ICES WKHIST REPORT 2008

ICES Resource Management Committee

ICES CM 2008/RMC:04

Report of the Workshop on historical data on fisheries and fish (WKHIST)

11–15 August 2008

ICES Headquarters, Copenhagen,

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

There is growing interest in the discovery, recovery, digitization and analysis of historical data on fish and fisheries which are expected to give insight in long-term trends in the ecosystems that have been exploited by humans. Historical data can refer to catches, survey information, catch rates, length and/or age compositions, tax records and even menu-cards of restaurants. An important impetus to the historical work has been provided by the History of Marine Animal Populations (HMAP) project (2000–2010) that is funded under the Census of Marine Life.

ICES has hosted the workshop on historical data on fisheries and fish [WKHIST] in an attempt to provide links between the marine environmental history community and the marine science community. The workshop took place at ICES Headquarters, Copenhagen from 11–15 August 2008 and was attended by 14 scientists from different disciplinary backgrounds.

During the workshop an inventory was compiled of all the historical information that has been identified in locations like national and city-archives, libraries of marine science organizations and zoological musea (see: *WKHIST 2008 data inventory.xls*). Some of the data sources have already been transcribed and results were presented on the content analyses of the information. Four examples of the case studies are summarized below:

1. *Northwest Atlantic: 1850s Cod Biomass Estimate on the Scotian Shelf.* This project estimated the adult cod biomass on the Scotian Shelf in 1852 by extracting daily catch records from the logbooks of 236 American fishing vessels. The total removals of cod for the Scotian Shelf were approximately 200,000 tonne per year or altogether 1.6 million over 8 years (1852–1859). The Chapman-Delury method was used with the total removals and the Catch Per Unit Effort (cpue) to derive an adult cod biomass estimate of **1.26 million tonne** (Figure 1) which is in stark contrast to the average annual biomass estimate of **50 000 tonne** in the 1990s. The results of this study were published in the journal *Frontiers in Ecology and the Environment* (Rosenberg *et al.*, March 2005).

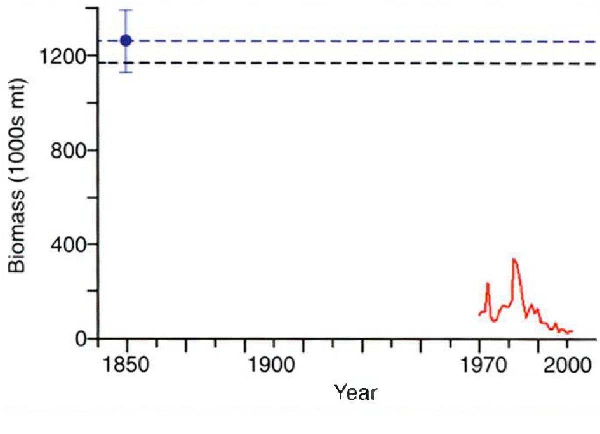


Figure 1. Historical estimate of Cod Biomass on the Scotian Shelf.

2. *Baltic cod: historical extension of time-series to early 20th century.* Major changes have occurred in the Baltic ecosystem and intensified over multi-annual and multidecadal time-scales: reduction in marine mammal predators, eutrophication, increased fishing pressure and changes in hydrographic conditions that affect cod recruitment. The analysis indicates that the fishery over the 20th century has demonstrated an expan-

sion to offshore areas. In the beginning of the 20th century, catches were low and mostly confined to coastal areas. Average stock size (SSB) has been around 100–250 thousand tonnes during the century except for the period between 1975–1990.

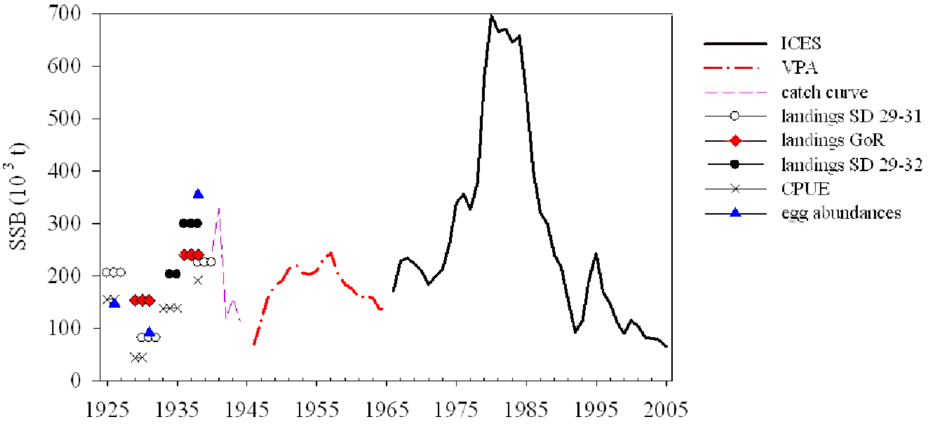


Figure 2. Long-term series of Baltic cod abundance (SSB).

3. North Sea herring: differences in fishing power between North Sea herring fishing vessels from the 16th – 20th century. The analysis is based on a time-series from Dutch fishing vessels catching herring with driftnets in the North Sea from 1604–1966. Until 1875 the Dutch herring fisheries were still operating a fleet of hoeker type vessels using driftnets made of hemp. The hoeker was very similar to a Dutch 15th century fishing vessel. From 1866 the hoeker was gradually replaced by the faster logger whereas cotton became the preferred fabric for driftnets. Sailing luggers were in use until 1929, whereas steam (from 1892) and motor propulsion (from 1901). The analysis suggests that the fishing power increased more than twenty-fold over the period. However, the relative cpue in hoeker-units (Figure 2) suggests that the relative stock abundance of herring was ten times higher in the 1600s than in the 1950s, and that by the 1800s it had already dropped to 50–60% of the level of the 1600s.

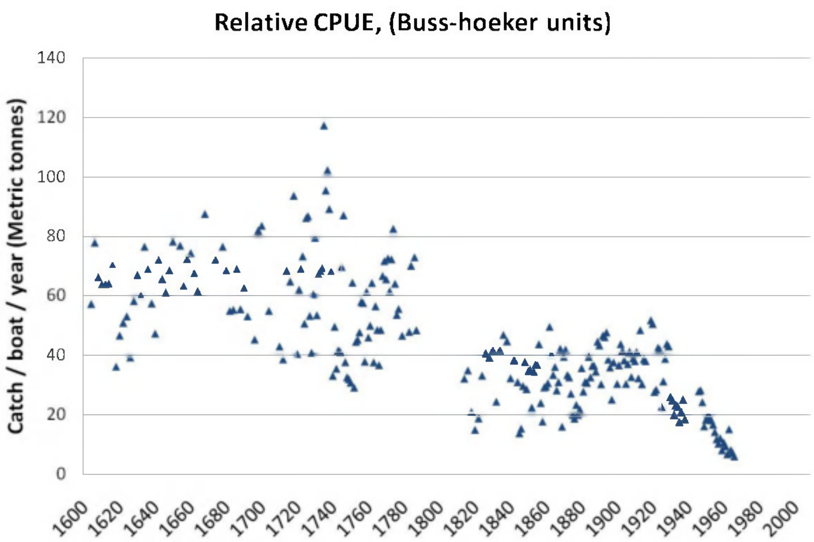
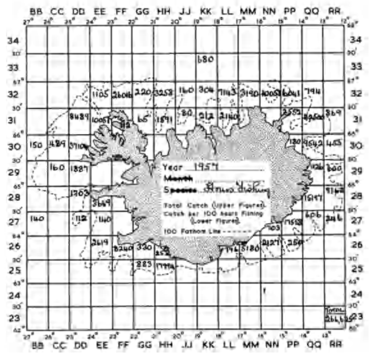


Figure 3. Long-term series of catch rates in Dutch herring fisheries.



4. *Statistical charts from England* An extensive series of historical Defra 'Statistical Charts' have recently been documented and catalogued. The charts provide detailed information on locations of catches landed by British fishing vessels for over 60 years (1913–81 except war years). Each chart given information on catches, effort and catch rates by rectangle. In total 2922 annual charts and 34 416 monthly charts have been catalogued. Cefas staff is now in the process of digitizing the annual charts. These charts provide a rich data source for analysing long term, spatial changes in fish stocks and fisheries, including possible effects of environmental and anthropogenic factors.

The inventory has also highlighted that many historical data sources have not yet been digitized. These include for example long series (e.g. 1910–1960) of vessel logbooks of fishermen with day by day reporting of catch, effort and location and many statistical tables from the period of the beginning of marine science.

The workshop concluded that there is a high urgency to recover the historical information. At present, the scientific community seems to be losing valuable information at a higher pace than we are collecting new information. The workshop therefore recommended a series of dedicated data recovery projects and regional projects to analyse the long-term trends in e.g. the North Sea, the Baltic Sea, Icelandic waters, the Mediterranean and the Northwest Atlantic. The workshop also recommends setting up an ICES Study Group on the history of fish and fisheries (SGHIST) which should inter alia initiate studies on the history of fishing technologies and fishing power and carry out cross-regional comparisons historical analyses.

WKHIST proposes that a theme session should be convened at the ICES Annual Science Conference in 2010 with the topic: "Linking the history to the present: understanding the history of fish, fisheries and management."

During the period 26–28 May 2009 a large conference will be organized in Vancouver, Canada under the title "Oceans Past II" (http://hmapcoml.org/oceanspast). It is anticipated that many historical studies that have been completed today will be presented at that conference. The workshop suggests that as a follow-up, ICES could organize a theme session at the ICES ASC 2010 and bring many of the historical studies directly to the attention of the ICES scientific community and thereby improve the understanding of the long-term dynamics of marine ecosystems.

1 Introduction

1.1 Background

There is growing interest in historical data on fish and fisheries. The interest is on the discovery, recovery, digitization and analysis of historical data. The analysis of historical data is expected to give insight in long-term historical trends in fish stocks and fisheries, which can be related to long-term changes in environmental indicators.

Historical data on fish and fisheries can refer to information on catches, survey information, catch rates, length and/or age compositions, tax records and any other sources that can provide information of stock dynamics before 1960.

The work will link to the History of Marine Animal Populations project that is funded under the Census of Marine Life and which aims to discover historical data sources. Several fisheries research institutes in Europe have started to make inventories of historical information.

ICES has hosted the workshop on historical data on fisheries and fish [WKHIST] in an attempt to provide links between the marine environmental history community and the marine science community. The workshop took place at ICES Headquarters, Copenhagen from 11–15 August 2008 and was attended by 14 scientists from different disciplinary backgrounds.

1.2 Terms of reference

The **Workshop on historical data on fisheries and fish** [WKHIST] (Co-Chairs: Martin Pastoors*, The Netherlands, and Bo Poulsen*, Denmark) will meet at ICES Headquarters, Copenhagen, Denmark, from 11 August 2008 (13:00) until 15 August (13:00) to:

a) compile an inventory of historical data on marine fisheries and fish stocks and the status of the data (paper, reference, digitized). The historical data should focus on the period 1850–1960 but earlier data should also be included;

b) compile and develop methods for estimating changes in technical efficiency in historical fisheries;

c) develop a workplan for case studies on historical stock dynamics in the ICES area and link this to overall changes in the environment.

WKHIST will report by 10 September 2008 for the attention of the Resource Management Committee.

1.3 Structure of the report

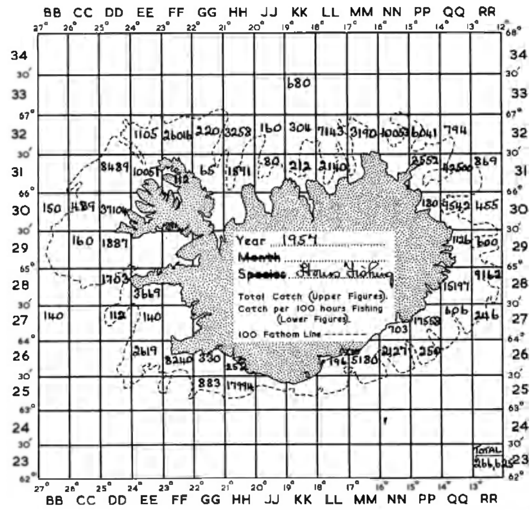
Section 2 contains a brief summary of the presentations that were presented to WKHIST. Section 3 deals with ToR a (inventory of historical data), Section 4 with ToR b (methods for analysing historical data) and Section 5 deals with ToR c (workplan for future work).

