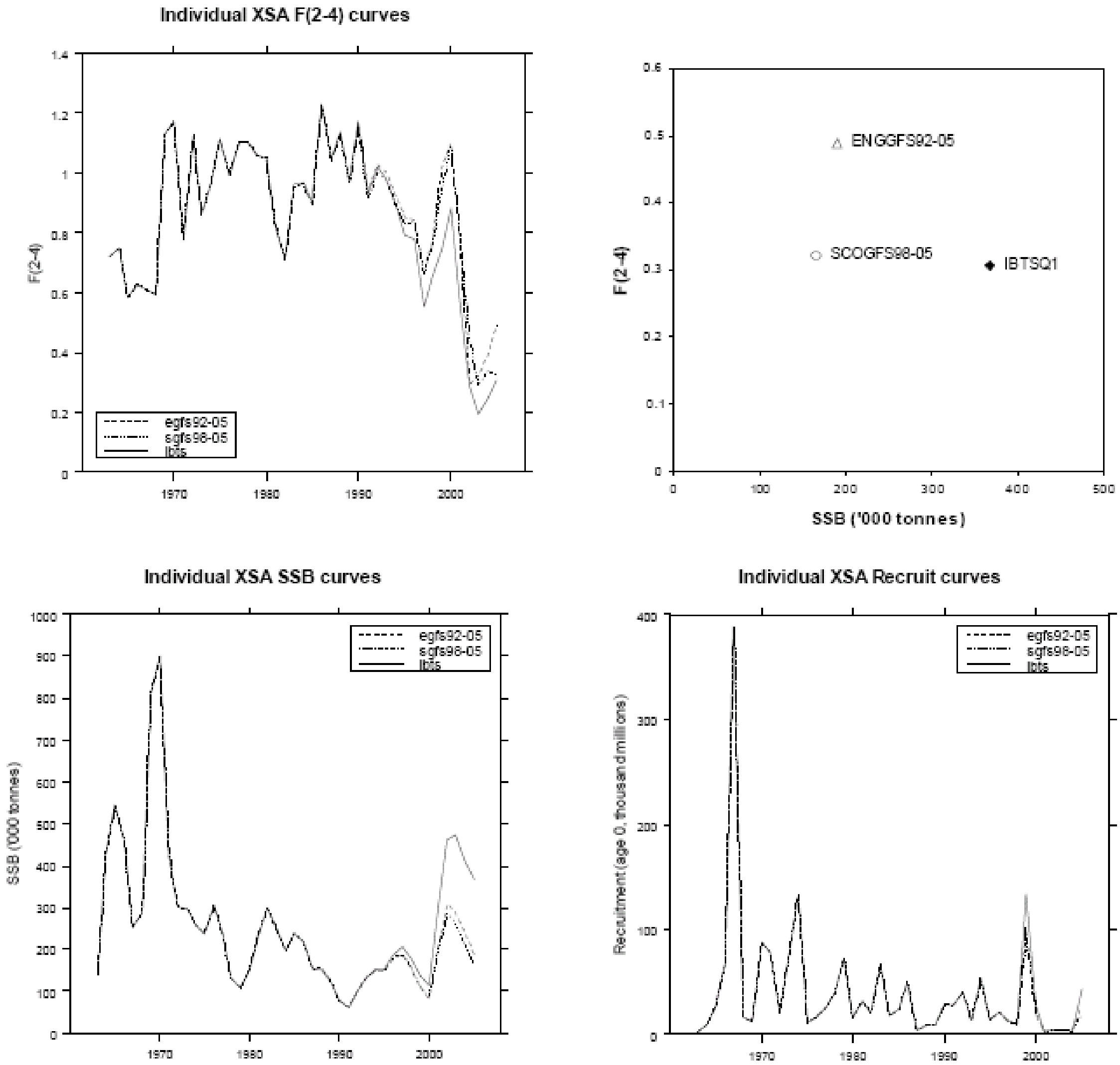


Fig. 15. North Sea haddock. Results of XSA runs tuned using individual survey series on their own. SSB and F values in the top r.h. plot are for the terminal year.

