MareFrame

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Deliverable No. 5.2

Project acronym:

MareFrame

Project title:

„Co-creating Ecosystem-based Fisheries Management Solutions"

Grant agreement No: **613571**

Project co-funded by the European Commission within the

Seventh Framework Programme

Start date of project: **1st January 2014**

Duration: **48 months**

Due date of deliverable:	31/07/2014
Submission date:	22/11/2014
File Name:	D5.2 MAREFRAME_Data available for modelling in case study areas
Revision number:	02
Document status:	Final[1]
Dissemination Level:	PU[2]

Revision Control

Role	Name	Organisation	Date	File suffix[3]
Author	John Pope	NRC		JP
Author	Valerio Bartolino	SLU		VB
Authors	Alan R. Baudron & Paul G Fernandes	UNIABDN		JGP
Author	Dr. Gheorghe Radu	INCDM		GR

1 Document will be a draft until it was approved by the coordinator

2 PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services)

3 The initials of the revising individual in capital letters

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Author	Javier Ruiz	CSIC		JR
Authors	M. Sinerchia, F. Colloca	CNR-IAMC		FC/MS
Task leader	Bjarki Þór Elvarsson	MRI		BE
WP leader	Francesco Colloca	CNR		FC
Coordinator	Anna K. Daníelsdóttir	Matis	02.12.2014	AKD
Administrative Coordinator	Oddur M. Gunnarsson	Matis		OMG
Scientific Coordinator	Gunnar Stefánsson	UI	28.11.2014	GS

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Deliverable D5.2

Data available for modelling in case study areas

08/12/2014

Executive Summary

MareFrame Deliverable 5.2 (D5.2) on "data available for modelling in case study areas" identifies relevant data for ecosystem modelling in WP4 for each case study area/ecosystem as input for database implementation in WP3. It is the second deliverable of WP5 "Apply new methods in case studies" and will apply the modelling approaches developed in WP4 on marine ecosystems. MareFrame Case studies (CSs) represent different European seas and the Chatham Rise east of New Zealand, covering a wide range of ecosystems (i.e. open marine waters or semi-enclosed seas) biological complexity (e.g. Baltic Sea/Mediterranean Sea/North Sea), ecological knowledge (e.g. data-poor/data rich areas) and a large array of management practices, issues and priorities. In D5.2 the relevant data available for the development of models in WP4 are identified and described in terms of spatio-temporal coverage and formats. Data cover the different ecosystem components identified in Deliverable 5.1 (D5.1) for ecosystem modelling in case study areas, namely:

- physical-chemical data (e.g. sea surface temperature, chlorophyll a)
- oceanographic data (e.g currents directions and speeds);
- topographic data (e.g. depth);
- functional groups identified in D5.1 (e.g. time series of biomass, stomach contents and food preferences, consumption, mortality);
- fisheries and commercial stocks (e.g. landings and discards, by-catch, socio-economic data; survey data; stock biomass, fishing mortality and reference points);

These data are complemented with new information and knowledge available (e.g. genetics, microchemistry, isotope. etc.), required by WP2 ("*Select and apply new analytical methods*"), considered as relevant and applicable for inclusion in assessment models or general ecosystem models in each CS area.

Contents

Introduction

Deliverable 5.2 summarizes results obtained for Task 5.2. This was aimed to identify relevant data for ecosystem modelling in WP4 that are available as input for database implementation in WP3. In addition, the data identified in D5.2 will be also used to develop management scenarios in WP5 and to analyse the tradeoffs associated to specific management measures applied in case study areas. The types and quantity of data identified for modelling vary largely among case study areas (CS) according to different aspects, namely:

- The complexity of the ecosystem models applied, from high complexity models such as ATLANTIS to intermediate complexity tools (e.g. GADGET)
- The amount of data available as such (i.e. data rich areas/poor data areas)
- The complexity of the management scenarios to be evaluated in WP5.

Typically a number of data types are routinely collected in CS areas for the purposes of fisheries management (e.g. fisheries data collectection, surveys), monitoring and conservation of the ecosystem. These are complemented with physical-chemical data from remote sensing databases and other sources, as well as with data gathered by projects or research programmes (local, national or international), targeting specific ecosystem components (e.g. plankton, benthos, seabirds, mammals, etc.). D. 5.2 summarizes therefore, the types of data that will be used for ecosystem modelling in CS areas, their formats and spatio-temporal resolution.

I. Baltic Sea case study

Spatial units

Most of the sampling activities directed to the assessment of fish stocks in the Baltic Sea relate to the spatial units system defined by ICES. ICES Subdivisions and statistical rectangles are used as statistical strata of internationally coordinated scientific surveys and as well as fisheries sampling programmes. Within this system, the Baltic Sea is embedded into the Subdivisions 21-32 (Fig. 1). The ICES Subdivisions have been defined historically based on a combination of ecological and geographical considerations. In the Baltic the ICES Subdivisions approximate some of the main sub-basins (i.e., SD 32 corresponds to the Gulf of Finland, SD 22-24 is the western Baltic, SD 25-28 is the central Baltic). Each subdivision is then devided into regular rectangles of 0.5 degrees in latitude and 1 degree in longitude.

The subdivisions are generally suitable to capture large scale spatial patterns especially for those fish stocks characterized by wide distributions spanning across different sub-basins of the Baltic Sea. However, subdivisions may be too coarse to capture smaller scale variations in the spatial distribution such as those within a sub-basin. On the contrary, the ICES rectangles are sufficiently small in most cases to capture important sub-basin patterns of fish and fisheries, but they may suffer lack of data for a statistical representation of many biological variables over the large spatial extents. Many biological and physical variables collected for the purpose of fish stock assessment can be considered homogeneous within ICES rectangles, with the exception of few variables and areas (i.e., depth has a wide range in some rectangles in the Gotland Basin, temperature and other hydrographic variables may have sharp gradients within rectangles in very coastal waters). The ICES rectangles are likely too small to be directly used as individual spatial units in most of the Baltic Sea ecosystem models implemented in the MareFrame project, but if needed they will offer the flexibility to customize the aggregation of data over spatial units different from the sometimes artificial boundaries of the ICES subdivisions, or they may be used to identify areas of transition and mixing between subdivisions. This makes the ICES rectangles a potentially suitable spatial unit for storing data for the implementation of spatially-disaggregated stock assessment and ecosystem models for the Baltic Sea.

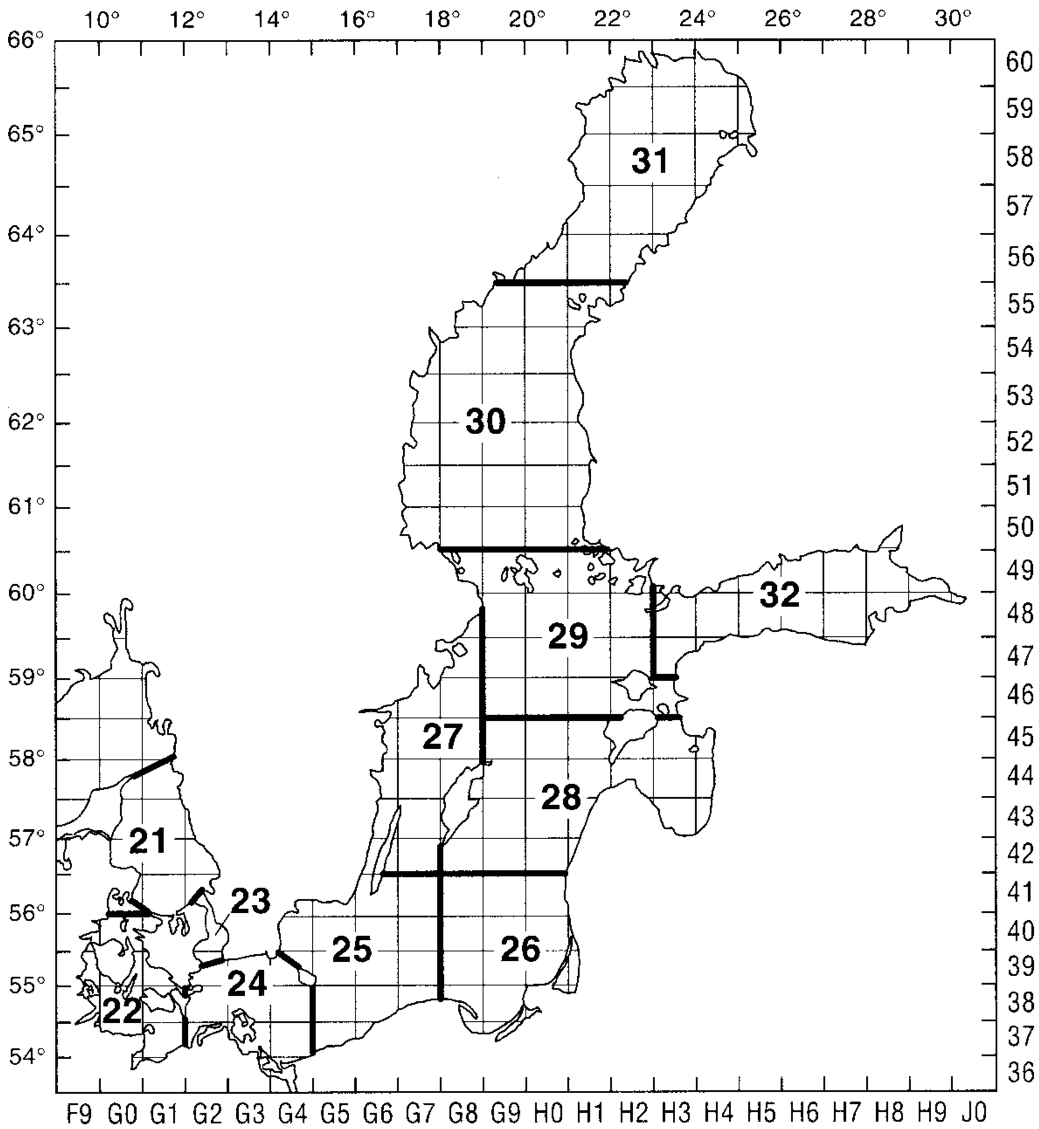


Figure 1 - ICES Sub-division borders and rectangles codes in the Baltic Sea. On the x-axis (e.g. F9, G0) are rectangle coordinates in longitude dimension at 1° intervals and on the right y-axis (e.g. 60, 59) are rectangle coordinates in latitude dimension at 0.5° intervals. Thus, rectangles are named e.g. 59F9.

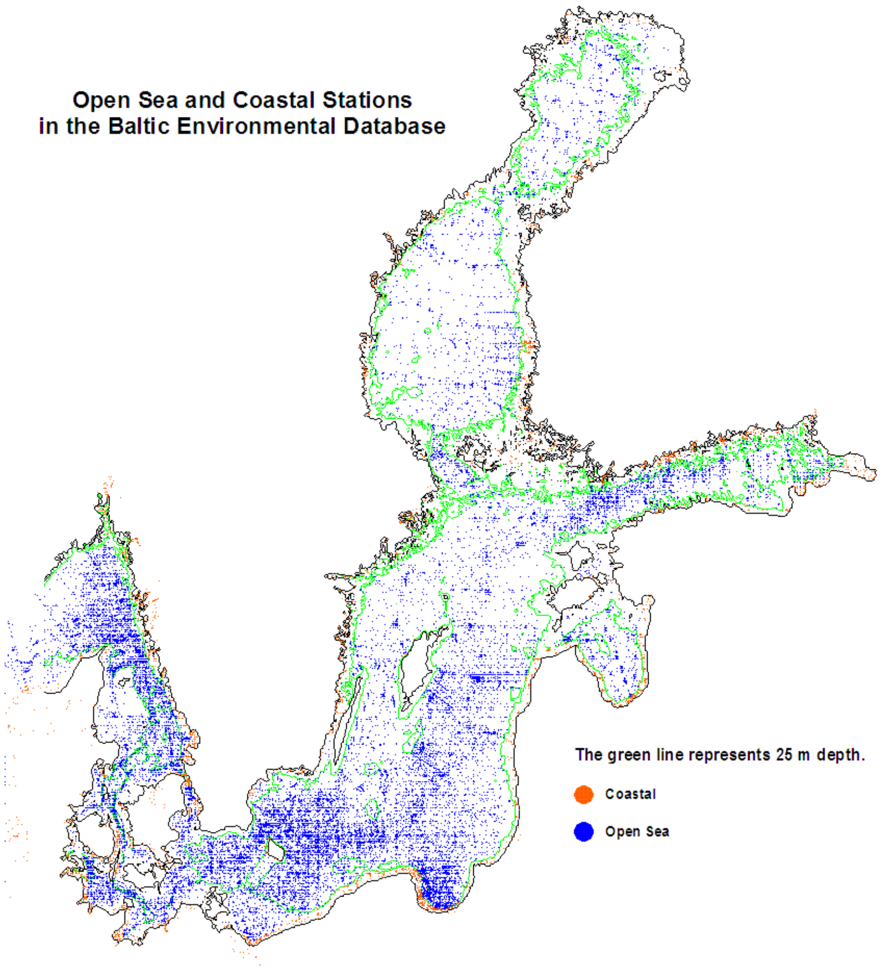


Figure 2 - The total number of station positions regardless dates and sources of data

Oceanography

The Baltic Environmental Database - BED - was initiated in 1990 as part of a research project 'Large-scale Environmental Effects and Ecological Processes in the Baltic Sea' financed by the Swedish Environmental Agency (for details see Wulff F., 1990). The basic idea has been to make available data set on the conditions in the Baltic Sea and on forcing functions so that budget and models of the physics and biogeochemical cycles of organic matter and nutrients can be developed (Fig. 2).

The BED database cointains the following information:

- Bathymetry
- Nutrients and hydrography
- Sediment data
- Atmospheric inputs of nutrients
- Runoff and nutrient inputs from rivers and non-monitored areas
- Weather

Bathymetric data

The most up-to-date source with high-resolution sampled bottom parameter info seems to be the "IOW, Institut f. Ostseeforschung, Warnemuende/Germany". (They also possess hi-res digitized bathymetric maps of the Baltic Sea)

Nutrients and hydrography

BED includes chemical and hydrographical sets since 1877. These data are available for everybody on the Internet via Das and *Nest* with the exception of the 5 last years and some specific datasets.

- TEMP Temperature (Celsius)
- SALIN Salinity (PSU)
- SALIN_MET Measurement method: 8 = CTD, 11 = Titrimetric, 12 = Conductivimetric.
- TOTOXY Total Oxygen (ml/l)
- DENSITY Water density
- OBSDEP Observation depth
- PO4P Phosphate (µmol/l)
- TOTP Total Phosphorus (µmol/l)
- SIO4 Silicate (µmol/l)
- NO3N Nitrate (µmol/l)
- NO2N Nitrite (µmol/l)
- NO23N Nitrite + Nitrate (µmol/l)
- NH4N Ammonia (µmol/l)
- TOTN Total Nitrogen (µmol/l)
- CHL Chlorophyll (µg/l)

Sediments

This database is currently under construction. This will be done through a compilation of various kinds of data on sediment characteristics, sediment storage and burial, sediment-water exchange, denitrification, and sediment deposition.

Atmospheric inputs

Gridded atmospheric input data as monthly mean values for 1970-1991 with a spatial resolution of 1x1 degree squares for the entire Baltic drainage basin.

Runoff and nutrient inputs from rivers and non-monitored areas

This database has a monthly time resolution (for the period 1970-1990) with exception of Denmark that provided annual estimations. The data were collected from the different national monitoring programs and additional samplings were carried out. The monitored river loads data series are partly updated until year 2012.

Weather

These data are mean values for 1979-1994, interpolated and gridded into 1x1 squares for the entire Baltic drainage basin. The variables are Atmospheric pressure, winds, temperature, relative humidity in %, cloudiness in %, and precipitation. Besides that, we use to get information on weather observations for some sampling cruises where the following variables are included: Wind direction, Wind speed, Air Temp. (dry bulb), Air Temp. (wet bulb), Weather, Light, Cloud, State of the sea, Ice, Secchi.

Functional groups used in the model

Functional groups based on existing model (source of data, time series: surveys, etc.).

Fish (see section on commercial and survey data below)

Benthos data from NMFRI

Zooplankton from ICES database

Commercial activities

Commercial catches of cod, herring and sprat are independently collected by each Baltic country according to national sampling programmes. Sampling takes place at a number of different occasions including fishing harbours, actions, buyers, and on-board of fishing vessels. Since the early 2000s fisheries data have been collect and managed mostly within the Data Collection Framework (DCF). Information on commercial catch amount and biological composition (i.e., age, maturity) will be available with different coverage and resolution through the ICES assessment working group (WGBFAS) and the STECF-JRC.

COD

Annual total landings since 1966 (WGBFAS 2013, Tab 2.4.1);

Catch-at-age and mean weight-at-age in landings and discards since 1966 (WGBFAS 2013, Tab 2.4.11-12)

Total landings by quarter, ICES sub-division and gear since 1991 (WGBFAS 2013, Tab. 2.4.2);

Catch-at-age (incl. discards) and mean weight-at-age by quarter, ICES sub-division and gear since 1991 (WGBFAS 2013, Tab 2.4.8a,b);

Total landings and discards by quarter, ICES rectangle and gear since 2003 (STECF-JRC)

HERRING

Annual total landings since 1977 (WGBFAS 2013, Tab 6.2.1)

Catch-at-age and mean weight-at-age since 1977 (WGBFAS 2013, Tab 6.2.5-6)

Catch-at-age and mean weight-at-age by quarter and ICES sub-division since early 1990s (WGBFAS 2013, Tab 6.2.4)

Total landings by quarter, ICES rectangle and gear since 2003 (STECF-JRC)

SPRAT

Annual total landings since 1977 (WGBFAS 2013, Tab 7.1)

Catch-at-age and mean weight-at-age since 1974 (WGBFAS 2013, Tab 7.6-7)

Catch-at-age and mean weight-at-age by quarter and ICES sub-division since early 1990s (WGBFAS 2013, Tab 7.3)

Total landings by quarter, ICES rectangle and gear since 2003 (STECF-JRC)

In addition, information for all the fisheries and stocks investigated will include:

Fishing effort by year, quarter, ICES rectangle, country, gear, vessel size since 2003 (STECF-JRC)

Main output of current ICES assessment of cod, herring and sprat, including fishing mortality, spawning stock biomass, recruitment

Surveys

The EU sampling program (European Council regulation 1543/2000) sets the data collection requirements for the EU Common Fisheries Policy and identifies priority surveys for cod, herring and sprat in the Baltic. The ICES Baltic International Fish Survey Working Group (WGBIFS) coordinates the surveys among the Baltic Sea countries.

Bottom Trawl Surveys

The first attempts to coordinate national bottom trawl surveys in the Baltic were made in the early 1980s, and they were continued with varying intensity in subsequent years to harmonize and compare the sampling gears, and the spatial and temporal distribution of the sampling effort (Schulz and Grygiel, 1984; 1987, ICES, 1987; Oeberst and Frieß 1994, Oeberst and Grygiel, 2004). These efforts resulted into the Baltic International Trawl Survey (BITS).

The BITS is directed to the demersal species, i.e. cod and flounder and other flatfishes in the Baltic Sea, however in recent years other species are also intensively investigated to support ecosystem analyses.

Major changes in the survey design and calibration:

1985 - first attempt to determine conversion factors among different gears

1999 - development of new standard fishing gears (type TV3#520 and TV3#930). From autumn 1999, a number of fishery laboratories of the Baltic countries conducted intercalibration experiments between national and new standard gear (ICES 2001a, 2003) and conversion factors between the new standard and the national gears were estimated (Anon, 2001a, ICES, 2002, Oeberst and Grygiel 2002, 2004, Lewy et al., 2004).

2000 - generalized linear models are used to calculate the "fishing power" of national bottom trawls. The "fishing power" factors are used to transform the national catch per unit of effort into cpue-values of the former standard GOV trawl (Sparholt and Tomkiewicz, 2000).

2001 - new coordinated survey design was established in 2001. Stratified random trawl surveys use the ICES Subdivisions and their depth layers as strata to reflect the variability of the distribution pattern of target species.

Age structure time series from the BITS start in 1982 based on national surveys, although data from nationally coordinated surveys based on a common fishing gear are available from 2000.

Timing, area covered by the survey and sampling locations

The spatial extent of the BITS is mostly determined by the overall distribution of cod in the Baltic Sea (Fig. 3). For this reason the BITS is conducted in the ICES Subdivisions 22–28, but expansion of the survey to the northern areas of the Baltic Sea (ICES Subdivisions 29–32) is possible depending on the development and distribution of the eastern Baltic cod stock. The BITS is a stratified random survey based on 5 depth strata 20–40 m, 41–60 m, 61–80 m, 81–100 m, 101–120 m. The allocation of hauls is based on a factor weighting both the area of ICES Subdivisions and the distribution pattern of cod. In practice, the total number of planned trawl stations is allocated to Subdivisions according to the area and the 5 years running mean of the cpue derived from the BITS survey in spring. The resulting number of planned stations for each ICES Subdivision is then allocated to the depth layers (see WGBIFS report). Because certain areas are closed for fishing activities in the Baltic Sea as a result of munitions, electrical cables, gas pipelines and dense ships traffic, a Tow Database was established in 2001. Sampling locations are randomly selected among all the positions suitable for demersal trawling as indicated in the Tow Database (see WGBFIS report).

The BITS is traditionally a spring survey conducted during 15 February–31 March. Since 2001, an additional autumn survey is conducted based on the same survey design during 1–30 November. Sampling is limited to daylight, the duration of the standard haul is 30 minutes at a towing speed of 3 knots. Selected hauls are omitted if hydrological measurements reveal that oxygen concentrations are <1.5 ml/l in the layer of vertical net opening (no cod is assumed to occur below this threshold of oxygen concentration).

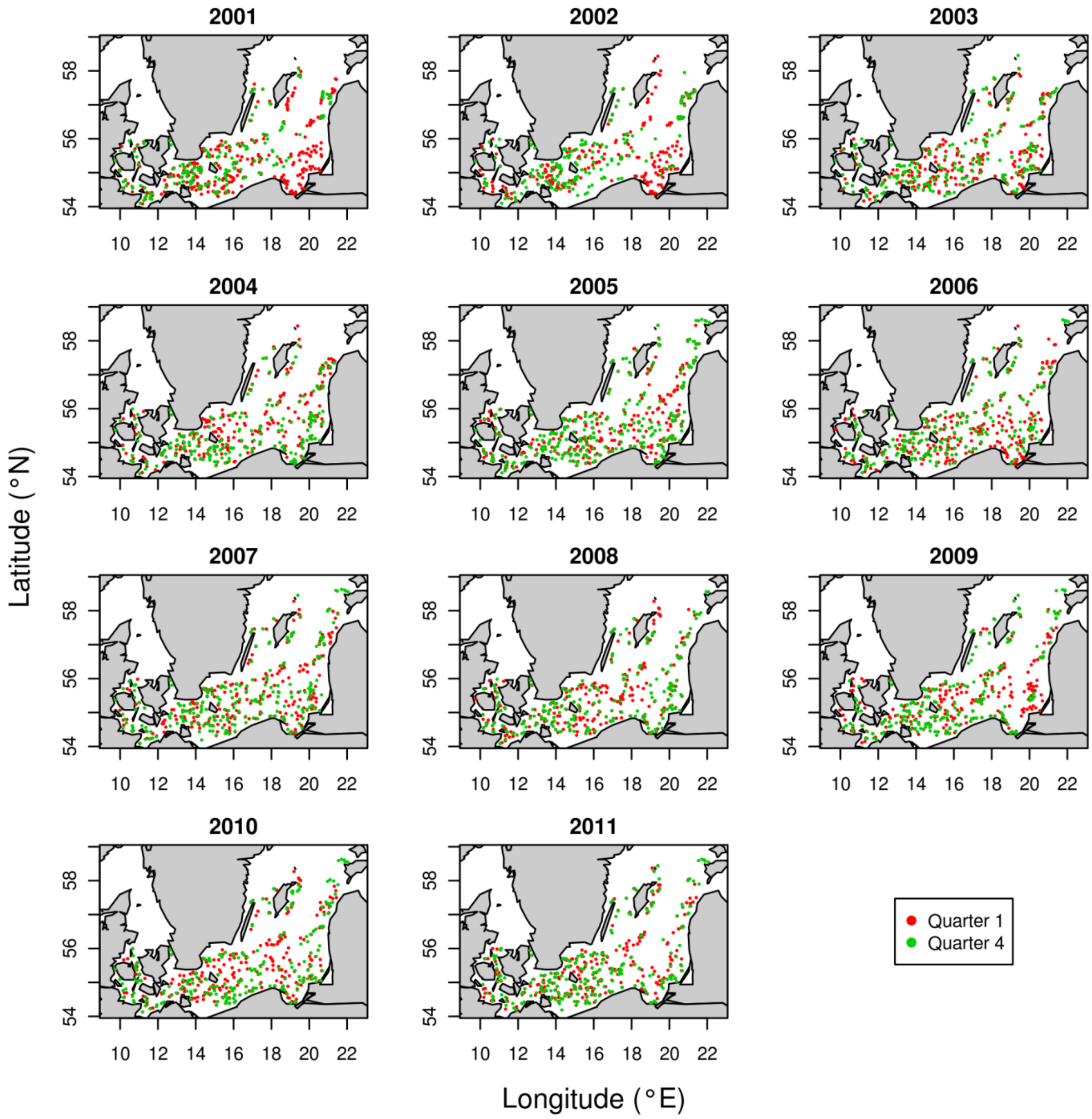


Figure 3 – Location of the BITS sampling stations from ICES Subdivisions 22-28 in quarter 1 and 4 in the period 2001-2011.

Sampling gear

The TV-3 bottom trawl is used as standard fishing gear during the BITS surveys in the Baltic Sea since 2001. Two types of TV-3 trawl were developed, one small of 520 meshes and one large of 930 meshes in circumference. The small standard trawl type TV-3#520 is used for vessels up to around 800 HP and the larger standard trawl type TV-3#930 for vessels with higher towing power. Small adaptation of large TV-3 was carried out by Denmark, which added a stone panel to reduce the danger of trawl damage by large stones. Denmark and Germany conduct all hauls in the ICES Subdivisions 22–24 in order to reduce the effects of the conversion factors between the small and large version of the new standard trawls. Vessels of both countries (RV "Havfisken" and RV "Solea") use the small version of the standard trawl. The large version of the standard trawl is used by Denmark (RV "Dana"), Poland, Russia and Sweden in the ICES Subdivisions 22 - 28. The ICES Subdivision 28 and small part of the ICES Subdivision 26 are covered by Estonia, Latvia, and Lithuania, which also use the small version of TV-3.

Biological sampling

Collection of biological data follows the same protocol during the two BITS surveys. The total catch in number of individuals and weight by species is measured or estimated for the species identified in the catch. In cases of exceptionally large catches (e.g. over 500 kg) or other circumstances which do not allow the sorting of total catch, the species composition is estimated using sub-samples of the total catch. A number of different methods are applied for sub-sampling according to different circumstances (see BITS manual for more details).

The total length of individual fish is measured for all main fish species (i.e., cod, herring, sprat, flounder and other flatfishes) using sub-samples of the catch. All the individuals in a randomly selected sub-sample are measured for length. Length is measured to 0.5-cm below for herring and sprat, andto 1-cm below for all the other species. The sample size is represented by a minimum number of individuals to be length measured (in sample or subsample) proportional to the number of length classes:

Number of length-classes	Number of individuals
1-10	100
11-20	200
More than 20	300

If a larger number of fish is sampled per length group, weight, age, sex and maturity stage are measured only on the above specified numbers of individuals. Measurements of individual weight, age, sex and maturity stage are required for cod and flounder, while they are collected on other species such as herring and sprat only when capacities are available. The data are used calculate age-length-keys (ALK) by ICES Subdivision and quarter which are then applied to convert length into age-distribution (see the BITS manual for further details on the surveys and on the use of the data for calculation of indices of abundance).

BITS data are stored at ICES in the DATRAS database in the form of three tables (see http://www.ices.dk/marine-data/data-portals/Pages/DATRAS.aspx):

HH: Record with detailed haul information

HL: Length frequency data

CA: Sex-maturity-age–length keys (SMALK's) for the ICES Subdivision

Acoustic Surveys

Hydroacoustic surveys have been conducted in the Baltic Sea internationally since 1978. The starting point was the cooperation between Sweden and the German Democratic Republic in October 1978, which produced the first acoustic estimates of total biomass of herring and sprat in the Baltic Proper (Håkansson et al., 1979). Since then there has been at least one annual hydroacoustic survey for herring and sprat stocks mainly for assessment purposes and results have been reported to ICES to be used for stock assessment (ICES, 1994a, 1995a, 1995b; 2006; Hagström et al., 1991). Two acoustic survey programmes are conducted in the Baltic, the Baltic International Acoustic Survey (BIAS) and the Baltic Acoustic Spring Survey (BASS).

During the surveys, herring and sprat normally cannot be distinguished from other species by visual inspection of the echogram. Both herring and sprat tend to be distributed in scattering layers or in pelagic layers of small schools, and it is not possible to ascribe values to typical herring schools.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Thus, species allocation is based entirely upon trawl catch composition. The estimates of total fish density are then allocated to species and age groups according to the trawl catch composition in the corresponding ICES rectangle.

Timing, area covered by the survey and sampling locations

The acoustic surveys cover large part of the Baltic Sea. The sampled areas extend to the ICES Subdivisions 24-32 and 25-26,29 in the BIAS and BASS, respectively. The stratification is based on ICES statistical rectangles with a range of 0.5 degrees in latitude and 1 degree in longitude. Each rectangle of the survey area was allocated to one country in 2005, thus each country has a mandatory responsible area (Fig. 4). The study area is limited inshore by the 10 m depth line.

Parallel transects are spaced on regular rectangle basis at a maximum distance of 15 nautical miles (NM). The transect density is about 60 NM per area of 1000 NM^2.

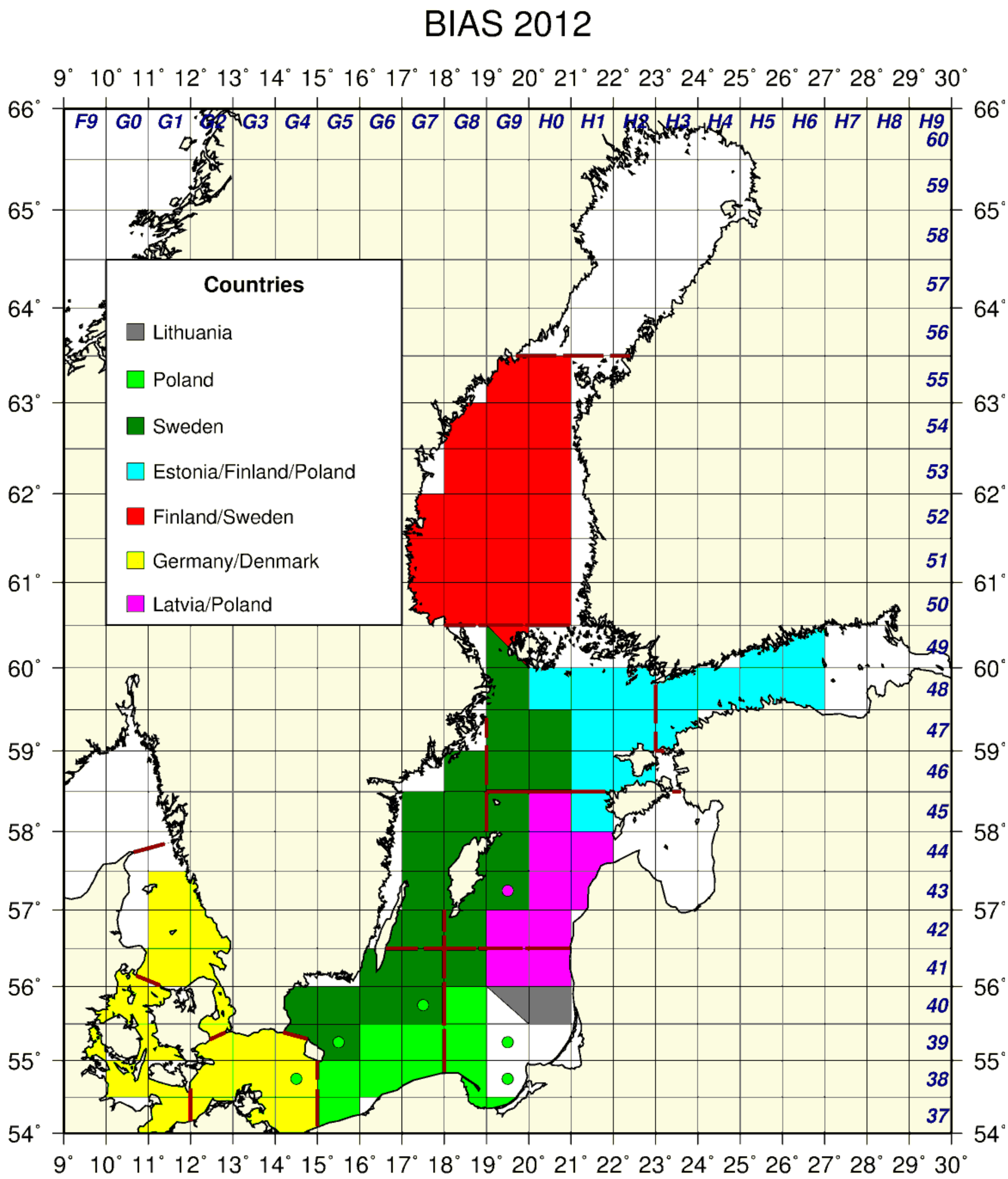


Figure 4 - Map of the BIAS surveys conducted in September-October 2012. Various colours indicate the countries, which covered specific ICES-rectangles and delivered data to BIASdatabase, thus was responsible for this rectangle. Dot with different colour within a rectangle explain additional data in BIAS-database partly or totally covered by other countries.

The BASS and BIAS are carried out yearly in May and September/October, respectively. The Spring survey is mainly concluded to estimate indices of abundance of sprat. The Autumn survey is routinely used to estimate indices for both herring and sprat. The standard temporal coverage, as currently considered for assessment purposes, is from 1991 for the BIAS and from 1999 for the BASS. Historical abundance at-age acoustic estimates are only available for the BIAS for the period 1978-1984 at the ICES Subdivision level and for the period 1985-1990 at the ICES rectangle level.

In the shallow water areas of the western Baltic a great part of the pelagic fish are concentrated close to the bottom during daytime (Orlowski 2000; 2001). Therefore, these areas are surveyed only during night-time (Orlowski 2005).

Sampling gear

The standard equipment used for the survey is the Simrad EK/EY-60 echosounder at the standard frequency of 38 kHz. The acoustic surveys are coupled to pelagic trawling to determine the species composition and length, age and weight distributions of target species detected by the echosounder. A minimum of 2 hauls per ICES rectangle are conducted. The standard trawling time is 30 minutes at speed of 3.0-3.5 knots. The stretched mesh size in the codend of the pelagic trawl used in the ICES Subdivisions 22–24 and 25–32 are 20 and 12 mm, respectively.

Biological sampling

The total catch weight per species are calculated for all species occurring in the pelagic trawl. In case of homogenous large catches of clupeids a sub-sample of at least 50 kg is taken and sorted for the identification of the species. In case of heterogeneous large catches consisting of a mixture of clupeids and few larger species, the total catch is partitioned into the part of larger species and that of the mixture of clupeids. From the mixture of clupeids, a sub-sample of at least 50 kg is taken to calculate the proportion by species. Length is defined as total length (measured from tip of snout to tip of caudal fin). Both herring and sprat are measured from each catch and sorted into 0.5 cm classes (mid-points x.25 and x.75 cm), and into 1 cm classes for all other species (mid-points x.5 cm). In case of large catches of clupeids with a narrow length spectrum, a sub-sample of at least 200 specimens per species is collected for length measurements (400 speciemens per species if the catch has a wide length distribution). For other species at least 50 specimens are measured. All herring and sprat measured for length are also weighted. Otoliths are sampled for the three target species (herring, sprat, cod). Minimum sampling levels per ICES Subdivision are represented by 5 otoliths per length-class for fish length <10 cm, and 10 otoliths per length-class for fish length >=10 cm.

Acoustic survey data are not stored as disaggregated information into a centralized databse system, but are partly available in aggregated form through the WGBIFS. For the purposes of our project the following acoustic data will be retrieve and compiled for herring and sprat:

- Number-at-age x rectangle
- Individual weight-at-age x rectangle
- Length frequency data (HL)
- Sex-maturity-age-length keys (CA)

Wherever HL and CA are not available from certain countries, they will be replaced with ALK x ICES subdivision.

Stomach data

Information on cod diet are available from a number of different sources and time periods. Historical stomach data spanning from 1977-1993 have been previously compiled and represent the core dataset currently used for multlispecies assessement in the Baltic (ICES 2013). Prey sizes were mainly recorded by 5 cm groups for the period 1977–1981. In cases where data were given by smaller length classes they are allocated to the relevant 5 cm group. Data for the period 1982-1993 are given by 1 cm class. Data are compiled by 1 cm length groups for sprat and 2 cm length groups for herring (ICES 2009b). Unidentified clupeids and preys with missing length information are allocated to the species and length groups according to the observed prey composition and prey size structure in the basic stratum (cod length, prey, subdivision, quarter). In addition, stomach data collected in 2012-2014 under the new stomach sampling program (EU program Mare/2012/02) will be harmonized and included.