2 Abstracts of presentations

George Engelhard:

British historical catch and effort charts by rectangle (1913–1981 except war years) and digital extension to present

This presentation introduced the extensive series of historical Defra 'Statistical Charts' that have recently been documented and catalogued (see Engelhard 2005). The charts provide detailed information on locations of catches landed by British fishing vessels. For over 60 years (1913–81 except war years), these charts were produced by the Directorate of Fisheries Research, now Cefas, in Lowestoft where they are also currently held. Each chart displays, for a specific region, fleet component, and fish species, (1) the total quantity of fish landed in England and Wales and/or Scotland; (2) the catch rate per 100 hours of fishing; and/or (3) the number of hours fishing. These statistics are shown for each ICES rectangle (1° longitude by 30′ latitude) and combined for the entire region. The charts display either monthly or annual statistics, and comprise of 2922 annual charts and 34 416 monthly charts. Regions and periods covered include: North Sea (1913–81 excluding both world wars), Iceland (1952–73), Faroe (1946–80), West of Scotland and Rockall (1955–81), West of Ireland and Channels (1972–81). The majority of charts focus on demersal landings; from 1977–81, pelagic landings are also provided. The most complete region- and fleet-specific time-series is that on 'first-class steam trawlers' in the North Sea (1913–1976). The above-mentioned catalogue provides detailed information on the temporal, regional, species and fleet coverage of the 'Statistical Charts' and is available online (www.cefas.co.uk/publications/scientific-series/technical-reports/technical-report-128.aspx), with a searchable online metadatabase. Cefas staff is now in the process of digitizing annual charts, which at the time of writing has been achieved for trawl effort and catches of 3 commercially important demersal species in the North Sea. Combined, these charts provide a rich data source for analysing long term, spatial changes in fish stocks and fisheries, including possible effects of environmental and anthropogenic factors.



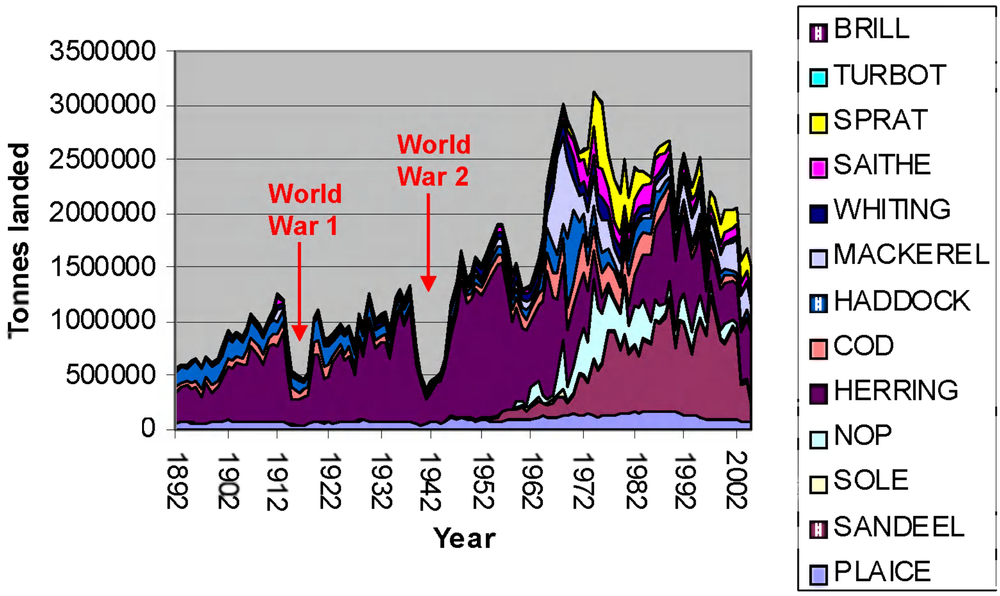
John K Pinnegar, Georg Engelhard and Steve Mackinson:

Online fish stomach database (1894–1915, DAPSTOM)

In recent years considerable emphasis has been placed on finding 'ecosystem-based' approaches to fisheries management and multispecies models are seen as crucial to addressing this new agenda. However, there are currently, very few long-term datasets within the European context available for parameterising such models. Cefas scientists have collected almost 100 years worth of fish stomach content data, from the seas around the UK (North Sea, Irish Sea, and Celtic Sea). Much of these data is now available in electronic form, through the DAPSTOM data portal (www.cefas.co.uk/dapstom) The DAPSTOM project was initially financed through the 'data rescue' fund of the EU Network of Excellence "EUROCEANS". The online database contains information (103927 records) on 82 predator species (most of those occurring in northern European groundfish surveys) and can be searched by predator name or by prey name for given sea areas and years. The online version (Version 1.5) of the database currently contains information from 73 individual research cruises, spanning the 38 year period between 1968 and 2006. However, recent efforts have been made to digitize older data (1903–1909) from the research cruises of RV Huxley (as part of a forthcoming ICES CM paper). Information was collected on the 'food of fishes' on many of the earliest cruises, and some of these data has been published by Todd in 1905 and 1907. Initial analyses have revealed that species such as cod, grey gurnard and whiting previously consumed far fewer fish than has been the case in recent years, concentrating on decapod crustaceans rather than species such as sandeels. Sandeels are currently viewed as a keystone prey resource within the North Sea, sustaining many fish, seabird and mammal species. However, the evidence would seem to suggest that they may have been much less important in the past and perhaps less abundant, with some authors indicating that their populations may have expanded from relatively low levels in the late 1960s associated with the decline of herring and mackerel (Andersen and Ursin 1977; Cushing 1980). A similar conclusion was reached by Jones (1954) based on stomach content data from eastern Scotland.

Fishery catch data (ICES catches from 1892 – present): reconstructing a time-series of international landings for the North Sea.

ICES collates fisheries catch data for all nations fishing in the North Sea (DK, UK, NO, NE, GE, FR, BE, SW), and makes this information available in electronic form through 'Fishstat' (1973–2005). Prior to 'Fishstat' (1903–1972) these data were available in paper form, as the annually produced publication Bulletin Statistique. Effort is currently underway (within ICES) to digitize this information and to produce a 'standard' time-series of fisheries catches for the ICES region (see contribution by Hans Lassen below). In the meantime Cefas scientists have been working with their own version of the dataseries digitized in collaboration with the University of British Columbia and extending backwards to 1892. As well as the data contained in Bulletin Statistique, Kyle (1905) provided international fisheries data for the period 1892–1902, but only for certain key species (plaice, sole, turbot, brill, herring, haddock, cod). For other species (mackerel, sprat, saithe, whiting, ling, tusk, halibut, skates) Hoek and Kyle (1905) collated data from England, Scotland, Netherlands and Germany, but these have been supplemented with additional Scottish and English data because these two nations dominated North Sea trawl fisheries at this time.

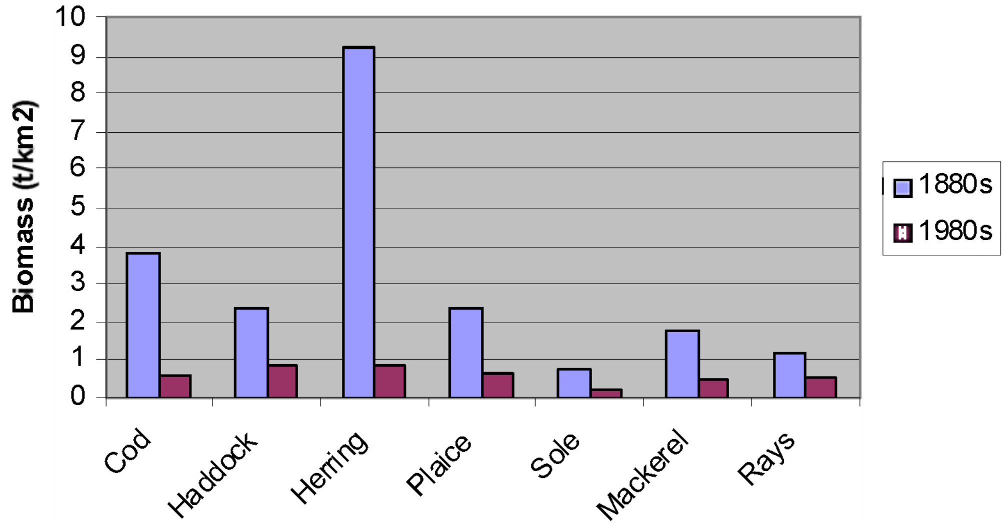


Total international catches from the North Sea, spanning 1892–2005. Herring was the most important species in the North Sea until the 1970s when the fishery was closed and the stock collapsed. Industrial fisheries for sandeel, Norway pout, mackerel and sprat primarily developed in the 1960s and 1970s.

Recreating 114 years in the North Sea using Ecopath and Ecosim

Ecopath is a foodweb model, and includes all system fluxes from detritus and bacteria up to seals and whales. Ecosim' is a time-dynamic version of Ecopath and can be used to simulate the wider ecosystem impacts of different fishing practices and to search for optimal management strategies (from an ecological or economic perspective). Ecosim can be 'tuned' to fit long-term time-series data or 'forced' using assumptions about climatic conditions and this methodology has come to be known as the 'Back to the Future' approach, whereby a model is constructed to represent a period in the past then projected forward in time using time-series data to try to explain how events may have unfolded, prior to the current situation.

Mackinson (2001) attempted to explore what the structure of the North Sea ecosystem may have looked like prior to the development of industrialized fisheries. He constructed a model for the period immediately prior to the arrival of the first British steam trawlers, Zodiac and Aries in 1881. Every effort has been made to derive historical information for parameterisation of the 1880s model and the sources are fully documented in a UBC Fisheries Centre Research Report, which can be downloaded from the Internet (www.fisheries.ubc.ca/archive/publications/reports/fcrr.php). This report lists many contemporary sources and available dataseries including the number of sailing herring drifters and their cpue in the North Sea spanning 1818–1900. Initial comparisons between the 1880s model of Mackinson (2001) and a more recent model for the same geographic area by Christensen (1995) revealed that all commercial fish species were much more abundant in the 1880s compared to the 1980s (Figure 6), and also that Fishing mortality (F) was much higher in the 1980s compared to the 1880s when predation (M2) was the dominant cause of mortality.



Comparison of biomass estimates for key commercial fish species in the North Sea in the 1880s and the 1980s (based on Mackinson 2001).

UK catch data for fish transported on the railways 1879–1902).

Before detailed fishery landings statistics were collected for the UK, the government published information on the quantities of fish transported inland by railway. This practice continued even after the onset of more rigorous data collection, and it finally ceased in 1902. Data are organized by railway company (e.g. Great Western, North Eastern etc.) and by port, and this includes separately aggregated information from Ireland and Scotland. An overview of the data clearly shows the expansion of the railway network at this time, which grew to encompass nearly every port in the UK. The railway network subsequently declined to a smaller number of ports following the British Government's attempt in the 1960s to reduce the running costs of the nationalised railways. Scanned images of the reports are available on the website of the UK Marine & Fisheries Agency (www.mfa.gov.uk/statistics/ukseafish-arch-historical.htm#1890) and some of the information has been digitized by Cefas staff as part of EU Framework 6 project 'Incofish' (www.hull.ac.uk/incofish/DataStore/DataStore.htm#62). One important finding from looking at these data is that the tonnage of finfish transported in 1902 (473274 metric tonnes) was 3½ times that landed at English and Welsh ports in 2002 (128300 metric tonnes). At this time, the UK fishing fleet caught by far the greatest proportion of fish from the North and Irish Seas (up to 80%), but in subsequent years other European countries began fishing and the UK share of total international landings declined. A comparison of the reported landings at UK ports (1886–1902) with the quantity transported inland by railway has revealed that the vast majority of fish being landed into the UK was subsequently moved by railway to inland towns and cities (e.g. via Billingsgate market in London).

Einar Hjorleifsson:

A brief and incomplete overview of the fisheries data archives available in Iceland.

An overview of fisheries data in the 20th century and before the 20th century was presented both from Icelandic sources and from UK, Dutch and Danish sources. For more information in Section 3.3.

Margit Eero, Fritz Köster, Brian MacKenzie:

The eastern Baltic cod: reconstruction of stock dynamics and exploitation history back to 1925.

The stock development and exploitation intensity of the eastern Baltic cod are available from ICES assessments since 1966. Major changes have occurred in the Baltic ecosystem and intensified over multi-annual and multidecadal time-scales. These include reduction in marine mammal predators, eutrophication and increased fishing. Additionally, hydrographic conditions influencing cod recruitment have varied widely during the 20th century. Due to shortness of time-series of stock dynamics available from ICES assessment it is difficult to resolve the relative impacts of these different human and natural drivers on long-term dynamics of the cod population. This has motivated compilation of historical materials in order to extend the knowledge of dynamics of the eastern Baltic cod stock in the 20th century.

For the period 1946–1965 data on catch-at-age, individual weight and cpue were compiled from various literature sources and fisheries institutes around the Baltic and the standard VPA-based assessment was extended backwards for 20 more years than available from ICES. For the period 1925–1944, multiple analysis using different types of data (length composition of catches, catch rates, egg abundances, spatial distribution of catches) were conducted in order to provide estimates of stock size and fishing mortality in this period. The results from different analyses were consistent. The relative stock dynamics in this period was additionally validated with data on cod landings by different countries, share of cod in landings and in fisheries revenue and information on prices of commercial fish. The extended time-series of stock dynamics and exploitation intensity provide important information for resolving the relative impacts of key forcing factors, i.e. climate, fishing, marine mammal predation, eutrophication, on long-term dynamics of the eastern Baltic cod.