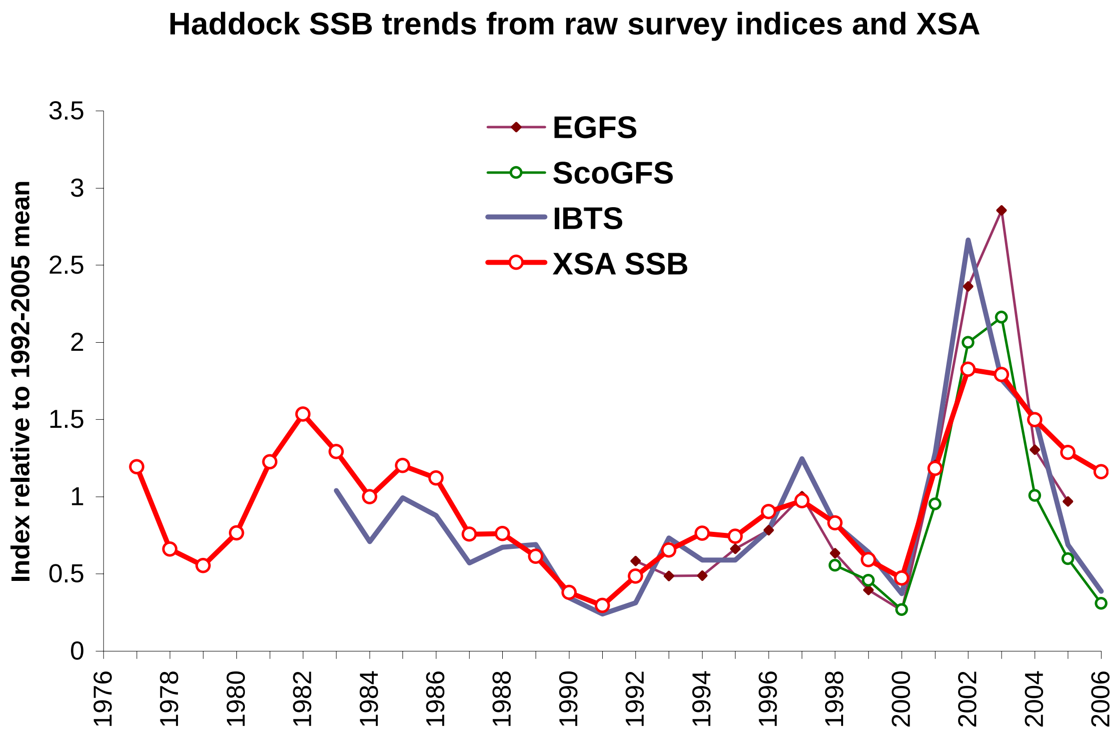


Fig. 16. North Sea haddock. Comparison of temporal trends in SSB given by the final XSA run and as given by the raw survey indices for all available ages converted to SSB (including 6+ group in IBTSQ1). Values are standardised to the 1992-2005 mean of each series. The older ScoGFS (pre 1998) and EGFS (pre 1992) are excluded due to lack of compatibility with the more recent series.

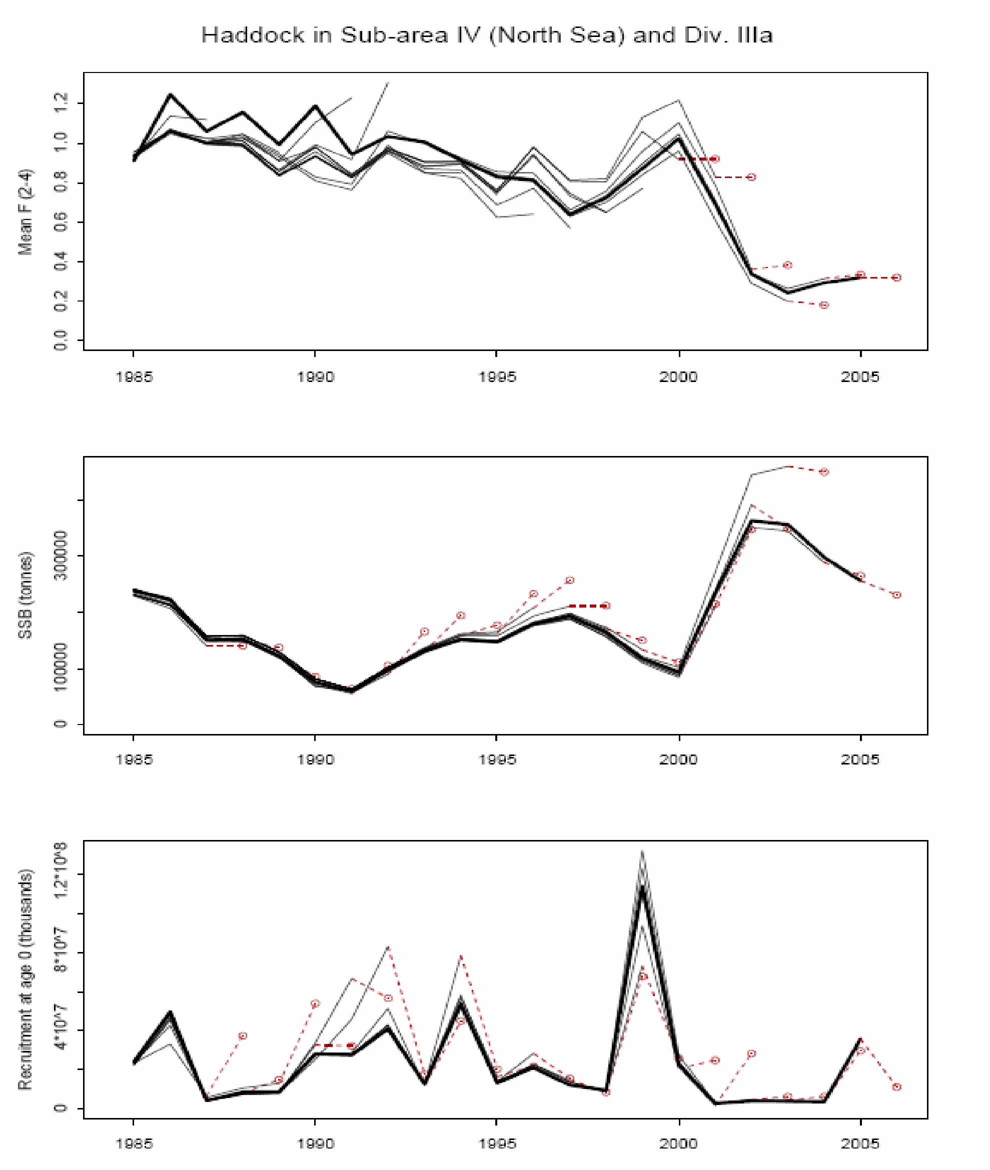


Fig. 17. North Sea haddock: Historical performance of the assessment as given by successive Working Groups (dashed lines and circles represent values used for short-term predictions).