Stock definition

The beginning of data analyses dedicated to population genetic structure recognition started in the 60s. Using haemoglobin, allozymes or mtDNA genetic polymorphism of economically important species was studied for a large geographical scale. In the 90s, microsatellite DNA markers characterized with very high genetic resolution were developed. Since that time temporal and spatial population differentiation was revealed within many smaller body of water, also for cod, herring and sprat inhabiting Baltic Sea (Nielsen et al. 2003, Jörgensen et al. 2005, Limborg et al. 2009). The sample collection for genetic structure analyses of herring covered whole part of the Baltic Sea (ICES Subdivisions 22-32) and for cod and sprat the ICES Subdivisions 22-28 were sampled (Figure 5,6). Data were compared and analysed together with samples from Kattegat, Skagerrak and North Sea are. Sampling sites were located in well know or presumably spawning places and specimens were collected mainly during spawning time.

Figure 5 – Location of sampling sites for cod genetic structure analyses (from Nielsen et al. 2003).

Figure 6 – Location of sampling sites for sprat genetic structure analyses (Limborg et al. 2009).

Cod, herring and sprat management units are mainly congruent with genetic structure data of the species. In some cases (i.e. herring) the stock assessment units are even more disunited than genetic results suggest.

COD

Genetic structure justified separation for western and eastern cod stock management. Inside the Baltic Sea (for samples from Gotland, Gdansk and Bornholm Basin) population structure wasn't observed. Genetic differentiation between the North Sea samples and the rest increased along a transect to the Baltic proper, with a large increase in level of differentiation occurring in the Western Baltic area. The existence of intermediate genotypes in the transition area (Kattegat, Belt Sea, Sound, and Western Baltic) was demonstrated. This indicated the presence of hybrid swarm in transition zone flanked by pure nonadmixture populations in the North Sea and Baltic Sea. Genetic structure analyses for North Sea and Baltic Sea based on new generation markers – SNP (unpublished data 2013) were congruent with previous results.

HERRING

Significant genetic differentiation was present through the Baltic Sea, though pairwise Fst values were generally low (≤0.027). Identified two zones of lowered gene flow were concordant with the separation of the Baltic Sea into major basin, with environmental gradients and differences in migration behaviour. Samples aggregated in 3 groups: 1) Rügen, 2) Gdańsk Bay, Hanö Bay, Gulf of Riga, Baltic Proper, 3) Gulf of Finland, Aland Archipelago, Bothnian Sea, and Bothnian Bay.

SPRAT

Weak structure among samples within the Baltic Sea (pairwise θ = 0.001 to 0.006) was observed. A sharp genetic division separating samples from the north-eastern Atlantic Ocean and the Baltic Sea was revealed. (pairwise θ = 0.019 to 0.031).

Socioeconomic data

The EU Joint Research Council (JRC) provides a data set about national economic information by fleet segment in 2008-2012. Data can be segregated by country, year, supra region, sub-region, fishing technology (gear), and vessel length category. It is not possible, however, to segregate data by fish species which may be regarded as a major drawback influencing usefulness of these data. Variables in the data set are: Income from landings, Other income, Income from leasing fishing rights, Direct income subsidies, and Income from landings. With respect to expenditure, variables are: Wages and salaries of crew, Annual depreciation costs, Energy costs, Non-variable costs, Repair & maintenance costs, Rights costs, Unpaid labour value, Other variable costs . Also cpital value of the fleet segments is described using variables: Financial position, Tangible asset value (replacement), Investment (Capital value), and Fishing rights. This data set includes also variables about the fleet capacity: Average vessel age, Average vessel length, Vessel tonnage, Engine power, and Total number of vessel by the same segregation variables as the economic data. Variables for effort are: Number of fishing trips and Energy consumption.

JRC (2013) also provides annual comprehensive overview reports on the structure and economic performance of EU Member States fishing fleets. Again, these reports are segregated by fleet segments without reference to fish species they are catching. Expert knowledge is necessary to assign the fleet segments in the database with the actual fisheries targeting specific species and stocks. Even when receiving the supporting external expert help, it is anticipated that any attempts to make this type of assignment will be incomplete due to temporal and spatial mismatch between the fleet segments and the targeted stocks. The level of incompleteness will vary among the fleet segments. In a recent bioeconomic fisheries application (Voss et al. 2011) the cost function of the North Sea herring fishery was adopted to the Baltic sprat fishery. As there are significant differences in the gears used and fishery operations in these two fisheries, determined by the different schooling behavior between the North Sea herring and Baltic sprat, the authors‘ choice to adopt the cost function from the North Sea implies the lack of useful economic data in the Baltic.

II. North Sea case study

Spatial units (model domain and subunits)

The models proposed to explore the possibilities for EAFM management of the North Sea are as follows:-

1. Sized based models that use survey size composition data as their main data input. These could operate North Sea wide or potentially down to statistical rectangles (0.5° Latitude by 1° Longitude).
2. Age based models of the MSVPA or Boricom type. These will mostly work on a North Sea wide basis but some sub areas may need to be added to consider questions such as the management of the important nephrops fisheries that are made by functional units (ie sub stocks and sub divisions of the North Sea.
3. A comparison model based upon biomass flow such as EwE.
4. Summary Bulk Biomass models to make the results of models 1 and/or 2 explicit to stakeholders.

It is not proposed to make any explicit coupled oceanographic/ecosystem model (e.g. Atlantis) of the North Sea and the need for detailed Oceanographic and plankton data is far less in the proposed models.

Ideally, the models would work to a finer resolution than the whole North Sea. Data from some sources can be resolved to the level of ICES statistical rectangles(.5°lat by 1°long.). This is the case for the IBTS survey data. (see for example http://ecosystemdata.ices.dk/Map/index.aspx?Action=AddLayer&DataSet=657&LatN=&LatS=&LonE=&LonW=&Sdate=&Edate=)

Other data resources e.g. some catch at age data are only reliably available at the spatial level of the entire North Sea but nevertheless some is available by fishing fleet. To use such data on a finer scale than exists will require some ingenuity, for example it may be possible to use survey data or some stakeholder information to fill in some of the deficiencies.

This should be attempted since it seems likely that some area based problems will have to be addressed if models are to cover important issues such as that of managing the North Sea nephrops which is fished by area based functional units and which is also an important source of by-catch of other species. (It will also be important to consider area if it is intended to compare management types such as closed areas and with the more usual common fisheries management tools such as catch limits, effort restrictions or gear restrictions.

Oceanography.

As explained above there is not a particularly strong need for detailed oceanographic data for use in the models proposed for the North Sea. However, considerable amounts of such data are archived at ICES should their use be required at any point. Their main value to this project will most likely be in choosing sensible sub regions. Depth, bottom topography and sediment types are available by finer divisions than are likely to be required in any proposed model for the North Sea.

Temperature and Salinity data are available at a range of area and time scales and are archived at ICES but most certainly it is available at the scale used by the IBTS surveys (i.e. by rectangle in both spring and fall) and by much finer time and spatial steps for particular stations and sections. However these finer scales are beyond the scope of the modelling work proposed for the North Sea.

Chlorophyll and primary production. Estimates of annual production should suffice for the proposed models of type 3

Hydrology and other environmental variables. These will have only a limited role, possibly in defining sub areas. Consequently existing analyses should suffice.

Fish Species likely to be used in the models

(source of data, time series: surveys, etc.)

- Fish catch data are available from the entire North Sea since 1903. The following table lists the primary fish species to be included in models.

Table 1 Data sources for commercial fish species included in models

Species	Catch and Effort	Catch at Age Data	Survey catch rate and length Data
cod	STECF By fleet	ICES 1973-2013 (roundfisharea)	ICES 1977-2012 (by rectangle)
haddock	STECF By fleet	ICES 1972-2013 (roundfisharea)	ICES 1977-2012 (by rectangle)
whiting	STECF by fleet	ICES 1990-2013 (roundfisharea)	ICES 1977-2012 (by rectangle)
saithe	STECF by fleet	ICES 1967-2013 (roundfisharea)	ICES 1977-2012 (by rectangle)
mackerel	STECF by fleet	ICES ?-2013 (North Sea fraction of stock)	ICES 1977-2012 (by rectangle)
herring	STECF by fleet	ICES 1948-2013 (North Sea)	ICES 1977-2012 (by rectangle)
sprat	STECF by fleet	ICES 1974-2013 (North Sea)	ICES 1977-2012 (by rectangle)
Norway pout	STECF by fleet	ICES 1983-2013	ICES 1977-2012

		(N North Sea)	(by rectangle)
sandeel	STECF by fleet	ICES 1983-2013 (3 substocks)	Poorly sampled by survey
Grey Gurnard	?		
Other fish as appropriate	?		ICES 1977-2012 (by rectangle)

Shellfish. Nephrops catch, effort and size distribution are available by functional units.

Benthos. The results of one off surveys are available at the resolution of statistical rectangle

Zooplankton. For the models proposed (i.e. model 3) only overall production from the entire North Sea will be required.

Birds. The potential effects of fishing on birds vary markedly by species. Time series of overall species abundance are available from relevant ICES Working Group reports.

Mammals One off sighting surveys of cetaceans have been made. The figures are more likely to be reliable at a North Sea wide level but knowledge of hot spots will also be of value and need to be further explored. Annual population estimates for grey and harbour seals are available from ICES Working Group reports.

Others Not applicable

Commercial activities

Port sampling.

Fleets are all sampled at ports for catch quota and fishing effort compliance purposes. This is also typically used to provide the basis for length and age samples.

Discards (by fleet, species, area). Important fleets are sampled at sea to provide discard information by species and as far as sampling density allows by area.

Biological data on catches (age/length composition, maturity, etc.) are collected as part of the port sampling process but there are variable time series of usable data (see table above)

Fishing effort (by fleet, metier, areaSocio-economic data) STECF studies provide this form of data for recent years and these give catch and effort by major fleets and rectangle

Assessment data (Fishing mortality, Stock biomass, numbers at age, ref. Points) All of the species mentioned in the table other than grey gurnards (see http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2012/2012/gug-347d.pdf) and other fish have single species age based assessment conducted by ICES that provide estimates of fishing mortality rate, stock biomass, numbers at age and mortality and biomass reference points. (see Multispecies assessments of fishing mortality and predation mortality are also available. Reference points for these model however, are conditional on fishery and the stock status of other stocks as well as to the species in question.

Survey data

Abundance by size indices. Survey data are available from the spring and fall IBTS surveys at a rectangle level. These provide catch by size by rectangle. However, for some of the less numerous commercial species e.g. cod such rectangle data is likely to be based on only a relatively few individuals and consequently to be rather variable.

Biological data (age/length composition, maturity, etc. are also available from survey results. They are also the main source of information on the species, size composition and distribution of other fish species.

Stomach contents. Stomach contents of cod, whiting, haddock, saithe and mackerel were collected comprehensively for each quarter of the year for all areas of the North Sea in 1981 and 1991. Collections were also made for some species and quarters for intermediate years. There is of course also a good deal of less synoptic data that has been collected but it is more difficult to use this because feeding varies by area, by time of year and by the relative abundance of prey from year to year. The need to use the data from just two years means that feeding model have to use restrictive hypotheses about the nature of predation if they are to be extended to un-sampled years and even more restrictive hypotheses if they are to be used in predictions of future states of the system.

Stock definition

- A major issue is the amount of time that migratory stocks such as Mackerel and Horse Mackerel spend in the North Sea each year. Some rather limited information exists for this and is to be found in ICES working group reports.

Extensive tagging data exists for many of the main species and some genetic data has also been collected. The main messages of these data are that typically fish range far less widely than the entire North Sea and that hence there are sub populations. However, it is highly doubtful that these data are sufficient to give detailed migration patterns at a rectangle level. Consequently it would seem more feasible to use diffusion models at this disaggregation level. These models might reasonably be calibrated from existing tagging data and in some cases illuminated by process studies such as those conducted with smart tags.

Other data

Maturity data and egg surveys conducted in the area gives information on the existence of separate substock spawning areas. These are reasonably well established for the North Sea.

New data (from WP2)

Trophic level studies are the most likely to be of value for calibrating some of the proposed models.

Other data and parameters

Existing single and multispecies models of the North Sea provide a sound basis for developing models for EAFM with much of the data assembled, reasonable estimates of consumption made and feasible parameter sets provided. Stakeholder information is another (as yet untapped) source which should be explored and may help fill lacunae in the models.

Conclusions.

Sufficient data are available at ICES in data archives and in working group reports, from STECF publications and in the literature to support North Sea wide multispecies models that can explore EAFM management questions in reasonable detail at the whole North Sea spatial scale. Data also exists which should also make it feasible to attempt modelling at a finer spatial scale as and where this is required to explore EAFM management. The likely scale of such models would be by statistical rectangle and these models would need to draw heavily on the IBTS survey data to give spatial resolution since other important assessment data are on a coarser scale. It is proposed to attend ICES WGSAM in October 2014 to become more closely involved with the working groups detailed data and also with the mixed fishery working group that meets concurrently.

III. Iceland

Spatial units

To facilitate flexible development of statistical fisheries models proper handling of data and related extraction processes is beneficial. For instance the bulk of ICES stock assessment reports deal primarily with available data and similarly most of the work goes into finding said data.

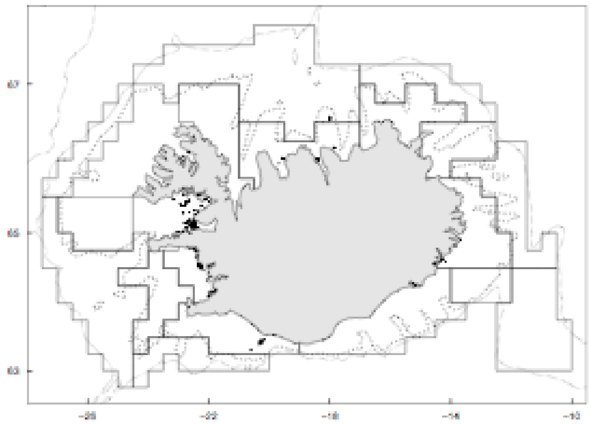


Figure 1: A graphical representation of the dst2 subdivisions on the Icelandic continental shelf area used for the data warehouse.

The dst2–project included the creation of a dedicated database specially designed to accomodate the needs of a stock assessment. It contains minimally aggregated data on the species of interest, aggregation based on geographical units specially chosen to reduce intra-division correlations with a minimal time step of 1 month. In addition the database was designed to be portable and widely applicable in the sense that the ETL process is based on strict ascii files. The design and implementation is fully open source.

The spatial scheme for the database is a hierarchical structure and represents spatial structure that is suitable for the types of models that can be implemented in Atlantis, EwE, and Gadget. This should reflect hydrography, bathymetry, species distribution and to lesser degree fishing controls. In this scheme all data is aggregated within spatial subdivisions, but sufficiently disaggregated to allow for detailed modelling of relevant processes. For modelling, the spatial structure needs to allow for adequate definitions of spatial stock structure, migration patterns, and predator-prey overlap. Each area should also be considered relatively homogeneous in terms of bathymetry, hydrography, and general oceanographic processes.

The process of defining these spatial subdivisions is described in MRI (2005). It follows previous work on Bormicon areas, introduced in MRI (1997). The main spatial features accounted for by this spatial scheme are:

- Division at depth 500m, which represents the border of the Icelandic continental shelf area.
- Hydrography separates the shelf area to northern and southern areas.
- Larger divisions are split into subdivisions by 200m depth contour lines. These subdivisions are illutstrated in Figure 1.

The motivation for this definition is mainly ecological, where the area definitions follow main features of the Icelandic continental shelf area. These subdivisions were validated by minimising their intracorrelation by a study of a combination of spatial rectangles and the output from a clustering analysis of samples obtained in annual spring and autumn surveys within the Icelandic EEZ.

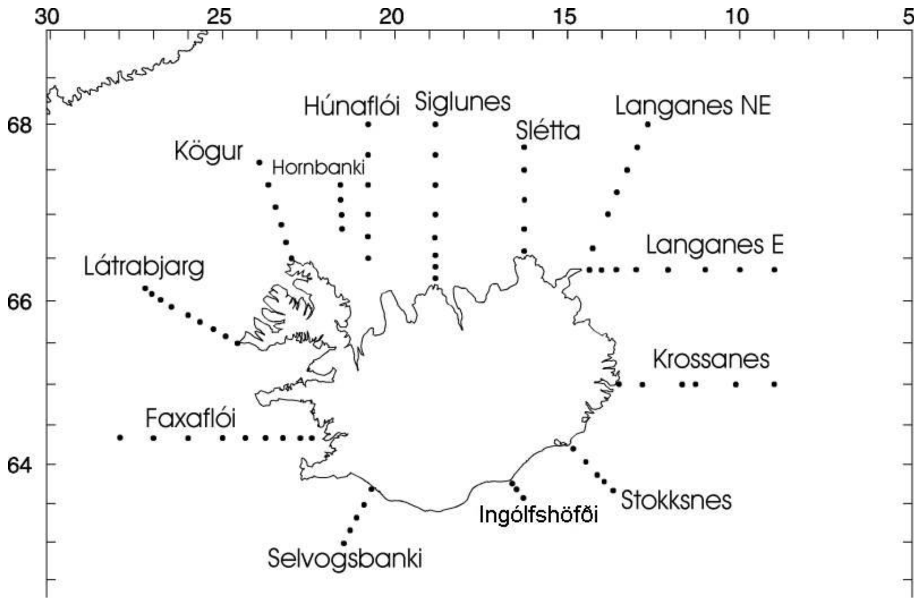
As noted above all data within those subdivisions are aggregated by relevant dimensions such as species, age, length and maturity, where relevant and possible. A single subdivision therefore represents a ragged array of measurements of a particular stock within the spatial subdivision at a certain time. The input files for the various stock assessment models are then created by simply adding the ragged arrays together to form the input. This effectively treats the subdivisions as independently and identically distributed samples. The independence arises from the way the subdivisions were created, while the identical distribution arises from the observation made in Taylor (2002).

Oceanography

According to Icelandic law, one of the duties of the Marine Research Institute (MRI) is to improve knowledge on the physical- and chemical oceanography of Icelandic waters, particularly in relation with biological resources. The oceanography group at MRI runs various projects that conform within this mandate. Among these research projects that monitor the environment and climate.

Since 1950 there have been annual observations of temperature and salinity in spring at a number of fixed positions or stations on the Icelandic shelf in order to trace climatic variations. These stations are on lines or sections that are named after places on shore.

Figure 1: Locations of fixed measurement stations



After 1970, MRI started to conduct measurements on these fixed stations four times a year, in February/March, May/June, August/September and October/November. Most often this is done in connection with other surveys such as juvenile studies in August and capelin assessment in the autumn. At the same time as the observations of temperature and salinity take place various other monitoring activities are carried out. During the spring cruise, measurements are taken on nutrients, primary production of phytoplankton and abundance and species of zooplankton to name a few.

Originally these spring cruises were done in connection with herring surveys and these spring observations have been ongoing since 1950. In the quarterly cruises, there has been regular monitoring of carbon dioxide in the sea in addition to several other samples taken for analysis of, for example, trace elements, radioactivity and sediment flux. Continuous monitoring of the inflow of Atlantic water into the area north of Iceland is also carried out by MRI using moored current meters. Temperature and salinity data are recorded by vessel, location (lat,lon), date, time of day and depth. Available online at http://www.hafro.is/~argos/snid/snid.php

For Atlantis, the water temperature, salinity, and water flux oceanographic data will be synthesized using model output from an oceanographic model, Cartesian coordinates Ocean model with three-Dimensional adaptive mesh refinement and primitive Equations (CODE), of the Icelandic waters (Logemann and Harms, 2006). At present monthly data are available from 1992 – 2012, however, the CODE team is planning on running their model from 1948 - 2012 and when this data becomes available it will be assimilated into the oceanographic model for Atlantis.

Biological data

Port sampling

Biological data from the commercial longline and trawl fleet catches are collected from landings by scientists and technicians of the MRI in Iceland. The biological data collected include length (to the nearest cm), sex and maturity stage (if possible since most fish that are landed are gutted), and otoliths for age reading. Most of the fish that otoliths were sampled from were also weighted (to the nearest gram). Biological sampling is also collected directly on board on the commercial vessels during trips by personnel of the Directorate of Fisheries in Iceland or from landings (at harbour). These are only length samples. The general process of the sampling strategy is to take one sample of a species for every species specific number of tonnes landed. Each sample consists of 150 fishes. Otoliths are extracted from 50 fish, when possible, which are also length measured and weighed gutted. In most cases fish are landed gutted so it not possible to determine sex and maturity. If fish are landed un-gutted, the un-gutted weight is measured and the fish is sexed and maturity determined. The remaining 100 in the sample are only length measured.

The biological data from the fishery is stored in a database at the Marine Research Institute. The data is used for description of the fishery.

Technical interactions

See commercial activities.

Discards

Discarding is banned in the Icelandic demersal fishery. Based on limited data discard rates are estimated to be very low (<1% in either numbers or weight). Policies in the management system, such as converting quota share from one species to another, are used by the fleet to a large extent and this is thought to discourage discards in mixed fisheries.

Surveys

Two main bottom-trawl surveys are conducted by the Marine Research Institute, the Icelandic Groundfish Survey (IGS or the Spring Survey) and the Autumn Groundfish Survey (AGS or the Autumn Survey). The Spring Survey has been conducted annually in March since 1985 on the continental shelf at depths shallower than 500 m and has a relatively dense station-net (approx. 550 stations). The Autumn Survey has been conducted in October since 1996 and covers larger area than the Spring Survey. It is conducted on the continental shelf and slopes and extends to depths down to 1500 m. The number of stations is about 380 so the distance between stations is often greater. The main target species in the Autumn Survey are Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*).

A number of smaller surveys are conducted in Icelandic waters which are aimed at species that are not detected by these two main surveys. These include special separate surveys for the pelagic fish, mackerel, herring and capelin. Two shrimps survey, inshore and offshore, and a nephrop survey. Furthermore a gillnet survey, testing the efficiency of various gears, has been conducted for a number of years.

The text in the following description of the surveys is mostly a translation from Björnsson *et al.* (2007).

Spring survey

From the commencing of the Spring Survey, the stated aim has been to estimate the abundance of demersal fish stocks, particularly the cod stock with increased accuracy and thereby strengthening the scientific basis of fisheries management. That is, to get fisheries independent estimates of abundance that would result in increased accuracy in stock assessment relative to the period before the Spring Survey. Another aim was to start and maintain dialogue with fishermen and other stakeholders.

To help in the planning, experienced captains were asked to map out and describe the various fishing grounds around Iceland and then they were asked to choose half of the tow-stations taken in the survey. The other half was chosen randomly.

Timing, area covered and tow location

It was decided that the optimal time of the year to conduct the survey would be in March, or during the spawning of cod in Icelandic waters. During this time of the year, cod are most easily available to the survey gear as diurnal vertical migrations are at minimum in March (Pálsson, 1984). Previous survey attempts had taken place in March and for possible comparison with that data it made sense to conduct the survey in March.

The total number of stations was decided to be 600 (Figure 2). The reason of having so many stations was to decrease variance in indices but was inside the constraints of what was feasible in terms of survey vessels and workforce available. With 500–600 tow-stations the expected CV of the survey would be around 13%.

The survey covers the Icelandic continental shelf down to 500 m and to the EEZ-line between Iceland and Faroe Islands. Allocation of stations and data collection are based on a division between Northern and Southern areas. The Northern area is the colder part of Icelandic waters where the main nursery grounds of cod are located, whereas the main spawning grounds are found in the warmer Southern area. It was assumed that 25–30% of the cod stock (in abundance) would be in the southern area at the survey time but 70–75% in the north. Because of this, 425 stations were allocated in the colder northern area and 175 stations were allocated in the southern area. The two areas were then divided into ten strata, four in the south and six in the north.

Stratification in the survey and the allocation of stations was based on pre-estimated cod density patterns in different "statistical squares" (Palsson *et al*., 1989). The statistical squares were grouped into ten strata depending on cod density. The number of stations allocated to each stratum was in proportion to the product of the area of the stratum and cod density. Finally the number of stations within each stratum was allocated to each statistical square in proportion to the size of the square. Within statistical squares, stations were divided equally between fishermen and fishery scientist at the MRI for decisions of location. The scientist selected random position for their stations, whereas the fishermen selected their stations from their fishing experience. Up to 16 stations are in each statistical square in the Northern area and up to seven in the Southern area. The captains were asked to decide the towing direction for all the stations.

Vessels, fishing gear and fishing method

In the early stages of the planning it was apparent that consistency in conducting the survey on both spatial and temporal scale was of paramount importance. It was decided to rent commercial stern-trawlers built in Japan in 1972–1973 to conduct the survey. Each year, up to five trawlers have participated in the survey each in a dedicated area (NW, N, E, S, SW). The ten Japanese-built trawlers were all built on the same plan and were considered identical for all practical purposes. The trawlers were thought to be in service at least until the year 2000. This has been the case and most of these trawlers still fish in Icelandic waters but have had some modifications since the start of the survey, most of them in 1986–1988.

The survey gear is based on the trawl that was the most commonly used by the commercial trawling fleet in 1984–1985. It has relatively small vertical opening of 2–3 m. The headline is 105 feet, fishing line is 63 feet, foot-rope 180 feet and the trawl weight 4200 kg (1900 kg submerged).

Length of each tow was set 4 nautical miles and towing speed at approx. 3.8 nautical miles per hour. Minimum towing distance so that the tow is considered valid for index calculation is 2 nautical miles. Towing is stopped if wind is more than 17–21 m/sec, (8 on Beaufort scale).

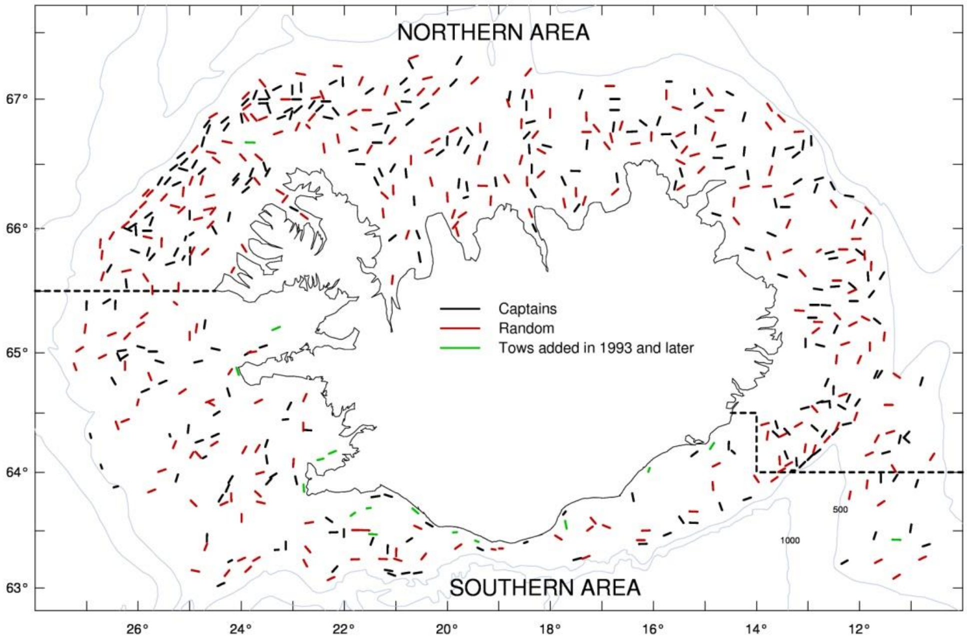


Figure 2. Stations in the Spring Survey in March. Black lines indicate the tow-stations selected by captains of commercial trawlers, red lines are the tow-stations selected randomly, and green lines are the tow-stations that were added in 1993 or later. The broken black lines indicate the original division of the study area into Northern and Southern area. The 500 and 1000 m depth contours are shown.

Later changes in vessels and fishing gear

The trawlers used in the survey have been changed somewhat since the beginning of the survey. The changes include alteration of hull shape (bulbous bow), the hull extended by several meters, larger engines, and some other minor alterations. These alterations have most likely changed the qualities of the ships but it is very difficult to quantify these changes.

The trawlers are now considered old and it is likely that they will soon disappear from the Icelandic fleet. Some search for replacements is ongoing. In recent years, the MRI research vessels have taken part in the Spring Survey after elaborate comparison studies. The r/v Bjarni Sæmundsson has surveyed the NW-region since 2007 and r/v Árni Friðriksson has surveyed the Faroe-Iceland ridge in recent years and will in 2010 survey the SW-area.

The trawl has not changed since the start of the survey. The weight of the otter-boards has increased from 1720–1830 kg to 1880–1970 kg. The increase in the weight of the otter-boards may have increased the horizontal opening of the trawl and hence decreased the vertical opening. However, these changes should be relatively small as the size (area) and shape of the otter-boards is unchanged.

Later changes in trawl-stations

Initially, the numbers of trawl stations surveyed was expected to be 600 (Figure 2). However, this number was not covered until 1995. The first year 593 stations were surveyed but in 1988 the stations had been decreased down to 545 mainly due to bottom topography (rough bottom that was impossible to tow), but also due to drift ice that year. In 1989–1992, between 567 and 574 stations were surveyed annually. In 1993, 30 stations were added in shallower waters as an answer to fishermen's critique.

In short, until 1995 between 596 and 600 stations were surveyed annually. In 1996 14 stations that were added in 1993 were omitted. Since 1991 additional tows have been taken at the edge of the survey area if the amount of cod has been high at the outermost stations.

In 1996, the whole survey design was evaluated with the aim of reduce cost. The number of stations was decreased to 532 stations. The main change was to omit all of the 24 stations from the Iceland-Faroe Ridge. This was the state of affairs until 2004 when in response to increased abundance of cod on the Faroe-Iceland ridge 9 stations were added. Since 2005 all of the 24 stations omitted in 1996 have been surveyed each year.

In the early 1990s there was a change from Loran C positioning system to GPS. This may have slightly changed the positioning of the stations, as the Loran C system was not as accurate as the GPS.

Autumn survey

The Icelandic Autumn Survey has been conducted annually since 1996 by the MRI. The objective is to gather fishery independent information on biology, distribution and biomass of demersal fish species in Icelandic waters, with particular emphasis on Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*). This is because the Spring Survey does not cover the distribution of these deep-water species. Secondary aim of the survey is to have another fishery independent estimate on abundance, biomass and biology of demersal species, such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and golden redfish (*Sebastes marinus*), in order to improve the precision of stock assessment.

Timing, area covered and tow location

The Autumn Survey is conducted in October as it is considered the most suitable month in relation to diurnal vertical migration, distribution and availability of Greenland halibut and deep-sea redfish. The research area is the Icelandic continental shelf and slopes within the Icelandic EEZ to depths down to 1500 m. The research area is divided into a shallow-water area (0–400 m) and a deep-water area (400–1500 m). The shallow-water area is the same area covered in the Spring Survey. The deep-water area is directed at the distribution of Greenland halibut, mainly found at depths from 800–1400 m west, north and east of Iceland, and deep-water redfish, mainly found at 500–1200 m depths southeast, south and southwest of Iceland and on the Reykjanes Ridge.

Preparation and later alterations to the survey

Initially, a total of 430 stations were divided between the two areas. Of them, 150 stations were allocated to the shallow-water area and randomly selected from the Spring Survey station list. In the deep-water area, half of the 280 stations were randomly positioned in the area. The other half were randomly chosen from logbooks of the commercial bottom-trawl fleet fishing for Greenland halibut and deep-water redfish in 1991–1995. The locations of those stations were, therefore, based on distribution and pre-estimated density of the species.

Because MRI was not able to finance a project in order of this magnitude, it was decided to focus the deep-water part of the survey on the Greenland halibut main distributional area. For this reason, important deep-water redfish areas south and west of Iceland were omitted. The number and location of stations in the shallow-water area were unchanged.

The number of stations in the deep-water area was therefore reduced to 150. A total of 100 stations were randomly positioned in the area. The remaining stations were located on important Greenland halibut fishing grounds west, north and east of Iceland and randomly selected from a logbook database of the bottom-trawl fleet fishing for Greenland halibut 1991–1995. The number of stations in each area was partly based on total commercial catch.

In 2000, with the arrival of a new research vessel, MRI was able finance the project according to the original plan. Stations were added to cover the distribution of deep-water redfish and the location of the stations selected in a similar manner as for Greenland halibut. A total of 30 stations were randomly assigned to the distribution area of deep-water redfish and 30 stations were randomly assigned to the main deep-water redfish fishing grounds based on logbooks of the bottom trawl fleet 1996–1999.

In addition, 14 stations were randomly added in the deep-water area in areas where great variation had been observed in 1996–1999. However, because of rough bottom which made it impossible to tow, five stations have been omitted. Finally, 12 stations were added in 1999 in the shallow-water area, making total stations in the shallow-water area 162. Total number of stations taken since 2000 has been around 381 (Figure 3).

The r/v "Bjarni Sæmundsson" has been used in the shallow-water area from the beginning of the survey. For the deep-water area MRI rented one commercial trawler 1996–1999, but in 2000 the commercial trawler was replaced by the r/v "Árni Friðriksson".

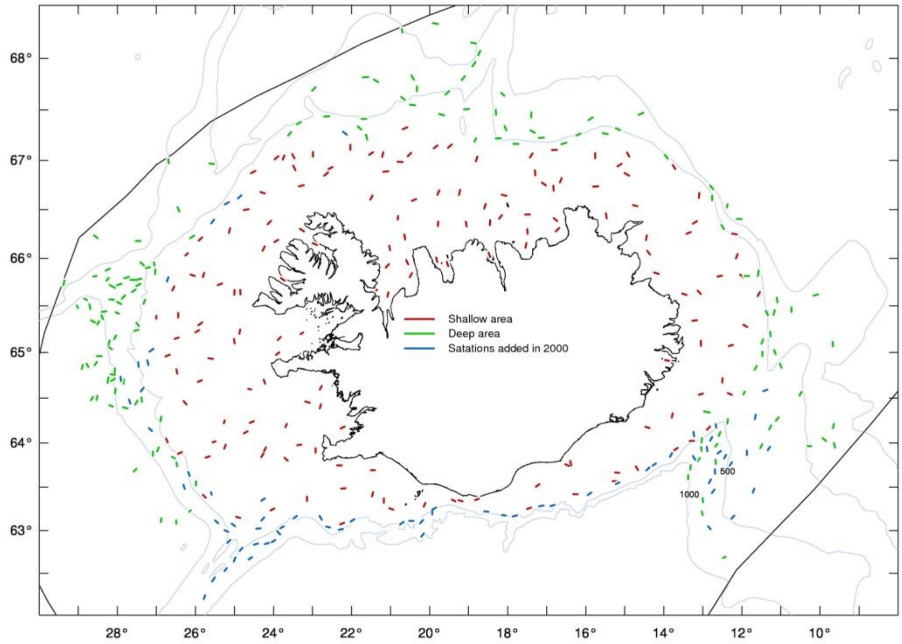


Figure 3. Stations in the Autumn Groundfish Survey (AGS). R/v "Bjarni Sæmundsson" takes stations in the shallow-water area (red lines) and r/v "Árni Friðriksson" takes stations in the deep-water areas (green lines), the blue lines are stations added in 2000.

Fishing gear

Two types of the bottom survey trawl "Gulltoppur" are used for sampling: "Gulltoppur" is used in the shallow water and "Gulltoppur 66.6m" is used in deep waters. The trawls were common among the Icelandic bottom-trawl fleet in the mid 1990s and are well suited for fisheries on cod, Greenland halibut and redfish. "Gulltoppur", the bottom trawl used in the shallow water, has a headline of 31.0 m, and the fishing line is 19.6 m. The deep-water trawl, "Gulltoppur 66.6m" has a headline of 35.6 m and the fishing line is 22.6 m. The towing speed is 3.8 knots over the bottom. The trawling distance is 3.0 nautical miles calculated with GPS when the trawl touches the bottom until the hauling begins (i.e. excluding setting and hauling of the trawl).

Data sampling

The data sampling in the Spring and Autumn surveys is quite similar. In short there is more emphasis on stomach content analysis in the Autumn Survey than the Spring Survey.

Length measurements and counting

All fish species are measured for length. For the majority of species, total length is measured to the nearest cm from the tip of the snout to the tip of the longer lobe of the caudal fin. At each station, the general rule is to measure at least 4 times the length interval of a given species. Example: If the continuous length distribution of a species at a given station is between 15 and 45 cm, the length interval is 30 cm and the number of measurements needed is 120. If the catch of said species at this station exceeds 120 individuals, the rest is counted.

Care is taken to ensure that the length measurement sampling is random so that the fish measured reflect the length distribution of the haul in question.

Recording of weight, sex and maturity stages

Sex and maturity data has been sampled from the start of both surveys.

Otolith sampling

A minimum of five otoliths in the Spring and Autumn Surveys are collected and a maximum of 25. Otoliths are sampled at a four fish interval so that if in total 40 fish of a species are caught in a single haul, 10 otoliths are sampled.

Stomach sampling and analysis

Stomach samples are routinely sampled both surveys.

Information on tow, gear and environmental factors

At each station/haul relevant information on the haul and environmental factors, are filled out by the captain and the first officer in co-operation with the cruise leader.