Emily Klein:

Historical (1870s – 2006) Atlantic herring fishery in the Gulf of Maine

This paper involves utilizing time-series analysis to address fisheries over an extended time period, specifically addressing the Gulf of Maine (GOM) Atlantic herring (*Clupea harengus*) fishery for 1871–2007. Initially, data were collected from various archives and libraries, and the resulting data were from various sources. These disparate datasets needed to be combined for a complete time-series before analysis could be carried out. The main obstacle was merging the various herring products reported by Canada into a common weight unit (the pound). Many different products were reported in the statistics (14), and in the qualitative literature (14). Further, these products were not reported consistently and the units for them changed in time, as well. Reports may list eight products in one year, but only four the next, in addition to the units changing for a single product (e.g. from "in cans" to "cwt"). To address this problem, factors for converting these products from the various units to the pound were found in the qualitative literature. These conversion factors allowed for complete dataseries, beginning in 1871 for Canada and 1880 for Maine.

In addition, I developed a time line of events from the qualitative literature that may possibly have an impact on the herring fishery through time. Visual examination compared this time line to a time plot of the herring fishery for possible exhibited impacts in the series. Once time-series were constructed, underlying long-term patterns were investigated using time-series analysis. This statistical approach identifies the consistent pattern in a time-series, which were determined for both the Maine and

Canadian herring fisheries. From here, intervention analysis identified the outliers in this pattern, and these were compared with events in the qualitative time line. Cross-correlation was used to analyze some oceanographic data (SST and salinity) in concert with the herring fishery over time for possible relationships.

Stefan Claeson:

Historical fishing grounds atlas and GIS database for HMAP

This presentation reviews the development and database structure of a global atlas of historical fishing grounds for the History of Marine Animal Populations (HMAP) Program. The goal of this mapping project is to identify areas of historical human-environment interactions and assess the cumulative impact of fishing upon these areas or marine ecosystems. A survey has been designed specifically to solicit the knowledge and expert opinion of leading researchers from HMAP projects. The survey requests that researchers identify, map and characterize historical fishing areas, and describe changes in the conditions and trends in resource exploitation based on quantitative or qualitative historical data. This information will be used to make inter- and intra-regional comparisons, map the spread of fishing technologies, identify patterns of behaviour in human-environment interactions, and analyze the long-term resilience of specific marine species and ecosystems to fishing pressures.

Giacomo Chato Osio and Francesco Ferretti:

Historical fisheries data in the Mediterranean Sea

This presentation overviews the current status of Mediterranean marine resources, explores the availability of historical data, methodologies and some preliminary results.

The Mediterranean Sea consists of 21 neighbouring countries, of these, five are EU member States and occupy a third of the Mediterranean coastline. Currently there are no long time-series of estimated biomass of single-stocks, and stock assessment is still a rare occurrence. Full assessments have been made only for a few important commercial species, mostly over small geographic areas. Most of the assessed stock appears to be overexploited but often to an unknown extent as there is no historical reference points. An analysis of trends in pelagic sharks has revealled that Hammerhead (*Sphyrna* spp.), blue (*Prionace glauca*), mackerel (*Isurus oxyrinchus* and *Lamna nasus*), and thresher sharks (*Alopias vulpinus*) declined between 96 and 99.99% relative to their former abundance (Ferretti etal.2008).

Fisheries from the Romans to the middle Ages were carried out from the beach, along the shoreline or on marshes and lagoons. Since the 16th century, the fishery, a small-scale artisanal fishery, with the exception of the bluefin tuna fishery, was targeting pelagic species and coastal and shallow demersal fish. Two important technological developments around this time were first the introduction of pelagic gear like the "Sardinal", an early version of purse-seine for small pelagics in the 16th century, and the invention of trawl gear by the Catalans and Neapolitans at the end of the 17th century. The first steam trawlers appeared in Algeria around 1880 and in Italy in 1920. After WWII almost all trawlers were equipped with motor engines and ever since the HP has been increasing. Available data sources to reconstruct the evolution of the fishing effort are presented and are being digitized and tabulated.

Historical landings data is being gathered in order to reconstruct trends and to build commercial cpues by scaling landings with fishing effort.

Trawl survey data can be an important data source to assess trends in biomass indices, biodiversity and spatial distribution of stocks. There are however multiple methodological challenges as a result of gear change across surveys and consequent potential change in catchability. Statistical methods such as generalized linear models and state space models are proposed as appropriate analytical tools for these types of historical data. An inventory of historical trawl survey data is presented for the period 1948–present and preliminary survey cpues are discussed for the Adriatic Sea.

Hans Lassen:

ICES digitized catch information

Currently the catch statistics database maintained by ICES and Eurostat contains time-series of data from 1973. However there is considerable interest from fishery managers, scientists, environmentalists and others in extending the time-series to include data for earlier years.

ICES was founded in 1902 and from very early has been collecting catch statistics from the national authorities. These data have been published in volumes of the Bulletins Statistiques des Pêches maritimes (more recently renamed Fishery Statistics Yearbook – but now discontinued). Thus the raw material appropriate to extend the catch database is available.

In 2001 ICES and Eurostat signed a Partnership Agreement involving, inter alia, cooperation in the collection, processing and publication of catch statistics. Eurostat became responsible for the processing of the current data and for maintaining the database of catch statistics. The Partnership Agreement also foresaw cooperation between the two organizations in projects of mutual interest and it was agreed that the extension of the catch database should be the first of such projects. Particular urgency was attributed to this project because the two officials in the secretariats with a long experience of processing catch statistics were approaching the end of their careers with the subsequent fear of loss of institutional knowledge.

The reconstruction has been taken in two steps. The initial step is to recover the data for the period 1950 – 1972. This would result in a database covering the same period as that maintained by FAO. The reconstruction has now been sent to the national respondents and has been agreed upon.

The second stage is to reconstruct the period 1903–1949. This step is currently ongoing. It is expected that the draft reconstruction can be sent to the national respondents for approval by the end of 2008.

Bo Poulsen:

Status of HMAP and other current research programmes on historical marine ecology.

The History of Marine Animal Populations (HMAP) (http://hmapcoml.org/) sponsored by the A.P. Sloan Foundation is a global research initiative initiated in 2000 and scheduled to end in 2010. HMAP aims at studying the past ocean life and human interaction with the sea. Within HMAP 12 regional focus areas and 4 global/intercontinental projects have been studied by some 100 researchers. We analyze marine population data before and after human impacts on the ocean became significant with the goal of enhancing knowledge and understanding of how the diversity, distribution and abundance of marine life in the World's oceans changes over the long term. This is now often referred to as the "HMAP approach" to studies of marine life, past and present. Other significant contributions in this direction include the EU project, INCOFISH (2005–2008) http://www.hull.ac.uk/incofish/index.htm, with an emphasis on addressing the challenge of shifting baselines and the Canadian led Sea Around Us project http://www.seaaroundus.org/ which has an historical component digitizing historical expeditions and surveys. The European network of excellence, MarBEF also features historical aspects of fish and fisheries studies, http://www.marbef.org/. All projects seek to develop large-scale databases of historical relationship between ocean life and human society, and HMAP as well as INCOFISH data is archived at the University of Hull in England. The target for 2010 is to reach 1 million records.

Within the community of historical research a Dutch led consortium, REDS, recently received a large grant from the Dutch Science Foundation for the purpose of digitizing the Sound Toll Registers (1497–1857) containing information on cargos on all ship passages between the North Sea and the Baltic Sea. When realized this will be a gem of information for historical ecology and environmental investigations.

Bo Poulsen:

Measuring fishing power: What is the difference in fishing power between North Sea fishing vessels from the 16th – 20th century?

In literature on fisheries history it is a standard observation that because of the nature of the technology employed, pre-industrial fisheries did not have a decisive impact on the fishing resource. Similarly it is a trivial observation that modern fisheries have large and severe impacts on the World's marine resources. But, what is actually the difference in catching power between fishing vessels of the pre-industrial and industrial era? Early 20th century scientist, Garstang claimed that the catching power of a steam vessel was four times that of a sailing vessel.

This paper analyses time-series from Dutch fishing vessels catching herring with driftnets in the North Sea from 1604–1966. Until 1875 the Dutch herring fisheries were still operating a fleet of hoeker type vessels using driftnets made of hemp. The hoeker was very similar to a Dutch 15th century fishing vessel. From 1866 the hoeker was gradually replaced by the faster logger, of French origin, whereas cotton became the preferred fabric for driftnets. Sailing luggers were in use until 1929, after steam propulsion had been introduced in 1892 and motor propulsion in 1901. This means that each period with overlaps between older and newer types of vessels offers an opportunity to compare the relative cpue between the different vessel types. The findings suggest that the fishing power increased more than twenty-fold over the course of the period in question. However, long-term changes in the relative cpue when expressed in hoeker-units suggest that in the 1600s the relative stock abundance of herring was ten times higher than in the 1950s, and that already by the 1800s it had dropped to 50–60% of its level in the 1600s.

George Engelhard:

120 years of changes in fishing power of English North Sea trawlers.

This presentation gives an overview of the historical development of English trawlers in the North Sea and includes an attempt to quantify how their fishing power has changed over the past 120 years. Fishing power expresses how vessels differ in the quantity of fish they would catch per unit time if they were to fish at the same time and location, and it is well known that with 'technological creep', fishing power has tended to improve over time. Typically, fishing power studies are limited to comparisons over 1–2 decades, and this was the first time such a trend was quantified over a 120-year time-span. A review of fishing history reveals how sailing trawlers, steam trawlers, and currently both motor otter trawlers and twin beam trawlers have in turn dominated the trawl fisheries. A huge, overall increase in fishing power has indeed occurred, but the trend has been all but linear: fishing power has sometimes "leaped" forward within a few years (most dramatically when the steam trawler was introduced), but at times has also stagnated for decades (partly as a result of both World Wars when many trawlers including the best ones, were taken out of the fishing fleet to serve as minesweepers). Compared to historical sailing trawlers, motor otter trawlers around the Millennium are estimated to have 50 times higher cod fishing power, and twin beam trawlers to have 100 times higher plaice fishing power. But this does not mean that fisheries have become more profitable, because increases in catch rates have lagged far behind those in fishing power, and all points in the direction of heavy overcapacity of the current international North Sea trawling fleet.

Irene Mantzouni and Brian R. MacKenzie:

Possible linkages between historical reconstruction and meta-analysis Metadata analysis

The aim of this presentation is to illustrate the potency of meta-analytic approaches regarding the analysis of fisheries data, and to explore possible ways in which the methods can be applied in historical reconstruction. To this end, we present the application of hierarchical (mixed models and Bayesian inference) models for the study and integration of temperature and habitat size effects on the parameters of the N Atlantic cod stock-recruit models. The method offers various advantages and can be especially useful with fisheries data which are usually limited and characterized by high variability. The productivity parameters depend on both species traits, which are common across stocks, and also on the ecosystem conditions experienced by individual populations. These across stocks relationships in the parameters can be integrated in the hierarchical model structure and thus "strength is borrowed" across stocks. The insights provided can elaborate the parameterization and standardization of historical data analysis models, in particular when the information required cannot be readily extracted from the existing sources. Conversely, meta-analyzing current knowledge of stock dynamics under climatic forcing together with the historical data becoming increasingly available will provide an integrated view of the marine ecosystems.

Catherine Marzin:

Application of historical data for management

This is an overview of ongoing research on the historical ecology of sanctuaries, specifically at Stellwagen Bank and the Florida Keys national marine sanctuaries, and the management applications for such research. Current historical ecology efforts at the sanctuaries involve gathering and analyzing historical fisheries and marine ecology documents and apply population dynamics models on the data in order to assess environmental change from the perspective of living marine resources. Such historical analyses expand our understanding of the extent of changes experienced by the marine environment. They have the potential of alleviate the effect of the "shifting baseline syndrome", by providing estimates of past ecological conditions such as historical baseline biomass and biodiversity. For an agency like NOAA's Office of the

National Marine Sanctuaries, historical analyses have implications to management by expanding the overall understanding of marine ecosystems.

The mission of the marine sanctuaries is to serve as the trustee for the nation's system of marine protected areas, to conserve, protect, and enhance their biodiversity, ecological integrity and cultural legacy. Yet, while there are currently efforts to characterize these varied ecosystems, little is known about the early state of the sanctuaries. By the time the sanctuaries were established, their original marine ecosystem had already been impacted by various human activities. And the problem is compounded by the fact that most changes have been unnoticed because of the creeping effect of the "shifting baseline syndrome". In order to succeed in its mission, and set realistic restoration targets, it is imperative that sanctuary managers are provided with the best scientific estimates of baselines for ecological indicators, and with the underlying causes for the change from these baselines.

Dave Reid and Norman Graham:

Gear characteristics and fishing power

Most previous work has treated gear type and to some extent, effort, in very general terms and restricted consideration of gear to a few generic categories, e.g. otter and beam trawls. SG-GEM considered that effort should be based on actual effective effort i.e. swept-area, and that this should consider the characteristics of the gear and its deployment and be as detailed in time and space as possible. The implications of this in a historical context are that care is needed when interpreting historical cpue and LPUE data. Changes in vessel characteristics over time e.g. size and power may not necessarily result in scaled increases in LPUE of the same magnitude. An example was presented from Scottish work. This revealed that the size of gear in the Scottish otter trawl fleets was largely unrelated to the power of the vessel towing the gear. While this is probably not true for all fisheries or even this fishery historically, it does show that it is important not to make assumptions about the geaRVessel size relationship. Detailed information on gear deployed is only available in restricted cases, these should be catalogued and analyses carried out where possible.

3 Inventory of historical data (ToR a)

The inventory of historical data is contained in the spreadsheet *WKHIST 2008 data inventory.xls* which is available on the WKHIST Internet page.

3.1 North Sea

The North Sea has been harvested for fish since at least 1000 AD. Ongoing project, Fish Bones http://hmapcoml.org/projects/fishbone/ is investigating the time of arrival and spread of sea fishing using a variety of analyses on archaeological records such as fish bones, human bones and fishing gear. However, after ca. 15–1600 AD it becomes possible to use historical evidence of fishery fluctuations that can be derived from commercial data. Written testimonies exist to construct time-series of fish landings, exports, numbers of vessels and market prices. This means that fish, which for centuries have been of commercial interest, feature prominently in many archives. Especially for cod, salmon, sardines, anchovy and herring then, historical evidence of historical variability in fisheries and fish populations do exist for the North Sea. Some of this variability has been linked to climatic variability. Further recovery of historical data from archives and museums can potentially provide rich sources of information for documenting fish and fisheries and for identifying the reasons for these variations as well as estimates of total removals, spatial distribution and cpue.

In 2002 the HMAP project held a North Sea history workshop, with papers on various possibilities of North Sea data recovery. A summary is available here: http://hmapcoml.org/projects/northsea/documents/NSworkshoprep.pdf Since 2002 several efforts have increased our understanding of the historical ecology and fisheries history of the North Sea and led to the digitization of several important time-series and snapshots. The present status in 2008 therefore consists of the following:

Total North Sea herring

For herring total removals of herring 1600-present is currently being reconstructed by Bo Poulsen, Roskilde University, and the dataset will be available on the HMAP dataportal. With regards cpue (catch per boat per day at sea) for the Dutch driftnet herring fisheries have been reconstructed from 1600–1966 using landing testimonies, tax records and custom records from (Poulsen, 2008 and in prep.)

Denmark

Danish national fisheries statistics, *Fiskeriberetning*, exist in printed format from 1888–1977, and since 1991 in *Fiskeristatistisk Årbog*. For the years in between digitized data is available from the Danish central bureau of fisheries, Fiskeridirektoratet, http://fd.fvm.dk/Forside.aspx?ID=16432 . For the entire period information on landings, effort (no. vessels, gear, fishermen) and prices are available. With regards spatial distribution a number of fishermen's logbook are archived in the Fisheries and Maritime Museum, Esbjerg (www.fimus.dk), but their content remains to be investigated and none of the information contained in this material has yet been digitized.

A number of datasets preceding the advent of modern government statistics are available in digital format from the HMAP data portal. Going back to 1667, data from various Limfjord fisheries are available, concerning landings, effort, and cpue for herring, eel and whitefish fisheries. From 1865–1925 landings, prices and effort are digitized for multiple species targeted in the Limfjord. (http://www.hull.ac.uk/incofish/DataStore/DataStore.htm). From the Danish North Sea coast 17th century landings for whiting and plaice have been reconstructed using tax records (Holm and Bager, 2001).

Germany

Until the 1880s the German North Sea fishery was of minor relevance for the German economy, but from then on a deep-sea trawling fleet was built up supplemented by state-owned fishing port and state-operated fish auctions. In 1893 the German association of sea fisheries (Deutscher Seefischerverein) started to collect data on catch (divided by species) and fishing effort (days at sea). Since the late 1890s this series includes landings information. Port authorities collected catch data per ship since the 1890s including species, quantity and price. After 1918 annual reports ("blue books") are available in printed format until the present day. These include detailed information on the fishing fleet (registration number, technical standard and size of vessels), landings (species, quality, average price) and fishing effort by fishing area. After 1945 this series includes data on the economic situation of German fisheries and summaries of topics relating to fisheries research, fish processing and international fish trade. For the German North Sea fishery, all statistical material is available in printed format, for instance at the German Maritime Museum (http://www.deutsches-schiffahrtsmuseum.de/).

It remains to be investigated to what extent logbook information is available for commercial fishing vessels as well as survey vessels.

Great Britain

British Sea Fisheries Statistical Tables

These are long series of books published annually since 1887, containing extensive British fisheries statistics (usually for the year prior to publication of each volume). In fishing ports throughout Great Britain, detailed fisheries statistics have been collected by Ministry staff since the 1880s. For years prior to 1886 (and dating back to ~1855) there are also fisheries data, but these tend to be organized in much less consistent way. These include the fish transports inland by train as described above; and rich qualitative data in the form of interviews with fishermen of the time.

In England and Wales, the systematic data collection at fishing ports was first undertaken in 1886. The tabulated results of these for the period 1886–1964 were published as the annual series Sea Fisheries Statistical Tables—England and Wales (since 1965 incorporated in UK Sea Fisheries statistics) produced by Defra (Department of Environment, Food and Rural Affairs) and its predecessors MAF (Ministry of Agriculture and Fisheries) and MAFF (Ministry of Agriculture, Fisheries and Food). There is a slightly older time-series of tables for Scotland dating back to 1883, the Scottish Sea Fisheries Statistical Tables (now Scottish Sea Fisheries Statistics; in the first years under slightly different names). The Scottish series was produced by SEERAD (Scottish Executive Environmental Rural Affairs Department) and its predecessors SHD (Scottish Home Department) and DAFS (Department of Agriculture and Fisheries Scotland).

In the late 1800s, records tended to be confined only to the 16 'main' fish species landed and were organized by port or segment of coast. This collecting system was significantly improved in 1906, to include particulars of the fishing grounds visited and the number of day's absence from ports, as well as a much increased number of fish species. In 1913, information on the number of hours actually spent fishing was first collected as a more accurate measure of fishing effort than days absence. From 1906–19, origins of landings were ascribed to fairly broad depth-related regions in the North Sea; in 1920 the current system was adopted by which all landings are attributed to rectangles of 1° longitude by 30′ latitude (strictly: attributed to those rectangles where at least 70% of the landing was caught). In 1913, data on hours fished by rectangle could be collected for ~5% of the British North Sea steam trawler fleet; no such data were collected during WWI but by 1923 this information was achieved for virtually the entire steam trawl fleet. The Statistical Tables show the data at the spatially aggregated level of ICES Subarea or Division, or by fishing port. Data by rectangle are available in unpublished format as the so-called 'Statistical Charts' series (see below).

Great Britain prior to c. 1870: (for more information on this: Dr Robb Robinson, MHSC, Hull (R.N.Robinson@hull.ac.uk) and David J. Starkey, d.j.starkey@hull.ac.uk)

In addition to what is already digitized on the British herring fisheries, records are obtainable for offshore fisheries on common commercial species and the fishing fleet from archival sources. This means that they are either in a printed or manuscript format.

Until 1850 the Scottish fishery Board had a substantial remit in England in relation to the cod and herring fisheries. Around 1820 for example the Board had officers stationed at London, Bristol, Liverpool, Yarmouth, North Sunderland, St. Ives, and Whitehaven and on the Yorkshire Coast. Its surviving records from this period are useful but less substantial than for Scotland.

Data on the number of fishing vessels working from different ports is published from 1869 in the Annual returns of Trade and Navigation. Much more information on the offshore fishing fleet can be extracted from the Registers of Shipping compiled at each Customs Port from the late 1780s. Many registers have survived. Northway and Robinson demonstrated that it is possible to reconstitute fishing fleets from the data contained in these registers and from this it should be possible to make estimates about the level of British fishing effort being deployed in the offshore North Sea fisheries at various times during the nineteenth century. In the case of the Yorkshire Coast, for example, the offshore fleet can be reconstituted from the 1780s and a similar exercise or Hull is possible from the 1820s.

British Sea Fisheries Statistical charts:

An extensive series exists of over 37,000 historical 'Statistical Charts' with spatially detailed British fisheries statistics, held at the Centre for Environment, Fisheries and Aquaculture Science (Cefas), Lowestoft, UK. These charts provide annual and monthly data on landings, effort and cpue at a fine spatial scale for the period 1913–81 (excluding both world wars), for various components of the British commercial fishing fleet. These values are indicated separately for each ICES rectangle (1° longitude by 30′ latitude) as well as for the entire area charted (generally equivalent to ICES fishing areas; see Figure 1 for an example). The largest subset of charts covers the North Sea (both pre- and post-war years); smaller but still substantial subsets of charts cover the Faroe Grounds, Iceland, West of Scotland and Rockall, the Irish and Celtic Seas and English Channel (post-war years). The focus is on demersal fisheries, with only a small proportion of charts devoted to pelagic fisheries. The most complete region- and fleet-specific time-series is that on 'first-class steam trawlers' in the North Sea (1913–1976).

A catalogue of the charts was published as a Cefas technical report (Engelhard 2005), and is also available online (http://www.cefas.co.uk/publications/scientific-series/technical-reports/technical-report-128.aspx). This catalogue describes the temporal, regional, species and fleet coverage of the 'Statistical Charts'; outlining the history of each fishing fleet with focus on the periods and regions where charts are available. Reference is made to an online set of spreadsheets that may facilitate searching what material is available. Locating individual charts is made possible via reference numbers provided in both report and worksheets; these relate to numbered box files stored at CEFAS that contain the actual charts.

Combined, the 'Statistical Charts' provide consistent, standardized data over a considerable time-span, for Britain's former and current fishing grounds, covering an important portion of the fishing history of this nation. The charts provide a rich data source for analysing long-term, spatial changes in fish stocks and fisheries, including possible effects of environmental and anthropogenic factors. Importantly, the time-series can be extended into the present through the Fisheries Activity Database (FAD) of Defra, which is an electronic database, starting in 1982, of effort and landings into England and Wales by individual fishing trip (the historical data are aggregated by fleet).

British Research Surveys

In England, Cefas scientists and their predecessors in the Ministry of Agriculture, Fisheries & Food (MAFF) have been collecting information on fish abundance and movement patterns since the laboratory was first established in Lowestoft in 1903. In 1902 the steam trawler 'Huxley' was chartered by the Marine Biological Association, in order to carry out initial fishery investigations as a UK contribution under the fledgling International Council for the Exploration of the Seas (ICES) (Garstang, 1905). Scientific surveys have been conducted on an annual basis by UK research vessels ever since, and much of this information is still available in logbooks and published manuscripts from the time. In 2001 Goodwin *et al*. produced a catalogue of these logbooks and the accompanying station details, collating information on the geographic coverage, and the types of information contained within each document. This catalogue can be searched online (www.cefas.co.uk/publications/scientific-series/technical-reports/technical-report-112.aspx) and the storage location of the original paper sources is indicated.

Over the 100 year period many different research vessels have been utilized and there has not yet been a systematic effort to digitize all of the information available. However there have been attempts to compare fish abundance estimates from the earliest period (RV "Huxley", 1903–1909) with those of more recent years, e.g. Rogers and Ellis (2000), Rijnsdorp *et al*. (1996).

Rogers and Ellis (2000) examined catches from surveys in three areas around the British Isles (in 1901 to 1907) and compared these with survey catches in the same areas from 1989 to 1997. The authors found that the basic characteristics of the trawl gears were broadly comparable in the two periods, and they argued that it should be possible to use this information to describe changes in demersal fish assemblages over the last 80 years. In the southern North Sea, the authors found that fish populations became more diverse, as plaice *Pleuronectes platessa* and whiting *Merlangius merlangus* became less abundant, and the relative abundance of several non-target species such as dragonet *Callionymus* spp., bib *Trisopterus luscus*, and bull-rout *Myoxocephalus scorpius* increased. In addition, the proportions of larger teleosts (maximum body length >30 cm) in catches decreased in all regions during the time period, except in the Irish Sea where plaice replaced grey gurnard *Eutrigla gurnardus* as a dominant species.

In Start Bay (NW English Channel) and the Irish Sea, species diversity was the same in both periods, although the most abundant species in each period were not the same. There was a decline in abundance of large sharks, skates and rays, including the common skate, *Raja batis*, white skate *R. alba* and the angel shark Squatina squatina. During historical surveys, 60% of the elasmobranch fauna consisted of thornback ray *Raja clavata*, whereas in contemporary surveys the lesser spotted dogfish *Scyliorhinus canicula* was the most abundant elasmobranch. Changes in length–frequency distribution of fish in both target and non-target categories, and other observed changes, were thought to be a response to commercial exploitation, and corresponded to similar observations recorded elsewhere.