Tow information

- **General:** Year, Station, Vessel registry no., Cruise ID, Day/month, Statist. Square, Sub-square, Tow number, Gear type no., Mesh size, Briddles length (m).
- **Start of haul:** Pos. N, Pos. W, Time (hour:min), Tow direction in degrees, Bottom depth (m), Towing depth (m), Vert. opening (m), Horizontal opening (m).
- **End of haul:** Pos. N, Pos. W, Time (hour:min), Warp length (fm), Bottom depth (m), Tow length (naut. miles), Tow time (min) , Tow speed (knots).
- **Environmental factors:** Wind direction, Air temperature °C, Wind speed, Bottom temperature °C, Sea surface, Surface temperature °C, Towing depth temperature °C, Cloud cover, Air pressure, Drift ice.

Species information

- **General**: Sample id, species, length, number at length, sex, maturity
- **Age:** Sample id, species, length, age, number within sample, sex, maturity, ungutted and gutted weight, liver weight, gonad weight.

Marine mammals

Regular systematic research on behalf of the MRI was formally initiated in 1979 with the establishment of a full time whale specialist position at the institute. Before that, British scientists had conducted research on whales for around a decade in cooperation with the MRI. MRI's research has mostly been directed at the whale species that were exploited up to IWC's temporary ban on commercial whaling (moratorium) took effect in 1986, i.e fin whales, sei whales and minke whales.

During 1986-1989 an extensive whale research programme was conducted by the MRI with the main objective of strengthening the basis for management advice before IWC's reconsideration of the moratorium, which was originally scheduled to be finished in 1990 at the latest. The research programme was extensive, and constituted a milestone in our knowledge of the biology and ecology of cetaceans in Icelandic waters. In cooperation with adjacent states in the North Atlantic, large scale sightings surveys were conducted in 1987 and 1989, providing the first reliable estimates of the abundance of the exploited species in the central and eastern parts of the North Atlantic. As a part of the research programme 292 fin whales and 70 sei whales were caught for various biological investigations during the four year study period. These studies included research on biological parameters (age, growth, reproduction etc.), feeding ecology, population genetics and energetics.

Since the conclusion of the four-year research programme in 1990, MRI's main cetacean research activities have been in the following fields:

- Sightings surveys are the largest research projects conducted in the field of whale research. In order to monitor population size in connection with management it is generally considered appropriate to estimate abundance every 5-6 years. During 1995 and 2001 large scale surveys were conducted on the North Atlantic comparable to those in 1987 and 1989.

- Research on population structure and behaviour by the aid of photo-identification and skin biopsy sampling. At the MRI these techniques have been applied in research on killer whales since 1981 and humpback whales and blue whales since 1990.
- Research on harbour porpoises and white-beaked dolphins that have drowned in fishing gear (bycatch). This includes studies on feeding ecology, reproduction, age composition, population genetics and energetics.
- Strandings. Monitoring and biological sampling of cetaceans that have stranded or beached on the coast of Iceland. As whaling has only involved a small part of the species found in Icelandic waters, this is the only opportunity for sampling of many species.
- Feeding ecology and multi-species modeling. Although information is scarce on feeding ecology of most of the 12 species regularly occurring in Icelandic waters, information on biomass and residence time gives indications of total consumption by cetaceans in Icelandic waters, and possible effects on the yield of commercially important fish species.
- Tracking the movements of baleen whales by satellite telemetry. In the last few years experiments have been conducted on the use of satellite linked tags to follow the movements and dive pattern of minke, fin and blue whales in Icelandic waters.
- Seasonal variation in the distribution of cetaceans in coastal Icelandic waters. In 1999, an agreement was made between the MRI and a few whale watching firms on systematic registration of information on cetaceans seen during whale watching trips.

In August 2003, a comprehensive research project on minke whales in Icelandic waters was initiated. The main objectives of the research were to collect basic information on the feeding ecology of minke whale in Icelandic waters. In addition to studies on the diet composition by analysing the stomach contents, other data that is essential for estimation of minke whale predation on various prey species were collected. Those included data on energetics, food requirements and seasonal and spatial variation in whale abundance.

The following secondary objectives of the research were:

- To investigate the stock structure of the minke whale in the North Atlantic by genetic methodology and satellite telemetry.
- To investigate parasites and diseases in the minke whale in Icelandic waters.
- To collect information on age and reproduction of minke whales in Icelandic waters.
- To investigate the concentration of organochlorines and trace elements in various organs and tissue types.
  Finally the applicability of various alternative research methods were compared to the more traditional methods.

All data collected on whales in Icelandic waters are stored in the institutional database. The types of data stored are:

- **General information**: ID, location (lat, lon), type of sampling, species, date, length, weight, girth, maturity, sex, age.
- **Stomach contents**: ID, stomach sample id, prey species, length, age, number of occurrance, number undigested, number digested, digestion state, weight.
- **Additional analysis**: Featuses, number of pregnancies, testicle and ovary maturity, stable

isotopes, fatty acid, parasites

Species interactions

Feeding habits of fish, and other marine animals in Icelandic waters, have been investigated during the last decades. The feeding habits of marine fish are highly variable, in Icelandic waters as well as in other marine ecosystems. Generally, however, prey size increases with increasing size of the predatory fish. Pelagic fish, e.g. capelin, herring and blue whiting, prey mostly on zooplanktonic animals throughout their entire life, but to a limited extent on other fish. Demersal fish, on the other hand, start by preying on pelagic or demersal crustaceans during their first years of life, switching to other prey later on. Many demersal fish, e.g. cod, Greenland halibut and whiting, switch over to other fish like capelin and sandeels during this "second" phase. Other fish, e.g. haddock and long rough dab, switch over to benthic animals such as polychaetes and ophiuroids. Still other fish, like redfish, stick to the crustaceans but prefer larger animals as prey. Notwithstanding such main patterns, feeding habits of marine fish are subject to distinct variations with respect to seasons, oceanic areas and various environmental factors. The trophic webs of marine environments are, therefore, highly complex.

Fisheries in Icelandic waters had limited effect in terms of multi-species interactions during more than half of the last century, excluding the herring fishery. The fishery was directed towards fish species, mainly cod, which were not preyed upon by other fish. This situation changed drastically in the early 1960s with a large scale capelin fishery, and in the late 1980s with a fishery for deep-water shrimp. Those fisheries constituted a harvesting of a new trophic level, i.e., the level of prey of demersal fish, with basically unknown consequences for the stocks in questions.

In view of such profound changes, species interactions became an increasing object of research in the following decades. Clear interactions have become apparent, e.g., between the size of the capelin stock and the growth of cod. The size of the capelin stock was shown to be an important factor for the yield of cod. It has also been shown that the cod stock has a large predatory effect on the recruitment of deep-water shrimp. Thus, survival and yield of deep-water shrimp is dependent upon the size of the cod stock, although the latter is not significantly affected in terms of growth. Such relationships reflect only a fraction of the interactions among marine animals, but demonstrate nevertheless that species interactions are relevant in fisheries management.

Stomach contents

Sampled during spring and autumn surveys. Samples are taken from individual stomachs and the analysis of the contents entered into the database linking specific prey to a single predator. The available data is stored with the following attributes.

- **Prey info**: Sample id, stomach sample id, predator species, prey species, length, number of occurrance, number undigested, number digested, number vomitted.

Commercial activities

Icelandic catches in tonnes by species, month, area and gear are obtained from Statistical Iceland and Directorate of Fisheries. Catches are only landed in authorized ports where all catches are weighed and recorded. The distribution of catches is obtained from logbook statistic where location of each haul, effort, depth of trawling and total catch of ling is given. Logbook statistics are available since 1991. Landings of foreign vessels are given by the Icelandic Coast Guard and reported to the Directorate of Fisheries.

Stock definition

Tagging

Fish tagging experiments have been conducted in Icelandic waters since early twentieth century. These tagging experiments have been carried out on several commercial fish stocks mainly: cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), plaice (*Pleuronectes platessa*), saithe (*Pollachius virens*), wolfish (*Anarhichas lupus*), and to lesser degree: deep-sea redfish (*Sebastes mentella*), lumpsucker (*Cyclopterus lumpus*), halibut (*Hippoglossus hippoglossus*), dab (*Limanda limanda*), witch (*Glyptocephalus cynoglossus*), anglerfish or monkfish (*Lophius piscadorius*) and rough dab (*Hippoglossoides platessoides*). Some invertebrates have also been tagged like Norway lobster (*Nephrops norvegicus*), deep water shrimp (*Pandalus borealis*) and Iceland scallop (*Chlamys islandica*).

Until 1994 only so called conventional tags were used of various types that have in common that they have identification letters and numbers (Thorsteinsson et al, 2002). Ftrom 1995 the Marine Research Institute has also used electronic tags or Data Storage Tags (DSTs). These are capsules with sensors and memory chips for recording and storing environmental data. The fundamental data that has been collected is ambient temperature and depth of the fish. The development of this technology has been very fast in the last decade and more sensors have been developed such as salinity, tilt, sound and more (www.star-oddi.com). Fish that have been tagged by DST, by MRI in fisheries research are: cod, saithe, plaice, Greenland halibut, haddock, deep-sea redfish and anglerfish.

Where as the conventional tagging methods yield only data that is collected at release and recapture the use of electronic tags give the additional possibility of data collection in the period between release and recapture. This does not mean that conventional tags are obsolete. Depending on purpose of tagging experiments one could use either conventional tags, electronic devices or both in combinations. Tagging experiments have mostly been conducted to assess or investigate various aspects of population biology such as abundance, distribution, behaviour, mortality, growth, population structure and for monitoring stocks.

Types of data available:

- **Mark-recapture**: tagId, fishId, tagMarker, tagNumber, sampleId, tSpecies, tLength, tWeight, tSex, tMaturity, tCruise, tStation, tDate, tYear, tMonth, tDay, tLat, tLon, tSquare, tSS, tDepth, tGear, recaptureID, rSpecies, rShipId, rShipName, rLat, rLon, rSquare, rSS, rName, rOcean, rGear, rDate, rYear, rMonth, rDay, rYear1, rMonth1, rLength, rSex, rMaturity, rAge, DSTid, tAge, yc, das, mas, dLength, Growth, tReg, rReg

Genetic data

Differ by species, for marine mammals see Pampoulie et al (2013) and for cod Pampoulie et al. (2012).

Other

NA

Socioeconomic data

Socioenoconomic data is collected by Statistics Iceland, a governmental institution that gathers statistics on the state of the economy, business stastistics and social statistics. The available data is described at http://www.statice.is/Statistics/

IV. Northern Waters case study

Introduction

The West of Scotland Ecosystem comprises the shelf area west of Scotland (ICES subarea VIa) which covers inshore and offshore waters from the west coast of Scotland to 12°W of longitude. The geomorphology of the area is complex with the coastline including beaches, fjords and numerous islands. The seabed generally consists of extensive areas of sand and muddy-sand interspersed with rocky outcrops, reefs, shelves and seamounts. From east to west water depths range from the Malin and Hebrides Shelves which are shallower than 250m to the Rockall Trough where depth can excess 2500 m (ICES, 2011). This ecosystem encompasses a wide range of commercial fish species and is of economic importance for many fisheries. This report details the data needed to parameterise ecosystem model for the West of Scotland case study, their availability and where to obtain them.

Spatial units

The West coast of Scotland ecosystem is modelled as a single spatial entity which covers an area of 110,000 km^2.

Oceanography and bottom topography

Topography

Bathymetry data for the area VIa are freely available online at: http://maps.ngdc.noaa.gov/viewers/index.html. The methodology used to obtain these data is detailed on the website.

Temperature and salinity

Several temperature datasets covering area VIa are available. Gridded sea surface temperature (SST) datasets are derived from a combination of satellite and in-situ observations interpolated to provide global coverage. Such data are available for download from the National Oceanic and Atmospheric (NOAA) website at: http://www.emc.ncep.noaa.gov/research/cmb/sst_analysis/. Similar data exist also for salinity and can be accessed via: http://www.nodc.noaa.gov/General/salinity.html.

Locally, other datasets exist regarding area VIa. The ICES Annual Ocean Climate Status Summary (IAOCSS) provides long-term time-series for temperature and salinity anomalies from the Rockall Trough situated west of Britain and Ireland dating back to 1975. Long term oceanographic observations are available for Ellett Line and the Tiree Passage Mooring as well as a number of inshore recording stations (maintained by the Scottish Association for Marine Science http://www.sams.ac.uk/). A few temperature record datasets for inshore waters of the Scottish west coast are also available from Scottish monitoring stations located in Loch Maddy

(North Uist), Loch Ewe, Mallaig and Millport. The Millport time series is the longest and goes back to 1953 while other datasets only go back to 1999. These datasets are available for download as daily averages from www.marine-scotland.ac.uk.

Chlorophyll and primary production

Global estimates of primary production based on estimated chlorophyll from remote sensing are available from the ocean productivity group at Oregon University (http://www.science.oregonstate.edu/ocean.productivity/). The Continuous Plankton Recorder (CPR) also provides a measure of phytoplankton concentrations (Batten *et al.*, 2003). The CPR is towed behind ships of opportunity and collects plankton samples which are subsequently analysed at the Sir Alister Hardy Foundation for Ocean Science (Plymouth, UK). In the northeast Atlantic the CPR has been operated since the 1940s and it now comprises the largest marine ecological monitoring dataset in existence.

Hydrology

Several studies have investigated the hydrodynamics of the West of Scotland and provide data and knowledge about the oceanography of this region. The oceanography in subarea VIa is strongly influenced by the North Atlantic Current (NAC) which is partially responsible for the temperate climate experienced west of Scotland when compared with other regions at similar latitudes (Rahmstorf, 2003). The main oceanographic front in the area is the Irish Shelf Front that occurs to the south and west of Ireland (at 11°W), and exists all year-round. This front marks the boundary between waters of the shelf (often mixed vertically by the tide) and offshore North Atlantic waters (Reid *et al.*, 2001). Water circulation on the shelf follows the poleward flowing slope current which is stronger in summer (Huthnance, 1986). The Rockall Trough is an important pathway by which North Atlantic surface waters reach the Norwegian Sea. Along the eastern edge of the Rockall Trough, this flow of water is also known as the European Slope Current (ESC) which is a persistent feature active from the south of the Porcupine Seabight to the north of the Shetland Islands. Over the Rockall plateau, domes of cold water indicate retentive circulation (ICES, 2013). Closer inshore the Scottish Coastal Current (SCC) flows northwards carrying a mix of Irish and Clyde sea water from the North Channel. As it flows north the SCC mixes with fresh water from the Scottish Highlands. Water in the SCC takes around 4-6 months to move from the North Channel to Cape Wrath (Inall *et al.*, 2009). When coupled with ocean currents and tides the complex geomorphology of the region produces a wide variety of oceanographic features including tidal jets, density-driven recirculation gyres and Taylor columns as well as partially isolated fjordic systems with periodic overturning (Inall and Sherwin, 2006). Because of the complex fjordic nature of the western coast of Scotland there is also a substantial fresh-water input from the numerous sea-lochs, notably the Firth of Lorne sea loch system (Nolan and Lyons, 2006).

Other environmental variables

Several indices exist to quantify large-scale atmospheric circulation over the Northern Hemisphere such as the North Atlantic Oscillation (NAO) and the East Atlantic pattern (EA).

NAO and EA data are available for download on a monthly basis from: ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh.

Another mode of variability occurring in the North Atlantic Ocean is the Atlantic Multidecadal Oscillation (AMO). It is defined as sea surface temperature anomaly from detrended mean global warming value. Monthly means of this parameter are available from the Physical Science Division of NOAA (www.esrl.noaa.gov).

The Gulf Stream index (GSNW) is a measure of the latitudinal position of the north wall of the Gulf Stream where it breaks away from the east coast of North America. Positive values of this index are indicative of a displacement to the north of the long-term mean location of the Gulf Stream, while negative values indicate a southward movement (Nunn *et al*., 2007). GSNW data are available from the website of the Plymouth Marine Laboratory at www.pmlgulfstream.org.uk.

Ekman wind transport data in $kg.m^{-1}.s^{-1}$ in both north-south and east-west directions are available for the northeast Atlantic shelf. These datasets can be downloaded as 1ºx1º grids

On daily intervals at: www.las.pfeg.noaa.gov.

Functional groups used in the model

Fish

The West coast of Scotland ecosystem model includes the following fish species:

- Cod *Gadus morhua*
- Haddock *Melanogrammus aeglefinus*
- Whiting *Merlangius merlangus*
- Saithe *Pollachius virens*
- Hake *Merluccius merluccius*
- Grey gurnard *Eutrigla gurnardus*
- Herring *Clupea harengus*
- Mackerel *Scomber scombrus*
- Blue whiting *Micromesistius poutassou*
- Norway Pout *Trisopterus esmarkii*
- Sprat *Sprattus sprattus*
- Anglerfish *Lophius piscatorius*
- Megrim *Lepidorhombus whiffiagonis*

Biological data are obtained from scientific surveys and commercial sampling in area VIa, as detailed in the section 'Survey data' below.

Crustaceans

The West coast of Scotland ecosystem model includes the Norway lobster *Nephrops norvegicus*. Biological data are obtained from scientific surveys and commercial sampling in area VIa, as detailed in the section 'Survey data' below.

Benthos and zooplankton

The biomass time series of benthos and zooplankton are virtually impossible to estimates as very little data exists regarding this functional group. As a proxy, each one of these two resources is represented by a biomass spectrum of slope λ, the value of which is determined when parameterising the model.

Mammals

Two species of marine mammals are included in the West coast of Scotland ecosystem model: grey seals *Halichoerus grypus* and harbour seals *Phoca vitulina*.

A pup count of grey seals of is carried out annually (SCOS, 2008). This count is estimated to be accurate to within ±13%. The pup count has been linked to total population size using various models of which the outputs vary considerably (SCOS 2008). Estimates of the total abundance of the grey seal population are thus associated with high uncertainty. According to Trites and Pauly (1998), the mean weight of a male grey seal is estimated to be 168kg while the mean weight of a female is estimated to be 152kg. The food requirements of grey seals depend on the oiliness of the prey. For an average seal daily consumption estimates are 7kg of cod or 4kg of sand eel (SCOS, 2008). Hammond and Harris (2006) conducted analysis of scat samples to estimate that grey seals in the Hebrides consumed on average 4.99kg of fish per day. According to Trites and Pauly (1998), the mean daily ration R of a marine mammal as a percentage of body weight W is: $R=0.1W^{0.8}$.

Numbers of harbour seals are estimated from counts at haul out sites. The Sea Mammal Research Unit (SMRU) carry out a survey every five years only for practical reasons (SCOS 2008). Survey data for harbour seals extends back as far as1992 for the Outer Hebrides and 1994 for the Scottish Highlands. It is estimated that 30 to 40% of the seals are not counted during the surveys due to individuals being underwater and abundance estimates should account for this. The average weight of adult harbour seals is estimated at 63.6kg (Trites and Pauly, 1998). The daily harbour seal ration is considered to be 3kg of oily fish or 5kg of gadoids (SCOS 2008).

Diet and stomach content data

Stomach content data are extremely useful for ecosystem models parameterisation and are often unavailable due to the extensive sampling required to obtain them. Two sources of stomach data are available for the Celtic and Irish seas which encompass area VIa (Pinnegar, 2003). UK researchers collected stomachs for 66 species during annual groundfish surveys from 1986 to1994, while French researchers sampled stomachs of seven species aboard commercial fishing vessels from 1977 to 1992.

Commercial activities

Annual catches, landings and discards

Fisheries data for the West of Scotland (area VIa) can be obtained from various sources. The ICES stock assessment report from the Working Group for Celtic Seas Ecoregion (WGCSE) contains annual catches and landings as well as estimated discards and bycatches by species for the whole VIa area (ICES, 2013). These commercial catches are used as input data by WGCSE for stock assessment purposes.

Regional landings and effort

The Marine Management Organisation (MMO) of the UK government holds regional landings and effort data for the ICES area VIa. These regional data can be obtained as far back as 2001. Regional landings can be obtained from both British and foreign vessels by:

- Species
- Fleet segment
- Vessel length
- Gear used
- Sector
- Country of landing
- Area of capture

Regional effort data (in $kW.days^{-1}$) can be obtained by vessel length and area of operation (i.e. in and out of the cod recovery zone).

These data can be downloaded freely from the MMO website (https://www.gov.uk/government/organisations/marine-management-organisation).

Socio-economic data

The MMO also holds data related to employment and socio-economic performance of the fisheries. These data include:

- Size of the UK fishing fleet, by country of administration and/or vessel length
- Age of UK vessels by country of administration
- Number of fishermen employed
- Number of accidents, lost vessels and fatalities for UK vessels
- Fish trade flows for the UK
- Import and export of fish
- GDP for fishing
- Average price of landings by vessel length

These data can be downloaded freely from the MMO website (https://www.gov.uk/government/organisations/marine-management-organisation).

Survey data

Survey data are available for commercial species managed by ICES such as in area VIa. These data include abundance indices, distribution, age-length keys, sex ratios and maturity estimates.

Abundance indices

Abundances indices from scientific surveys consist in length frequency observations. Abundance indices are available from ICES from 1985 onwards for the following species:

- Cod
- Haddock
- Whiting
- Saithe
- Hake
- Herring
- Mackerel
- Norway pout
- Sprat

They can be downloaded from the ICES website at http://www.ices.dk/marine-data/data-portals/Pages/DATRAS.aspx.

Abundance indices are also available from Marine Scotland from 2005 onwards for the following species:

- Cod
- Haddock
- Whiting
- Saithe
- Hake
- Herring

- Mackerel
- Norway pout
- Sprat
- Anglerfish
- Megrim

These data can be obtained from Marine Scotland upon request.

Biological data (length-at-age and maturity)

Age-length keys (observed length-at-age) and sex maturity age-length keys (observed length-at-age and maturity status) from scientific surveys are available from ICES from 1985 onwards for the following species:

- Cod
- Haddock
- Whiting
- Saithe
- Hake
- Herring
- Mackerel
- Norway pout
- Sprat

They can be downloaded from the ICES website at http://www.ices.dk/marine-data/data-portals/Pages/DATRAS.aspx.

Both age-length keys and sex maturity age-length keys are also available form Marine Scotland from 2005 onwards for the following species:

- Cod
- Haddock
- Whiting
- Saithe
- Hake
- Herring
- Mackerel
- Norway pout
- Sprat
- Anglerfish
- Megrim

These data can be obtained from Marine Scotland upon request.

Stock definition

The definition of commercial stocks on the West coast of Scotland has been established through genetic studies. Information on stock definition these studies and further references can be found in the WGCSE report (ICES, 2013).

Novel approaches such as the FishPopTrace project recently provided more insight of the genetics of commercial fish populations. Relevant data can be accessed at https://fishpoptrace.jrc.ec.europa.eu/map/genetics_geobrowser/. However, at this time data for the ICES area VIa can only be obtained for European hake.

Other data and parameters (growth, etc.)

Growth parameters such as von Bertalanffy parameters (i.e. asymptotic length L_∞ and Brody growth constant K) are useful to depict the growth dynamics of different species in length-based ecosystem models. The von Bertalanffy parameters can be obtained for a wide range of species from the fishbase website at http://www.fishbase.org/.

V. Southern Western Waters case study

Spatial units (model domain and subunits)

The study area is the Atlantic waters in Iberian Peninsula. The case study includes two different subcases: one for the whole area where hake is the main species and the other for the Gulf of Cádiz where anchovy is the main species.

Oceanography

- Topography (e.g. depth, bottom stepness, etc.) Available for the whole area. In the gulf of Cádiz there are extensive studies of the processes driving its morfology.
- Temperature. SST availble with a time span of decades through AVHRR (early eighties).
- Salinity Extensive reanalysis excercise allow to reconstruct 3D temperature, salinity and density fields in the area since 1995
- Chlorophill and primary production Available through Sea Surface Colour since 1996 through SeaWifs, MODIS and EnviSat series of radiometers
- Other environmental variables;
  - Sea Surface Height products are availbale with increased resolution since 1997.
  - Guadalquivir River dischargues since 1930
  - Easterlies forcings since 1985
  - Mediterranean outflow since 2006

Functional groups used in the model

Fish

- Hake: ICES data from 1982 to 2013
- Anchovy: ICES data from 1989 to 2013
- Sardine: ICES data from 1978 to 2013

Mammals.

Small cetacean information is scarce and in complemented with information from literature. Transects abundance indices from SCANS survey in 2003. Biological information from strandings (2000 to 2013). Sex, age, maturity, stomach content and causes of dead (natural or fishing activity)

- Common dolphin (2606 strandings)
- Bottlenose dolphin (361 strandings)
- Habour porpoise (255 strandings)

Commercial activities

- Port sampling for landings and onboard sampling for discards (hake)
- Quarterly landings and discards (by fleet, species, area)
- Biological data on catches:

  1. Hake: length composition and maturity at length

2. Anchovy: age/length composition and maturity at length and age)
3. Sardine: age composition and maturity at age.

- Fishing effort (by fleet since 2004)

Assessment data (Fishing mortality, Stock biomass, numbers at age, ref. Points)

Hake, anchovy and sardine are evaluated yearly by ICES. Results from these assessment (F, SSB and reference points are available). Hake reference points will be evaluated before next ICES working group (May, 2015)

Survey data

Abundance indices (hake, anchovy and sardine from ICES). Hake: 3 surveys covering the whole area. These surveys provide information about length, maturity and stomach content (only in the North of Spain).

Stock definition

There are two hake stocks, Northern and Southern. The separation of these two stock is not based on biological features but admininstrative ones. The discusion about stock conectivity is open now.

New data (from WP2)

Genetic and microchemistry (hake) and isotopes (anchovy). Sex ratio at length are available to develope a sex separated model for hake in MareFrame

Other data and parameters (e.g. mortality, consumption, etc.)

Available information from ICES will be complemented with data from literature.

VI Mediterranean-Strait of Sicily case study

Introduction

The main input data for Atlantis are listed in table 1 and described in details in the following sections.

There are two main input data types required to run the model:

1. Ecosystem structure and properties. These provide information on how the ecosystem is represented (model domain subdivision in polygons and vertical layer, number of functional groups, etc.) and dictate the structure of most of the input files required by the model. The initial condition file, represents a complete snapshot of the whole ecosystem (physical, biological, chemical) providing the biomass of all functional groups and their spatial distributions;
2. Forcing files, time series of variables driving the ecosystem (temperature, salinity, currents, river run-off, atmospheric driven nutrients enrichment, etc.)

Category	**File name**	**Size**
1. Ecosystem structure and properties		
Spatial units (model domain and subunits)	geometry.bgm	~220 MB
Initial condition file	in.nc	12 MB
Functional groups classification	functionalgroups.csv	4 KB
Biological information on functional groups	biol.prm	164KB
Forcing file selection	force.prm	105KB
Forcing options and flags	physics.prm	12 KB
Fisheries fleet	harvest.prm	616 KB
2. Forcing		
Hydrodynamic	hydro.nc	~220 MB*
Temperature	temp.nc	105KB*
Salinity	sal.nc	105KB*
Solar radiation	solar.ts	59 KB*
River discharge and atmospheric enrichment	pointsource.ts per box	8 KB*
Catch	catch.ts per box	30 MB*

Table 1 – Atlantis input and forcing files structure.

* File size for a 10 years period

A subset of these data will be also used to model interactions between hake and its main fish prey (e.g. horse mackerel) with GADGET.

Spatial units - model domain and subunit

The case study area corresponds to the North sector f the Strait of Sicily (Fig. 1) and includes the FAO-GFCM geographical sub-areas (GSAs) 15 (Malta Island) and 16 (South of Sicily).

The Atlantis model domain was divided into 37 polygons, 5 of which are islands (fig.1), matched to the major geographical and bioregional features of the simulated marine system. All input and output data are organised according to the model vertical and horizontal displacement of the polygons in a 37x6 grid format.

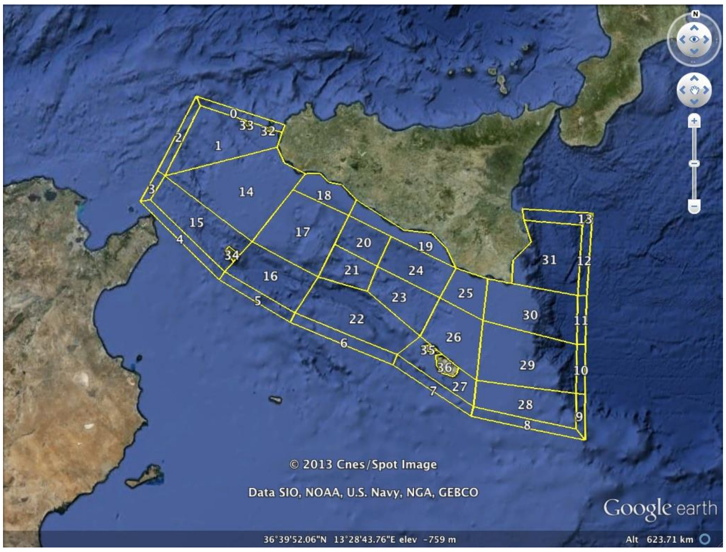


Figure 1 – Model domain containing 37 polygons

Each polygon is vertically divided in up to 5 water layers, depending on the average box depth, and 1 sediment layer (fig.2 and tab.2).

Maximum 5 water layers depending on average polygon depth and 1 sediment layer, for a maximum of 6 layers (fig.2). The average polygon depths varied between 60m (box 19, 2 water layer and 1 sediment layer) and 2050m (box 31, 5 water layers and 1 sediment layer). The thickness of the water layers is described in tab.2.

All information are contained by a single text file geometry.bgm, which was created using GIS software and combined to an Atlantis specific tools dedicated to convert shapefiles to the .bgm format expected by Atlantis.

Layer	Depths m
1	0-50
2	50-150
3	150-300
4	300-600
5	600-bottom
6	Sediment 30 cm

Table 2 – Model vertical layers thickness

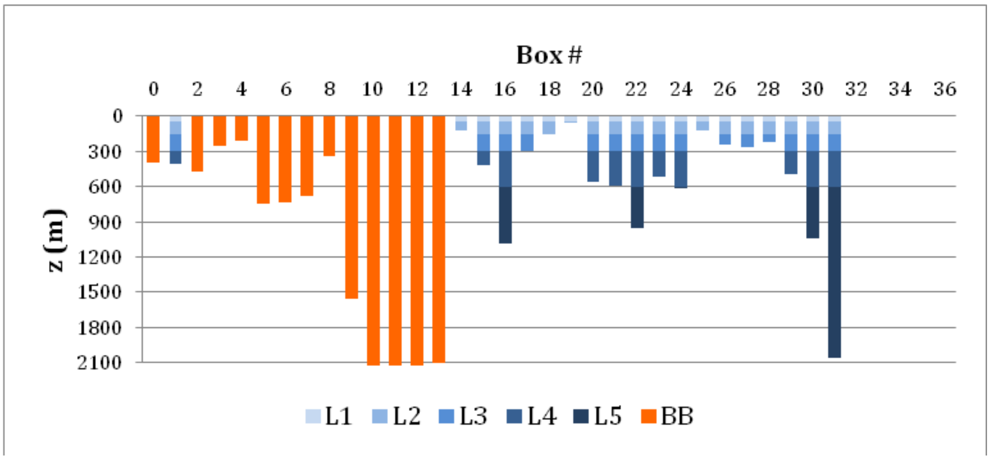


Figure 2 – Depth layers per box (BB indicates Boundary Boxes which are not explicitly modelled), box 32-36 are islands.

Oceanography and bottom topograhy

Topography

For Atlantis, depth was taken from the GEBCO Digital Atlas, in particular using the GEBCO_08 Grid (fig.3a), which is a global terrain model for ocean and land, at 30 arc-second (1km) intervals, and generated by combining quality-controlled ship depth soundings with interpolation between sounding points guided by satellite-derived gravity data. This data was averaged to get Atlantis box depths (fig.3b).

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

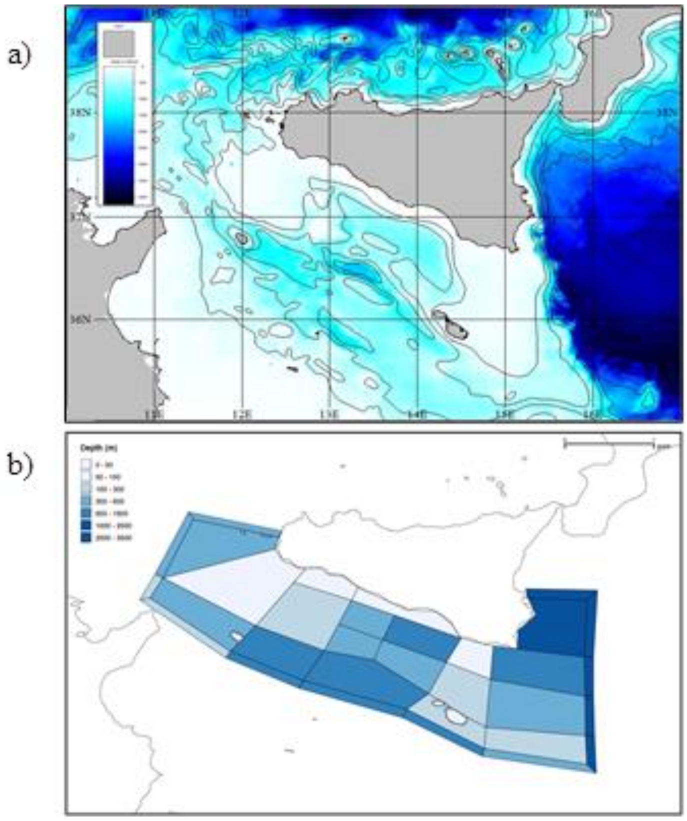


Figure 3 - a) GEBCO_08 Grid and b) Atlantis polygons average depth.

From a large data set collected over a ten-year period from 1990 to 2000, hauls with presence of indicator species and substrate-type records were selected (fig.4, Garofalo et al. 2002). Through the analysis of this information, with catch data, a biocenosis category, based on the Pérès–Picard (1964) classification, was assigned to each sampling site. Nine biocenosis/facies types were identified: SFBC (well-graded fine sand), HP (Posidonia oceanica meadows), VTC (coastal terrigenous mud), C (coralligenous), DC (coastal detritus), DL (open-sea detrital bottoms), VB-VSG (sandy muds with gravels), VB-C (compacted muds), VB-PSF (soft muds with fluid surface film). The habitat composition of each box is represented by a percentage cover of each habitat type, including biogenic (e.g. seagrass, macroalgae).

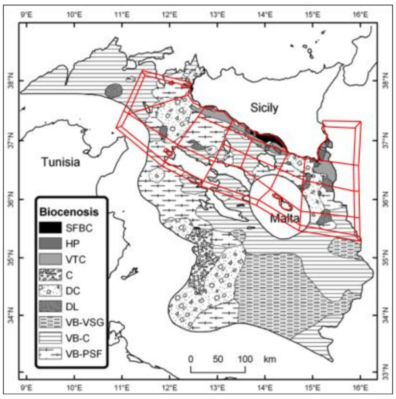


Figure 4 - Benthic biocenosis (adapted from Garofalo et al, 2002). Within the Atlantis model domain 7 dominant biocenosis/facies types were identified: SFBC (well-graded fine sand), HP (Posidonia meadows), VTC (coastal terrigenous mud), DC (coastal detritus), DL (open-sea detrital bottoms), VB-C (compacted muds), VB-PSF (soft muds with fluid surface film).

Temperature and Salinity

The main source of temperature and salinity data for running Atlantis was derived from the biogeochemical model OPATM -BFM (Lazzari et al., 2010). Temperature and salinity time series with a 10 days temporal resolution from the OPATM-BFM model were vertically and horizontally averaged in order to produce a dataset matching Atlantis spatial and vertical resolution (37 boxes x 6 layers = 222 entries, in the initial condition file and the 222 entries per time step in the forcing file). This was used to initialize and force the model. Bottom temperature was also recorded during the MEDITS hauls. Temperature and salinity data are stored as separate netcdf files with three dimensions: time, box, layer.

Nutrients

Nutrients data were only used for model initialization, as the model handles nutrients flux explicitly. The initial concentration of ammonia, nitrate, silicate and phosphate per box and per layer were taken from OPATM-BFM output with a 10 days temporal resolution. Nutrients are assumed to be homogeneously distributed within each layer of each box and, as described in the temperature and salinity section, were vertically and horizontally averaged in order to produce a dataset matching Atlantis spatial and vertical resolution (37 boxes x 6 layers = 222 entries). Nutrients data, stored in the initial condition netcdf file, feature two dimensions: box, layer.

Chlorophyll and primary production

Data on the concentration and spatial distribution of total chlorophyll were taken from OPATM-BFM output with a 10 days temporal resolution and were only used for model initialization, as primary production is modelled explicitly. Chlorophyll data were averaged to match Atlantis spatial and vertical resolution (37 boxes x 6 layers = 222 entries).

Hydrodynamics

The outputs from the OPATM-BFM model are used to provide advection and diffusion for Atlantis. Atlantis expects the currents to be in the form of bulk exchanges between boxes/layers. These bulk exchanges were calculated by imposing Atlantis model geometry on the hydrodynamic model and then integrating the currents that pass through the faces (horizontal) and layers (vertical) of the model geometry. Information are stored as a series of netCDF files per timestep, per box, per layer.

Solar radiation

For the present-day model runs, the meteorological forcing was taken from ERA-Interim data atmospheric reanalysis data. The spatial resolution is about 0.7° and the temporal resolution is daily (http://www.ecmwf.int/research/ era/do/get/era-interim). Includes 2 variables: time (d) and short wave radiation (Wm^{-2}) per polygon.

River runoff and atmospheric nutrient enrichment

Nitrate and phosphate fluxes: present-day values for river discharge rate and nutrient concentrations were taken from the Global NEWS dataset (fig.5) (http://www.marine.rutgers.edu/globalnews/index.htm).

A point-source file is associated to each box giving for each nutrient the inflow from river runoff and from the atmosphere. Temporal variation is not accounted for so that river flow and nutrient levels are assumed to be constant in time.

For future scenarios, flow volumes will be left unchanged, while nutrients will be adjusted to future projections levels.

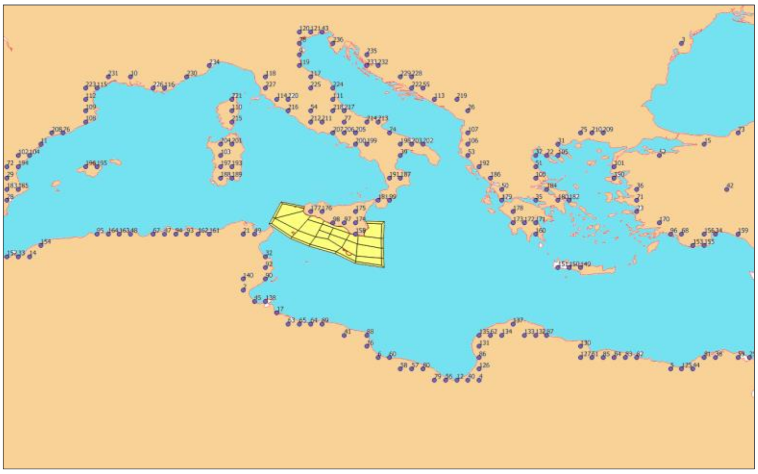


Figure 5 - Global NEWS river runoff dataset

Functional groups

Demersal fish and shellfish

Biomass indices from surveys, adjusted by means of catchability coefficients, are used to derive biomass estimates for functional groups of demersal and pelagic species of fish, crustaceans and cephalopods.

Bottom trawl survey data are available for the period 1994-2008 (GRUND) and 1994-2013 (MEDITS). The main data available are: i) biomass and density indices by hauls of both vertebrates and invertebrates (including macro-epibenthic organisms) caught; ii) biometric (lengths/weights) and biological data (sex and maturity) for a pool of about 35 target species; iii) latitude, longitude, depth and bottom temperature of each haul.

Small pelagic fish and shellfish

National pelagic surveys, carried in the area out in the period 1998-2008, where replaced since 2009 by the international program MEDIAS.

Data available are biomass estimates of sardine an anchovy coupled with biometric and biological data on these two species.

Either MEDITS and MEDIAS data are collected under the EU Data Collection Framework and stored in institutional and internal databases.

Mesopelagics

A hydrographic and ichthyoplanktonic survey (Cutitta et al., 2004) carried out in the Strait of Sicily in July 2000 provided data on the species composition, abundance and distribution of mesopelagic fish larvae. Data from this study and from MEDITS data revealed that the mesopelagic community was dominated by *Cyclothone braueri* (67.6% of the total), *Electrona Risso* (7.8%) and *Myctophum punctatum* (7.7%). The biological parameters for this functional group are therefore based on *Cyclothone braueri*.

Large pelagics

Catch data on the two main stocks of large pelagic fish, bluefin tuna and swordfish, are analysed periodically by ICCAT to derive population and mortality estimates and for bluefin tuna establish TAC and national quotas. Estimates for the portion of total biomass of the two stocks existing in the Strait of

Sicily are derived from the last ICCAT assessments. In this exercise also the spatial distribution of CPUE is considered.

Marine mammals

The Strait of Sicily area plays a fundamental role in large cetacean migration. The cetacean fauna of the area is rich. Fin whales are known to congregate in late February and early March in the coastal waters of the island of Lampedusa (Italy), Sicilian Channel, to feed on the euphausiid Nyctiphanes couchii (Canese et al., 2006.). Sperm whale (*Physeter macrocephalus*) occurs all year round. Several studies document the distribution and abundance of different cetaceans, such as the bottlenose dolphin, common dolphin and striped dolphin in the area (see Gannier, 2005; UNEP-MAP-RAC/SPA. 2014, Vella and Vella, 2012).

IAMC has carried out long term studies were carried out in the coastal waters of south-western Sicily from 2003 to 2007 on resident populations of bottlenose dolphins. During sightings, information about position, group size, presence of calves and presence of fishing boats were always registered. The study was carried out also in pelagic waters of the Sicilian Channel from 1999 to date to assess the distribution and the occurrence of the most common cetacean species in this part of Mediterranean Sea. These surveys were carried out on board of the R/V "Urania", "Dalla Porta", " Tethis" oceanographic vessels of IAMC-CNR.

Conversion of numeric indices in biomass is carried out using the mean weight reported in Trites and Pauly (1998) and Schmitz and Lavigne (1984).

Birds

The Sicily channel hosts one of the biggest colonies of Cory's Shearwater (Calonectris diomedea diomedea) in the Mediterranean (Brichetti and Fracasso 2003), one of the most important Mediterranean marine pelagic birds.

Estimates of the biomass of the Cory's Shearwater as well as of *Puffinus yelkouan* and seagulls can be found in Baccetti *et al.,* 2009 and Capizzi *et al.*, 2010.

Turtles

Lampedusa and Linosa (two Natura 2000 sites) are among the last known nesting sites of Loggerhead (*Caretta caretta*) in this part of the Mediterranean where this species can lay its eggs. From 1995 Rescue Centre activity has marked more than 600 sea turtles and released in these years. During this period, it has been observed that one female turtle which was captured and marked in 1996 was observed nesting again in Linosa eight years later.

Benthos

The south coasts of Sicily are featured by a high heterogeneity in benthic communities along the continental shelf. Several biocenosis/benthic assemblage types were identified such as, SFBC (well-graded fine sand), HP (*Posidonia oceanica* meadows), VTC (coastal terrigenous mud), C (coralligenous), DC (coastal detritus), DL (open-sea detrital bottoms), VB-VSG (sandy muds with gravels), VB-C (compacted muds), VB-PSF, (soft muds with fluid surface film), DL (offshore detritic bottoms),

In particular the *Posidonia* meadows along the SW sector are considered among the largest of the Mediterranean.

There is however a lack of quantitative data on the biomass of the macro benthic taxa in the area. The only data available have been collected and stored in a IAMC database in the Gulf of Castellammare, that is located on the NW coasts of Sicily.

Quantitative data on the macro-epibenthos, such as sponges, large echinoderms, cnidares, gastropods, etc., have been collected during the Medits survey

Maps of benthic biocenosis, including Posidonia oceanica meadows, have been incorporate into ATLANTIS.

Phytoplankton

As already said, the initial concentration of chlorophyll was taken from the outputs of the OPATM-BFM. This was subdivided, on the base of observed biomass and abundance data for the Strait of Sicily in 3 groups of primary producers: picophyotplankton, diatoms and dinoflagellates. After initialization these functional groups are explicitly modelled by Atlantis.

Picophytoplankton

The initial biomass of picophytoplankton, in particular the most dominant and

Prochlorochoccus was taken from observation in the area (Brunet et al., 2006; Lasternas *et al*., 2010). This was converted into biomass using the elemental composition of marine *Prochlorococcus* from Bertilsson *et al.* 2003.

Diatoms

Results reported in literature derived from two oceanographic cruises (PROSOPE and BOUM, Crombet et al. 2011) provides data on the biogenic content, abundance and vertical distribution of diatom assemblages, which were dominated by *Chaetoceros spp*., to initialize the model.

Dinoflagellates

The initial concentration of dinoflagellates (*Gymnodinium spp.*) was taken from Lasternas at al., 2010 as a reference level.

Zooplankton

Microzooplankton

Data for the initialization of microzooplankton biomass and distribution were taken from reports derived from the BOUM cruise (Nowaczyk et al., 2011).

These are then modelled explicitly by Atlantis.

Mesozooplankton

Mesozooplankton biomass and spatial distribution from OPATM-BFM model were used for model initialization. These are then modelled explicitly by Atlantis.

Stomach contents

The Gadget model will be based on data on hake stomach contents composition by quarter to understand the impact of the hake stock on its main fish prey.

Atlantis is making use of stomach contents data available for the Strait of Sicily (e.g. red shrimps, hake, anchovy, sardine, Triglidae, etc.), complemented with data from the Gulf of Castellammare (about 30 species) and other Tyrrhenian areas.

For the other functional groups diet data have been gathered from published studies.

Field data on consumption rate of Mediterranean fish are available for a set of species (Carpentieri et al., 2006, 2007, 2008). For other species the Q/B has been calculated using empirical equations (Pauly et al., 1990; Palomares and Pauly 1989; 1998).

Commercial activities

Data collection on fisheries and commercial stocks

Along the south coasts of Sicily (GSA 16) and in Malta waters (GSA 15), as in the other EU Mediterranean waters, fisheries dependent data are collected by Member States under the Data Collection Framework (DCF) according to the FAO-GFCM Geographical Sub-Areas (GSAs), which represent management units established in 2001 and amended in 2009 (GFCM Resolution GFCM/33/2009/2). Appendix VII of the Commission Decision 93/2010, adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector for the period 2011-2013 (DCF).

Data are available since 2002 and stored into a IAMC database to be annually delivered to the Italian Ministry for Agricultural Policy and the European commission. DCF requirements in Mediterranean EU waters are related to a total number of 90 species/groups of species, 28 bony fish, 49 elasmobranches, 6 cephalopods, 6 crustaceans, and 1 bivalve, respectively. Species are categorized according to two species groups, Group 1 (n= 63, species that drive the international management process including species under EU management plans or EU recovery plans or EU long-term multi-annual plans or EU action plans for conservation and management based on Council Regulation (EC) No 2371/2002) and Group 2 (n =27, other internationally regulated species and major non-internationally regulated by-catch species). Moreover, only for 10 species weight, sex and maturity should be recorded on a yearly basis (i.e. *Aristeomorpha foliacea*, *Aristeus antennatus*, *Nephrops norvegicus*, *Parapenaeus longirostris*, *Engraulis encrasicolous*, *Sardina pilchardus*, *Merluccius merluccius*, *Mullus barbatus*, *Mullus surmuletus*, *Solea solea*), while such data should be recorded over a three year frequency for 32 species.

DCF data collection includes, among others, landings and discards of the most important métiers in the EU Mediterranean Member States, the biological data of the most important stocks, the collection of socio-economic data, the estimate of ecosystem indicators.

Catch data are stored in an internal IAMC database and include for each species and métier :

- Landings and discards by quarter and métier;the following information;
- Size/age structure of landings and discards;
- Sex and maturity composition;

Data are available for the main fishing métiers to reconstruct their impact on the main commercial stocks in terms of catches, fishing effor and mortality.

In addition, large pelagic stocks are assessed by ICCAT at large geographical scale: eastern Atlantic and Mediterranean for bluefin tuna (*Thunnus thynnus*) and Mediterranean for swordfish (*Xiphias gladius*).

It is worth noting that the quality of available data in some cases is not sufficient to allow some analytical approaches to be applied.

Fishing effort

Data on the fishing effort of the main fishing métiers are available as number of days at sea, and KW*days at sea.

Vessel Monitoring System

VMS were introduced in 2002 by the European Union for the remote control of fishing vessels and collected within Data Collection Framework since 2006. Specifically, the VMS data, available for about 300 vessels operating in the area, covers the years 2006–2010 (see fig. below., Russo et al., 2014). Data for 2011-2013 still needs to be gathered and elaborated. The VMS data were processed following the methodology described in Russo et al., 2013 and combined with landing/discards data to calculate the catch in any single Atlantis box. (Fig. 6)

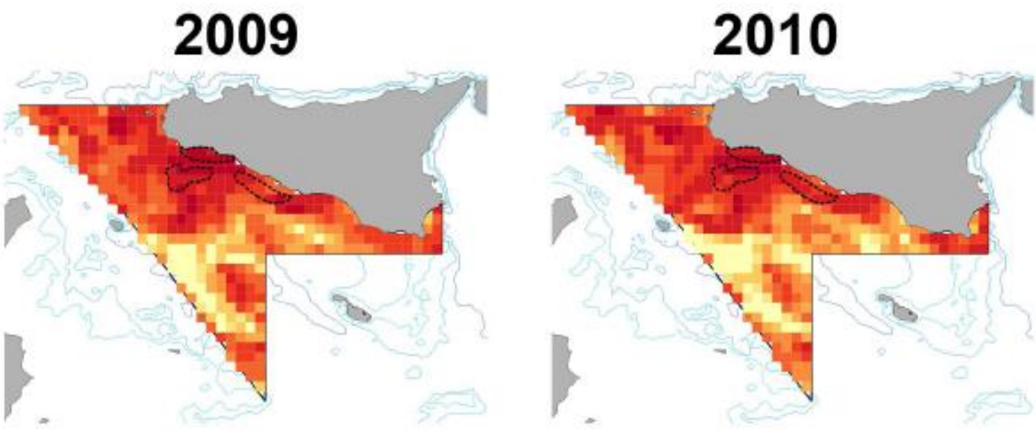


Figure 6 - Distributions of the fishing effort in years 2009–2010 (a). Each map represents the 6 min 66 min grid in which the Log10 of the number of fishing points (VMS frequency = 10 minutes) is reported in a yellow-red scale colour (from Russo et al., 2014).

Stock assessment data

Stock assessments are carried out both by the working groups of the GFCM and the Scientific, Technical and Economic Committee for Fisheries (STECF) of the EC. GFCM plays a key role in fostering the development of assessment on shared stocks between EU and non-EU countries also in cooperation with the FAO regional project MedSudMed.

The lack of a systematic data collection hindered the assessment of fish stocks in the area until the early 2000s when the EU Data Collection Regulation (DCR, EU reg. 1543/2000) was enforced in all EU Member States.

Analytical stock assessments have been produced for 11 stocks (*Mullus barbatus, Mullus surmuletus, Merluccius merluccius, Pagellus erythrinus, Lophius boudegassa, Raja clavata, Galeus melastomus, Aristeus antennatus, Aristaeomorpha foliacea, Parapenaeus longirostris, Nephrops norvegicus*).

For these stocks are available data on numbers at age , total and spawning stock biomass, recruitment, fishing mortality. F_{01} as proxy for F_{msy} is used as limit reference points to evaluate the status of the stocks.

Fisheries independent data (surveys)

Bottom trawl surveys are carried out in the Italian sector of the Strait of Sicily since mid '80s. A national survey (GRUND) was carried in the period 1985-2008. The International MEDITS bottom trawl survey started in 1994 covering an area of about 45,000 km^2 between 10 and 800 m depth. The program adopted a stratified random sampling design with allocation of hauls proportional to strata extension. The surveys were carried out using the same vessel, equipment and protocol throughout the entire period. A total of 56 hauls were made from 1994-2002 in spring keeping fixed their locations (Fig. 7) and increased to 120 since 2002. Abundances and biomasses standardized to 1 km^2 ($N\ km^{-2}$; $kg\ km^{-2}$), were calculated for each species caught. For a subset of about 40 target species (table 3) are routinely collected also length, sex and maturity data.

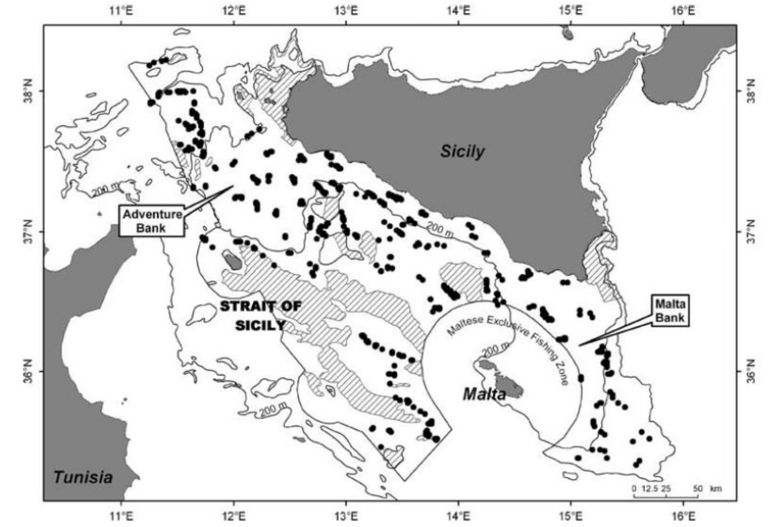


Figure 7 - Map of the study area showing the location of the sampling stations from 1994 to 2003. The dashed zones indicate untrawlable areas and water depths of more than 800 m (from Garofalo et al., 2007)

VI. List of the reference species

Scientific name	Date[1]	CODE	Common name	
			Français	English
Aspitrigla cuculus	1998	ASPI CUC	Grondin rouge	Red gurnard
Boops boops	2006	BOOPBOO	Bogue	Bogue
Citharus linguatula	1994	CITH MAC	Feuille	Spotted flounder
Eutrigla gurnardus	1994	EUTR GUR	Grondin gris	Grey gurnard
Galeus melastomus	1998	GALU MEL	Chien espagnol	Blackmouth catshark
Helicolenus dactylopterus	1994	HELI DAC	Rascasse de fond	Rockfish
Lepidorhombus boscii	1994	LEPM BOS	Cardine à quatre taches	Four-spotted megrim
Lophius budegassa	1994	LOPH BUD	Baudroie rousse	Black-bellied angler
Lophius piscatorius	1994	LOPH PIS	Baudroie commune	Angler
Merluccius merluccius	1994	MERL MER	Merlu commun	European hake
Micromesistius poutassou	1994	MICM POU	Merlan bleu	Blue whiting
Mullus barbatus	1994	MULL BAR	Rouget-barbet de vase	Red mullet
Mullus surmuletus	1994	MULL SUR	Rouget-barbet de roche	Striped red mullet
Pagellus acarne	1994	PAGE ACA	Pageot acarné	Axillary seabream
Pagellus bogaraveo	1994	PAGE BOG	Dorade rose	Blackspot seabream
Pagellus erythrinus	1994	PAGE ERY	Pageot commun	Common pandora
Sparus pagrus	> 1996	SPAR PAG	Pagre commun	Common seabream
Phycis blennoides	1994	PHYI BLE	Phycis de fond	Greater forkbeard
Raja clavata	1994	RAJA CLA	Raie bouclée	Thornback ray
Scyliorhinus canicula	1998	SCYO CAN	Petite roussette	Smallspotted catshark
Solea vulgaris	1994	SOLE VUL	Sole commune	Common sole
Spicara flexuosa	1994	SPIC FLE	Gerle	Picarel
Spicara smaris	1998	SPIC SMA	Picarel	Picarel
Trachurus mediterraneus	1994	TRAC MED	Chinchard à queue jaune	Mediterranean horse mackerel
Trachurus trachurus	1994	TRAC TRA	Chinchard d'Europe	Atlantic horse mackerel
Trigla lucerna	2006	TRIGLUC	Grondin-perlon	Tub gurnard
Trigloporus lastoviza	1998	TRIP LAS	Grondin camard	Streaked gurnard
Trisopterus minutus capelanus	1994	TRIS CAP	Capelan	Poor-cod
Zeus faber	1994	ZEUS FAB	Saint-Pierre	John dory
Selacians[2]	2006			
Aristaeomorpha foliacea	1994	ARIS FOL	Gambon rouge	Giant red shrimp
Aristeus antennatus	1994	ARIT ANT	Crevette rouge	Blue and red shrimp
Nephrops norvegicus	1994	NEPR NOR	Langoustine	Norway lobster
Parapenaeus longirostris	1994	PAPE LON	Crevette rose du large	Deep-water pink shrimp
Eledone cirrhosa	1994	ELED CIR	Poulpe blanc	Horned octopus
Eledone moschata	1997	ELED MOS	Elédone musquée	Musky octopus
Illex coindetti	1994	ILLE COI	Encornet rouge	Broadtail squid
Loligo vulgaris	1994	LOLI VUL	Encornet	European squid
Octopus vulgaris	1994	OCTO VUL	Pieuvre	Common octopus
Sepia officinalis	1994	SEPI OFF	Seiche commune	Common cuttlefish

[1] Year in which the species was introduced in the list (or removed if the year is preceded by >)
[2] It is recommended to carry out the observations referring to this list to all the selacian species in the GSAs where it is technically possible. To allow coherent analyses of the results, it is highlighted that the decision to enlarge or not biological observations on selacians must be applied consistently during all the surveys.

Table 3 - MEDITS survey: list of reference species

New data (from WP2)

There are two main other sources of information that can be considered for their incorporation into Atlantis and Gadget models for the Strait of Sicily (SS) ecosystem, namely: genetics/genomics, stable isotopes, vessel monitoring system data. Most of the work done in the last months was devoted to data gathering and compilation for their integration into Atlantis. The implementation of Gadget has been delayed to next September.

- Genetics data: genomics of hake juveniles (Merluccius merluccius) from the two main persistent nursery grounds (Adventure Bank on the eastern side of the SS, Malta Bank on the western side of SS). The two groups of juveniles displayed genetics discontinuities that might be interpreted as an evidence of reduced connectivity and mixing between the two areas (Milano et al., 2014). Genetic data available for Parapenaeus longirostris also clearly show a gradual discrepancy along a west-east gradient, with some geographical areas with a some degree of isolation (Lo Brutto et al., 2013).

We can argue that the two nurseries basically depends on two different pools of spawners distributed upstream the nursery grounds. This aspect can be explicitly implemented into ATLANTIS to separate the effect of human (e.g. fishing) and environment (e.g. climate forcing) on the two sub-groups of specimens.

- Stable isotopes data: measures of δ13C and δ13N for 42 species from three different Sicilian coastal areas (Fanelli et al., 2009, 2010, 2011; Sinopoli et al., 2012). This data combined with stomach contents data are used to define functional groups and assign species accordingly based on their trophic role. In addition, ontogenetic changes in isotopic composition of target commercial species (e.g. hake, red mullet) were used to better separate specimens in size classes to be incorporated into Atlantis food web structure.

Other data and parameters (e.g. mortality, consumption, etc.)

For a description of this information see Appendix 1 "Use of data into ATLANTIS".

APPENDIX 1

USE OF DATA INTO ATLANTIS

Functional groups (functionalgroups.csv)

The biological groups included in Atlantis, described in the report D5.1, were made up of functional groups (aggregate groups of species with similar size, diet, predators, habitat preferences, migratory patterns and life history strategy) and dominant target species in the Sicily Channel fisheries. The biological community was constructed using data from the MEDITS survey programme (International bottom trawl survey in the Mediterranean, MEDITS). A total of 354 species sampled were aggregated into 45 functional groups, 19 of which vertebrates (table A1), with some of the most commercially important species represented at species level, currently *Aristaeomorpha foliacea, Engraulis encrasicholus, Merluccius merluccius, Mullus barbatus, Parapaeneus longirostris, Sardina pilchardus*. Functional groups are spatially distributed over 7 habitat types: macroalgae, seagrass, rough, flat, mud, detritus, canyons.

The invertebrate groups are represented using biomass pools, while the cephalopods, prawns and vertebrates are presented as age structured stocks.

In addition to these living biological groups, pools of ammonia, nitrate, silica, carrion, labile and refractory detritus are also represented dynamically. The list of functional groups in the food web is given in Table.2 (more details in Appendix 1a).

Engraulis encrasicolus	Mesopelagic fish slope crustacean feeders	Seagrass
Sardina pilchardus	Mesopelagic fish slope jelly feeders	Benthic Carnivore
Merluccius merluccius	Mesopelagic fish slope piscivorous	Gelatinous zooplankton
Mullus barbatus	Macroepibenthos slope	Diatom
Aristaeomorpha foliacea	Macroepibenthos shelf	Dinoflagellates
Parapaeneus longirostris	Demersal selaceens shelf	Pico-phytoplankton
Small pelagics	Demersal selaceens slope	Microzooplankton
Medium pelagics	Natant decapods slope	Mesozooplankton
Large pelagics	Reptant decapods slope	Carnivorous zooplankton
Demersal fish slope	Reptant decapods shelf	Pelagic Bacteria
Demersal fish shelf crustacean feeders	Pelagic cephalopod	Sediment Bacteria
Demersal fish shelf mixed food	Benthic cephalopod	Meiobenthos
Demersal fish shelf piscivorous	Seabirds	Labile detritus
Demersal fish shelf rocky	Macroalgae	Refractory detritus
Epipelagic fish	Microphtybenthos	Carrion

Tab. A1 – List of preliminary functional groups. Highlighted in green target species.

The list of functional groups and information on their functional type (e.g. fish, plant, invertebrate, epibenthic, etc.), number of age classes, predatory status are contained in the functionalgroups.csv file.

Biological environment

The initial conditions file provides a description of all variables per box per layer. It includes all information on the spatial distribution and biomass of all functional groups, nutrients, sea environmental conditions, fisheries operating in the Sicily Channel and seafloor types: macroalgae, seagrass, rough, flat, mud, detritus, canyons. Each polygon can include different types expressed as percentage of area covered. The biological groups included in Atlantis Sic.

Data are structure as a 37x6 data grid.

Invertebrates

Invertebrate groups are represented as biomass pools, while for some groups of particular interest, such as cephalopods and prawns, are presented as age structured stocks. The biomass of each functional group is distributed per box and depth layer (37x6 = 222 entries).

Vertebrates

Vertebrate groups are represented as age-classes, typically 10. The biomass of functional group is calculated as the sum of the biomass of all age-classes.

The initial spatial distribution of each age-class is given by their number ("_Nums") per polygon, per layer, and its biomass is calculated as the product of age specific individual structural and reserve weights ("_StructN" + "_ResN") and their abundance. So each vertebrate functional group abundance and biomass is spatially allocated using 10 (age classes) x 3 ("_Nums","_StructN", "_ResN") x 37 (boxes) x 6 (depth layers) = 6600 entries, most of which will be zeros (fig.3).

a. Harvest

The harvest.prm is for the fisheries analogous of biol.prm for functional groups. It includes information about the fishing fleets operating in the area and explicitly represented in the model:

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

1. bottom trawlers;
2. pelagic trawlers;
3. pelagic artisanal vessels;
4. demersal artisanal vessels;
5. purse seine;
6. demersal longline;
7. pelagic longline;
8. gillnets;
9. trammel nets.

Biological information on functional groups (biol.prm)

	Nutrients	Primary producers	Benthic invert.	Plankton	Nektonic invert.	Fish	Shark and rays	Mammals and birds	Humans
Period of activity			√	√	√	√	√	√	√
Habitat dependency		√	√	√	√	√	√	√	√
Distributions and abundances*	√	√	√	√	√	√	√	√	√ [1]
Swimming speeds						√	√	√	
Migration times and routes			√[2]		√[2]	√	√	√	
Diets[1]*			√	√	√	√	√	√	
Consumption and growth rates*		√	√	√	√	√	√	√	
Length-weight relationships*						√	√	√	
Size at age*						√	√	√	
Non-predation mortality rates		√	√	√	√	√	√	√	
Maximum age*						√	√	√	
Age at maturity						√	√	√	
Spawning area and season			√[2]		√[2]	√	√	√	
Larval or gestation period					√	√	√	√	
Location of recruits						√			
Fecundity			√[2]		√[2]	√	√	√	
Size of recruits (young of the year)				√		√	√	√	

1. Of human population per port; for defining home ports for fisheries as well as the level of recreational fishing pressure in an area, 2. Only if using age structured biomass pools that show migration through the year.

Table A2 - Key information of Atlantis model. Critical ecological data is marked with an *.

This section deals with the parameterization of biological functions of each functional group. The typical information required to implement an Atlantis model are listed in tab.A2 and are included in the biol.prm file.

a. Habitat usage and dependence

For each functional group it is possible to specify habitat usage and habitat dependency (habitat degradation might have a prefund effect on habitat dependent groups) preferences. It is also possible to include information on ontogenetic changes in habitat usage. **Habitat usage** simply reflects whether a group can access an area containing a habitat type. If a group can't access a habitat type, then it is also not possible for it to access any prey biomass associated with that habitat type. During trophic interactions the habitat usages of predator and prey are compared to see if the two groups can be in the same small-scale patches and thus able to interact directly. During fishing events a similar comparison is made between the habitat preferences (and thus fine scale distribution) of fish and the types of habitat a fishery can access. This dependency is only in effect in the bottom water column layer (where it contacts the epibenthic and sediment layers). **Habitat dependency** is a group characteristic that is in addition to its habitat usage (it is quite feasible for a group to use habitat, but not be dependent upon it). Habitat dependency can also modify the trophic interactions in that good quality habitat provides more cover for prey groups dependent upon it, whereas degraded habitat allows predators to access more of their prey.

Dependencies on particular habitats are drawn from Fishbase (Froese and Pauly, 2000), benthic biocenosis analyses in the Strait of Sicily (fig.4) as well as from literature.

b. Spatial range, movement and migration

This section contains detailed information on functional groups spatial distribution and movement. In particular it needs data on the maximum biomass observed for any given polygon, extracted from GRUND e MEDITS datasets; average swimming speed; minimum and maximum occurrence depth; home range radius (optional) for migrating species; temperature and salinity occurrence range; number, weight and period of migration in and out of the model domain (e.g. tuna) taken from literature, reports and FishBase.

c. Diet

This section deals with functional groups feeding habits (e.g. whether, nocturnal, diurnal or both), feeding rates (Holling type II) and size dependent feeding regulation. This is expressed, for vertebrates, as maximum and minimum gape size, to determine available prey groups, and individual weight for invertebrates.

d. Growth

Information on length-weight relationships, growth rates for vertebrate and invertebrates, energy allocation to structural vs. reserve weight, respiration rate, vertebrate size at age and length-weight relationship parameters taken from local studies, literature, reports and FishBase (tab.A3).

Functional Group	Most representative species in terms of biomass	L-W a	b	Reference
ARF - Red shrimp	*Aristaeomorpha foliacea*	0,00310	2,41850	Gancitano et al., 2012
CEB - Cephalopods benthic	*Octopus spp.*	0,00170	2,68130	Fiorentino et al., 2008
CEP - Cephalopods pelagics	*Illex coindetii*	0,13970	2,42430	Gancitano et al., 2012
DFH - Demersal fish shelf crustacean feeders	*Lepidotrigla cavillone*	0,00780	3,20000	FishBase
DFS - Demersal fish slope	*Phycis blennoides*	0,00004	2,80000	MedSudMed n.2
DSH - Demersal selaceens shelf	*Raja clavata*	0,00300	3,71470	Gancitano et al., 2012
DSM - Demersal fish shelf mixed food	*Solea solea*	0,00620	3,00000	FishBase
DSP - Demersals shelf fish piscivorous	*Lophius piscatorius*	0,01460	2,98550	Gancitano et al., 2012
DSR - Demersal fish shelf rocky	*Diplodus annularis*	0,00008	2,70250	CNR-IAMC
DSS - Demersal selaceens slope	*Galeus melastomus*	0,000003	3,00330	CNR-IAMC
ENG - Anchovy	*Engraulis encrasicholus*	0,00200	3,52980	Basilone et al. 2003
EPI - Epipelagic fish	*Spicara maena*	0,01250	3,00000	FishBase
HAK - Hake	*Merluccius merluccius*	0,00500	3,13000	CNR-IAMC 2006
LPL - Large pelagics	*Xiphias gladius*	0,00400	3,20000	FishBase
MPL - Medium pelagics	*Trachurus trachurus*	0,01430	2,84610	Gancitano et al., 2012
MSC - Mesopelagic slope fish crustacean feeders	*Myctophidae spp*	0,00804	3,00000	FishBase
MSG - Mesopelagic slope fish jelly fish feeders	*Centrolophus niger*	0,00240	3,34600	FishBase
MSP - Mesopelagic slope fish piscivorous	*Stomias boa*	0,00030	3,50620	FishBase
MUL - Mullus	*Mullus barbatus*	0,00930	3,05960	CNR-IAMC 2006
PWL - Deep sea pink shrimp	*Parapenaeus longirostris*	0,00251	2,54360	CNR-IAMC 2006
SAR - Sardine	*Sardina pilchardus*	0,00280	3,37000	SAC GFCM 2011
SPL - Small pelagics	*Sardinella aurita*	0,00001	2,95370	CNR-IAMC

Table A3 – Length-weight relationship for commercial stocks of fish and shellfish

e. Reproduction and recruitment

Information on reproduction and recruitment available, local studies technical reports, assessments and literature include: minimum and maximum temperature for spawning, vertebrate SSB-R relationship choice and parameterization (Ricker, Beverton-Holt, lognormal, hockey stick, etc.), first age-class at maturity, spawning period, duration and areas, age–class proportion of egg producers, recruitment period and nursery areas, size or weight of recruit.

f. Mortality

Estimates of total mortality (M) and fishing mortality (F) are derived from analytical assessments. For the stocks where standard assessments are lacking, we derived mortality estimates (Z) from MEDITS data using a catch curve approach. In other cases where available, or from FishBase.

For cephalopods and non-commercial crustaceans a possible approach to derive Z (P/B) estimates is to use the empirical equation of Bray (1990, 1999a, 1999b, 2001, 2012):

$$\log(P/B) = 1.672 + 0.993 * \log(1/A_{Max}) - 0.035 * \log(M_{Max}) - 300.447 * 1/(T + 273)$$

where:

A_{max} = maximum observed age (years)

M_{max} = maximum observed body mass (kJ)

T = average water temperature (deg. Centigrade)

g. Trophic interactions matrix

In its basic implementation the model trophic structure was built in line with previous implementations of the model in other areas. This was then adjusted using stomach content data collected in the Strait of Sicily and refined with the inclusion of different functional groups and on the base the work done in WP2 by gathering novel information from isotope analysis on the trophic linkages between groups. The values in the matrix represent the availability of the prey to the predator, ranging between 0 and 1, assuming they are big enough to be eaten, there are no refuges, etc. All of those conditional steps will down scale this value via additional explicit calculations. Fig.A1 shows the structure of the diet matrix, which is found in the biol.prm file.

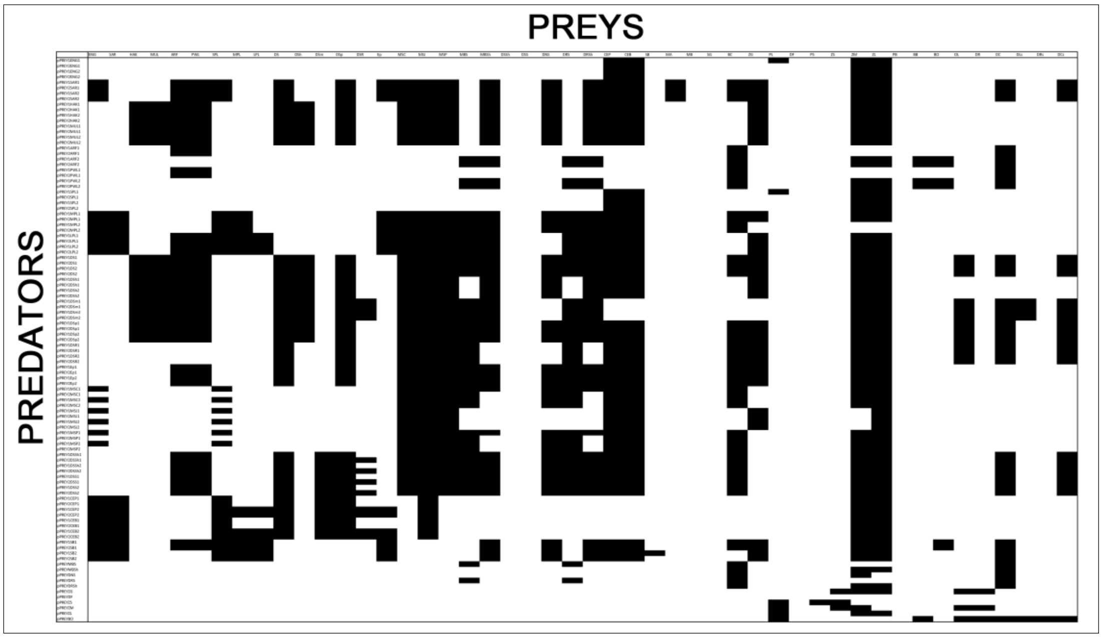


Fig. A1 – Atlantis trophic interactions matrix. Black indicates interaction.

Forcing file selection, options and flags (force.prm and physics.prm)

These files provide the system information on the way the physcics code is expected to run. In particular, physics.prm provides the user with a choice of different functional forms for physical processes representation (e.g. vertical mixing, oxygen profiles, resuspension, etc.). Additionally, in physics.prm flags to switch on-off processes (e.g. atmospheric and river run-off injection of nutrients). Force.prm informs the system about which forcing files to use in running the simulations: i.e. hydro.nc, temp.nc, sal.nc, solar.ts, pointsource.ts, and catch.ts.