Rijnsdorp *et al*. (1996) also used data from the early cruises of RV Huxley but in addition, the authors utilized information from the Dutch research vessel RV 'Wodan'. A comparison of catch rates of demersal fish during beam trawl and otter trawl surveys carried out in the period 1990–1995 and 1906–1909 indicated lesser abundance in recent years for the total assemblage as well as for individual groups. There appear to have been shifts in the community associated with reduced diversity and evenness indices. Length-frequency distributions of roundfish and flatfish exhibited a marked shift towards smaller fish.

There have been no attempts to digitize survey information for the period spanning 1910 to 1970, although some research vessels operated in a consistent manner and in the same geographic region for many years. For example RV "George Bligh" operated continuously from 1923 to 1939, whereas the RV "Sir Lancelot" and the RV "Platessa" operated from 1946 to 1967. Most of the information available was collected in the North or Irish Seas, however the research vessel *Ernest Holt* was launched in 1949 (Graham *et al.,* 1954), and was specially designed to operate in the Arctic Ocean where it collected data from the area around Spitsbergen with occasional trips to Iceland and Greenland between the years 1949 and 1970.

The Netherlands

Snapshots of the spatial distribution of the Dutch herring fisheries have likewise been constructed from a variety of logbooks from c. 1700–1922. (Poulsen, 2008). The distribution of fishing effort from logbooks is a valid proxy for the spatial distribution of the herring as well.

Some of the oldest logbooks date from the 1850s and 1860s. In 1856 the director of the KNMI (Royal Netherlands Meteorological Institute), Buijs-Ballot wrote to all ship owners of the Dutch herring industry, and asked for their help with '…clarifying the optimal circumstances for fishing herring'. In order to underline the high quality and the credibility of the information found in these logbooks it is useful to note just how systematic and rigorous, this investigation was carried out.

The KNMI supplied the herring fishermen with standardized, pre-formatted booklets with an extremely detailed and carefully laid out questionnaire with space for 19 different types of information, many with several variables. Moreover, the layout facilitated that up to five logs per day could be noted down. In each log a note could be made on the exact position of the vessel, the depth at sea, and the type of bottom encountered, as well as a number of meteorological observations, such as the direction and speed of the wind and the weather situation in general.

In addition as something completely new, the KNMI willingly sponsored three state-of-the-art Celsius thermometers for each ship. All thermometers were tested before use and a remark on the deviation of each thermometer was written in the preamble of each ship's booklet, where an instruction on how to use the thermometers was also found. One thermometer was to be used for measuring air temperature; one was for the temperature of the sea surface, and the last one was lowered deeper down the water for measurement. All this information was asked for so it could be compared with information on the actual fishing. During days of fishing, it was possible to write down at what time in the evening the herring nets had been set out, as well as the hour of pulling them later in the morning. If the fishing had been successful the size of the catch, as well as the average size of the herring caught, were also marked, along with the quality of herring.

Today less than a handful of the annual reports still exist in Dutch libraries and museums and seemingly no use has been made of these during the last 140 years. Furthermore, these reports are the only trace of any research efforts based on the submitted logbooks, but fortunately many of the original booklets from the herring vessels remain deposited in the archive of the KNMI. 20 of the existing logbooks have been digitized for their information on temperature, catch and location and will be made available on the HMAP data portal (Poulsen 2008).

The further potential of recovering logbook material is very large. In the city archive of Vlaardingen alone, there are estimated 150–200 logbooks from the late 1800s onwards, which contain daily information on location, effort, catch and occasionally information on weather and fuel consumption.

Norway, Belgium, France

The potential of carrying out investigations of North Sea historical ecology with material from Norway, Belgium and France remains to be investigated.

3.2 Baltic Sea

Studies in fisheries history in the Baltic Sea have resulted in the compilation of several databases which cover different subregions of the Baltic Sea during different time-periods and are available through the HMAP-CoML database. Most comprehensive databases with data analysis and interpretations are available for the eastern Baltic cod population (since the 1880s). It is believed that most essential data-source for this fish since the late 19th century is studied and that the likelihood to obtain data that would result in substantial new information is low. The obtained data also indicate that historical information on the majority of fish species other than cod and herring before the mid-20th century is relatively scarce (Ojaveer *et al.*, 2007, Lajus *et al.*, 2007, Gaumiga *et al.*, 2007).

The ICES assessments for the three main fish species in the central Baltic, i.e. cod, herring and sprat, start from 1966 and 1974, respectively. For the eastern Baltic cod catch-at-age, individual weight and cpue data have been compiled from various national literature sources and fisheries institutes and the VPA-based assessment has recently been extended back to 1946 (Eero *et al.*, 2007). For the period 1925–1944, multiple analyses with consistent results on spawner biomass and fishing mortality of eastern Baltic cod have been conducted, using data on length compositions, catch rates from research surveys, egg abundances and spatial distribution of catches (Eero *et al.*, 2008). The extended time-series of cod stock dynamics and exploitation intensity have been used to resolve the relative impacts of climate, fishing and human-induced ecosystem changes (reduction of marine mammal predators, eutrophication) on long-term dynamics of cod in the Baltic Sea (Eero 2008).

For the period 1550–1860, archives of several countries around the Baltic Sea have been investigated and a significant amount of original data have been made available for analysing multidecadal and multi-century scale variations in the cod population in the eastern Baltic Sea (MacKenzie *et al.*, 2007).

3.3 Icelandic waters

Fisheries information prior to the 20th century

Estimates of annual historical landings from the Icelandic ecosystem of many of the important species by country are available in Bulletins Statistiques from 1905 onward, data from 1950 now being available in a digital format at ICES. Prior to the 20th century data on landings are incomplete, but the principal nations with substantial effort and thus removal were Icelandic, English, Dutch and French fishing fleets.

Icelandic fisheries: Compilation of total annual landings of the Icelanders, based on export records of dried and salted cod and estimates of native consumption have been compiled by Karlsson (2007). This provides a continuous record back from 1904 to 1871 with additional estimates available for the latter part of the eighteenth century. Karlsson also provides information on the annual numbers of rowing boats from 1770 onwards, with some intermittent years with missing data. Estimates of realized effort are however difficult to make from these records, although Karlsson does make such an attempt. Jonsson (1994) attempted to provide a crude estimate of the average annual share as a proxy for catch per unit effort, by converting qualitative data to a numerical one, using a scale from 1 to 6.

English fisheries: The earliest record of English fisheries from the Icelandic annals is from 1412. Intermitted accounts indicate that they had a significant presence in Icelandic waters until around 1550 (reviewed by Jones 2000). A revival in the fishery occurred after 1815 but no overall estimates of catch or effort have been compiled for the 19th century, although it is likely that this fleet took a substantial portion of the total catch from Icelandic waters.

Dutch fisheries: The earliest record of the Dutch fisheries is from 1655. Estimates of the annual number of ships have been compiled for the period 1683–1689, 1751–1786 and 1802–1852 (Thomas 1935, see Jonsson 1994) with information on the average last per ship for some years in the period 1751–1786. Given the logbook record keeping of the Dutch fleet in the North Sea herring fisheries (see Section 3.1) it may be worth investigating availability of such logbooks for Dutch fishing in Icelandic waters.

French fisheries: The earliest knowledge of the French fisheries is from 1616 when 7 ships are known to have been sent fishing in Icelandic waters. Estimates of annual number of ships, number of fishermen and tonnes landed have been compiled by Palmadottir (1989, see Jonsson 1994), spanning a time period from 1763 onward. Significant French presences lasted until WWI, the effort in the interwar period being relatively low compared with that of the past.

Material from the 20th century

Scientific measurements

Icelandic source: The Marine Research Institute (MRI) and its predecessors have been collecting data on the fisheries on a continuous basis since 1928. Initially the focus was on sampling information on the catch composition (size and age) of the Icelandic cod fisheries but with time an ever increasing number of stocks was included and the variables sampled increased. Various research cruises on chartered boats were also undertaken relatively early on. Through time the data storage of the old historical archives was non-systematic and undoubtedly many of it forever lost. However, in order to salvage what of the original recording was still available, in 1995 a program was initiated where all available fish measurements, whether from the commercial fisheries or scientific cruises were collated, sorted and physically categorized by year of sampling. This data is being converted into numerical format, currently all data back to 1957 have been entered into a centralized relational (Oracle) database of the Marine Research Institute. The aim of the MRI is that computer entering of the data prior to 1957 will be completed by the end of the year 2010.

Foreign sources: In England, Cefas scientists and their predecessors in the Ministry of Agriculture, Fisheries & Food (MAFF) have been collecting information on fish abundance and movement patterns since the laboratory was first established in Lowestoft in 1903. The historical RV catalogue from Lowestoft (Goodwin *et al.*, 2001) shows that survey vessels were doing research in Icelandic waters in the 1950s and 1960s, material that could complement the data source of the Icelanders that is currently been digitized (see above). The Danish public record office, Rigsarkivet, is another potentially rich source of information for fisheries in Icelandic and Greenlandic waters. In a manuscript format the Rigsarkivet holds ca. 20 logbooks from survey fisheries from 1906–1920s. Daily information on location and catches of species such as cod and halibut can be derived from this. Sources from other countries, in particular from Germany and Russia, doing research in Icelandic waters undoubtedly exist but an inventory on the availability is unknown to the group.

Information from the fisheries: Landings, catch, fleet and effort information

Icelandic source: Information of the catch by fleet, season, month and landing port are available since after WWII, although the format of the recording has not been consisted throughout the time period. The major sources are: 1) 1957–1976 Ægir (monthly publication of the Fisheries Association of Iceland – Fiskifelag Islands), 2) 1977–1998 Útvegur (Annual report of the Fisheries Association of Iceland), giving information of landings and effort by month, species, gear. Both these sources are only available in printed format at present, but this source could be used to establish time-trends in cpue by fleet from the 1950s to the present. Data on the detail of fishing activity of the Icelandic fleet prior to WWII were not systematically collated. In addition, no systematic information of spatial distribution of the fishing activity of the Icelandic fleet is available until the commencement of logbooks, although crude geographical allocation for the fleets consisting of short distant may be possible, based on estimates of catch by season and port of landing.

Foreign source: Time series information about landings and effort from the earlier part of the 20th century for the UK fleet have been published in the UK Sea Fisheries Statistics (pdf format available at http://www.mfa.gov.uk/statistics/ukseafish-arch-historical.htm) and Scottish Sea Fisheries Statistics (pdf format available at http://www.scotland.gov.uk/Topics/Statistics/Browse/Agriculture-Fisheries/PubFisheries). These documents contain information about UK landings from Icelandic waters as well as information on effort, at least for some part of the time-series. These sources are thus potential candidates for establishment of a crude cpue time-series for the time period from the early part of the 20th century until the 1970s. Systematic compilations by other nations were not evaluated by the group, although they undoubtedly exist. A valuable series of catch and effort in Icelandic waters of the English fleet by statistical squares is available as archived maps (see British Sea Fisheries Statistical charts above), most likely providing the only fine-scale information ongeographical distribution of foreign operations in Icelandic waters during the early part of the last century (for a review see Engelhard 2005).

The Danish public records office, Rigsarkivet, is another potentially rich source of information for fisheries in Icelandic and Greenlandic waters. In a manuscript format the Rigsarkivet holds ca. 20 logbooks from survey fisheries from 1906–1920s. Daily information on location and catches of species such as cod and halibut can be derived from this.

3.4 Mediterranean waters

Chato Osio and Francesco Ferretti, within the project “Recovery Scenarios for the Northwestern Mediterranean Marine Ecosystem: motivating policy action on an ecosystem basis”, has started an extensive bibliographic research on digital databases and in historical archives. A complete bibliographic research was carried out at the libraries of the Naples Anton Dohrn, Villefranche’s CNRS, the Monaco Aquarium, the Sete IFREMER, the Paris Ichthyological Museum, Barcelona’s ICM, the Split IOF, FAO, Rome’s Ministry of Agriculture, CNR and ISTAT; Chioggia, Porto Santo Stefano and Trieste fish markets; and other minor sources. Digital copies have been generated in pdf formats. Overall, 700 papers ranging from the year 1757 to 2007 have been gathered and 220 pdf documents have been created. From the historical documents, several viable datasets were extracted, entered in a digital format and transformed into workable spreadsheets. The data entry work is still in progress. To date, there are 105 workable datasets.

Landings and fishing effort data

In Italy, since 1863, the Istituto di Statistica Italiano (ISTAT) has been collating data on the fishing fleets with the resolution of maritime district, number of boats, tonnage, HP, number of fishermen, fishing areas and targets (fish, coral, sponge) when fishing abroad. Since 1953, the fleet statistics have improved and now include age, type of vessel, gear specifics such as freezing capacity, radar and other acoustic devices. For the same period fish landings are reported by region and maritime district at monthly resolution and with approximately 40 species/groupings. In addition there are several reports scattered in time with detailed effort and landings data for specific areas.