APPENDIX 1a - Functional groups

Invertebrates, plants, detritus and nutrients

PL - Large Phytoplankton	Diatoms
PS - Small Phytoplankton	Picophytoplankton: Synechoccus, Prochlorochoccus, picoeukariotes
DF - Dinoflagellates	Dinoflagellates
ZS - Small Zooplankton	Copepodites
ZM -Mesozooplankton	Copepods
ZL - Large Zooplankton	Krill and chaetognath
ZG - Gelatinous Zooplankton	Salps (pryosomes), coelenterates
PB - Pelagic Bacteria	Pelagic Bacteria
CEP - Pelagic cephalopods	*Abralia veraniji, Alloteuthis media, Alloteuthis spp, Alloteuthis subulata, Ancistroteuthis lichteinsteini, Argonauta argo, Bathypolypus sponsalis, Heteroteuthis dispar, Histhioteuthis bonnellii, Histhioteuthis reversa, Histhioteuthis spp, Illex coindetii, Loligo forbesi, Loligo vulgaris, Ommastrephes bartramii, Onychoteuthis banksi, Todarodes sagittatus, Todaropsis eblanae*
BB - Sediment bacteria	Aerobic and anaerobic bacteria
BC - Carnivoruos infauna	Polychaetes
MBS - Macroepibenthos Slope	*Alpheus glaber, Anamathia rissoana, Anapagurus laevis, Crustacea, Dardanus arrosor, Goneplax rhomboides, Isopoda, Lepas anatifera, Macropodia longipes, Macropodia longirostris, Macropodia rostrata, Pagurus alatus, Parthenope macrochelos, Parthenope massena*
MBH - Macroepibenthos Shelf	*Other Crustaceans, Clibanarius erythropus, Dardanus calidus, Diogenes pugilator, Dromia personata, Ebalia deshayesi, Eriphia verrugosa, Eurynome aspera, Ilia nucleus, Inachus dorsettensis, Inachus parvirostris, Inachus spp, Inachus thoracicus, Latreillia elegans, Paguri-Anomura, Paguristes eremita, Pagurus cuanensis, Pagurus prideaux, Pagurus spp, Pilumnus hirtellus, Pinnotheres pisum, Pisa armata, Pisa nodipes, Scalpellum scalpellum*
DNS - Natant Decapods Slope	*Acanthephyra eximia, Acanthephyra purpurea, Aristeus antennatus, Chlorotocus crassicornis, Crangonidae, Gennadas elegans, Pasiphaea multidentata, Pasiphaea sivado, Plesionika acanthonotus, Plesionika antigai, Plesionika edwardsii, Plesionika gigliolii, Plesionika heterocarpus, Plesionika martia, Pontocaris cataphractus,*

	Pontocaris lacazei, Processidae spp, Rissoides desmaresti, Rissoides pallidus, Sergestes robustus, Sergestes spp, Sicyonia carinata, Solenocera membranacea
DRH - Reptant Decapods Shelf	*Galathea intermedia, Homarus gammarus, Liocarcinus corrugatus, Liocarcinus depurator, Maja crispata, Maja goltziana, Maja squinado, Maja verrucosa, Medorippe lanata, Palinurus elephas, Scyllarides latus, Squilla mantis*
DRS - Reptant Decapods Slope	*Bathynectes maravigna, Calappa granulata, Ethusa mascarone, Galathea dispersa, Geryon longipes, Homola barbata, Liocarcinus arcuatus, Macropipus tuberculatus, Monodaeus couchii, Munida intermedia, Munida iris, Munida spp, Nephrops norvegicus, Palinurus mauritanicus, Paromola cuvieri, Polycheles typhlops*
BO - Meiobenthos	Mainly composed of nematodes
MB - Microphytobenthos	Mainly sediment diatoms
ARF - Red prawn	*Aristaeomorpha foliacea*
PWL - Pink prawn	*Parapaeneus longirostris*
CEB -Benthic cephalopods	*Eledone cirrhosa, Eledone moschata, Neorossia caroli, Octopus defilippi, Octopus macropus, Octopus salutii, Octopus spp, Octopus vulgaris, Pteroctopus tetracirrhus, Rondeletiola minor, Rossia macrosoma, Scaeurgus unicirrhus, Sepia elegans, Sepia officinalis, Sepia orbignyana, Sepia spp, Sepietta oweniana, Sepietta spp, Sepiola affinis, Sepiola intermedia, Sepiola rondeleti, Sepiola spp, Sepiolinae*
MA - Macroalgae	*Vidalia etc.*
SG - Seagrass	*Posidonia oceanica*
DL - Labile Detritus	
DR - Refractory Detritus	
DC - Carrion	
NUTRIENTS	Dissolved organic nitrogen, Ammonia, Nitrate, Silicate, Phosphorous

Vertebrates species aggregation into functional groups

DFH - Dem fish shelf crust feed	*Scorpaena elongata*	*Diplodus vulgaris*	*Caelorhynchus caelorhynchus*
Argentina sphyraena	*Trigla lyra*	*Epinephelus aeneus*	*Capros aper*
Arnoglossus imperialis	**DSH - Dem selaceens shelf**	*Hippocampus hippocampus*	*Carapus acus*
Arnoglossus laterna	*Dasyatis pastinaca*	*Labrus mixtus*	*Ceratoscopelus maderensis*
Arnoglossus rueppelli	*Mustelus asterias*	*Liza aurata*	*Chlorophthalmus agassizi*
Arnoglossus thori	*Mustelus mustelus*	*Mugil cephalus*	*Diaphus holti*

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Aspitrigla cuculus
Blennius ocellaris
Bothus podas
Buglossidium luteum
Callionymus lyra
Callionymus maculatus
Callionymus risso
Cepola macrophtalma
Chelidonichthys gurnardus
Chelidonichthys lastoviza
Chelidonichthys lucerna
Chelidonichthys obscurus
Citharus linguatula
Coris julis
Dactylopterus volitans
Dalophis imberbis
Deltentosteus quadrimaculatus
Echelus myrus
Gaidropsarus biscayensis
Gaidropsaurus mediterraneus
Gaidropsaurus spp
Gnathophis mistax
Gobius cobitis
Gobius cruentatus
Gobius niger
Gobius spp
FIGLepidotrigla cavillone
Lepidotrigla dieuzeidei
Lesueurigobius friesii
Lesueurigobius sanzoi
Lesueurigobius sueri
Microchirus ocellatus
Microchirus variegatus
Ophidium barbatum
Mustelus punctulatus
Myliobatis aquila
Raja alba
Raja asterias
Raja batis
Raja brachyura
Raja circularis
Raja clavata
Raja fullonica
Raja melitensis
Raja miraletus
Raja montagui
Raja naevus
Raja oxyrinchus
Raja polystigma
Raja radula
Raja spp
Torpedo marmorata
Torpedo nobiliana
Torpedo torpedo

DSM - Dem fish shelf mixed

Altri Serranidi
Balistes capriscus
Hippocampus spp
Lithognathus mormyrus
Mullus surmuletus
Serranus cabrilla
Solea solea
Solea spp
Solea variegata
Sphoeroides pachygaster
Symbolophorus veranyi
Symphodus mediterraneus
Symphurus ligulatus
Muraena helena
Pagrus caeruleostictus
Pagrus pagrus
Phycis phycis
Sciaena umbra
Scorpaena loppei
Scorpaena notata
Scorpaena porcus
Scorpaena scrofa
Scorpaena spp
Spondyliosoma cantharus
Umbrina canariensis

DSS - Dem selaceens slope

Centrophorus granulosus
Centrophorus uyato
Chimaera monstrosa
Dalatias licha
Etmopterus spinax
Galeus melastomus
Heptranchias perlo
Hexanchus griseus
Oxynotus centrina
Squalus acanthias
Squalus blainvillei

ENG - Anchovy

Engraulis encrasicholus

EPI - Epipelagic fish

Anthias anthias
Aphia minuta
Boops boops
Callanthias ruber
Centracanthus cirrus
Glossanodon leioglossus
Scyliorhinus canicula
Diaphus metopoclampus
Diaphus rafinesquei
Diaphus spp
Electrona rissoi
Epigonus denticulatus
Epigonus telescopus
Evermanella balbo
Facciolella oxyrhyncha
Gadella maraldi
Gadiculus argenteus
Hoplostethus mediterraneus
Hygophum benoiti
Hymenocephalus italicus
Lampanyctus crocodilus
Lampanyctus pusillus
Lappanella fasciata
Lepidopus caudatus
Lestidiops jayakari jayakari
Lobianchia dofleini
Macroramphousus gracilis
Macrorhamphosus scolopax
Maurolicus muelleri
Micromesistius poutassou
Myctophidae spp
Myctophum punctatum
Nansenia oblita
Nemichthys scolopaceus
Nettastoma melanurum
Nezumia aequalis
Nezumia sclerorhynchus
Notacanthus bonaparte
Notoscopelus elongatus
Paralepis c. coronogoides
Paralepis HYA

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Pagellus acarne	*Symphurus nigrescens*	*Scyliorhinus stellaris*	*Sudis hyalina*
Pagellus erythrinus	*Symphurus spp*	*Spicara flexuosa*	**MSG - Mesop slope jelly feed**
Pomatoschistus minutus	*Syngnathus abaster*	*Spicara maena*	*Centrolophus niger*
Psetta maxima	**DSP - Dem shelf fish pisc**	*Spicara smaris*	*Cubiceps gracilis*
Serranus hepatus	*Conger conger*	**HAK - Hake**	*Ruvettus pretiosus*
Synapturichthys kleinii	*Lophius budegassa*	*Merluccius merluccius*	*Schedophilus medusofagus*
Synchiropus phaeton	*Lophius piscatorius*	**LPL - Large pelagics**	**MSP - Mesop slope fish pisc**
Triglidae	*Synodus saurus*	*Pteromylaeus bovinus*	*Chauliodus sloani*
Trisopterus m. capelanus	*Trachinus araneus*	*Xiphias gladius*	*Stomias boa*
DFS - Dem fish slope	*Trachinus draco*	**MPL – Medium pelagics**	**MUL – Mullus**
Helicolenus d. dactylopterus	*Trachinus radiatus*	*Naucrates ductor*	*Mullus barbatus*
Lepidorhombus boscii	*Uranoscopus scaber*	*Sphyraena sphyraena*	**SAR - Sardine**
Lepidorhombus whiffjagonis	*Zeus faber*	*Trachurus mediterraneus*	*Sardina pilchardus*
Molva dipterygia	**DSR - Dem fish shelf rocky**	*Trachurus picturatus*	**SB - Seabirds**
Molva molva	*Alepocephalus rostratus*	*Trachurus trachurus*	**SPL - Small pelagics**
Mora moro	*Dentex dentex*	**MSC - Mesop slope crust feed**	*Alosa fallax*
Ophisurus serpens	*Dentex gibbosus*	*Argyropelecus hemigymnus*	*Sardinella aurita*
Pagellus bogaraveo	*Dentex macrophthalmus*	*Bathypterois mediterraneus*	*Scomber colias*
Peristedion cataphractum	*Diplodus annularis*	*Bellottia apoda*	*Scomber scombrus*
Phycis blennoides	*Diplodus puntazzo*	*Benthocometes robustus*	*Scomber spp*

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

VII. Black Sea case study

Introduction

Place of implementation:

Western sector of the Black Sea (Romanian coastline)

Fig.1 Area of project implementation

Main objective of the case study

Restoration of turbot fisheries to more productive levels, considering both the effect of fisheries and ecosystem change occurred in the last decades.

Turbot- *Psetta maxima maeotica* (Pallas, 1814)

Turbot is a long living species with a slow growth rate. Turbot is demesal species and occurs all over the shelf area of all Black Sea coastal states at depths up to 100 m -140 m, grouped in local shoals. Species inhabits sandy or silt bottoms, mussel beds or mixed types. The spawning process is taking place in spring season – between March/April and June. Turbot in the Black Sea is represented by several local populations which migrate and mixing in the adjacent zones (Fig.3). Local populations are independent units of the stock and have to be covered in order to ensure an accurate assessment of the stock at regional level.

At Romanian littoral, in winter adults are encountered at depths of 70-100m; in spring (March - April) are nearing of shore until 18 - 30m for reproduction. After spawning, adults are spreading and retiring again towards deeper water. Turbot migrations are relative shorts and perpendicular on shore (Fig. 4).

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

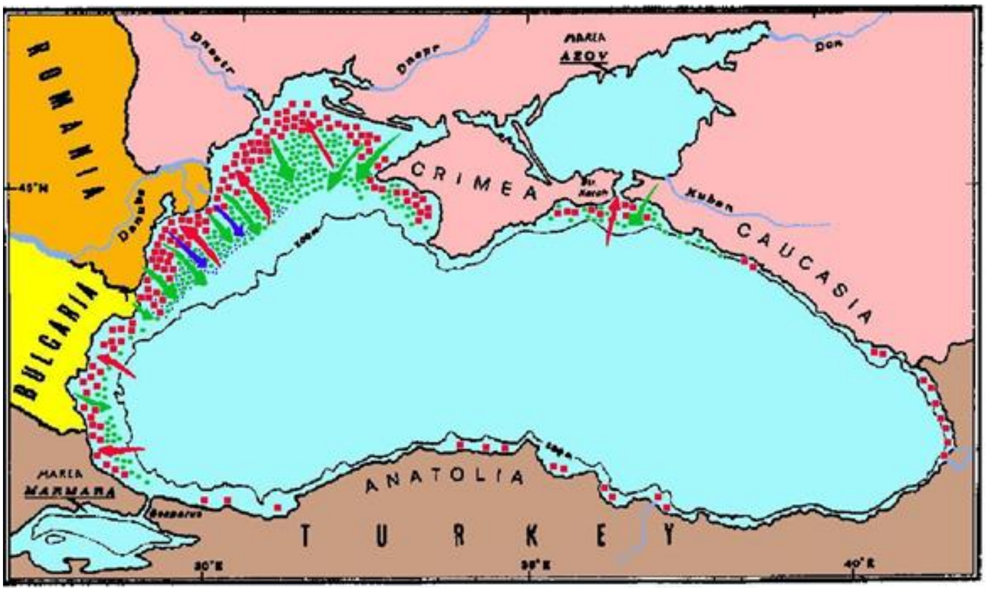


Fig.3 Distribution of the turbot in the Black Sea area

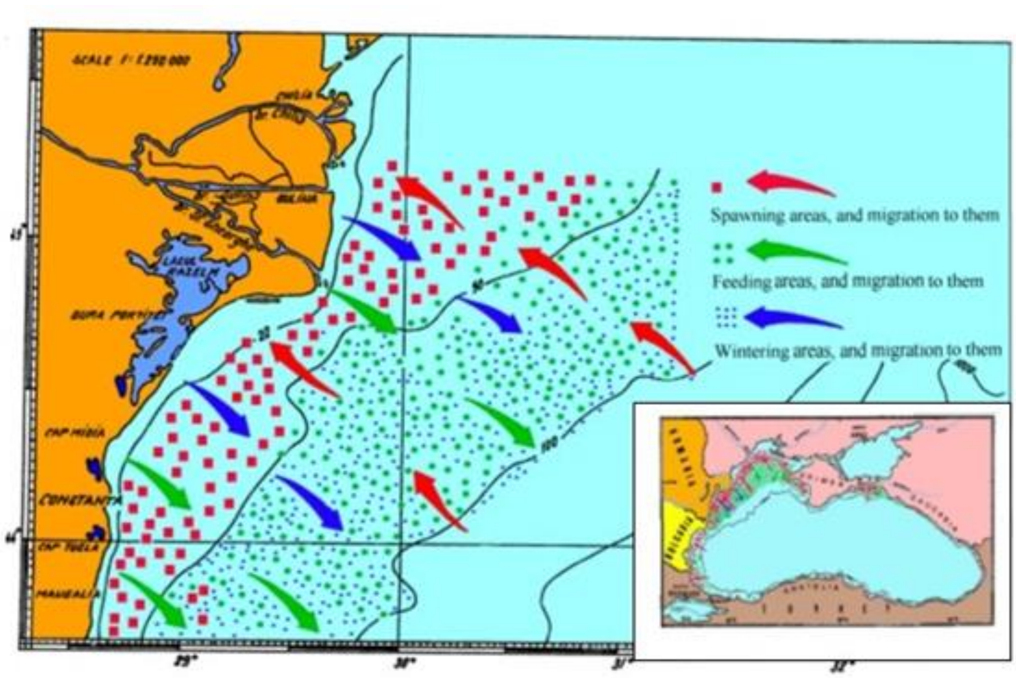


Fig.4 Distribution of the turbot in the Romanian marine area

Spatial units

For this case study, data from Romanian marine area (oceanography-water circulation pattern, environmental features, main fishing grounds, nutrients and primary production, food-web and key species and fisheries data) are available from National Institute for Marine Research and Development "Grigore Antipa", Constanta. At the Black Sea level, data are from literature (BSC, 2008 - State of the Environment of the Black Sea) and from Scientific, Technical and Economic Committee for Fisheries (STECF)/(BS-EWG)Black Sea working group for stock assessment.

Due to existing gaps of information mainly in terms of accurate fisheries statistics and availability of biological data, the assessment can be based on the analysis of the best available information obtained from:

- Romanian data;
- Data from the western Black Sea;
- Combined data of all Black Sea countries.

Oceanography and bottom topograhy

Topography

The Romanian fishing area is comprised between Sulina and Vama-Veche; coastline extends for over 240km, which can be divided into two main geographical and geomorphologic sectors:

- 1/ the northern sector (about 158km in length) lies between the secondary delta of the Chilia branch and Constantza, constituted of alluvial sediments;
- 2/ the southern sector (about 85km in length) lies between Constantza and Vama-Veche characterised by promontories with active, high cliffs, separated by large zones with accumulative beaches often protecting littoral lakes.

The distance from the sea shore to the shelf limits (200m depth) varies from 100 to 200km in the northern sector and to 50 km in the southern one. The submarine slope of the shelf is very gentle in the north, while in the southern sector the slope increase very quickly (Fig. 5).

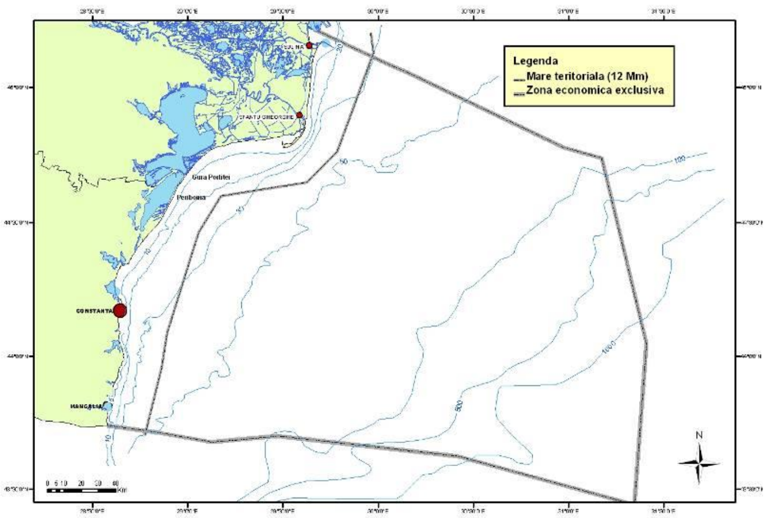


Fig.5 Bathymetry in the territorial waters and Exclusive Economic Zone of Romania

The Black Sea basin can be divided into four physiographic areas: the shelf representing about 29.9% of the total area of the sea, the basin slope - about 27.3% of the total area, the basin apron, with 30.6%, and the abyssal plain - 12.2% The Black Sea basin can be divided into four physiographic provinces: the shelf representing about 29.9% of the total area of the sea, the basin slope - about 27.3% of the total area, the basin apron, with 30.6%, and the abyssal plain - 12.2%.

One of the most prominent physiographic features is the very large shallow (less than 200 m deep) continental shelf within the northwestern Black Sea (about 25 % of the total area of the sea). The Crimean, Caucasian and southern coastal zones are bordered by very narrow shelves and often intersected by the submarine canyons (Fig.6).

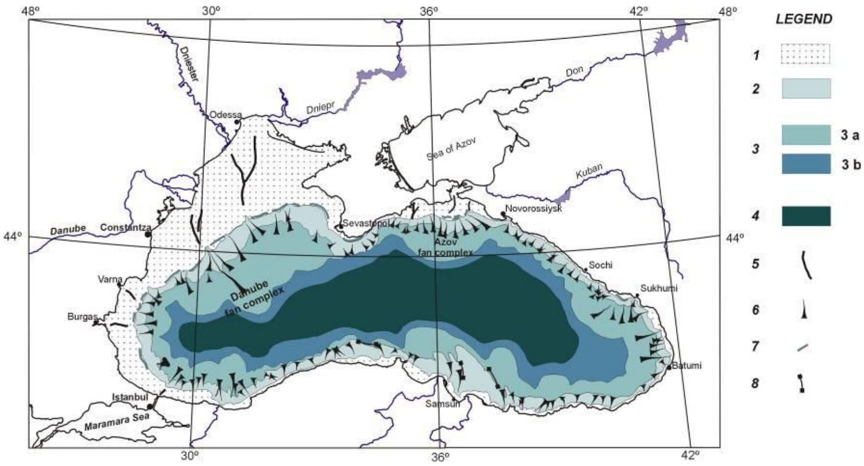


Fig.6 . Geomorphologic zoning of the Black Sea (after Ross et al.,1974, Panin and Ion, 1997).

Legend; 1, continental shelf; 2, continental slope; 3, basin apron: 3 a - deep sea fan complexes; 3 b - lower apron; 4, deep sea (abyssal) plain; 5, paleo-channels on the continental shelf filled up with Holocene and recent fine grained sediments; 6, main submarine valleys - canyons; 7, paleo-cliffs near the shelf break; 8, fracture zones expressed in the bottom morphology.

The NIMRD oceanographic data set contains cruises physical and chemical data collected in the framework of different national/international projects as well as the National Monitoring Programme for the period 1963 -2012. The data are obtained from standard depths (0 m, 10m, 20m, ……..) sampling on the Romanian coastal and shelf waters (Fig.7).

Data can be downloaded via:

www.nodc.ro/http://romania-seadatanet.maris2.nl/v_cdi_v3/browse_step.asp

The national data collection stored at RoNODC (Romanian National Oceanographic and Environmental Data Center) (www.nodc.ro) consists mainly of data collected by NIMRD "Grigore Antipa", Luminiţa Buga RoNODC Data Manager, lbuga@web.de, lbuga@alpha.rmri.ro

RoNODC holds unrestricted as well as restricted data belonging to NIMRD. The restricted data are under the national policy.

RoNODC can give access to the data belonging NIMRD for:

1. scientific purposes with a prior agreement between the user and NIMRD or with a marginal cost only

2. publishing data with proper attribution or co-authorship

3. any other purpose for which NIMRD will prepare an estimate of the cost before any data delivery.

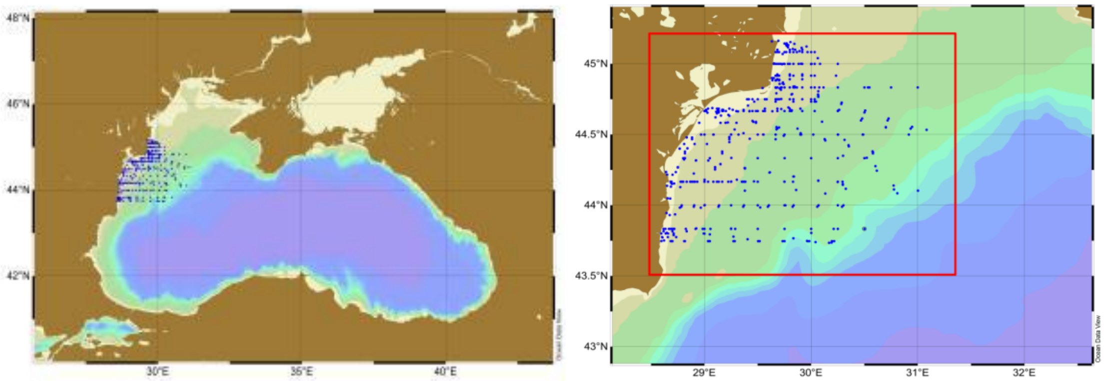


Fig.7 Spatial coverage of NIMRD data sets

For the purposes of MareFrame project and required parameters (Water temperature, Salinity, Dissolved Oxygen, Nutrients) the following querying (filtering) criteria were applied:

1. period: 2000-2012
2. domain:
   - latitude north/south: 45/43.5
   - longitude west/east: 28/31
3. maximum station depth: 150 m

Filtering results: Total depth profiles (stations): 783 (Fig.8)

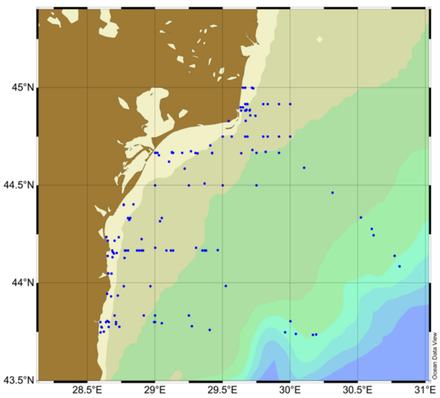


Fig.8 Spatial Coverage (2000-2012) 783 stations

Water Temperature data

Total number of measurements: 2611(Fig.9).

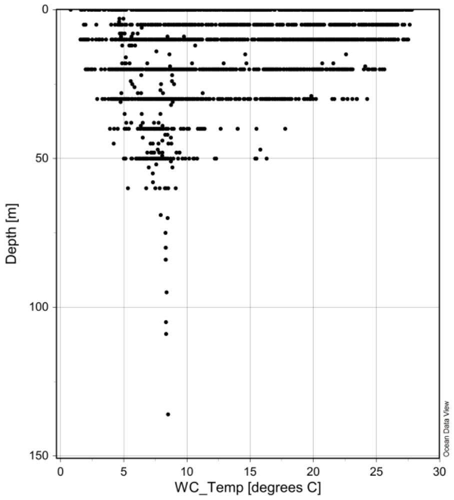


Fig. 9 Water Temperature plots

Salinity data

Total number of measurements: 2635 (Fig.10).

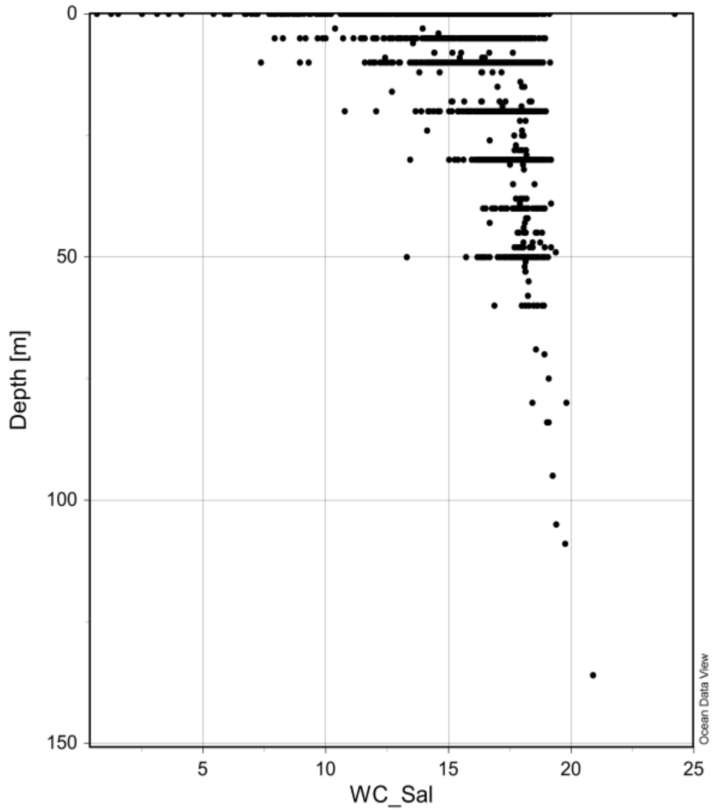


Fig.10 Salinity plots

Dissolved Oxygen

Total number of measurements: 2658 (Fig.11).

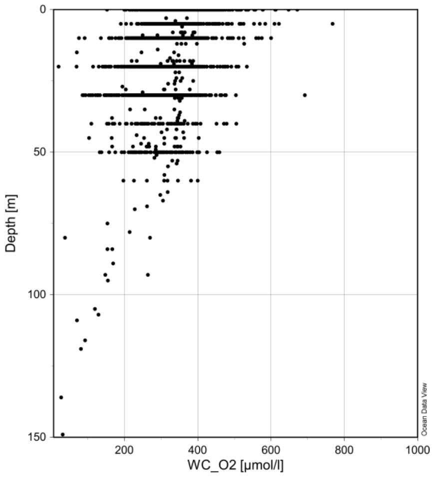


Fig.11 Oxygen plots

Nitrite data

Total number of measurements: 2627(Fig.12).

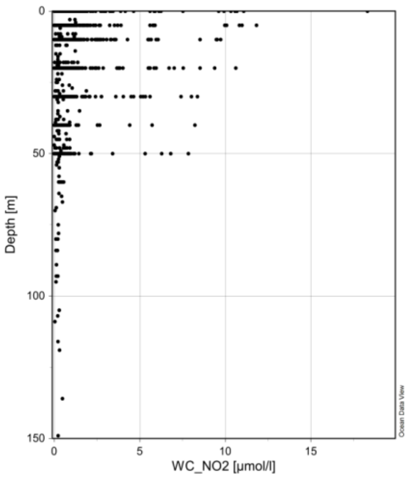


Fig. 12 Nitrite plots

Nitrate data

Total number of measurements: 2656(Fig.13).

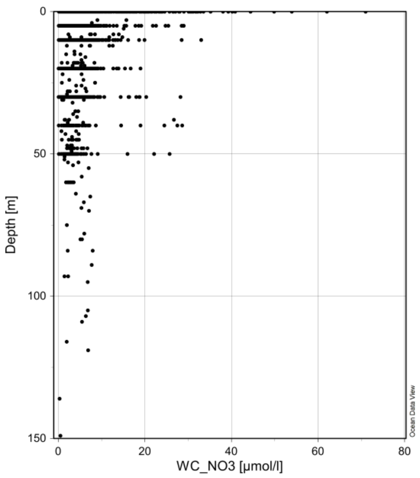


Fig.13 Nitrate plots

Ammonium data

Total number of measurements: 2630 (Fig.14).

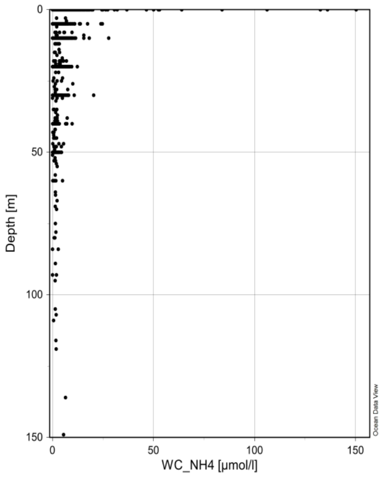


Fig.14.Ammonium plots

Phosphate data

Total number of measurements: 2655 (Fig.15).

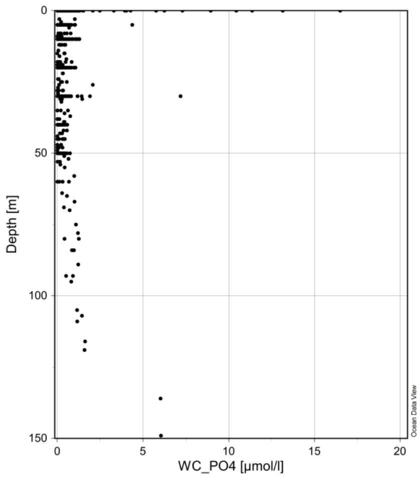


Fig. 15 Phosphate plots

Functional groups used in the model

(source of data, time series: surveys, etc.)

Phytoplankton

NIMRD Constanta has data for phytoplankton

The phytoplankton data are average data per station (density and biomass by major groups and total quantities), for different month depending of season cruise.

In general are seasonal data, but after the 2000 usually are data from spring and summer.

Place of sampling	Density (cells/L)	Biomass (mg/m3)
Est Constanta	1990-2012	1990-2012
Shelf	1990-2012	1990-2012

Zooplankton data

NIMRD Constanta has data for zooplankton.

Zooplankton data available at national level from 1977 to 2013 by species, zooplankton data are based on sampling at sea

In order to determine the status of the zooplankton population we use several indicators such as:

- Percentage of copepods from mesozooplankton (biomass %)
- Total mesozooplankton biomass (mg.m^{-3})
- Percentage of *Noctiluca* from total mesozooplankton (biomss %)
- Biomass of *M. leidyi*
- Percentage of NIS from total zooplankton
- Phytoplankton/zooplankton ratio

Data Set Description from 1990

***DATASET-NAME: Est Constanta**

***TIME-PERIOD:** 1990 – 03, 06, 08; 1991 – 07, 10; 1992 – 07, 10; 1993 – 02, 03, 06, 08; 1994 – 03, 05, 08 (year – month)

***PLATFORM/SHIP :** R/V *Palamida*

***STATION :** 5 stations (EC1, EC2, EC3, EC4, EC5) (Fig.16).

***GEOGRAPHIC-COVERAGE:** 44°10'N, 28°41.5'E – EC1; 44°10'N, 28°47'E – EC2; 44°10'N, 28°54'E – EC3; 44°10'N, 29°08'E – EC4; 44°10'N, 29°22'E – EC5;

***DATE & HOUR : LOCAL TIME:** no specific hour

***SAMPLING FREQUENCY:** seasonaly

*** BOTTOM DEPTH :** EC1-15m, EC2-32m, EC3-38m, EC4-46m, EC5-53m

***MEASURED/DETERMINED-PARAMETERS:**

Mesozooplankton species composition, biomas and abundance (taxonomic list, ex. m^{-3}, Ind. m^{-3})

***COMPUTED/CONVERTED-PARAMETERS:** Total zooplancton density (ind/m3), Total zooplankton biomass (mg/m3)

***TAXONOMIC-IDENTIFICATION:** *copepods (calanoids, cyclopoids), cladoserans, gelatinous zooplankton, meroplankton larva (decapoda, cirripeda, bivalvia, gasteropoda, polychaeta, phoronida) , other groups(chaetognaths, appendicularians, ciliats, tintinoidea, rotatoria,).*

***REFERENCE:** NIMRD – Est Constanta

***DATA-WEBSITE:** not yet

***ORIGINATOR:** NIMRD

***CENTRE:** NIMRD

***STORAGE-MEDIUM:** Excel files, and hard copy

***AVAILABILITY: on request** (according to originator policy)

***CONTACT:** florintimofte@yahoo.com, **ftimofte@alpha.rmri.ro**

***COMPLETED-BY:** Florin TIMOFTE

***ENTRY-DATE:** july 2014

Fig.16 Stations map

<u>*DATASET-NAME: Longitudinale</u>

***PROJECT: Longitudinale**

***TIME-PERIOD:** 1990 – 06, 07, 08, 10; 1991 – 07, 08 (year – month)

***PLATFORM/SHIP :** R/V *Palamida*

***STATION :** 14 stations (L1-L14) (Fig.17).

***GEOGRAPHIC-COVERAGE:** 44°10' - 44°40.5'N, 28°41.5' – 29°22'E

***DATE & HOUR : LOCAL TIME:** no specific hour

***SAMPLING FREQUENCY:** seasonaly

*** BOTTOM DEPTH :** 9-42m

***MEASURED/DETERMINED-PARAMETERS:**

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Mesozooplankton species composition, biomas and abundance (taxonomic list, ex. m^{-3}, Ind. m^{-3})

***COMPUTED/CONVERTED-PARAMETERS:** Total zooplancton density (ind/m3), Total zooplankton biomass (mg/m3).

***TAXONOMIC-IDENTIFICATION:** *copepods (calanoids, cyclopoids), cladoserans, gelatinous zooplankton, meroplankton larva (decapoda, cirripeda, bivalvia, gasteropoda, polychaeta, phoronida) , other groups(chaetognaths, appendicularians, ciliats, tintinoidea, rotatoria,).*

***TAXONOMISTS IN CHARGE OF THE DETERMINATION :** Adriana Petran**,** Mariana Moldoveanu

*SUMMARY:

Longitudinale dataset is based on a long-term study caried out on two paralel transects in front of the midle of the romanian litoral between 1984- 1991 (expedition were made seasonaly). The whole dataset is composed of 287 samples.

At this stage the data are for NIMRD internal restricted use only.

***REFERENCE:** NIMRD – Longitudinale

***DATA-WEBSITE:** not yet

***ORIGINATOR:** NIMRD

***CENTRE:** NIMRD

***STORAGE-MEDIUM:** Excel files, and hard copy

***AVAILABILITY:** on request (according to originator policy)

*SUPPLY-DETAILS:

***CONTACT:** florintimofte@yahoo.com**,** ftimofte@alpha.rmri.ro

***COMPLETED-BY:** Florin TIMOFTE

***ENTRY-DATE: july 2014**

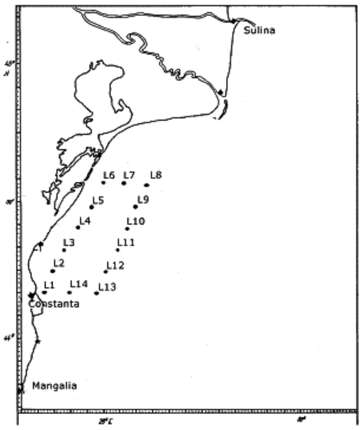


Fig.17 Stations map

<u>DATASET-NAME: Platforma</u>

***PROJECT: Platforma**

***TIME-PERIOD:** 1991 – 03, 05, 10; 1992 – 02, 04, 06, 08, 09, 10; 1993 – 06, 08; 1994 – 02, 06, 07, 08; 1995 – 04, 09 (year – month)

***PLATFORM/SHIP :** R/V *Palamida*, R/V *Steaua de Mare*

***STATION :** 24 stations (P1-P24)

***GEOGRAPHIC-COVERAGE:** 43°50' - 44°50'N, 28°41.5' – 30°32.8'E

***DATE & HOUR : LOCAL TIME:** no specific hour

***SAMPLING FREQUENCY:** seasonaly

*** BOTTOM DEPTH :** 5-58m

***MEASURED/DETERMINED-PARAMETERS:**

Mesozooplankton species composition, biomas and abundance (taxonomic list, ex. m^{-3}, Ind. m^{-3})

***COMPUTED/CONVERTED-PARAMETERS:** Total zooplancton density (ind/m3), Total zooplankton biomass (mg/m3).

***TAXONOMIC-IDENTIFICATION:** *copepods (calanoids, cyclopoids), cladoserans, gelatinous zooplankton, meroplankton larva (decapoda, cirripeda, bivalvia, gasteropoda, polychaeta, phoronida) , other groups(chaetognaths, appendicularians, ciliats, tintinoidea, rotatoria,).*

***TAXONOMISTS IN CHARGE OF THE DETERMINATION :** Adriana Petran**,** Mariana Moldoveanu

*SUMMARY:

Platforma dataset is based on a long-term study caried out on a network of station along the romanian litoral between 1981- 1982 and 1991-1995 (expedition were made seasonaly). The whole dataset is composed of 606 samples.

At this stage the data are for NIMRD internal restricted use only.

***REFERENCE:** NIMRD – Platforma

***DATA-WEBSITE:** not yet

***ORIGINATOR:** NIMRD

***CENTRE:** NIMRD

***STORAGE-MEDIUM:** Excel files, and hard copy

***AVAILABILITY:** on request (according to originator policy)

*SUPPLY-DETAILS:

***CONTACT:** florintimofte@yahoo.com, ftimofte@alpha.rmri.ro

***COMPLETED-BY:** Florin TIMOFTE

***ENTRY-DATE: july 2014**

***DATASET-NAME: Poluare**

***PROJECT: Poluare**

***TIME-PERIOD:** 1996 – 05, 07, 09; 1997 – 06, 07, 08, 10; 1998 – 06, 07, 08, 09 (year – month)

***PLATFORM/SHIP :** R/V *Palamida,* R/V *Steaua de Mare*

***STATION :** 15 stations (N01, N02, CN1, CN2, CS1, CN2, ES1, ES2, TZ1, C01, C02, MG1, MG2, VV1, VV2) (Fig.18).

***GEOGRAPHIC-COVERAGE:** 44°19' - 43°44.3'N, 28°35' – 28°54'E

***DATE & HOUR : LOCAL TIME:** no specific hour

***SAMPLING FREQUENCY:** seasonaly

*** BOTTOM DEPTH :** 10-20m

***MEASURED/DETERMINED-PARAMETERS:**

Mesozooplankton species composition, biomas and abundance (taxonomic list, ex. m^{-3}, Ind. m^{-3})

***COMPUTED/CONVERTED-PARAMETERS:** Total zooplancton density (ind/m3), Total zooplankton biomass (mg/m3).

***TAXONOMIC-IDENTIFICATION:** *copepods (calanoids, cyclopoids), cladoserans, gelatinous zooplankton, meroplankton larva (decapoda, cirripeda, bivalvia, gasteropoda, polychaeta, phoronida) , other groups(chaetognaths, appendicularians, ciliats, tintinoidea, rotatoria,).*

***TAXONOMISTS IN CHARGE OF THE DETERMINATION :** Adriana Petran**,** Mariana Moldoveanu

*SUMMARY:

Poluare dataset is based on a long-term study caried out on a network of station along the south part of the romanian litoral between 1982- 1983 and 1996-1998 (expedition were made seasonaly). The whole dataset is composed of 335 samples.

At this stage the data are for NIMRD internal restricted use only.

***REFERENCE:** NIMRD – Poluare

***DATA-WEBSITE:** not yet

***ORIGINATOR:** NIMRD

***CENTRE:** NIMRD

***STORAGE-MEDIUM:** Excel files, and hard copy

***AVAILABILITY:** on request (according to originator policy)

*SUPPLY-DETAILS:

***CONTACT:** **florintimofte@yahoo.com**, **ftimofte@alpha.rmri.ro**

***COMPLETED-BY:** Florin TIMOFTE

***ENTRY-DATE: july 2014**

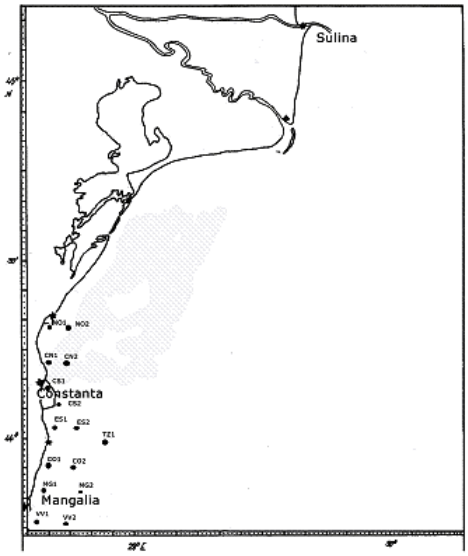


Fig.18 Stations map

<u>*DATASET-NAME: Shelf</u>

***PROJECT: Shelf**

***TIME-PERIOD:** April 1997-September 1999 (1997 – 04, 05, 07; 1998 – 05, 07, 09; 1999 – 04, 05, 06, 09) (year – month)

***PLATFORM/SHIP :** R/V *Steaua de Mare*

***STATION :** 34

***GEOGRAPHIC-COVERAGE:** 45°05' - 43°50'N, 28°41' – 29°55'E

***DATE & HOUR : LOCAL TIME:** no specific hour

***SAMPLING FREQUENCY:** seasonaly

*** BOTTOM DEPTH :** 10-50m

***MEASURED/DETERMINED-PARAMETERS:**

Mesozooplankton species composition, biomas and abundance (taxonomic list, ex. m^{-3}, Ind. m^{-3})

***COMPUTED/CONVERTED-PARAMETERS:** Total zooplancton density (ind/m3), Total zooplankton biomass (mg/m3).

***TAXONOMIC-IDENTIFICATION:** *copepods (calanoids, cyclopoids), cladoserans, gelatinous zooplankton, meroplankton larva (decapoda, cirripeda, bivalvia, gasteropoda, polychaeta, phoronida) , other groups(chaetognaths, appendicularians, ciliats, tintinoidea, rotatoria,).*

***DETAILED TAXONOMIC-IDENTIFICATION:** Yes, in hard copy only

***TAXONOMISTS IN CHARGE OF THE DETERMINATION :** Mariana Moldoveanu

*SUMMARY:

Shelf dataset is based on a long-term study caried out on a network of station along the romanian litoral between 1997-1999 (expedition were made seasonaly). The whole dataset is composed of 210 samples.

At this stage the data are for NIMRD internal restricted use only.

***REFERENCE:** NIMRD – Shelf

***DATA-WEBSITE:** not yet

***ORIGINATOR:** NIMRD

***CENTRE:** NIMRD

***STORAGE-MEDIUM:** Excel files, and hard copy

***AVAILABILITY: on request** (according to originator policy)

*SUPPLY-DETAILS:

***CONTACT:** **florintimofte@yahoo.com, ftimofte@alpha.rmri.ro**

***COMPLETED-BY:** Florin TIMOFTE

***ENTRY-DATE: july 2014**

***DATASET-NAME: DANUBS**

***PROJECT: DANUBS**

***TIME-PERIOD:** April 2000-October 2002 (2000 – 04, 06, 11; 2001 – 03, 06, 09, 10; 2002 – 04, 07, 09, 10) (year – month)

***PLATFORM/SHIP :** R/V *Steaua de Mare*

***STATION :** 18 (Fig.19).

***GEOGRAPHIC-COVERAGE:** 45°05' - 43°50'N, 28°41' – 29°55'E

***DATE & HOUR : LOCAL TIME:** no specific hour

***SAMPLING FREQUENCY:** seasonaly

*** BOTTOM DEPTH :** 10-50m

***MEASURED/DETERMINED-PARAMETERS:**

Mesozooplankton species composition, biomas and abundance (taxonomic list, ex. m^{-3}, Ind. m^{-3})

***COMPUTED/CONVERTED-PARAMETERS:** Total zooplancton density (ind/m3), Total zooplankton biomass (mg/m3).

***TAXONOMIC-IDENTIFICATION:** *copepods (calanoids, cyclopoids), cladoserans, gelatinous zooplankton, meroplankton larva (decapoda, cirripeda, bivalvia, gasteropoda, polychaeta, phoronida) , other groups(chaetognaths, appendicularians, ciliats, tintinoidea, rotatoria,).*

***TAXONOMISTS IN CHARGE OF THE DETERMINATION :** Mariana Moldoveanu, Florin Timofte.

*SUMMARY:

Shelf dataset is based on a long-term study caried out on a network of station along the romanian litoral between 2000-2002 (expedition were made seasonaly). The whole dataset is composed of 294 samples.

At this stage the data are for NIMRD internal restricted use only.

***REFERENCE:** NIMRD – DANUBS

***DATA-WEBSITE:** not yet

***ORIGINATOR:** NIMRD

***CENTRE:** NIMRD

***STORAGE-MEDIUM:** Excel files, and hard copy

***AVAILABILITY: on request** (according to originator policy)

*SUPPLY-DETAILS:

***CONTACT:** florintimofte@yahoo.com, **ftimofte@alpha.rmri.ro**

***COMPLETED-BY:** Florin TIMOFTE

***ENTRY-DATE: july 2014**

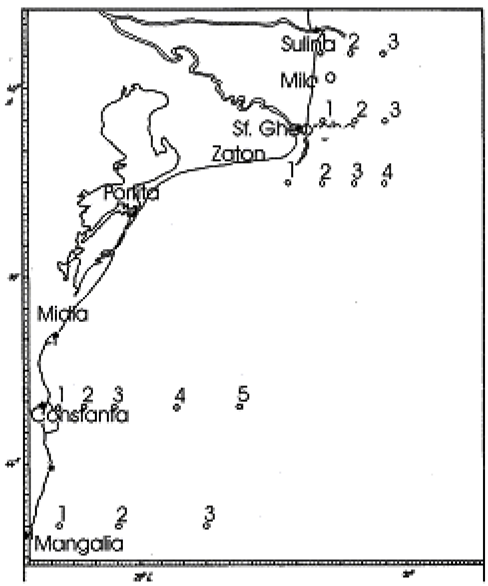


Fig. 19 Stations map

***DATASET-NAME: NIMRD** –, zooplankton

***PROJECT: National Monitoring Program,**

***TIME-PERIOD:** 2000-2012 (March-October)

***PLATFORM/SHIP :** R/V *Steaua de Mare*

***STATION :** 43 stations (13 transects) (Fig.20).

***GEOGRAPHIC-COVERAGE:** 45°08'32"N, 29°46'18"E - Sulina transect; 43°45'04"N, 28°37'16"E – Vama Veche transect;

***DATE & HOUR : LOCAL TIME:** no specific hour

***SAMPLING FREQUENCY:** seasonaly

*** BOTTOM DEPTH :** down to 60 m

***OBSERVED-PARAMETERS:** zooplankton.

***COMPUTED/CONVERTED-PARAMETERS:** Total zooplancton density (ind/m3), Total zooplankton biomass (mg/m3)

***TAXONOMIC-IDENTIFICATION:** *copepods (calanoids, cyclopoids), cladoserans, gelatinous zooplankton, meroplankton larva (decapoda, cirripeda, bivalvia, gasteropoda, polychaeta, phoronida) , other groups(chaetognaths, appendicularians, ciliats, tintinoidea, rotatoria,).*

***DETAILED TAXONOMIC-IDENTIFICATION:**

***TAXONOMISTS IN CHARGE OF THE DETERMINATION :** Florin Timofte

*SUMMARY: Zooplankton samples were collected in discrete layers

***DATA-WEBSITE:** No

***ORIGINATOR:** NIMRD

***CENTRE:** NIMRD

***STORAGE-MEDIUM:** Excel files

***AVAILABILITY:** **on request** (according to originator policy)

***SUPPLY-DETAILS:**

***CONTACT:** florintimofte@yahoo.comm ftimofte@alpha.rmri.ro

***COMPLETED-BY**: F. Timofte

***ENTRY-DATE: July, 2014**

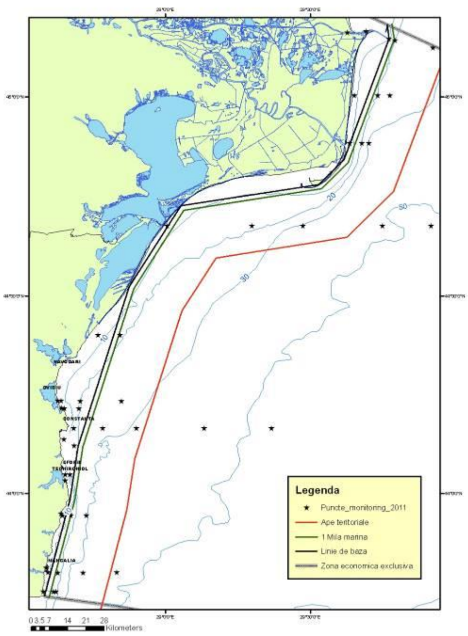


Fig.20 Map of the network stations of the Romanian Monitoring program

Benthos data

NIMRD Constanta has data for macrozoobenthos for the period 2000-2013 on the shelf area from Sulina to Vama-Veche, in three areas: in northern, central and southern coastline.

Data are seasonal, mainly in spring and autumn. The main groups observed are polychaetes, mollusca and crustaceans.

Mammals

NIMRD Constanta has data on Black Sea cetaceans (*Delphinus delphis*, *Tursiops truncatus and Phocoena phocoena from LIFE Nature Project(2002-2004)*. The data covers seasonal variation in the distribution of cetaceans in coastal Romanian waters, sightings surveys, strandings and by-catch monitoring.

Activity of strandings and by-catches monitoring continued until 2014 by NIMRD Constanta projects, some funded by ACCOBAMS. There is also a very good cooperation with NGO Mare Nostrum, environmental organization at the Romanian seaside.

Diet and stomach contents data

NIMRD Constanta has data for turbot on diet and stomach contents data in the last two years.

Biological

At the Romanian Black Sea coast is a routine in implementation of catch sampling, age reading, establish the qualitative and quantitative structure of catches, the population structure on age and length classes and also, to make at sea survey. The National Institute for Marine Research and Development "Grigore Antipa" Constantza has historical catch data on a period more than 50 years ago and catch structure on length and age classes, more than 40 years ago.

Considering that most fish species (except for some demersal species) from the Romanian coast have a regional distribution in the Black Sea, being fished jointly by neighbouring countries, NIMRD determined all the necessary parameters for participation at the joint assessment of the fish stocks, as follows: catch and effort; structure on length and age classes of the catches; biologic data (maturation degree, relation length/weight, etc.); generally data about the species biology (reproduction season, migration, etc.); growing parameters; mortality ratios; selectivity of gears, standardization of the fishing effort.

In summary, NIMRD has the following data:

- catch at national and regional level for the period 1951-2013;

- recruits, SSB and total biomass at regional level 1951-2012 (through analytical methods) for main species (sprat, turbot, whiting, horse mackerel and anchovy) from STECF/BS EWG for stock assessment;

- data on eggs and larvae at national level, through direct samples in the period 1995-2008 for sprat, whiting, anchovy and horse mackerel;

- recruits at national level, through direct samples in the period 1995-2008 for sprat, anchovy and horse mackerel;

- biomass of sprat, whiting, turbot, dogfish fishing agglomerations (swept area method) at national level in the period 1995-2013;

- growth parameters (Linf., k, t_0) at national level (1995-2103);

- fat contents for adults only in few years 1995-1998 and 2006-2007);

For assessment of eggs, larvae and juvenile abundance, spawners biomass and fishing agglomerations, the following methods were used at Romanian littoral:

- the swept area method for evaluation of eggs, larvae and juvenile abundance;

- the swept area method for evaluation the biomass of fishing agglomerations of sprat, whiting, turbot and dogfish;

- methods Sette-Ahlstorm (Sette and Ahlstrom, 1948) and Parker (Parker, 1980) have been used for to assess the biomass of spawners of anchovy and horse mackerel.

For sprat, the recruitment abundance was assessed by data of survey with fingerling trawl, which was regularly carried out in April-May. The biomass of adult agglomerations has been assessed by pelagic trawl with a rigging system ensuring it work near bottom.

For whiting, assessment of stock was made mainly by data of surveys with standard bottom trawl in March-April or in autumn season when density of near-bottom schools on the shelf is maximum.

Registration of spiny dogfish traditionally is made during spring and autumn surveys with standard bottom trawl.

Also, the stock of turbot has assessed by data surveys with standard bottom trawl in spring and autumn.

Anchovy and horse mackerel spawner biomass has been assessed using the data about eggs abundance that was determined with Bongo nets. In order to obtain materials to forecast the level of stock recruitment, in late summer (August-September), in surface layer of the sea, surveys have been carried out with special small-mesh fingerling trawl.

After accessing in EU, in 2008 NIMRD Constanta is one of the institutions designated for the implementation of the National Data Collection Programmes 2008-2010 and 2011-2013 as a partner of the National Agency for Fisheries and Aquaculture (NAFA). In the frame of this Programme, to evaluate the abundance and distribution of fish stocks independently of the data obtained from the commercial fisheries, Romania had liability undertake scientific research at sea. The research surveys qualified for this are listed in Appendix IX of the Commission Decision 93/2010. During this period have been undertaken annually two priority surveys in the Black Sea for turbot and sprat. Also, this Programme gives the possibility to collect the data regarding state of fish stocks and biological parameters of fish populations.

At the Romanian marine area, the swept area method is used for determining the index of abundance for sprat and turbot agglomerations as well as to establish the juvenile abundance. The methods use the following parameters: trawling speed, horizontal opening of trawl, time of trawling and value of catch from a trawling.

At the Romanian littoral for turbot demersal trawling was used the bottom trawl 22/27-34 with horizontal opening of 13m. The average speed of the vessel: 2,0 - 2.4 knots, the trawling time is standardized at 60 minutes.

Also, for sprat is used pelagic trawl with the following technical characteristic: 50/35-74, d=22 m. The average speed of the vessel is about 2.5 knots, the trawling time was standardised at 60 minutes.

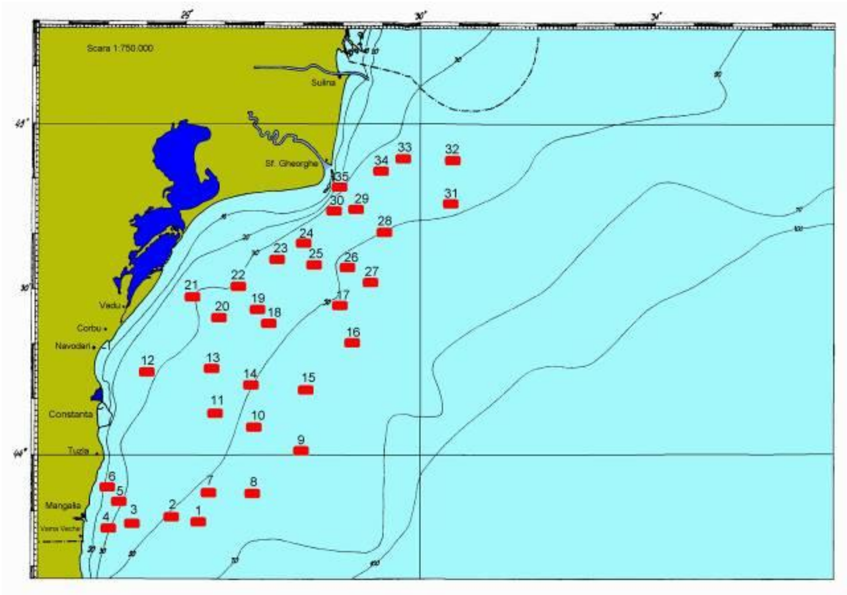


Fig.21 The distribution of the sampling points in the demersal trawl survey, Romanian area

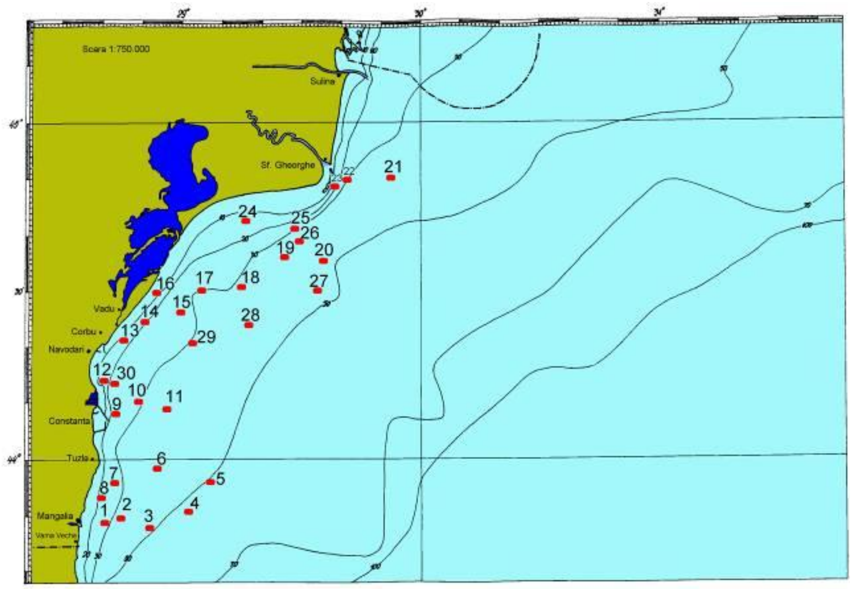


Fig. 22 The distribution of the sampling points in the pelagic trawl survey, Romanian area

Juvenile fish sampling

For juvenile fish, sampling is done with pelagic trawl Danielevski type, designed by the INCDM specialists. The project of this trawl was developed for trawler ships of 570 Hp (Nikolaev, 1988). Also, gear manufacturing was done in the same institutions with qualified personnel under technical assistance. Starting from the masurements verified experimentally and practically, the retention of fish greater than 15 mm and juveniles of the species group like sprat, anchovy, mackerel and a whiting with swimming reduced capacity compared with adults, the optimal speed of the trawl is in the range of 1 to 1.5 Nd (Anton, 2006). Vertical opening of the trawl is of 4-4.5m; horizontal opening is of 15m.

Juvenile fish samples are analyzed qualitatively and quantitatively after each trawling or preserved in 4-5% formalin and analyzed in the laboratory. Results are expressed as number of individuals/m^2 and are used to determine completion of the stock for each fish species.

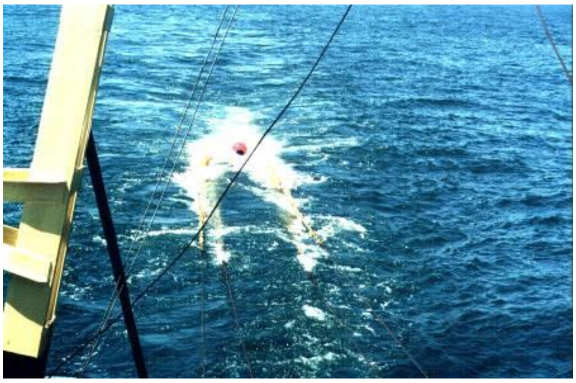


Fig.23 Pelagic trawl for juvenile sampling

Ichtioplancton sampling

Qualitative and quantitative of the ichtioplancton composition is determined by analyzing the samples taken from fixed stations (Fig.), located on the Romanian shelf (up to 70 m isobath), the method of collection and processing of samples being in generally accepted in the Black Sea area(E. Radu et al., 2002). The collection is made, usually with Bongo net of 60 cm diameter with 505 µm mesh (Fig. 3,4), equipped with a flowmeter to record distance covered by oblique hauling during 5 minutes at speed of 1.5-2 Nd. For each station are separately recorded the following data: station, time of sampling, the location of the station, water depth (m),the horizon where was released the Bongo net (m), the number of rotations made by flowmeter. Samples are preserved in formalin 4%, the processing being carried out in the laboratory. Laboratory analysis consists of sorting of each sample taken, under stereomicroscope, establishing quantitative and qualitative structure. Once established these elements, based on the aforementioned parameters, we can determine the density (individuals/m2) for each species. Then proceed to marking the average density on distribution maps (E. Radu et al., 2002). The data obtained are used to calculate the abundance of eggs, resulting in reproductive intensity, as a first element in the characterization of a fish population status.

Fig. 24 Bongo net

Station network used for ichtyoplancton sampling by NIMRD "Grigore Antipa"-Constanta is that used in the Cooperative Marine Science Program for the Black Sea (COMSBlack, 1992) for the Romanian seaside, being improved by adding a few stations in the shallow waters and Marine Reservation of the Danube Delta (Fig. 25).

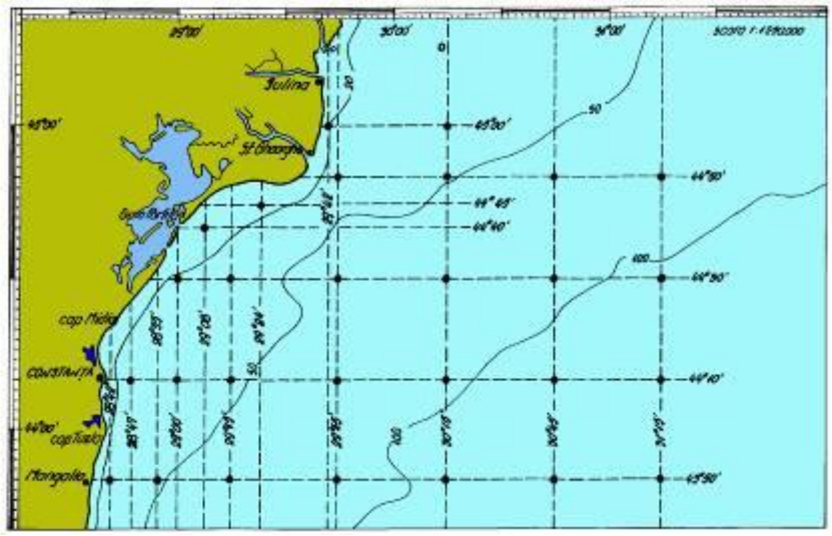


Fig.25 Station network used for ichtyoplancton and juvenile sampling by NIMRD "Grigore Antipa"-Constanta

Determination of spawning intensity and completion level for main pelagic species.

The period for research surveys will be established by each country in accordance with the optimal conditions specific for each geographic zone.

For the species with intense spawning during the cold season (sprat), the surveys will be planned in the period December-February-March, and for the thermophilic ones (anchovy, horse mackerel, blue fish) in the period June-July-August.

For the species spawning during the cold season, the eggs and larvae will be sampled from the whole column of water, and for the warm spawning species the sampling will be made from the water column above the thermocline.

Two surveys/year have to be organized for to establish the completion level of main pelagic species: one in April-May, which will pursue the way of reproduction developing and laying down the eggs in the cold season, the second one in late summer (August-September-October), in order to be qualitative and quantitative inventoried the juveniles occurred following the reproduction of thermophilic species.

Assessment of eggs, larvae and juveniles abundance will be made using the areas methods.

The biomass of spawners will be determined using the method of daily eggs and larvae production (Parker, Sette-Ahlstrom).

Sampling of catch

In order to study the fish populations, the method of random extracted samples is used; a sample represents a share from the whole population able to offer sufficient information for characterization the population.

There were established that the sample extracted for to study the biological parameters must have 200 individuals (for small-sized pelagic species: sprat, anchovy, mackerel). For pelagic big-sized species, the number of individuals from sample depend on the circumstances (i.e. size of catch).

The Parties established that the sampling frequency must be at least one sample per week.

Sampling of material for determination of length frequency.

The samples analyzing means: counting, biometry (measurements), gravimeter (weightings), sampling of otholits for aging, determination of sex and gonads maturation.

The characteristics determined by biometry measurements are: plastic characters (length, mass, thickness), and meristic characters (radii, scales, branchial spines).

Within these analyses, the elements necessary for growing parameter assessments are important, carrying out:

- the structure on length and age classes;
- the weight on length and age classes;
- sex ratios.

In the fishery biologic studies, the most utilized method is refers to the measurement of liniar dimensions of the fish or different component parts. Among numerous observation which can be made, the easiest is the total length. Other parameters are linked by the total length, such as mass and age, so each of them can be determined by length data. Measurements for determination the frequency of lengths of the fishing populations are used for assessment of their population stock.

There was established that the measurements will be made on total fish length, and when is necessary the standard length, and at fork for to establish some correlation's can be made.

For small-sized species, the measurements centralization will be carried out on interval classes of 0.5 cm, the measurements being centralized at inferior cm. For instance, the species with total length comprised between 11.0 and 11.4 cm are registered in length class of 11.00 cm. For large-size species, the interval between length classes is 3 cm.

In the frame of NIMRD was established as if at regional level, the Black and Mediterranean Seas, for some species will be used the centralization at nearly cm, then the new methodology will be adopted, and then the historical data will be correlated (transformed).

Collecting of material for determination of fish age

The samples for age determination will be collected using the stratified method, meaning providing a constant number of material - 10 individuals (preferably 5 males and 5 females) from the sample for length frequency study the for each length class.

The material used for age determination is represented basically by the otholiths, being specific for each species.

Establishing the gonads maturation degree

Once with the biometric measurements, the gonads are weight, both for females and males. It is indicated as these samplings to be made for the same sample collected for age determination. The gonads will be carefully collected from advanced stages females, to not hurt the ovary walls. The samples are labelled: the trawling number, the number of individual from the sample collected.

It was agreed at regional level that the scale for visual appreciation with six stages (Nikolski, ICSEAF) will be used for determination of gonads maturation stage.

Determination of growing parameters and mortality ratios

To determining the growing parameters and mortality ratios the following methods will be used: Gulland and Holt, Ford-Walford, Chapman, Bertalanffy, Beverton and Holt, Pauly, Rikhter and Efanov, etc.

Effort and catches data

The effort and catches data are collected from fishing logbooks, fishing licences and sales notes.

The data on the catches and landings have been obtained from Fisheries Logbooks and cover fish species, fishing gear for all the active vessels. The information is based on exhaustive data reported in logbooks. Also were used data sources as sale notes and Vessels Monitoring System (VMS).

Fishing Effort

Data are from completed logbooks for the parameters on fishing effort by techniques.

Data includes the following parameters information:

a) annually:

- number of vessels (vessel name, register number), including small boats;

- GT, kw, vessel age;

b) monthly:

- number of vessels, including small boats

- departure and arrival dates and time,

- fishing operation date and time, no. of hours fished, in the Black Sea there are not operations longer than one (1) day at sea- few days;

- kw*fishing days; GT*fishing days;

- number of trips;
- gear type used and number by each gear type;
    - number of traps;
    - number of hooks and number of lines;
    - soaking time by hours;
- value of landings total and per commercial species;
- live weight of landings total and per species.

Samples

The samples were extracted from the catch of trawler fishery, pound net fishery, gillnet fishery and long lines and hand lines fishery. The sampling schemes were organized in a way that sampling effort is distributed proportionally to the fishing effort. Relatively larger landings during the year imply higher sampling effort and vice versa. This assured that the biological data correspond directly to the national landing statistics.

Stocks definition

Tagging

NA

Genetic data

NA (Few data, irrelevant)

Other

NA

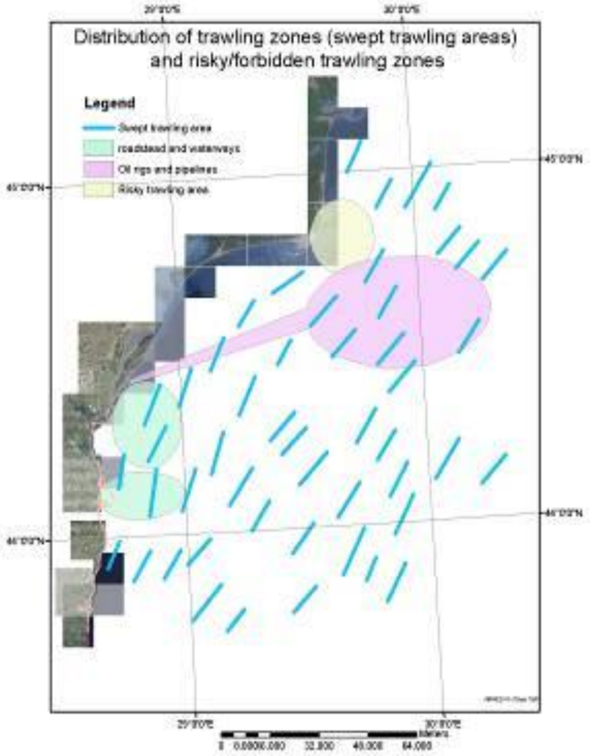


Fig. Trawling area at the Romanian littoral

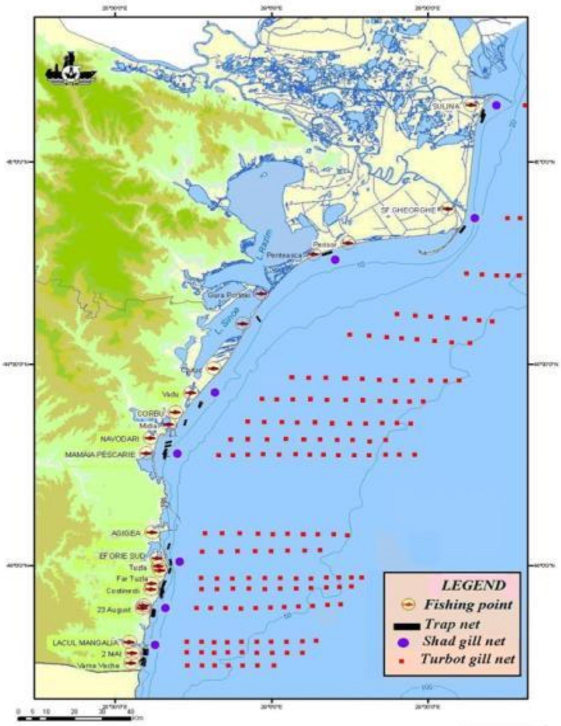


Fig. Distribution area for passive fishing gears

VIII Chatham Rise case study

Introduction

The Chatham Rise is a broad ridge lying to the east of central New Zealand and extending for c. 1400 km. Warm subtropical and cold sub-Antarctic waters meet at the western end of the Chatham Rise and then run eastwards forming the subtropical front, creating ideal conditions for primary productivity.

The subtropical convergence gives the region high biodiversity, and makes it the most productive in New Zealand waters. The ecosystem supports substantial commercial fisheries production (about 60% of all New Zealand's catches), and also a high diversity of seabird, cetacean, and large pelagic fish species, many of which are protected under New Zealand law but threatened by human activities. The region also includes a number of seamounts, hills and knolls, which are also often sites of high productivity and the focus of some important fisheries, but often support extensive coral growths, which are very sensitive to physical impact by fishing or other disturbance. In recent years, substantial deposits of phosphorite nodules have been discovered on the crest of the Rise, and there is interest in mining these deposits.

The EAFM issues examined within this case study will include balancing multiple stakeholder (fisheries, conservation, seabed mining) interests, and the impacts of climate change, within an Atlantis model. This case study will provide important comparisons in many parts of this proposal.

Spatial units

The Chatham Rise is a broad ridge lying to the east of central New Zealand and extending for c. 1400 km to c. 168° W, east of the Chatham Islands (**Error! Reference source not found.**). The case study will focus on the deep water ecosystem dominated by hoki (*Macruronus novaezelandiae*) in the area, from 200 to 800m.

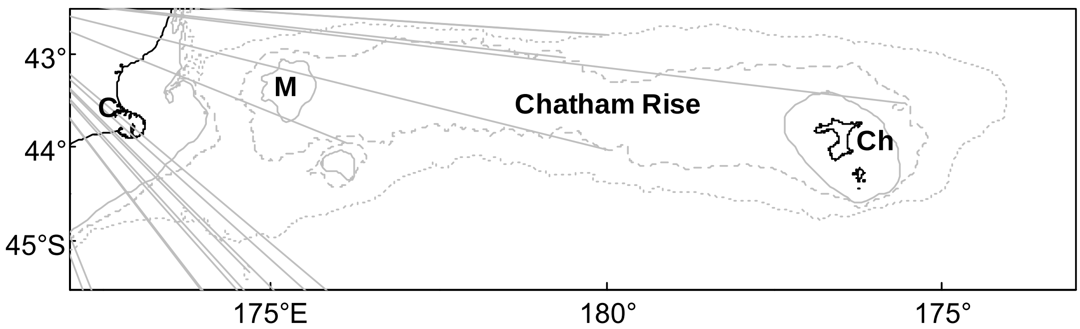


Figure 1: Chatham Rise case study area. C – Christchurch, Ch – Chatham Islands, M – Mernoo Bank.

Data is currently being collated to develop the bioregionalisation for the Chatham Rise region. This includes spatial data on catch composition, seabed communities and habitats, and other relevant information on oceanography. Once the bioregionalisation has been completed, the data will be stratified to the appropriate spatial areas for inclusion within the Atlantis model.