The French fleet statistics exist since the late 20th century but are available with large temporal gaps since 1908 by maritime district. These report number, tonnage, and HP of the fishing vessels plus number of fishermen [Statistiques des Peches Maritimes]. The same documents report the landing statistics by maritime district, year and by 55 species/groupings. The series are currently incomplete. Additional reports with higher resolution are available

In Spain, an extensive effort to build a landings and effort database has been carried out by Alegret and Garrido. The resulting database is a product of the collection, systematisation and digitization of statistics published between 1831 and 1984 in the Official Spanish Fisheries Yearbooks from the coast of Catalonia (www.hull.ac.uk/hmap). Additional data exist for other parts of Spain or with different resolution.

Some landings and effort data are available for Tunisia over the period 1930–1970.

Trawl surveys

In the Mediterranean region extensive trawl survey datasets are available (GRUND and MEDITS) that go respectively from 1985 and 1994 to the present. In addition, over the period 1930–1980, survey data is available gathered from grey literature and technical reports for France, Tunisia, Libya, Algeria and Egypt. Overall, there are 92 identified dataset of trawl surveys. The main surveys are plotted below and the displayed survey data, if not in digital format, has been tabulated by Osio and Ferretti.

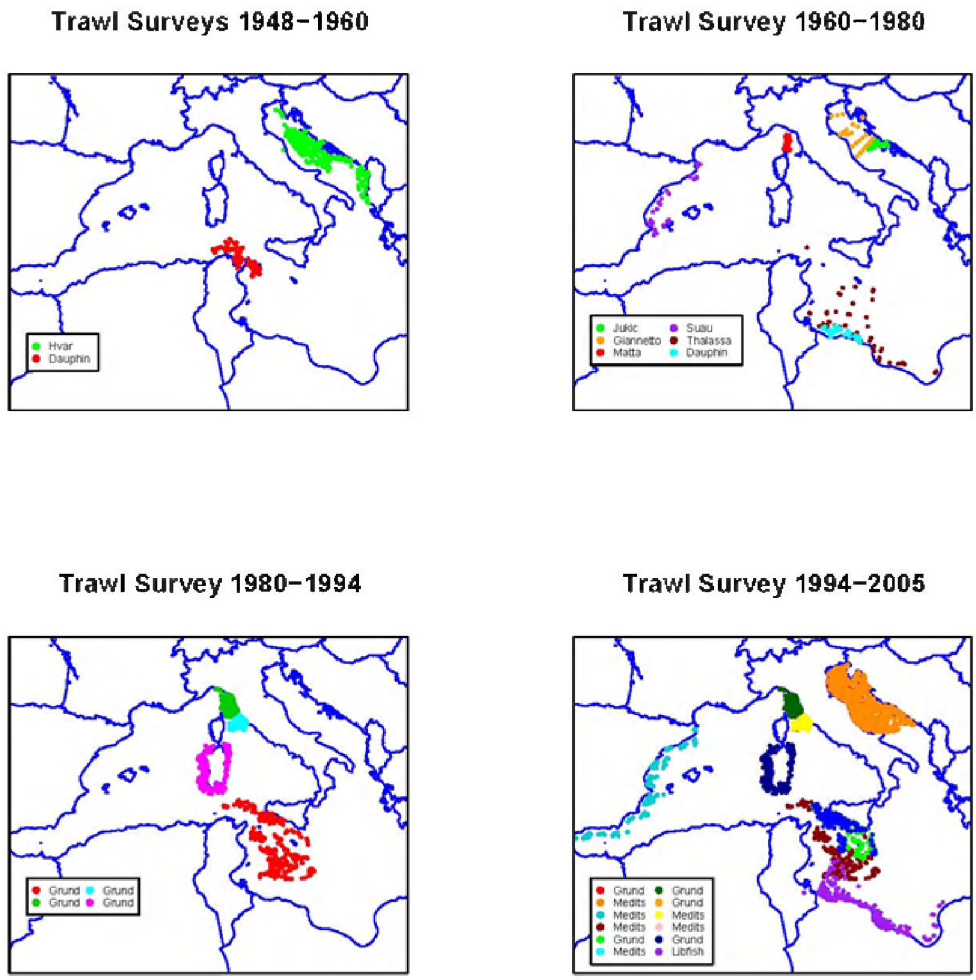


Figure 3.4.1 Trawl surveys in the Mediterranean Sea.

3.5 Northwest Atlantic Ocean

For the Northwest Atlantic Ocean region, historical catch and effort records of the United States and Canadian fisheries are only partially digitized. However, historical records pertaining to the Northwest Atlantic fisheries of Russia, France and the United Kingdom have generally not been scanned or digitized, yet paper documents and tables are known or believed to exist in these countries' national libraries and archives. Many of the available US sources that have been scanned, specifically those published by the US Fish Commission and Bureau of Fisheries (1871–1960), contain detailed catch and effort data. With the exception of the New England fisheries 1898–1935 (tabulated by Stefan Claesson 2008), most of the scanned records and fisheries data have not been digitized or tabulated in any comprehensive manner. Monthly data for Atlantic herring from the Fishery Statistics of Canada (1900–1947) have also been digitized by Emily Klein (2008). Data collection and tabulation is needed for gear technology and fishing vessel fleets. Much of this information is available in the US Fish Commission's reports and bulletins. These original government publications are scanned but are not digitized. Through a grant from NOAA and the Climate Data Modernization Program (CDMP [http://www.ncdc.noaa.gov/oa/climate/cdmp/cdmp.html]), efforts are underway to scan and digitize the oceanographic as well as fisheries data that can be integrated in climate databases such as the International Comprehensive Ocean-Atmosphere Data

Set (ICOADS) and the World Ocean Database (WOD). The scanned collections will contains some fisheries statistics as well as all scientific survey logbooks of the US Fish Commission. Information in the Annual Fishery Reports (1868 – 1963) and Fishery Statistics (1917 – 1962) of Canada are recommended for data recovery for their extensive statistics and qualitative descriptions of fisheries and industries. Statistics include catch, effort, gear, grounds, imports and exports. In the United States, tabulation or digitization of all US Fish Commission records, most of which have already been scanned, is also recommended. Finally, exploration or data mining for historical fisheries data pertaining to the Northwest Atlantic is recommended in Russia, France and the United Kingdom.

The Third JCOMM Workshop on Advances in Marine Climatology (CLIMAR-III) that was held in Gdynia, Poland, 6–9 March 2008 provided an interesting link between the disciplines of history of climate and history of ecology (http://www.marineclimatology.net). The climate and ecological histories (like WKHIST) share many common objectives.

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4 Methods for estimating technical efficiency

4.1 Introduction

Section 4 of the report presents an overview of the methods and literature to deal with historical data on marine resources and fisheries. The specific properties of handling historical data are to deal with gaps, disparate data and data where the sampling strategy is unknown. Some of the methods are also specifically applicable to analyzing or including qualitative information on the historical context in which data were assembled.

4.2 Exploration of simple trends and indicators

Construction of annual indices of stock abundance based on catch and effort data or research surveys are central to many fisheries' assessments as often these are the only sources of available data, especially for historical data (see Richards *et al.*, 1978 for an example of using old survey data).

Catch data from various forms of cpue's has traditionally been standardized and analyzed in the statistical framework of Generalized linear models (GLM). GLM's are powerful tools as they can model multiple factors for standardization and estimate trends. However when changes in catchability or contraction/expansion of the fishery happen and are not accounted for a GLM will ascribe the change to change in biomass. In the case of extending time-series of cpue's and standardizing the series with GLM's particular attention should be given to gear/catchability change and spatial distribution of effort.

These primary approaches, while informative for historical data in their own right, can also inform further analysis. They can provide information on which approaches to use (i.e. periodic fluctuations may suggest seasonal or frequency-domain time-series analysis, outliers may suggest the need for intervention analysis, or similar trends may suggest cause and effect). They can also inform analysis or provide confirmation for or questions about findings (i.e. models may suggest certain trends that are confirmed by time plots).

It is also possible to do preliminary comparisons between time-series and events in the qualitative literature that can be hypothesized as impacting the fishery. A qualitative timeline can be plotted against time-series and provide initial conclusions or hypotheses about specific years. These can then be tested via intervention analysis or other methods.

The identification and presence/absence of keystone species and evidence of regime shifts, including the presence or absence of specific species, can be important for understanding fisheries over time without specific analytical methods. Archaeological methods for the investigation of the presence/absence of species, historical biodiversity or species sizes or size-at age (see "Other methods/fields" and see work by J. Estes on Northwest Pacific sea otters and killer whales).

Other indicator-based approaches have been developed in the context of Ecological Quality Objectives (ECOQO) and could be applied to historical catch or survey data. Potential applicable indicators are:

- abundance/proportion of large fish in the catches (by species)
- average weight in population (in surveys)
- average maximum length (in surveys)

- density of top-predators, sensitive and opportunistic species

Suggested further reading:

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4.3 Catch at-age analyses

Several studies have been carried out on individual fish stocks where the traditional catch-at-age time-series has been extended backwards (e.g. back to the 1920s) based on the recovery of old age-reading material. The methods applied are generally similar to the methods used for assessing the state of stocks in the fisheries advice. However, additional assumptions are often required to address holes in the datasets. These methods are generally not carried out within a comprehensive statistical framework that incorporates all the sources of uncertainties.

Several studies have addressed the earliest part of the historical time-series in a different way from the more recent part because the Second World War did not allow the construction on one continuous time-series. The application of the catch-at-age analysis in the literature below is characterized by a somewhat ad-hoc application of different methods in different papers.

Suggested further reading:

Eero, M., F.W. Koster, M. Plikshs, and F. Thurow (2007) Eastern Baltic cod (*Gadus morhua callarias*) stock dynamics: extending the analytical assessment back to the mid-1940s

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4.4 Fishing power analyses

Analyses of changes in fishing power are important for interpretations of historical cpue data as a proxy for population abundance, especially when historical cpue are compared to 'modern' cpue values. Moreover, studies on fishing power can greatly improve our understanding of fleet dynamics, such as why certain fleets or fleet components became replaced by other fleets, are the effects of introductions of new gear technologies.

Fishing power one way of comparing catching efficiency of different fishing vessels or fleets, and is usually expressed as a factor with reference to a 'baseline' fleet. Garstang (1900), Gulland (1956) and Beverton and Holt (1957) are early studies on fishing power, and recent ones include Marchal *et al.* (2003, 2007) and Engelhard (2008). Simply stated, fishing power expresses differences in cpue between different vessels or fleets if they were (or would be) fishing at the same time and location. Estimations follow the principle that a comparison is made between coinciding cpue's for a particular fish species of usually an older, and over the period studied presumably static 'base vessel' (or 'base fleet') known or assumed not to have changed over the study period; and the cpue's of other vessels (fleet or fleets) that are newly developing. Ratios are calculated of spatially and temporally overlapping cpue's of the developing and base vessels/fleets, and with decent sample sizes the fishing power of one vessel or fleet can be expressed as base fleet or base vessel units. Figure 4.4.1 gives an example, where fishing power of steam trawlers from the early 20th Century is expressed in 'sailing smack units'. It should be noted that fishing power differences are species-specific; for example, the steam trawlers in Figure 4.4.1 had about 10–20 times higher cod fishing power, but only about 4 times higher plaice fishing power than the sailing trawlers.

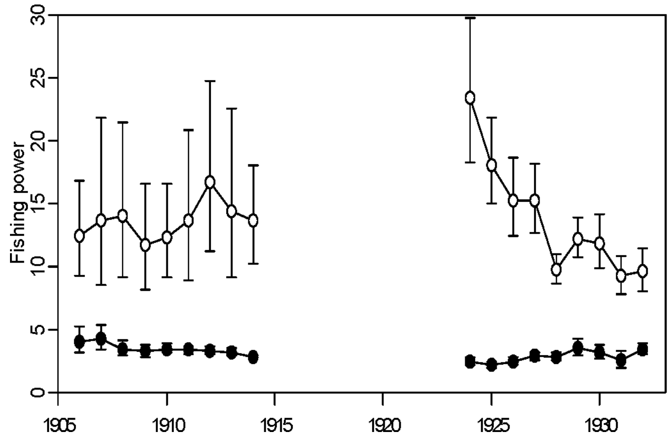

Figure 4.4.1. Fishing power of steam compared to sailing trawlers in the southern North Sea during the early 20th Century, when catching cod (open symbols) and plaice (closed symbols). Fishing power is defined as the ratio between steam and sailing trawler cpue's for the same year and same rectangle (1924–1932) or fishing ground (1906–1914). Symbols indicate geometric means with standard errors.