Oceanography and bottom topograhy

The bathymetry of the Chatham Rise is well documented (**Error! Reference source not found.**). Over the large-scale, the Chatham Rise appears smooth-topped, but at a more detailed level it includes four banks with depths of less than 250 m, and many underwater topographic features in deeper waters. Much of the area is composed of soft sediments, except where old volcanic rocks emerged above the sediment to form rocky banks such as Mernoo and Veryan Bank, and patches of rough ground on the eastern

Chatham Rise near the Chatham Islands. A large number of sediment samples are available for the region, from many years of study, but these have not been collated into a comprehensive sediment map of the area. Terrigenous sediments giving way to pelagic sediments at c. 179° E.

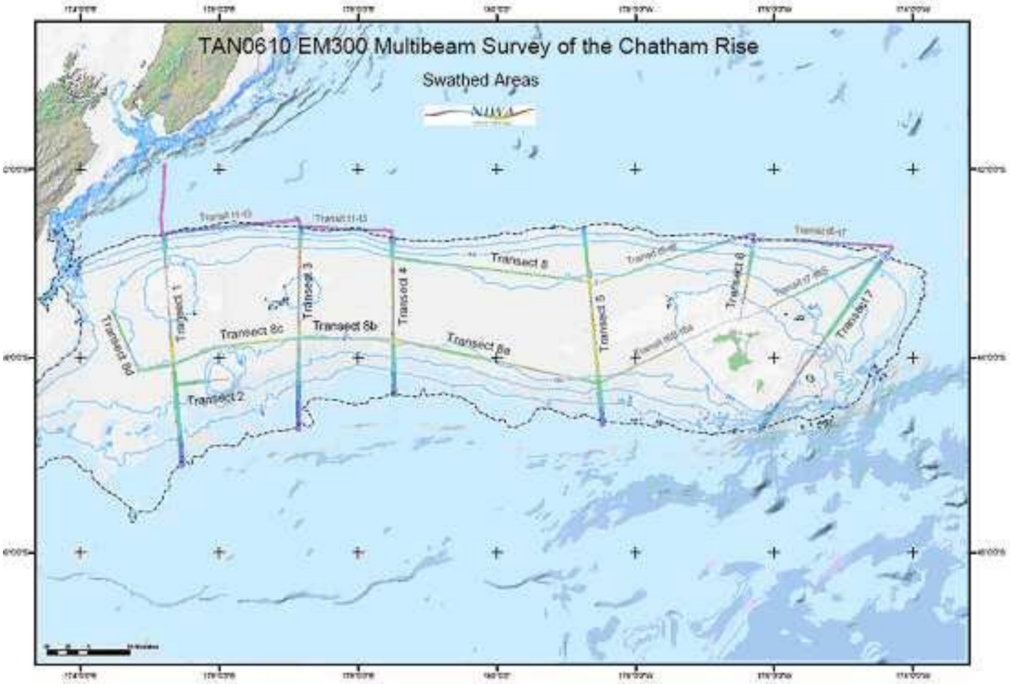


Figure 2: Chatham Rise region, showing recent multibeam survey transects

The Chatham Rise case study area also includes a number of seamounts, which are important for biodiversity, and fisheries. The largest group of these are the Graveyard seamounts. The Graveyard seamount complex (**Error! Reference source not found.**) consists of 28 seamounts on the northern slopes of the Chatham Rise. The largest rises from a depth of 1,100 metres to a peak at 750 metres below the surface.

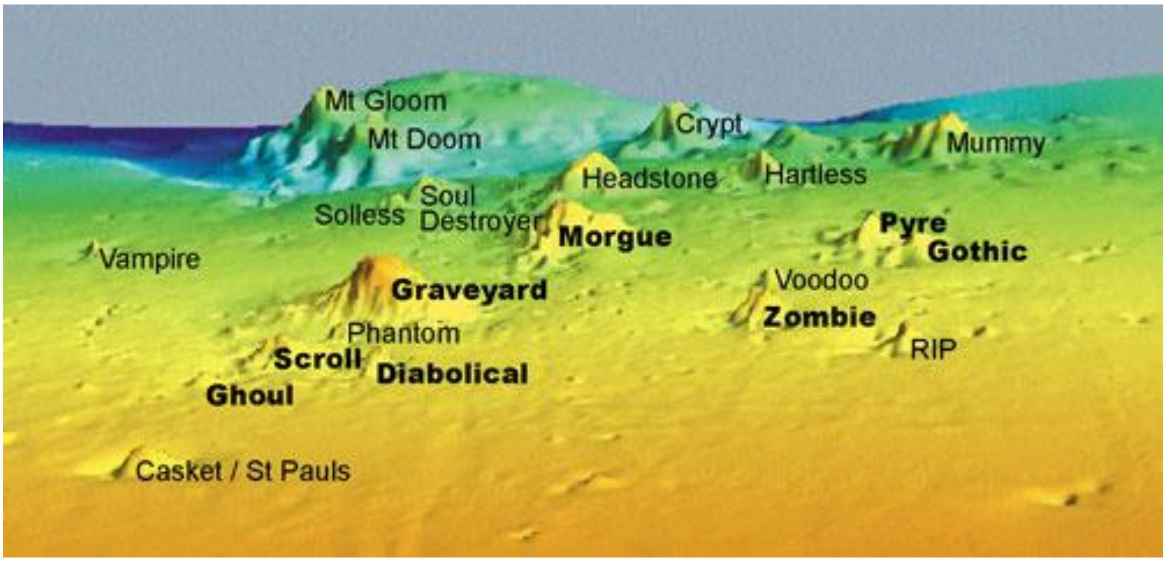


Figure 3: Graveyard seamount complex, Chatham Rise.

A wide range of oceanographic data are available for the Chatham Rise region, and once the spatial regions have been defined by the bioregionalisation, a ROMs model will be developed to provide the physical forcing for the Atlantis model. Data include satellite derived SST (**Error! Reference source**

not found.), research vessel CTD and expendable bathythermograph data, modelled seabed temperature (**Error! Reference source not found.**), general ocean circulation data (**Error! Reference source not found.**), satellite derived SSH (**Error! Reference source not found.**), and ocean drifter data (**Error! Reference source not found.**). Data on ocean acidity are also available (**Error! Reference source not found.**), and we aim to include investigation of climate change scenarios within our modelling.

Summarizing the oceanography, warm subtropical surface waters from the north and cold subantarctic surface waters from the south meet at the western end of the Chatham Rise and then run eastwards forming the subtropical front as they mix along the crest of the Rise. Bottom temperatures are usually 2–3°C warmer on the northern flank. The nutrient rich waters from the south mix with warm northern waters, and create ideal conditions for primary productivity and the animals that feed on this, making the seas the most productive around New Zealand. The cold-water current and mixing area extends northwards to a variable degree at the western end of the Chatham Rise (to the west of the Mernoo Bank), and this area is of especially high productivity, and is the focus for several commercial fisheries. To the north, east, and south, the Chatham Rise is effectively bounded by areas of deep (>3000 m) and cold (<2°C) water.

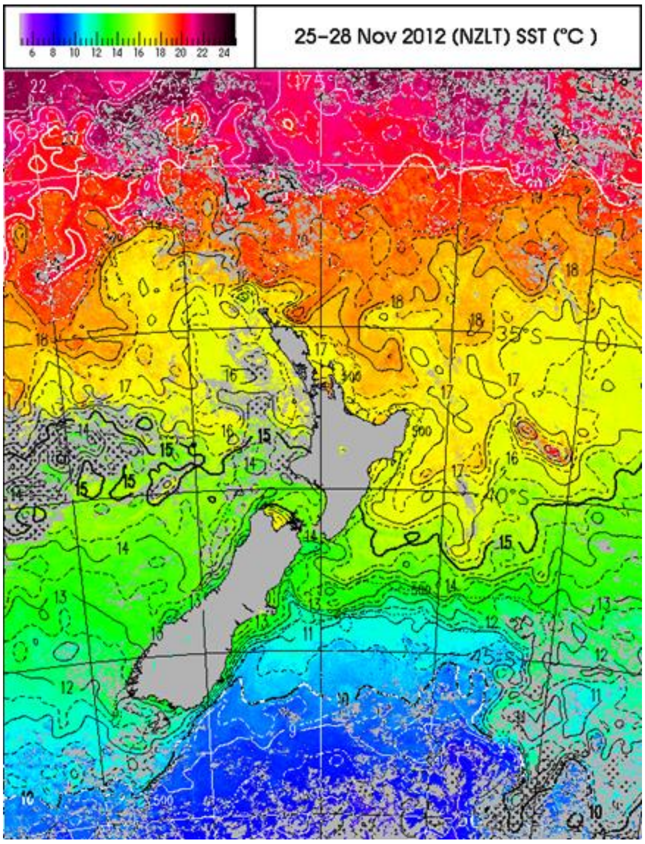


Figure 4: Satellite derived sea surface temperature for the New Zealand region for 25–28 Nov 2012.

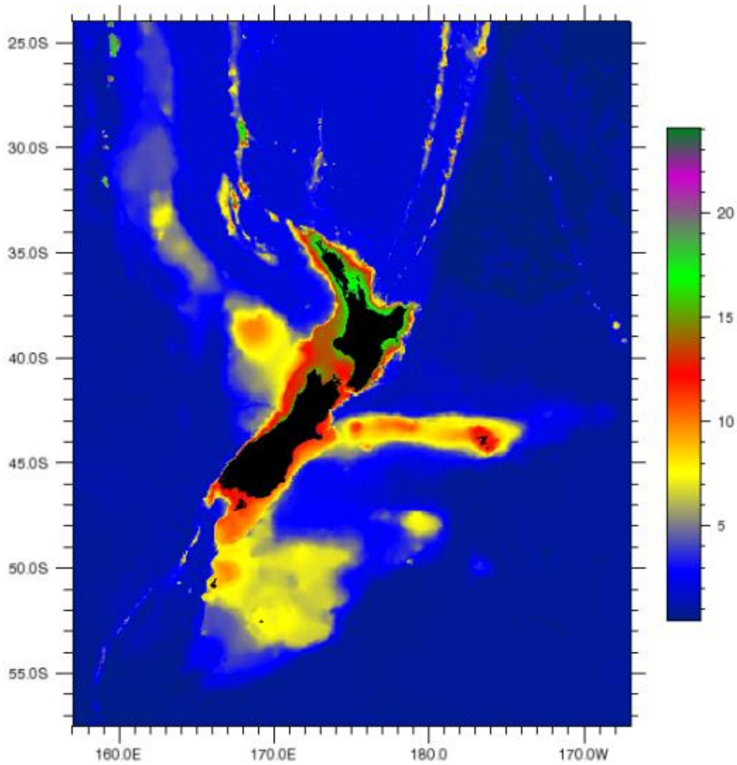


Figure 5: Estimated temperature at the sea-bed produced by 3-dimensional interpolation of temperature-depth-location data onto a Mercator projection grid at 1 km resolution (Pinkerton et al. 2005).

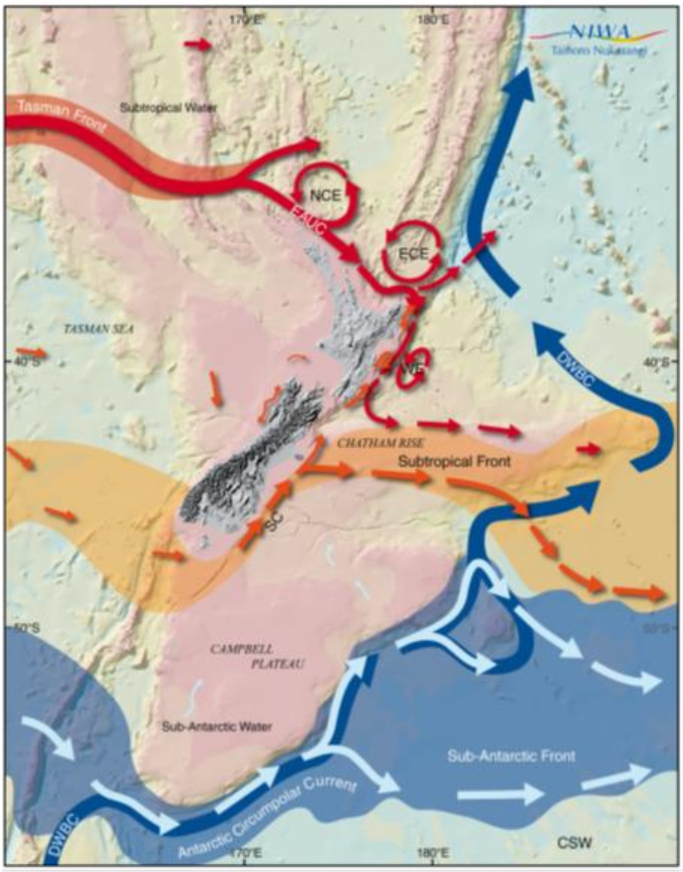


Figure 6: Ocean currents and water mass frontal systems in the New Zealand region. The Tasman Front (TF), the Subtropical Front (STF) and the Sub-Antarctic Front (SAF) approach New Zealand from the west. The STF represents the meeting of Subtropical Water (STW) and Sub-Antarctic Water (SAW), while the SAF is formed by the meeting of SAW and Circumpolar Surface Water (CSW). The fronts contain or generate currents and there are several permanent eddies off the eastern North Island (EAUC, East Auckland Current; WAUC, West Auckland Current; ECC, East Cape Current; DC, D'Urville Current; WC, Westland Current; SC, Southland Current; ACC, Antarctic Circumpolar Current; NCE, North Cape Eddy; ECE, East Cape Eddy; WE, Wairarapa Eddy). There are also areas of tidal mixing in Foveaux Strait between Stewart Island and the South Island, in Cook Strait between the North and South islands, and north of Cape Reinga.

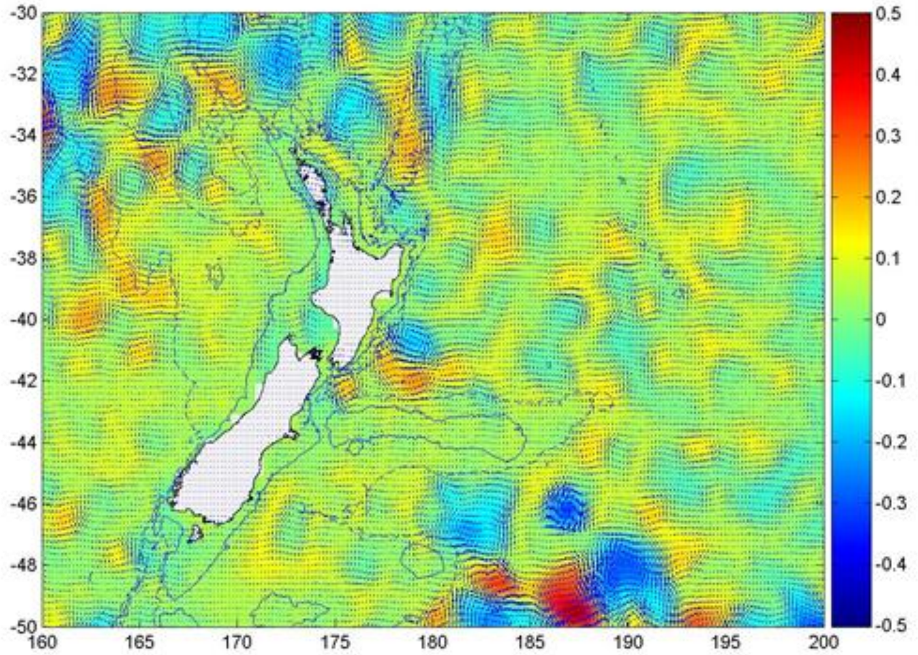


Figure 7: Sea surface height anomaly (m) for the New Zealand region from 1 January 2001 from AVISO merged dataset. Vectors show surface current anomalies corresponding to this anomaly.

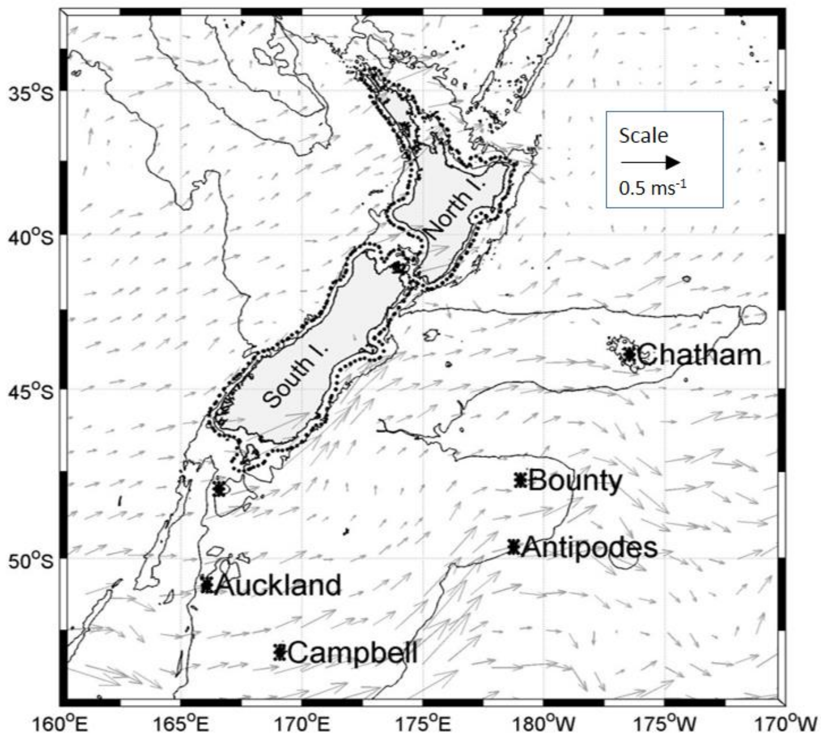


Figure 8 - Mean surface flow computed from the drifters passing through the New Zealand region.

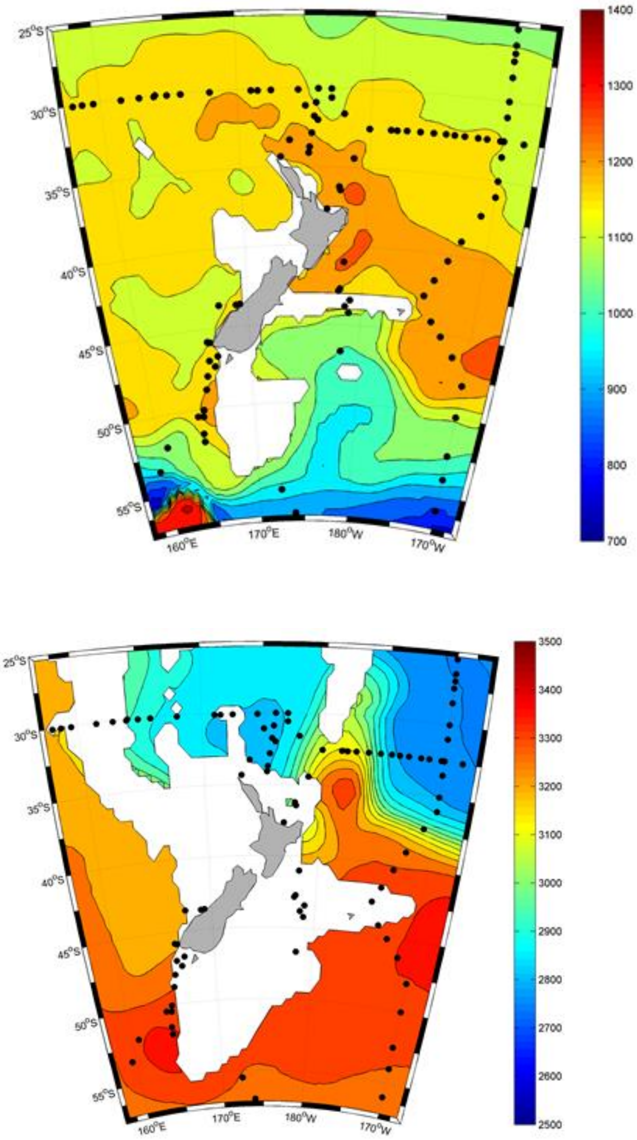


Figure 9 - Detailed aragonite saturation horizon (ASH, upper plot) and calcite saturation horizon (CSH, lower plot) maps using the algorithms and the CARS climatology for the New Zealand region. Plots show the depth of the respective horizons in metres. The location of the WOCE and NIWA stations where alkalinity and DIC were sampled are shown by black dots. The white regions in each plot represent topography shallower than the ASH and CSH (Tracey et al. 2013).

Satelite data are available for primary productivity around New Zealand (**Error! Reference source not found.**). The satellite-based method of observing, characterising and monitoring phytoplankton biomass has become standard for management and research purposes at moderate to large spatial and temporal scales (tens to thousands of kilometres; weeks to decades). The accuracy of the satellite based method (typically a target accuracy of within 35%) is much less than in situ methods, and periodic research and validation voyages in regions like the New Zealand EEZ are required to ensure that this target accuracy is being achieved and that data are fit for purpose.

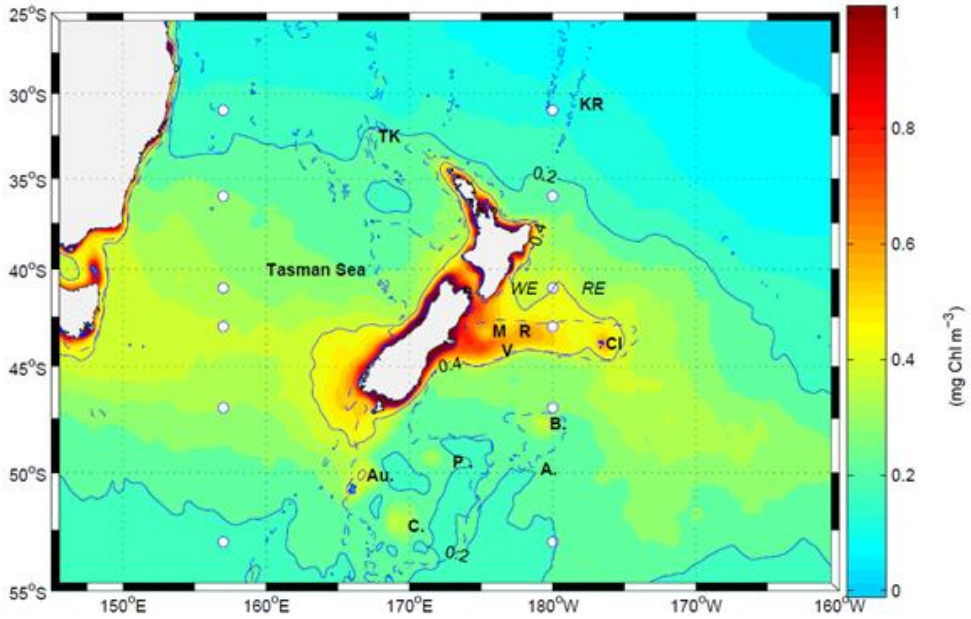


Figure 10 - Mean surface chlorophyll-a concentration (mg Chl-a m^{-3}) computed from 13 years of SeaWiFS data (1997 to 2010). The 0.2 and 0.4 mgChl-a m^{-3} contours (solid lines) and 1000 m isobaths (dashed line) are shown. Locations are: Three Kings Island (TK), Mernoo (M), Reserve (R) and Veryan (V) Banks, Auckland Islands (Au), Campbell (C), Chatham Islands (CI), Antipodes (A) and Bounty (B) Islands, Pukaki (P) Rise, Wairarapa (WE) and Rekohu (RE) eddies, and the Kermadec Ridge (KR).

Functional groups used in the model

A balanced trophic model for the Chatham Rise using the Ecopath approach is already available (Pinkerton 2011), and this will be developed further within the Atlantis model.

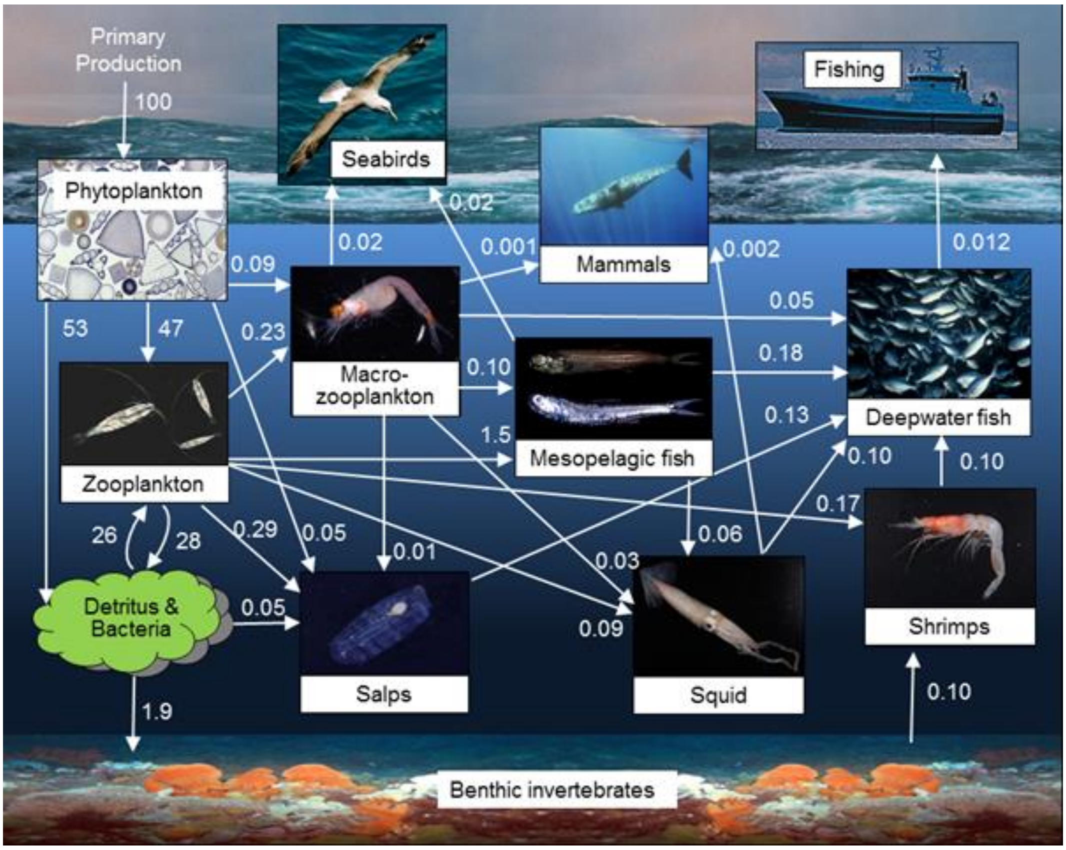


Figure 11 - Simplified trophic model of the Chatham Rise, New Zealand (based on precursor to Pinkerton 2011). The growth of phytoplankton generates organic matter that is the fuel for the marine ecosystem. Figures show the annual flow of energy through unit area of the food-web normalised to an NPP=100, based on an equilibrium mass-balance model (similar to Ecopath).

The subtropical convergence on the Chatham Rise gives the region high biodiversity, and makes it the most productive in New Zealand waters. The ecosystem supports substantial commercial fisheries production, with the main species at depths of 200–800 m being demersal finfish exploited primarily by bottom trawlers. The main commercial species are hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*), and ling (*Genypterus blacodes*), although trawl surveys regularly catch over 100 finfish species. The convergence is a meeting point of two different ecosystems, and as a result the fish assemblages are different on the north and south flanks of the Rise, although many species range over the entire area. The mesopelagic species assemblage has been found to change from north to south across the area, and recent research has found associated changes in the diet composition of many commercial fish species.

The high productivity of the Chatham Rise supports a high diversity of seabird, cetacean, and large pelagic fish species, many of which are protected under New Zealand law but threatened by human activities. New Zealand has the most diverse seabird community in the world, including many species which feed and reproduce on the Chatham Rise. These include the black-bellied storm petrel (*Fregetta tropica*), Buller's mollymawk (*Diomedea bulleri*), sooty shearwater (*Puffinus griseus*), northern royal albatross (*Diomedea sanfordi*), and the endemic Chatham Islands blue penguin (*Eudyptula minor chathamensis*). Cetaceans include dusky dolphins (*Lagenorhynchus obscurus*), sperm whales (*Physeter catodon*), and Sei whales (*Balaenoptera borealis*). The New Zealand fur seal (*Arctocephalus forsteri*) occurs on the Chatham Rise, and the white shark (*Carcharodon carcharias*) is a regular visitor to the waters around the Chatham Islands.

Annual (middle depths, 200-800m) trawl surveys have been conducted in the region since 1992 (O'Driscoll et al. 2011), and these provide abundance indices and size composition data for all the main species, and also a range of ecosystem indicators (Tuck et al. 2009). Multibeam backscatter data collected during these surveys (in more recent years) also provides an index of mesopelgic biomass, and can be used to derive indices of abundance of mesopelagic fish and krill in these regions. The main fishery species not adequately sampled by the middle depth surveys is the scampi *Metanephrops challengeri*, which has its own targeted trawl and photographic surveys every three years (Tuck et al. 2011).

Data on benthic communities is available from dedicated sampling, and trawl survey bycatch, but is patchy. The photographic surveys for scampi also provide data on epifauna in the regions they are conducted (Tuck & Spong 2013).

Trophic structure is quite well understood, and a number of studies have examined fish diet in the region (Dunn et al. 2009a, Dunn et al. 2009b, Dunn et al. 2010a, Dunn et al. 2010b, Dunn et al. 2010c, Horn & Dunn 2010, Horn et al. 2010, Horn et al. 2011, Stevens & Dunn 2011, Stevens 2012, Dunn et al. 2013, Horn et al. 2013b, Horn et al. 2013c).

Some of the seabirds interacting with Chatham Rise fisheries nest outside the NZ region, but for native species, reasonably regular surveys are conducted (e.g., Baker et al. 2013). Ministry for Primary Indistries (MPI) fisheries observers record all fishery interactions with protected species while on observer trips, and these data are used to estimate annual interactions (Thompson et al. 2012).

Commercial activities

Annual landings data are being collated for the commercial species in the area. Trip by trip landings data are available for all species included withon the Quota Management System (QMS), and MPI observer data will be used to estimate bycatch of non quota species (e.g., Anderson 2012). Fishing effort (and estimated catch for main species) is recorded at the tow by tow level for deepwater fisheries, and fishing effort on the Chatham Rise can therefore be mapped at reasonable accuracy, for estimation of benthic disturbance (**Error! Reference source not found.**).

Regular age or length based assessments are available for the main commercial species (e.g., Horn et al. 2013a, McKenzie 2013, Tuck 2013)

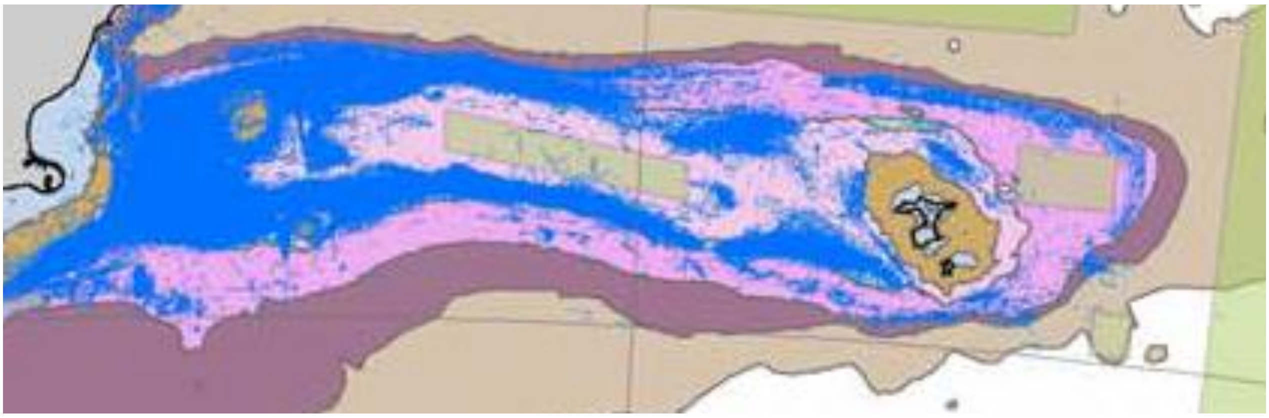


Figure 12 - Trawl footprint for Chatham Rise region for fishing years 1991/92 – 2005/06.

A range of studies have examined stock structure for New Zealand species occuring on the Chatham Rise, including genetics (Smith 1999), morphometics (Livingston & Schofield 1996) and examination of age structure (Ballara & O'Driscoll 2014). Data from multiple approaches are generally collated to make decisions on appropriate scales for stock assessments (Horn 2005).

New data

The main new data being collated within the MareFrame project is new diet data, particularly for rattail species.

Conclusion

Deliverable 5.2 covers a wide range of data types depending on the complexity of the ecosystem, their characteristics and ecological knowledge (e.g. data-poor/data rich areas) and a large array of management practices, issues and priorities. Even though case studies will combine knowledge based on various data types and of varying wealth of data the information categories are common to many of the CS to be modelled, namely:

- Spatial units: within the case-study areas information of the location of species/groups are recorded.
- Oceanography: data on ocean currents and temperature is collected
- Functional groups: depending on scope of the management and history of exploitation data is available on those.
- Commercial activity: sampling schemes from landings and national surveys
- Stock definition
- New data from WP2
- Other data and parameters: socio-economic data

Acknowledgements

We would like to thank all persons who contributed and helped to create this document.

References

Alheit, J., Möllmann, C., Dutz, J., Kornilovs, G., Loewe, P., Mohrholz, V., Wasmund, N., 2005. Synchronous ecological regime shifts in the central Baltic and the North Sea in the late 1980s. ICES Journal of Marine Science, 62:1205-1215. DOI:10.1016/j.icesjms.2005.04.024.

Allen, R., 1971. Relation between production and biomass. Journal of the Fisheries Research Board of Canada, 28:1573–1581.

Anderson, O.F. (2012). Fish and invertebrate bycatch and discards in New Zealand scampi fisheries from 1990–91 until 2009–10. New Zealand Aquatic Environment and Biodiversity Report 100: 65.

Arndt, E.A., Jansen, W., 1986. Neomysis integer (Leach) in the chain of boddens south of Darss/Zingst (Western Baltic). Ecophysiology and population dynamics. Ophelia, 4 Supplement, 1.15.

Arrhenius, F., 1996. Diet composition and food selectivity of 0-group herring (Clupea harengus L.) and sprat (Sprattus sprattus (L.)) in the northern Baltic Sea. – ICES Journal of Marine Science, 53: 701–712.

Arrhenius, F., and Hansson, S., 1993. Food consumption of larval, young and adult herring and sprat in the Baltic Sea. Marine Ecology Progress Series, 96: 125–137.

Baccetti, N., Capizzi, D., Corbi, F., Massa, B., Nissardi, S., Spano, G. & Sposimo, P., (2009). Breeding shearwaters on italian islands: polupation size, island selection and co-existence with their main alien predator, the black rat. Riv. ital. Orn., Milano, 78 (2): 83-100.

Baker, G.B.; Jensz, K.; Cunningham, R. (2013). White-capped albatross population estimate — 2011/12 and 2012/13. Department of Conservation Contract 4431 & Project POP2012-05. p. (Report prepared for Department of Conservation)

Bakun, A., 2006. Wasp-waist populations and marine ecosystem dynamics: navigating the "predator pit" topographies. Progress in Oceanography, 68: 271–288.

Ballara, S.; O'Driscoll, R. (2014). Catches, size, and age structure of the 2011-12 hoki fishery, and a summary of input data used for the 2013 stock assessment. New Zealand Fisheries Assessment Report 2014/05: 121p.

Batten, S. D., Clark, R., Flinkman, J. et al. 2003. CPR sampling: the technical background, materials and methods, consistency and comparability. Progress in Oceanography. 58: 193–215.

Bernard, C., and Rassoulzadegan, F., 1990. Bacteria or rnicroflagellates as a major food source for marine ciliates: possible implications for the microzooplankton. Marine Ecology Progress Series. 64: 147-155.

Bertilsson S. et al. 2003. Elemental composition of marine Prochlorococcus and Synechococcus: Implications for the ecological stoichiometry of the sea. Limnology and Oceanography 48(5): 1721–1731.

Bianchi, T.S., Engelhaupt, E., Westman, P., Andren, T., Rolff, C., Elmgren, R., 2000. Cyanobacterial blooms in the Baltic Sea: natural or human-induced? Limnology and Oceanography, 45:716–726.

BIOR database. Contact person: Kornilovs Georg - Fish Resources Research Department, Institute of Food Safety, Animal Health and Environment "BIOR" .

Brando, V. E., Ceccarelli, R., Libralato, S., Ravagnan, G., 2004. Assessment of environmental management effects in a shallow water basin using mass-balance models. Ecological Modelling, 172(2–4): 213–232.

Brichetti P, Fracasso G. 2003. Ornitologia Italiana. Vol. 1. Gavidae-Falconidae. Bologna: Alberto Perdisa Editore.

Brunet C., Casotti R., Vantrepotte V., Corato F., Conversano F. 2006. Picophytoplankton diversity and photoacclimation in the Strait of Sicily (Mediterranean Sea) in summer. I. Mesoscale variations. Aquatic Microbial Ecology 44(2): 127-141.