With multivariate statistical techniques such as GLM, variables can be studied that may explain differences in fishing power between vessels or fleets, such as engine power, tonnage, year of construction, gear characteristics, or the 'skipper effect' (Beverton and Holt 1957; Gascuel *et al.*, 1993; Marchal *et al.*, 2007). For the modern EU fleet, vessel-related variables such as engine power, vessel size, tonnage and year of construction, and their relationships with fleet capacity and cpue are being investigated in the EU project CAFE. Within ICES, the Study Group Combining Gear Parameters into Effort and Capacity Measures (SGEM) specifically looks at the effects of gear characteristics such as net size, rope length etc. on the cpue achieved by fishing vessels. SGEM (2008) note that care is needed when interpreting historical trends in LPUE, changes in vessel characteristics over time such as increases in power or size may not necessarily resulted in scaled increases in LPUE of the same magnitude. It is often assumed that such changes result in increases in the size or the amount of gear used, but this may not necessarily hold true. For example, the absence of a link in recent years between vessel power and gear size in the Scottish otter trawl fisheries is of relevance in interpreting LPUE information. Equally, an analysis of historical gear and vessel data would demonstrate whether this was a recent pattern in this fishery and whether this was also true historically. Investigation of this and similar questions would be valuable for both the interpretation of historical LPUE information and for understanding the current links between vessels and their gear. The motivation to change may be simply a desire to increase the amount of applied effort by allowing fishing in worse weather or to operate further offshore. Other considerations such as safety or market/quality issues (increased speed) may have little or no link with LPUE. To understand the relationship between vessel size, the amount of gear used and the applied effort (hours fished) more detailed information on these aspects of the fishing operation is needed. Such data may be available from the diaries of individual skippers, records from commercial fishing companies or from fishing gear suppliers.

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Marchal P, Ulrich C, Korsbrekke K, Pastoors M, Rackham B (2003) Annual trends in catchability and fish stock assessments. Sci. Mar. 67 (Suppl. 1): 63–73.

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4.5 Statistical approaches

4.5.1 Meta analysis

Meta-analysis refers to the analysis of analyses: the statistical analysis and synthesis of a large collection of results from individual studies or systems for the purpose of integrating the findings (Glass 1976, Gurevitch *et al.*, 2001). Meta-analytic, hierarchical modelling can be implemented either in a frequentist (e.g. mixed models (Pinheiro and Bates 2000)) or in a Bayesian (Gelman *et al.*, 1995, Gelman and Hill 2007) framework. Overall, these approaches constitute a rigorous probabilistic toolbox with explicit incorporation of sources of uncertainty (observation and model error) and the combination of data across various independent sources (Hilborn and Liermann 1998, Gelman and Hill 2007).

Meta-analysis can provide constructive insights, especially in cases when there are gaps in knowledge that hinder inference or that would require strong assumptions.

For example, the analysis of cpue in certain cases could be based on the efficiency of other fleets with similar characteristics. The large amount of information on the properties of the ocean ecosystem delivered by major international programs (GLOBEC, ICES, HMAP etc.) and the recent advances in computational statistics can facilitate strength borrowing between historical and recent data, with the aim of achieving a spatio-temporally integrated view of species and ecosystems.

In fisheries, hierarchical models are especially useful for identifying and quantifying processes acting on a broad spatial and/or temporal scale, like determining fish population dynamics across or within specific regions (Myers 2001). Stocks within species or related species with similar life-histories, often share common population dynamics patterns and respond to environmental effects in comparable ways (Brander 2000, Myers *et al.,* 2002, MacKenzie *et al.,* 2003). Consequently, it is possible to "borrow strength" (Myers *et al.,* 2001) or "stand on the shoulders of giants" (Hilborn and Liermann 1998) by combining data across stocks. Theoretical and technological advances in the recent years have further promoted the use of synthetic approaches, especially in stock assessments (e.g. Punt and Hilborn 1997) and in studies of stock-recruit dynamics (see Myers 2001, Myers 2002 for reviews).

The key step in hierarchical implementation is the incorporation of submodels on the parameters (Clark 2007), termed as stock-level models when used to combine information across fish populations. These submodels illustrate the distribution of a given parameter across the stocks included in the analysis. The parameters describing the probability distribution are known as hyperparameters and can be estimated by all the data. Further, the stock-level models can be extended to account for factors generating the among stocks differences in the parameter (e.g. ecosystem specific characteristics affecting the productivity of a stock).

In the Bayesian framework, they are referred to as priors, and can be used to introduce any available knowledge into the estimation of the stock-specific coefficients. Since the inference of single-stock parameters is based on these priors, strength is "borrowed" and the "loan" is higher for "poorer" (limited or highly variable observations) stocks (Gelman and Hill 2007).

Meta-analysis can act as an interface bringing together recent and historical knowledge of fish dynamics, ecosystems, climatic and anthropogenic effects. The synthetic results regarding demographic parameters at the species or the stock level can subsequently act as priors for the parameterization of historical biomass reconstruction models (e.g. Thurow 1997, McAllister *et al.,* 2001, Rose 2004, Rosenberg *et al.,* 2005, Christensen 2006).

The models can be further elaborated by incorporating environmental effects on the appropriate parameters (e.g. Rose 2004). Hierarchical models, combining data across a species range, are useful for synthesizing responses to wider amplitude of environmental conditions, thus revealing patterns on a higher organizational level (Myers *et al.,* 2001, MacKenzie *et al.,* 2003). These patterns, expressed as stock-level models, can be used to describe non-stationary parameters in a changing ecosystem. Conversely, extending the existing models, by including also the historical fluctuations in both population dynamics and environmental conditions, can help us predict responses to future changes with higher accuracy.

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4.5.2 Time series analysis

Time series analysis: Time series analysis (TSA): Statistical analysis for understanding underlying patterns in long-term fishery data. These patterns can be used for further analysis in addition to prediction and backcasting for missing observations. Further analysis includes intervention analysis to address significant outliers (events) or external forcing or multivariate TSA for cross-correlation analysis of multiple time-series (e.g. fisheries and environment or comparing two fisheries together for cause and effect).

Benefits: only need long-term time-series of catch (etc). Do not need additional information or derived variables (such as effort, cpue, etc). Appropriate use of time-series data that allows for correlation between observations, dependency on time, importance of observation order, and the fact that time-series data is not iid[1]. Very flexible, adaptable, simple, and easy to use. Can be applied to a wide variety of data and can incorporate many variables and non-linear relationships. Ability to incorporate hierarchical models and Bayesian and spatial statistics.

Drawbacks: need many observations to run – recommended as at least 40. TSA also does not allow for missing data, although methods to address this are available (maximum likelihood estimation and back casting work well). Multivariate TSA can be quite complicated and computationally difficult.

There are additional fields that have developed sophisticated time-series analysis methods that may be applicable to long-term fishery data. These fields address similar data, in the form of time-series, and similar general questions, i.e. the impact of events or behaviour, change over time, market, demand, consumer preference, etc. Financial and economics, in addition to marketing fields, use statistical approaches to understand consumer preference, demand, market changes, etc., in addition to the impact of events such as marketing campaigns or the introduction of a new product.

In the behavioural and social science fields, research addresses specific events such as the administration of a drug, in addition to understanding changes in behaviour or social events. The general questions here and the methods used to statistically address them are akin to those asked in understanding long-term marine and fishery change. The methods, therefore, intuitively lend themselves to fishery and fishery industry time-series data.

Suggested further reading:

Ellner, S. and P. Turchin (1995). "Chaos in a noisy world: New methods and evidence from time-series analysis." The American Naturalist, 145(3): 343–375.

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[1] iid = Independently and identically distributed; a property of a sequence of numbers

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Garcia, S. P., L. B. DeLancey, J. S. Almeida, and R. W. Chapman (2007). "Ecoforecasting in real time for commercial fisheries: the Atlantic white shrimp as a case study." Marine Biology 152: 155–24.

Hare, S. R. (1997). "Low frequency climate variability and salmon production." PhD. Dissertation, University of Washington, Seattle, WA.

Kim, S., S. Jung, and C. I. Zhang (1997). "The effect of seasonal anomalies of seawater temperature and salinity on the fluctuation in yield of small yellow croaker, Pseudosciaena polyactis, in the Yellow Sea." Fisheries Oceanography, 6(1): 1–9.

Jensen, A. L. (1976). "Time series analysis and forecasting of Atlantic menhaden catch." Chesapeake Science, 17(4): 305–307.

Park, H.-H. (1998). "Analysis and prediction of walleye pollock (Theragra chalcogramma) landings in Korea by time series analysis." Fisheries Research 38: 1–7.

Ryding, K. E., J. J. Millspaugh, and J. R. Skalski (2007) "Using time series to estimate rates of population change from abundance data." Journal of Wildlife Management 71(1): 202–207

Turchin, P., and A. D. Taylor (1992). "Complex dynamics in ecological time series." Ecology, 73(1): 289–305.

Yoo, S., and C. I. Zhang (1993). "Forecasting of hairtail (Trichiurus leplurus) landings in Korean waters by time series analysis." Bull. Korean Fish. Soc. 26(4): 363–368.

4.5.3 Kalman filters (state space models)

State space models are also classified under the broad category of time-series analysis. They are a statistical tool capable of dealing with non-linear data and that can tease apart and estimate the different sources of error (process and estimation errors). State-space models can deal with multiple measurement time-series and missing observations. Applications where state-space models are routinely used include development of forecasting models in fisheries stock assessments, analysis of animal tracking data, and analysis of population or community time-series data.

In state space modelling it is assumed that the development over time of a system, like the true biomass of a fish population, is determined by an unobserved series of vectors α_t with which are associated a series of observations y_t, such as the biomass from each survey tow. The relation between the α_t's and the y_t's is determined by the state space model and the purpose of the state space analysis is to infer the properties of the α_t's from THE knowledge of the y_t's . The filtering step, with Kalman filter, is used to update the knowledge of the system at each new y_t. Smoothing allows us to to base the estimates of the quantities of interest on the entire sample $y_1,\ldots, y_n$, and forecasting can be used to fill missing data. State space models estimate the uncertainty in the estimates in the α_t's range and in the forecasting.

Suggested further reading:

J. Durbin and S. Koopman, Time Series Analysis by State Space Methods. Oxford University Press, 2001.

P. de Valpine. and R. Hilborn. 2005. State-space likelihoods for non-linear fisheries time-series. Canadian Journal of Fisheries and Aquatic Sciences 62: 1937–1952.

R. B. Millar, R. Meyer, Non-linear state space modelling of fisheries biomass dynamics by using Metropolis-Hastings within-Gibbs sampling, Journal of the Royal Statistical Society: Series C (Applied Statistics), Vol 49, 3, pag. 327–342, 2000

4.5.4 Qualitative information analysis. Intervention analysis

The qualitative literature may be an important avenue for understanding historical fisheries. The use of qualitative data, both in terms of text or in terms of more specific records, such as fishermen interviews, is a field in its own right and additional approaches from here may be applicable to historical text. A specific use of fishermen interviews to look at changes in fisheries over time can be found in: Sáenz-Arroyo, A., C. M. Roberts, J. Torre, M. Carino-Olevera, and R. R. Enriquez-Andrade (2005). "Rapidly shifting environmental baselines among fishers of the Gulf of California." Proceedings of the Royal Society – Biology, 272: 1957–1962.

A specific additional method is intervention analysis, which is related to TSA. Intervention analysis (also called transfer function modelling, interrupted time-series analysis or impact assessment) addresses unexpected changes in time-series data that result from outside forces. In TSA, addressing these changes is important for accurate analysis, conclusion, and prediction. These changes are manifest as outliers or shifts in the parameters of the underlying patterns and models. Such analysis can be important for statistically detecting the significant impact of specific events (from management action to world wars). This can be an approach for incorporating qualitative or anecdotal information on socio-economic, political, technological, or other events or outside affects. Hypothesis testing of an event at a particular time is possible. The FinMetrics module of S-Plus statistical software (CITE) is simple to use for intervention analysis.

Drawbacks: Addressing lagged relationships or impacts (i.e. the effect is not demonstrated in the data immediately, but after a time interval, or lag) has not been attempted, or the literature on doing so is not yet known. Comparing intervention results can be very speculative and does not always provide definitive results. They should be considered carefully.

Suggested further reading:

Box, G. E. P., and G. C. Tiao (1975). "Intervention analysis with application to economic and environmental problems." Journal of the American Statistical Association 70(349): 70–79.

Box, G. E. P., and G. M. Jenkins (1976). Time series analysis: forecasting and control. Revised ed. Holden-Day, San Francisco, CA: 575 p.

Chang, I., G. C. Tiao, and C. Chen (1988). "Estimation of time series parameters in the presence of outliers." Technometrics 30(2): 193–204.

Chen, C., and G. C. Tiao (1990). "Random level-shift time series models, ARIMA approximations, and level-shift detection." Journal of Business & Economic Statistics 8(1): 83–97.

Glass, G. V. (1972). "Estimating the effects of intervention into a non-stationary time-series." American Education Research Journal, 9(3): 463–477.

Hartmann, D. P., J. M. Gottman, R. R. Jones, W. Gardner, A. E. Kazdin, and R. S. Vaught (1980). "Interrupted time-series analysis and its application to behavioral data." Journal of Applied Behavioral Analysis, 13: 543–559.

McDowall, D., R. McCleary, E. E. Meidinger, and R. A. Hay, Jr. (1980). Interrupted time series analysis. In: Series: Quantitative Applications in the Social Sciences. J. L. Sullivan eds. Sage Publications, Inc, Beverly Hills: 96p.

Murtaugh, P. A. (2000). "Paired intervention analysis in ecology." Journal of Agriculture, Biological, and Environmental Statistics, 5(3): 280–292.