Canese S, Cardinali A, Fortuna CM, Giusti M, Lauriano G, Salvati E, Greco S. 2006. The first identified winter feeding ground of fin whales (Balaenoptera physalus) in the Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 86: 903–907.

Capizzi, D., Baccetti, N. & Sposimo, P., 2010. Prioritizing rat eradication on islands by cost and effectiveness to protect nesting seabirds. Biological Conservation 143: 1716–1727.

Carpentieri P., Colloca F., Belluscio A., Criscoli A., Ardizzone G.D. 2006. Diel feeding periodicity and daily ration of shelf break fish species. J. Mar. Biol. Ass. U.K. 86: 5296/1-8.

Carpentieri P., Colloca F., Ardizzone G.D., 2007. Rhythms of feeding activity and food consumption of two mediterranean burrowing fish: Gnathophis mystax (Delaroche) and Chlopsis bicolor Rafinesque. Marine Ecology, 487-495.

Carpentieri P., Colloca F., Ardizzone G.D. 2008. Daily ration and feeding activity of juvenile hake in the central Mediterranean Sea. Journal of Marine Biology of United Kingdom. , 88: 1493-1501.

Cutitta A., Arigo A., Basilone G., Bonanno A., Buscaino G., Rollandi L.,Garcia Lafuente J., Garcia A., Mazzola S., Patti B. 2004. Mesopelagic fish larvae species in the Strait of Sicily and their relationships to main oceanographic events.

Cardinale, M., and Svedäng, H., 2011. The beauty of simplicity in science: Baltic cod stock improves rapidly in a 'cod hostile'ecosystem state. Marine Ecology Progress Series, 425:297–301.

Casini, M., Hjelm, J., Molinero, J.C., Lovgren, J., Cardinale, M., Bartolino, V., Belgrano, A., Kornilovs, G., 2009. Trophic cascades promote threshold-like shifts in pelagic marine ecosystems. Proceedings of the National Academy of Sciences of the United States of America, 106:197-202. DOI: 10.1073/pnas.0806649105.

Casini, M., Lovgren, J., Hjelm, J., Cardinale, M., Molinero, J.C., Kornilovs, G., 2008. Multi-level trophic cascades in a heavily exploited open marine ecosystem. Procedings of the Royal Society B: Biological Sciences, 275: 1793-1801.

Cardinale, M., Möllmann, C., Bartolino, V., Casini, M., Kornilovs, G., Raid, T., Margonski, P.,Grzyb, A., Raitaniemi, J., Gröhsler, J., Flinkman, J., 2009. Effect of environmental variability and spawner characteristics on the recruitment of Baltic herring Clupea harengus populations. Marine Ecology Progress Series, 388: 221-234.

Conley, D., Carstensen, J., Vaquer-Sunyer, R., Duarte, C., 2009. Ecosystem thresholds with hypoxia. Hydrobiologia, 629:21-29. DOI: 10.1007/s10750-009-9764-2.

Conley, D.J., Humborg, C., Rahm, L., Savchuk, O.P., Wulff, F., 2002. Hypoxia in the Baltic Sea and basin-scale changes in phosphorus biogeochemistry. Environmental Science and Technology, 36: 5315–5320.

Cury, P., Shannon, L., Roux, J., Daskalov, G., Jarre, A., Moloney, C., Pauly D. 2005. Trophodynamic indicators for an ecosystem approach to fisheries. ICES Journal of Marine Science, 62:430-442. DOI: 10.1016/j.icesjms.2004.12.006.

Darby, C.D., and Flatman, S., 1994. Virtual Population Analysis, Version 3.1 (Windows/Dos) user guide. Information Technology Series, MAFF Directorate of Fisheries Research, Lowestoft 1, 85 pp.

DAS and BED. http://nest.su.se/das/ (access:14/05/2010).

Dunn, M.R.; Connell, A.M.; Forman, J.; Stevens, D.W.; Horn, P.L. (2010a). Diet of Two Large Sympatric Teleosts, the Ling (Genypterus blacodes) and Hake (Merluccius australis). Plos One 5(10). <http://dx.doi.org/e13647. doi:10.1371/journal.pone.0013647>

Dunn, M.R.; Griggs, L.; Forman, J.; Horn, P. (2010b). Feeding habits and niche separation among the deep-sea chimaeroid fishes Harriotta raleighana, Hydrolagus bemisi and Hydrolagus novaezealandiae. Marine Ecology Progress Series 407: 209-225.

Dunn, M.R.; Horn, P.; Connell, A.; Stevens, D.W.; Forman, J.; Pinkerton, M.H.; Griggs, L.; Notman, P.; Wood, P. (2009a). Ecosystem-scale trophic relationships: diet composition and guild structure of middle-depths fish on the Chatham Rise. Final Research Report for Ministry of Fisheries research project ZBD2004-02. p. (Unpublished report held by MFish, Wellington.)

Dunn, M.R.; Hurst, R.; Renwick, J.A.; Francis, R.I.C.C.; Devine, J.; McKenzie, A. (2009b). Fish abundance and climate trends in New Zealand. New Zealand Aquatic Environment and Biodiversity Report 31: 74pp.

Dunn, M.R.; Stevens, D.W.; Forman, J.S.; Connell, A. (2013). Trophic Interactions and Distribution of Some Squaliforme Sharks, Including New Diet Descriptions for <italic>Deania calcea</italic> and <italic>Squalus acanthias</italic>. PLoS ONE 8(3): e59938. <http://dx.doi.org/10.1371/journal.pone.0059938>

Dunn, M.R.; Szabo, A.; McVeigh, M.S.; Smith, P.J. (2010c). The diet of deep sea sharks and the benefits of using DNA identification of prey. Deep-Sea Research I 57: 923-930.

Einar E. Nielsen. Michael M. Hansen, Daniel E. Ruzante, Dorte Meldrup and Peter Gronkjaer (2003) Evidence of a hybrid-zone in Atlantic cod (Gadus morhua) in the Baltic and the Danish Belt Sea revealed by individual admixture analysis Mol. Ecol. (2003) 12: 1497-1508

Elmgren, R., 1984. Trophic dynamics in the enclosed, brackish Baltic Sea. Rapports et Proces-Verbaux des Reunions. Conseil International pour l'Exploration de la Mer, 1983:152-169.

Fanelli E., Badalamenti F., D'anna G. & Pipitone C., 2009. Diet and trophic level of scaldfish Arnoglossus laterna in the southern Tyrrhenian Sea (western Mediterranean): contrasting trawled vs. untrawled areas. Journal Marine Biological Association U.K. 89: 817-828.

Fanelli E., Badalamenti F., D'anna G., Pipitone C. & Romano C., 2010. Trophodynamic effects of trawling on the feeding ecology of pandora, Pagellus erythrinus, off the northern Sicily coast (Mediterranean Sea). Marine and Freshwater Research. 61: 408-417.

Fanelli E., Badalamenti F., D'anna G., Pipitone C., Riginella E. & Azzurro E., 2011. Food partitioning and diet temporal variation by two coexisting sparids, Pagellus erythrinus and Pagellus acarne, in the Gulf of Castellammare (Mediterranean Sea). Journal of Fish Biology. 78: 869–900.

Fiorentino F., Ben Meriem S., Bahri T., Camilleri M., Dimech M., Ezzeddine-Naja S., Massa F., Jarboui O., Zgozi S. 2008. Synthesis of information on some target species in the MedSudMed Project area (central Mediterranean). GCP/RER/010/ITA/MSM-TD-15. MedSudMed Technical Documents, 15: 67 pp.

Froese, R. and D. Pauly, Editors. 2000. FishBase 2000: concepts, design and data sources. ICLARM, Los Baños, Laguna, Philippines. 344 p.

Gancitano V., Badalucco C., Cusumano S., Gancitano S., Giusto G.B., Ingrande G., Knittweis L., Sinacori G., Rizzo P. 2012. Age cohort analysis of red mullet, Mullus barbatus (L., 1758)(Pisces: Mullidae), in the Strait of Sicily (GSA 15&16). Biol. Mar. Mediterr. 19(1): 208-209.

Gannier, A., (2005). Summer distribution and relative abundance od delphinids in the Mediterranean Sea. Rev. Écol. (Terre Vie), vol. 60.

Garofalo, G., Gristina, M., Toccaceli, M., Giusto, G.B., Rizzo, P., Sinacori, G. 2002. Geostatistical modelling of biocenosis distribution in the Strait of Sicily. Presented at the 2nd International Symposium on GIS/Spatial Analyses in Fishery and Aquatic Sciences (University of Sussex, Brighton, UK, 3–6 September 2002).

Garofalo G, Fiorentino F, Gristina M, Cusumano S, Sinacori G., 2007. Stability of spatial pattern of fish species diversity in the Strait of Sicily (central Mediterranean). Hydrobiologia 580: 117–124.

Gårdmark, A., Nielsen, A., Floeter, J., Möllmann, C., 2011. Depleted marine fish stocks and ecosystem-based management: on the road to recovery, we need to be precautionary. ICES Journal of Marine Science. 68:212–220.

Gucu, A.C., 2002. Can overfishing be responsible for the successful establishment of Mnemiopsis leidyi in the Black Sea? Estuarine, Coastal and Shelf Science, 54: 439–451.

Hannon, B., and Jories, C., 1989. A sesonal analysis of Southern North Sea ecosystem. Ecology, 70: 1916-1934.

Hansson, S., Hjerne, O., Harvey, C., Kitchell, J.F. Cox, S.P. Essington, T.E. 2007. Managing Baltic sea fisheries under contrasting productions and Predation regimes – ecosystem model analyses. Ambio, 36:265-71.

Harding, K.C., and Härkönen, T.J., 1999. Development in the Baltic Gray Seal (Halichoerus grypus) and Ringed Seal (Phoca hispida) Populations during the 20th Century. Limnologica, 28(7): pp 619-627.

Harvey, C.J., Cox, S.P., Essington, T.E., Hansson, S., and Kitchell, J.F. 2003. An ecosystem model of food-web and fisheries interactions in the Baltic Sea. ICES Journal of Marine Science, 60, pp. 939-950.

Hinrichsen, H-H., Möllmann, C., Voss, R., Köster, F.W., Kornilovs, G., 2002. Biophysical modelling of larval Baltic cod (Gadus morhua) growth and survival. Canadian Journal of Fisheries and Aquatic Sciences, 59:1858-1873. doi:10.1139/f02-149

Horn, P. (2005). A review of the stock structure of ling (Genypterus blacodes) in New Zealand waters. New Zealand Fisheries Assessment Report 2005/59: 42p.

Horn, P.; Burrell, T.; Connell, A.; Dunn, M.R. (2011). A comparison of the diets of silver (Seriolella punctata) and white (Seriolella caerulea) warehou. Marine Biology Research 7: 576-591.

Horn, P.; Dunn, M.; Ballara, S. (2013a). Stock assessment of ling (Genypterus blacodes) on the Chatham Rise (LIN 3&4) and in the Sub-Antarctic (LIN 5&6) for the 2011-12 fishing year. New Zealand Fisheries Assessment Report 2013/6: 91p.

Horn, P.; Dunn, M.R. (2010). Inter-annual variability in the diets of hoki, hake, and ling on the Chatham Rise from 1990 to 2009. New Zealand Aquatic Environment and Biodiversity Report 54: 57pp.

Horn, P.; Dunn, M.R.; Forman, J. (2013b). The Diet and Trophic Niche of Orange Perch, Lepidoperca aurantia (Serranidae: Anthiinae) on Chatham Rise, New Zealand. Journal of Ichthyology 53: 310-316.

Horn, P.; Forman, J.; Dunn, M. (2010). Feeding habits of alfonsino Beryx splendens. Journal of Fish Biology 76: 2382-2400.

Horn, P.; Forman, J.; Dunn, M. (2013c). Moon phase influences the diet of southern Ray's bream Brama australis. Journal of Fish Biology 82: 1376-1389.

Hussy, K., St. John, M.A., Bottcher, U., 1997. Food resource utilization by juvenile Baltic cod Gadus morhua: a mechanism potentially influencing recruitment success at the demersal juvenile stage? Marine Ecology Progress Series 155:199-208.

Huthnance, J.M. 1986. The Rockall slope current and shelf-edge processes. Proceedings of the Royal Society of Edinburgh 88B, 83-101.

ICES, 2001. Report of the Study Group on Herring Assessment Units in the Baltic Sea. ICES CM 2001/ACFM:10.

ICES, 2002. Report of the Study Group on Herring Assessment Units in the Baltic Sea. ICES CM 2002/H:04. Ref. ACFM, D.

ICES, 2003. Report of the Study Group on Herring Assessment Units in the Baltic Sea. ICES CM 2003/H:02 Ref: WGBFAS.

ICES, 2007. Report of the Working Group on Marine Mammal Ecology (WGMME), 27–30 March 2007, Vilm, Germany. ICES CM 2007/ACE:03. ICES, Copenhagen.

ICES, 2008a. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 817 April 2008, ICES Headquarters, Copenhagen. ICES CM 2008\ACOM:06. 692 pp.

ICES, 2008b. Report of Working Group for Regional Ecosystem Description (WGRED). 25–29 FEBRUARY 2008 ICES, COPENHAGEN, DENMARK ICES CM 2008/ACOM:47 Ref. AMAWGC, 203 pp.

ICES, 2009a. Report of the ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea. ICES CM 2009/BCC:02. 80 pp.

ICES, 2009b. Report of the Working Group on Multispecies Assessment Methods (WGSAM) 5–9 October 2009 ICES Headquarters, Copenhagen. ICES CM 2009/RMC:10 pp:117.

ICES. 2013. Report of the Benchmark Workshop on Baltic Multispecies Assessments (WKBALT), 4–8 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:43. 399 pp.

ICES. 2011. Report of the ICES Advisory Committee 2011. ICES Advice, 2011. Book 5, 329, pp.

ICES, 2013. Report of the Working Group for the Celtic Seas Ecoregion (WGCSE). ICES CM 2013/ACOM:12.

Inall, M., Gillibrand, P., Griffiths, C., MacDougal, N. and Blackwell, K., 2009. On the oceanographic variability of the North-West European Shelf to the West of Scotland. Journal of Marine Systems 77: 210-226.

Inall, M.E. and Sherwin, T.J., 2006. Hydrography. DTI, SEA7 Technical Report.

Jarre-Teichmann, A., 1995. Seasonal mass-balance models of carbon flow in the Central Baltic Sea with emphasis on the upper trophic levels. ICES C.M. 1995/T:06.

Johansson, M., Gorokhova, E., Larsson, U., 2004. Annual variability in ciliate community structure, potential prey and predators in the open northern Baltic Sea proper. Journal of Plankton Research, 26:67-80.

Joint Research Centre. http://stecf.jrc.ec.europa.eu/data-reports, 2013_EU Fleet Econom and Transversal data_fleet segment level.xlsx. Accessed 02/09/2014.

JRC 2013. The 2013 Annual Economic Report on the EU Fishing Fleet (STECF 13-15). Anderson, J. and Carvalho, N. (Eds.). 305 pp. http://stecf.jrc.ec.europa.eu/documents/43805/581354/2013-09_STECF+13-15+-+AER+EU+Fleet+2013_JRC84745.pdf

Jörgensen, H.B.H., Hansen, M.M., Bekkevold, D., Ruzzante, D.E., Loeschcke V. (2005) Marine landscapes an population genetic structure of herring (Clupea harengus L.) in the Baltic Sea. Mol. Ecol. (2005) 14: 3219-3234

Kornilovs, G., Sidrevics, L., and Dippner, J.W., 2001. Fish and zooplankton interaction in the Central Baltic Sea. – ICES Journal of Marine Science, 58: 579–588.

Köster, F. W., Möllmann, C., Hinrichsen, H-H., Wieland, K., Tomkiewicz, J., Kraus, G., Voss, R., Makarchouk, A., MacKenzie, B.R., St. John, M. A., Schnack, D., Rohlf, N., Linkowski, T., and Beyer, J. E., 2005. Baltic cod recruitment - the impact of climate variability on key processes. ICES Journal of Marine Science, 62: 1408-1425.

Köster, F., and Möllmann, C., 2000. Trophodynamic control by clupeid predators on recruitment success in Baltic cod? ICES Journal of Marine Science, 57:310-323. DOI: 10.1006/jmsc.1999.0528.

Köster, F.W., Möllmann, C., Neuenfeldt, S., St. John, M.A., Plikshs, M., and Voss, R., 2001. Developing Baltic cod recruitment models. I. Resolving spatial and temporal dynamics of spawning stock and recruitment for cod, herring, and sprat. Canadian Journal of Fisheries and Aquatic Sciences. 58: 1516–1533.

Köster, F.W., Möllmann, C., Neuenfeldt, S., Vinther, M., St. John, M.A., Tomkiewicz, J., Voss, R., Hinrichsen, H.H., Kraus, G., and Schnack, D., 2003. Fish stock development in the Central Baltic Sea (1976-2000) in relation to variability in the physical environment. ICES Marine Science Symposia, 219: 294-306.

Lasternas S, Agustí S, Duarte CM. 2010. Phyto- and bacterioplankton abundance and viability and their relationship with phosphorus across the Mediterranean Sea. Aquatic Microbial Ecology 60: 175–191.

Lazzari P., Teruzzi A., Salon S., Campagna S., Calonaci C., Colella S., Tonani M., Crise A. 2010. Pre-operational short-term forecasts for Mediterranean Sea biogeochemistry. Ocean Sci., 6, 25–39.

Limborg, M.T., Pedersen, J.S., Hemmer-Hansen, J., Tomkiewicz, J., Bekkevold, D. (2009) Genetic population structure of European sprat (2009) Mar. Ecol. Prog. Ser. 379: 213-224.

Lindegren, M., Möllmann, C., Nielsen, A., and Stenseth, N.C., 2009. Preventing the collapse of the Baltic cod stock through an ecosystem-based management approach Proceedings of the National Academy of Science, 2009 106 (34) 14722-14727; doi:10.1073/pnas.0906620106.

Livingston, M.E.; Schofield, K.A. (1996). Stock discrimination of hoki (Macruronus novaezelandiae, Merlucciidae) in New Zealand waters using morphometrics. New Zealand Journal of Marine and Freshwater Research 30(2): 197-208. <http://dx.doi.org/10.1080/00288330.1996.9516708>

Lo Brutto S., Maggio T., Arculeo M. 2013. Isolation By Distance (IBD) signals in the deep-water rose shrimp Parapenaeus longirostris (Lucas, 1846) (Decapoda, Panaeidae) in the Mediterranean Sea. Marine Environmental Research, 90: 1-8.

Lundström, K., Hjerne, O., Alexanderson, A., & O., Karlsson, 2007. Estimation of grey seal (Halichoerus grypus) diet composition in the Baltic Sea. NAMMCO Scientific Publications, 6:177-196 .

Lundström, K., Hjerne, O., Lunneryd, S-G., and Karlsson, O., 2010. Understanding the diet composition of marine mammals: grey seals (Halichoerus grypus) in the Baltic Sea. – ICES Journal of Marine Science, 67.

Mackenzie, B., Hinrihsen, H.H., Plikhsh, M., Wieland, K., Zezera, A., S. 2000. Quantifying environmental heterogeneity: habitat size necessary for successful development of cod Gadus morhua eggs in the Baltic Sea. Marine Ecology Progress Series. 193:142-156

Mackenzie, B.R., and Köster, F.W., 2004. Fish production and climat: Sprat in the Baltic Sea. Ecology, 85(3), 784-794.

McKenzie, A. (2013). Assessment of hoki (Macruronus novaezelandiae) in 2012. New Zealand. New Zealand Fisheries Assessment Report 2013/27: 65p.

Margonski, P., Hansson, S., Tomczak, M., Grzebielec, R., 2010. Climate influence on Baltic cod, sprat, and herring stock-recruitment relationships. Progress in Oceanography, 87: 277–288.

McGurk, M.D., 1986. Natural mortality of marine pelagic fish eggs and larve: role of spatial patchiness. Marine Ecology Progress Series, Vol.34: 227-242.

Menden-Deuer, S., Lessard, E.J., 2000. Carbon to volume relationships for dinoflagellates, diatoms, and other protist plankton. Limnology & Oceanography, 45: 569-579.

MedSudMed n.2 Fiorentino F., Garofalo G., Gristina M., Gancitano S., Norrito G. 2002. Some relevant information on the spatial distribution of demersal resources, benthic biocoenoses and fishing pressure in the Strait of Sicily.

Milano I., Babbucci M., Cariani A., Atanassova M., Bekkevold D., Carvalho G., Espineira M., Fiorentino F.,Garofalo G., Geffen A. J.,Hansen J. H., Helyar S. J., Nielsen E.E., Ogden R., Patarnello T., Stagioni M., Fishpoptrace Consortium, Tinti F. & Bargelloni L., 2014. Outlier SNP markers reveal fine-scale genetic structuring across European hake populations (Merluccius merluccius). Molecular Ecology 23, 118–135. doi: 10.1111/mec.12568.

Möllman, C., Kornilovs, G., Fetter, M., Köster, F.W., 2004. Feeding ecology of central Baltic Sea herring and sprat. Journal of Fish Biology, 65, 1563–1581.

Möllmann, C., and Köster, F.W., 1996. Temporal and spatial variability of food consumption by herring and sprat populations in the Central Baltic. ICES CM 1996/J:17.

Möllmann, C., and Köster, F.W., 1999. Food consumpcion by clupeids in the Central Baltic: evidence for top-down control? ICES Journal of Marine Science, 56 (suppl.), 100-113.

Möllmann, C., Kornilovs, G., Sidrevics, L., 2000. Long-term dynamics of main mezozooplankton species in the central Baltic Sea. Journal of Plankton Research. Vol: 22. No.11. pp. 2015-2038.

Möllmann, C., Blenckner, T., Casini, M., Gårdmark, A., Lindegren, M., 2011. Beauty is in the eye of the beholder: management of Baltic cod stock requires an ecosystem approach. Marine Ecology Progress Series, 431: 293-297.

Möllmann, C., Diekmann, R., Muller-Karulis, B., Kornilovs, G., Plikshs, M., Axe, P., 2009. Reorganization of a large marine ecosystem due to atmospheric and anthropogenic pressure: a discontinuous regime shift in the Central Baltic Sea. Global Change Biology, 15:1377-1393. DOI: 10.1111/j.1365-2486.2008.01814.x.

Möllmann, C., Kornilovs, G., Fetter, M., Köster, F.W., and Hinrichsen, H-H., 2003. The marine copepod Pseudocalanus elongatus, as a mediator between climate variability and fisheries in the Central Baltic Sea. Fisheries Oceanography, 12: 360-368.

Möllmann, C., Muller-Karulis, B., Kornilovs, G., and St. John, M.A., 2008. Effects of climate and overfishing on zooplankton dynamics and ecosystem structure: regime shifts, trophic cascade, and feeback loops in a simple ecosystem. ICES Journal of Marine Science, 65: 302–310.

Nowaczyk A., Carlotti F., Thibault-Botha D., Pagano M. 2011. Distribution of epipelagic metazooplankton across the Mediterranean Sea during the summer BOUM cruise. Biogeosciences 8(8): 2159-2177.

Nolan, G. D., and Lyons, K. 2006. Ocean climate variability on the western Irish Shelf, an emerging time-series. ICESCM 2006/C:28.

Nunn, A. D., Harvey, J. P., Britton, J. R., Frear, P. A and Cowx, I. G. 2007. Fish, climate and the Gulf Stream: the influence of abiotic factors on the recruitment success of cyprinid fishes in lowland rivers. Freshwater Biology 52: 1576–1586

O'Driscoll, R.; MacGibbon, D.; Fu, D.; Lyon, W.; Stevens, D. (2011). A review of hoki and middle-depth trawl surveys of the Chatham Rise, January 1992–2010. New Zealand Fisheries Assessment Report 2011/47: 72p.

Ojaveer, E., Aps, R., 2003. Sprat, Sprattus sprattus balticus (Schn.). p.79-87. In: E. Ojaveer, E. Pihu and T. Saat (eds.) Fishes of Estonia. Estonian Academy Publishers, Tallinn.

Palomares, M.L. & D. Pauly, 1989. A multiple regression model for predicting the foodconsumption of marine fish population. Australian Journal of Marine and Freshwater Research 40(3): 259-284.

Palomares, M.L.D. & D. Pauly 1998. Predicting food consumption of fish populations as functions of mortality, food type, morphometrics, temperature and salinity. Marine and Freshwater Research 49: 447-453.

Pauly, D., Christensen, V. & Sambilay, V. 1990. Some Features of Fish Food Consumption estimates Used by Ecosystem Modellers. ICES, CM/G:17, 8 pp.

Pérès J.M. and Picard J. 1964. Nouveau manuel de bionomie benthique en Mediterranée. Recl. Trav. Stn. Mar. Endoume, 31 (47): 1–131.

Peters, J., Dutz, J., and Hagen, W., 2007. Role of essential fatty acids on the reproductive success of the copepod Temora longicornis in the North Sea. Marine Ecology Progress Series, 341: 153-163.

Peters, J., Renz, J., van Beusekom, J., Boersma, M., Hagen, W., 2006. Trophodynamics and seasonal cycle of the copepod Pseudocalanus acuspes in the Central Baltic Sea (Bornholm Basin): evidence from lipid composition. Marine Biology, DOI 10.1007/s00227–006–0290–8.

Pinkerton, M.H.; Richardson, K.M.; Boyd, P.W.; Gall, M.P.; Zeldis, J.; Oliver, M.D.; Murphy, R.J. (2005). Intercomparison of ocean colour band-ratio algorithms for chlorophyll concentration in the Subtropical Front east of New Zealand. Remote Sensing of Environment (97): 382-402.

Pinkerton, M.H. (2011). A balanced trophic model of the Chatham Rise, New Zealand. Research report for Coasts & Oceans OBI. NIWA, Wellington www.niwa.co.nz/our-science/oceans/research-projects: 60pp.

Pinnegar, J. K., Trenkel, V. M., Tidd, A. N., Dawson, W. A. and Du Buit, M. H. 2003. Does diet in Celtic Sea fishes reflect prey availability? Journal of Fish Biology, 63 (Suppl. A): 197-212.

Plikshs, M., Kalejs, M., Grauman, G., 1993. The influence of environmental conditions and spawning stock size on the yearclass strength of the Eastern Baltic cod. ICES CM 1993/J:22.

Russo T, Parisi A, Cataudella S. 2013. Spatial indicators of fishing pressure: Preliminary analyses and possible developments. Ecol Ind 26: 141–153.

Russo T, Parisi A, Garofalo G, Gristina M, Cataudella S, et al. 2014. SMART: A Spatially Explicit Bio-Economic Model for Assessing and Managing Demersal Fisheries, with an Application to Italian Trawlers in the Strait of Sicily. PLoS ONE 9(1): e86222. doi:10.1371/journal.pone.0086222.

Rahikainen, M., 2005. Evaluation and management of the Finnish herring fishery. University of Helsinki, Academic dissertation in Fisheries Science, Helsinki University Press, Helsinki.

Rahmstorf, S. 2003. The current climate. Nature 421, 699.

Reed, D.C., and Gustafsson, B.,G., 2011. Sedimentary phosphorus dynamics and the evolution of bottom-water hypoxia: A coupled benthic–pelagic model of a coastal system. Limnology and Oceanography, 56 (3), 2011, pp 1075 – 1092. Doi:10.4319/lo.2011.56.3.1075.

Renz, J., 2006. Life cycle and population dynamics of the calanoid copepod Pseudocalanus spp. in the Baltic Sea and North Sea. Universität Bremen, 142 pp.

Reid, P. C., Borges, M. and Svendsen, E. 2001. A regime shift in the North Sea circa 1988 linked to changes in the North Sea horse mackerel fishery. Fisheries Research. 50: 163–171.

Renz, J., Peters, J., and Hirche, H.J., 2007. Life-cycle of Pseudocalanus acuspes Giesbrecht (Copepoda, Calanoida) in the Central Baltic Sea: II. Reproduction, growth and secondary production. Marine Biology, 151: 515-527.

Rudstam, L.G., Hansson, S., Larsson, U., 1986. Abundance, species composition and production of mysid shrimps in a coastal area of the northern Baltic proper. Ophelia, 4: 225–238.

Rudstam, L.G., Aneer, G., Hilden, M., 1994. Top-down control in the pelagic Baltic ecosystem. Dana, 10, 100-129.

Schmitz, O.J., Lavigne, D.M. 1984. Intrinsic rate of increase, body size, and specific metrabolic rate in marine mammals. Oecologia, 62: 305-309.

Sinopoli M., Fanelli E., D'anna G., Badalamenti F. & Pipitone C., 2012 - Assessing the effects of a trawling ban on diet and trophic level of hake, Merluccius merluccius, in the southern Tyrrhenian Sea. Scientia Marina. 76: 677-690.

SCOS (2008). Scientific Advice on Matters Related to the Management of Seal Populations.

Sala, E., Aburto-Oropeza, M., Reza, G., Paredes, and L.G., Lopes-Lemus., 2004. Fishing down costal food webs in the Gulf of California. Fisheries, 29: 19-25.

Salemaa, H., Tyystjärvi-Muuronen, K., Aro, E., 1986. Life histories, distribution and abundance of Mysis mixta and Mysis relicta in the northern Baltic Sea. Ophelia, 4: 239–247.

Sandberg, J., 2007. Cross-ecosystem analyses of pelagic food web structure and processes in the Baltic Sea. Ecological Modelling, 201:243-261. DOI: 10.1016/j.ecolmodel.2006.09.023.

Sandberg, J., Elmgren, R., Wulff, F., 2000. Carbon flows in Baltic Sea food webs – a re-evaluation using a mass balance approach. Journal of Marine Systems, 25:249-260.

Savchuk, O., and Wulff, F., 2007. Modelling the Baltic Sea Eutrophication in a Decision Support System. Ambio, 36: 265-272.

Savchuk, O.P., and Wulff, F., 2009. Long-term modeling of large-scale nutrient cycles in the entire Baltic Sea, Hydrobiologia, 629:209—224, DOI 10.1007/s10750-009-9775-z.

Shannon, L.J., Moloney, C., Jarre-Teichmann, A., Field, J.G., 2003. Trophic flows in the southern Benguela during the 1980s and 1990s. Journal of Marine Systems, 39: 83–116.

Smith, P.J. (1999). Allozyme variation in scampi (Metanephrops challengeri) fisheries in New Zealand. New Zealand journal of Marien and Freshwater Research 33: 491-497.

Söderberg, S., 1972. Undersökning utförd på uppdrag av Svenska Ostkustfiskarenas Centralförbund; 1972. Sälens födoval och skadegörelse på laxfisket i Östersjön; p. 60.

Sokolov, A., Andrejev, A.A.,Wulff, F., Rodriguez-Medina, M., 1997. The Data Assimilation System for data analysis in the Baltic Sea. Systems Ecology Contributions, 3:66.

Stepputtis, D., 2006. Distribiution patterns of Baltic sprat (Sprattus sprattus L.). Causes and Consequences. Dissertation zur Erlangung des Doktorgrades der Mathematisch Naturwissenschaftilichen Fakultät der Christian-Albrechts-Usnversität zu Kiel.

Stevens, D.W. (2012). Notes on the diet of seven grenadier fishes (Macrouridae) from the lower continental slope of Chatham Rise, New Zealand. Journal of Ichthyology 52(10): 782-786. <http://dx.doi.org/10.1134/S003294521210013X>

Stevens, D.W.; Dunn, M.R. (2011). Different food preferences in four sympatric deep-sea Macrourid fishes. Marine Biology 158: 59-72.

Stoecker, D.K., and Evans, G.T., 1985. Effects of protozoan herbivory and carnivory in a microzooplankton food web. Marine Ecology Progress Series, 25, 159–167.

Strzyrzewska, K., 1979. Zmiany skladu i zasobow stad sledzi polodniowego baltyku w latach 1968-1977. Studia i Materialy, seria B num.43., Wydawnictwo MIR, Gdynia 1979.

Trites, A.W & Pauly, D., (1998). Estimating mean body masses of marine mammals from maximum body lengths. Can. J. Zool. 76: 886–896

Thurow, F., 1997. Estimation of the total fish biomass in the Baltic Sea during the 20th century. ICES Journal of Marine Science, 54: 444–46.

Tomczak, M.T., 2007. An evaluation of stock management practices for the central Baltic herring (Clupea harrengus membras). ICES CM 2007/L:09.

Tomczak, M.T., Müller-Karulis, B., Järv L., Kotta, J., Martin, G., Minde, A., Põllumäe, A., Razinkovas, A., Strake, S., Bucas, M., 2009. Analysis of trophic networks and carbon flows in south-eastern Baltic coastal ecosystems. Progress In Oceanography, 81:111-131. DOI: 10.1016/j.pocean.2009.04.017.

Thompson, F.N.; Abraham, E.R.; Berkenbusch, K. 2012. Marine mammal bycatch in New Zealand trawl fisheries, 1995-96 to 2010-11. Final Research Report for Ministry for Primary Industries project PRO2010/01A. p. (Unpublished report help by MPI, Wellington).

Tracey, D.; Bostock, H.C.; Currie, K.; Mikaloff-Fletcher, S.; Williams, M.; Hadfield, M.; Neil, H.L.; Guy, C.; Cummings, V. 2013. The potential impact of ocean acidification on deep-sea corals and fisheries habitat. New Zealand Aquatic Environment and Biodiversity Report: 102p.

Tuck, I. 2013. Characterisation and length-based population model for scampi (Metanephrops challengeri) on the Mernoo Bank (SCI 3). New Zealand Fisheries Assessment Report 2013/24: 165p.

Tuck, I.; Hartill, B.; Parkinson, D.; Smith, M.; Armiger, H.; Rush, N.; Drury, J. 2011. Estimating the abundance of scampi - Relative abundance of scampi, Metanephrops challengeri, from photographic surveys in SCI 3 (2009 & 2010). Final Research Report for Ministry of Fisheries research project SCI200901 & SCI 201001. p. (Unpublished report held by MFish, Wellington.)

Tuck, I.; Spong, K. 2013. Burrowing megafauna in SCI 3. New Zealand Fisheries Assessment Report 2013/20: 50p.

Tuck, I.D.; Cole, R.; Devine, J. 2009. Ecosystem indicators for New Zealand fisheries. New Zealand Aquatic Environment and Biodiversity Report No. 42: 180p.

Uzars, D., 1994. Feeding of cod (Gadus morhua callarias L.) in the central Baltic in relation to environmental changes. ICES Marine Science Symposia, 198: 612–623.

Uzars, D., and Plikshs, M., 2000. Cod (Gadus morhua L.) cannibalism in the Central Baltic: interannual variability and influence of recruit abundance and distribution. ICES Journal of Marine Science, 57: 324-329. DOI: 10.1006/jmsc.1999.0527.

UNEP-MAP-RAC/SPA. 2014. Status and conservation of cetaceans in the Sicily Channel/Tunisian Plateau. By M. Aissi. Draft internal report for the purposes of the Mediterranean Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, Malaga, Spain, 7-11 April 2014.

Vella A, Vella J. 20112. Central-southern Mediterranean submarine canyons and steep slopes: role played in the distribution of cetaceans, bluefin tunas, and elasmobranchs. In Mediterranean Submarine Canyons Ecology and Governance.

Viherluoto, M., Kuosa, H., Flinkman, J., Viitasalo, M., 2000. Food utilisation of pelagic mysids, Mysis mixta and M. relicta, during their growing season in the northern Baltic Sea. Marine Biology, 136: 553–559.

Viherluoto, M., and Viitasalo, M., 2001. Effect of light on the feeding rates of pelagic and littoral mysid shrimps: a trade-off between feeding success and predation avoidance. Journal of Experimental Marine Biology and Ecology, 261/2: 237-244.

Vinther, M., 2002. Multi Species Virtual Population Analysis for assessment of marine mammals and fisheries interactions. IWC/SC/J02/, vol: FW13, pages: 1-8, 2002. Presented at: 54th Annual Meeting, International Whaling Commission, Shimonoseki, Japan, May, 2002.

Vinther, M., Thomsen, L., Lewy, P., 1998. Specification and documentation of the 4M package containing multispecies, multi-fleet and multi-area models. Raport of ICES Study Group on Multispecies Model Implementation in the Baltic, pages: 65, 1998, ICES, Copenhagen.

von Bertalanffy, L.,1938. A quantitative theory of organic growth (Inquiries on growth laws II). Human Biology, 10: 181-213.

Voss, R., Hinrichsen, H-H., Quaas, M. F., Schmidt, J. O., and Tahvonen, O. 2011. Temperature change and Baltic sprat: from observations to ecological–economic modelling. ICES Journal of Marine Science, 68: 1244–1256.

Voss, R., Köster, F., Dickmann, M., 2003. Comparing the feeding habits of co-occurring sprat (Sprattus sprattus) and cod (Gadus morhua) larvae in the Bornholm Basin, Baltic Sea Fisheries Research, Vol: 63, Issue 1: 97-111.

Wasmund, N., and Uhlig, S., 2003. Phytoplankton trends in the Baltic Sea. ICES Journal of Marine Science, 60:177-186. DOI: 10.1016/s1054-3139(02)002801.

Witek, Z., 1995. Biological production and its utilisation within a Marine ecosystem in The Western Gdansk Basin. Sea Fisheries Institute, Gdynia, Poland. ISBN 83-902432-3-7, pp. 145 (In Polish).

Wulff, F. 1990. Large-scale environmental effects and ecological processes in the Baltic Sea : research programme for the period 1990-1995 and background documents. Rapport /Naturvård