Scheffer, M., S. Carpenter, J. A. Foley, C. Folke, and B. Walker (2001). "Catastrophic shifts in ecosystems." Nature, 413: 591–596.

Tsay, R. S. (1988) "Outliers, level shifts, and variance changes in time series." Journal of Forecasting, 7: 1–20.

Zivot, E. (2006). Modeling financial time series with S-Plus. Springer, New York, NY: 998p. (which provides an overview of the FinMetrics module and applied examples).

4.6 Ecosystem modelling: Ecopath/ecosim

Ecopath is a trophic mass-balance model, intended to summarize the abundances and interactions of all major functional groups in an ecosystem over a particular period of time. Ecosim is used for forecasting the impact of changes in fishing rates selectively across gear types, and to tune models to define time-series of biomass estimates. Ecospace allows spatial ecosystem modelling by replicating the Ecosim simulation across a grid of habitat cells, where the modelled species groups are allocated habitat preferences. The Ecopath models require data on fisheries by sector, production for biomass ratios, consumption rates, and diet matrix for up to 50 defined components. For modelling ecosystem in the past, the historical data may need to be supplemented with more recent estimates to fill any data gaps, as experienced by Mackinson (2001), when modelling historical trophic interactions in the North Sea in the 1880s. Despite their computational complexity and data requirements, these models may provide insight on changes across foodwebs over time.

Suggested further reading:

Christensen, V., S. Guénette, J.J. Heymans, C. Walters,R. Watson, D. Zeller, D. Pauly2003. Hundred-year decline of North Atlantic predatory fishes. . Fish & Fisheries, Vol. 4 Issue 1, p1–24;

Christensen V. and C.J. Walters. 2004. Ecopath with Ecosim: methods, capabilities and limitations. Ecological Modeling 172(2004) 109–139

Mackinson, S. (2001). Representing trophic interactions in the North Sea in the 1880s, using the Ecopath mass-balance approach.In: Fisheries impacts on North Atlantic ecosystems: models and analyses Guenette.(S. Guenette, V. Christensen and D. Pauly, eds.). 9 (4): 35–98.

Pauly, D. V. Christensen and C. Walters. 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. ICES Journal of Marine Science, 57:697–706.

Pitcher T.J. 2001. Fisheries managed to rebiold ecosystems? Reconstructing the past to salvage the future. Ecological applications, 11(2) pp.601–617.

4.7 Other methods/fields

4.7.1 Financial/Economic statistics

Methodological approaches for financial and economic data would appear to be applicable to fisheries data, especially time-series. These methods address input and output, risk (both internal and external), change over time, cause-and-effect, extraction, and returns. It seems appropriate to mine this highly developed field of statistics for applicable and useful methods.

4.7.2 Archaeological methods

Methods here for understanding long-term change and patterns, in addition to approaches for specific data, including insight that can be gleaned from archived shells, scales, fish bones (e.g. spines, vertebra, or otoliths), shell middens, sediment cores, etc. Not only can long-term series be developed on environmental change over time, but also changes in early human preference/fishery targets (shell middens) and size, diversity, and size-at age (from bones, middens, etc). This work can help push time-series back into prehistory or provide wider breadth of knowledge, especially linking marine species with environment (shell/bone layers tied to environmental changes).

Suggested further reading:

Jackson, J. B. C. (1997) "Reefs since Columbus." Coral Reefs 16 Suppl.: S23–S32.

Jackson, J. B. C. (2001). "What was natural in the coastal oceans?" PNAS, 98, 5411–18

Jackson, J. B. C, M. X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B.J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T.P. Hughes, S. Kidwell, C.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M.J. Tegner, and R.R. Warner (2001). "Historical overfishing and the recent collapse of coastal ecosystems." Science, 293: 629–38.

Barrett, J.H., Locker, A. M. And Roberts, C. M. 2004. Dark Age Economics Revisited: The English fish bone evidence AD 600–1600. Antiquity, 78. 618–636.

Cerrato, R. M. (2000) "What fish biologists should know about bivalve shells." Fisheries Research 46: 39–49.

Helama, S., B. R. Schone, A. J. Kirchefer, J. K. Nielsen, D. L. Rodland, and R. Janssen (2007). "Compound response of marine and terrestrial ecosystems to varying climate: Pre-anthropogenic perspective from bivalve shell growth increments and tree-rings." Marine Environmental Research 63(3): 185–199.

Poulsen, B. 2008. Dutch Herring: An environmental History, c. 1600–1860. Amsterdam: Aksant.

Poulsen, R. T. 2007. An Environmental History of North Sea Ling and Cod Fisheries, 1840–1914. Fiskeri- og Søfartsmuseets Studieserie, 22. Esbjerg.

5 Workplan for historical work within ICES

The Workshop on historical data on fisheries and fish [WKHIST] concluded that this field of work carried a great potential to progress towards a more comprehensive understanding of the dynamics of marine resources, fisheries and environmental drivers. Large collections of historical information have been identified and have been or could be made available for analysis. Therefore, WKHIST identified a number of future activities that could enhance the use of historical data and our understanding of long-term trends.

5.1 ICES activities

Study Group

WKHIST recommends that the ICES Study Group on the history of fish and fisheries should be established with a start in 2009. The objectives of the Study Group should be:

- coordination of (regional) data recovery programs
- initiate studies on the history of fishing technologies and fishing power
- development and application of methods that can be applied to historical data
- cross-regional comparisons of fish and fisheries (technology, effort, cpue, climatic conditions, long-term fleet dynamics)

The anticipated membership of the study group would consist of fisheries science experts, ecological experts, gear technology experts, historical experts and statistical/methodological experts.

More details can be found in Annex 2.

ICES Annual Science Conference theme session

WKHIST proposes that a theme session should be convened at the ICES Annual Science Conference in 2010 with the topic: "Linking the history to the present: understanding the history of fish, fisheries and management."

The theme session would follow-on from the HMAP conference on Oceans Past (May 26–28 2009, Vancouver. http://hmapcoml.org/oceanspast/). The theme session would link the results from the historical studies with the work carried out in several of the advisory functions of ICES. It would also provide a common interface where historical scientists, ecosystem scientist and fisheries scientists could meet to exchange results that can improve the understanding of the long-term dynamics of marine ecosystems.

More details can be found in Annex 3.

5.2 Potential projects

5.2.1 Data recovery project for European Marine Science Institutions and Zoological museums (scanning, digitizing)

Despite of various activities within different regional, European and global projects (incl. HMAP-CoML and INCOFISH), there are still unused historical material kept in national fisheries institutes, fisheries agencies and zoological museums, etc. However, the status of this material is unknown as is the content, scope and value of this information. This material most likely contains valuable information which will allow describing and analysing status and dynamics of fish and fisheries in the late 19th-early 20th century. Therefore, in order to save this valuable material and make it available and accessible for further analysis, we propose a project on 'Data recovery for European and North American Marine Science Institutions and Zoological museums' with the primary aim to scan and digitize the available historical material in order to make it accessible for wider scientific community.

5.2.2 Regional projects

The Post-doctoral researchers Margit Eero (DTU Aqua) and Stefan Claesson of University of New Hampshire (UNH) are beginning a synthesis of marine ecosystems within the North Atlantic Ocean for the HMAP Program. This work will involve analysis of catch rates and trends for regions throughout the North Atlantic Ocean.

Below, WKHIST has outlined the status of the information and analyses for different regions and has also indicated possible future research directions/projects.

North Sea

Several studies have been carried out on the history of North Sea fisheries and fish. Bo Poulsen has extensively analyzed the herring fisheries in the North Sea from 1600–1860 Poulsen, in press). Several authors have analyzed fragments of the 20th century data for demersal stocks (e.g. Rijnsdorp and Millner, 1996, Pope and Macer, 1996, Richards *et al* 1978) and pelagic stocks (e.g. Burd 1978). But recent inventories at CEFAS (Engelhard, 2005, Goodwin *et al* 2001) and archive work in the Netherlands (Poulsen, pers. comm.; Pastoors, pers. comm) have indicated that there are substantial amounts of information available on paper that would help the interpretation of long-term trends in the North Sea. The recovery of data on North Sea fisheries will be addressed in a proposed European data recovery project.

The aim of a possible dedicated project on the history of the North Sea will be to analyse the trends in fish and fisheries from 1850 onwards, focussing both on demersal and pelagic species. The project should ideally be set with participation of both historians, fisheries scientists, gear scientists and environmental scientists from all the countries bordering the North Sea.

References:

Burd, A. C. (1978). "Long term changes in North Sea herring stocks." Rapports et Procès Verbaux des Réunions Conseil International de l'Exploration de la Mer 172: 137–153.

Engelhard, G.H. (2005) Catalogue of Defra historical catch and effort charts: six decades of detailed spatial statistics for British fisheries. CEFAS Science series. Technical report no. 128.

Goodwin, N. B., P. J. Dare, S. J. Belson, K. L. Gunstone, J. R. Ellis and S. I. Rogers (2001). A catalogue of Defra historical research vessel data. CEFAS Science series. Technical report no. 112.

Poulsen (in press) Historical exploitation of North Sea herring stocks. Aksant, Amsterdam.

Pope, J. G. and C. T. Macer (1996). "An evaluation of the stock structure of North Sea cod, haddock, and whiting since 1920, together with a consideration of the impact of fisheries and predation effects on their biomass and recruitment." ICES Journal of Marine Science 53: 1157–1169.

Rijnsdorp, A. D. and R. S. Millner (1996). "Trends in population dynamics and exploitation of North Sea plaice (Pleuronectes platessa L.) since the late 1800s." ICES Journal of Marine Science 53: 1170–1184.

Richards, J., D. W. Armstrong, J. R. G. Hislop, A. S. Jermyn and M. D. Nicholson (1978). Trends in scottish research-vessel catches of various fish species in the North Sea, 1922–1971.In: Rapports et Procès Verbaux des Réunions Conseil International de l'Exploration de la Mer.(G. Hempel, ed.). 172: 211–224.

Iceland

Details of the Iceland study are described in Section 3.3.

Baltic Sea

Studies in fisheries history in the Baltic Sea have resulted in compilation of several databases which cover different subregions of the Baltic Sea during different time-periods and are available through HMAP-CoML database. Most comprehensive databases with data analysis and interpretations are available for the eastern Baltic cod population (since the 1880s). It is believed that most essential data-source for this fish since the late 19th century is studied and the likelihood to obtain data which result in substantially new information is low. The obtained data also indicate that historical information on the majority of other fish species than cod and herring before the mid-20th century is relatively scarce (Ojaveer *et al.,* 2007, Lajus *et al.,* 2007, Gaumiga *et al.,* 2007).

The ICES assessments for the three main fish species in the central Baltic, i.e. cod and herring and sprat start from 1966 and 1974, respectively. For the eastern Baltic cod catch-at-age, individual weight and cpue data have been compiled from various national literature sources and fisheries institutes and the VPA-based assessment has been extended back to 1946 (Eero *et al.,* 2007). For the period 1925–1944, multiple analyses with consistent results on spawner biomass and fishing mortality of eastern Baltic have been conducted using data on length compositions, catch rates from research surveys, egg abundances and spatial distribution of catches (Eero *et al.,* 2008). The extended time-series of cod stock dynamics and exploitation intensity have been used to resolve the relative impacts of climate, fishing and human-induced ecosystem changes (reduction of marine mammal predators, eutrophication) on long-term dynamics of cod in the Baltic Sea (Eero 2008).

For the period 1550–1860, archives of several countries around the Baltic Sea have been investigated and a significant amount of original data have been made available for analysing multidecadal and multi-century scale variations in the cod population in the eastern Baltic Sea (MacKenzie *et al.,* 2007).

Cod is the main predator fish in the central Baltic ecosystem, closely interlinked with the pelagic species (i.e. sprat and herring) through trophic relations. Therefore, future research effort towards reconstructing long-term development of these pelagic species could significantly improve our understanding of the functioning of the upper trophic level in the central ecosystem and improve our ability to make reliable predictions of future developments. In addition, it is hoped that historical data allow reconstruction also of the gulf-herring time-series and compare performance of the open sea and gulf herring populations during the first half of the 20th century. Further, it is also suggested to put further emphasis on archival work in German, Polish and also Finnish archives as fisheries archives in other countries (Denmark, Estonia, Latvia, Sweden and Russia) are relatively well studied and the available data to a large extent obtained.

References

Eero, M., Köster, F.W., Plikshs, M., Thurow, F. 2007. Eastern Baltic cod (*Gadus morhua callarias*) stock dynamics: Extending the analytical assessment back to the mid-1940s. ICES Journal of Marine Science, 64, 1257–1271.

Eero, M., Köster, F.W., MacKenzie, B.R. 2008. Reconstructing historical stock development of the eastern Baltic cod (Gadus morhua) before the beginning of intensive exploitation. Can. J. Fish. Aquat. Sci. (accepted)

Eero, M. 2008. Dynamics of the eastern Baltic cod (Gadus morhua) stock in the 20th century under variable climate and anthropogenic forcing. PhD dissertation, University of Southern Denmark

Gaumiga, R., Karlsons, G., Uzars, D., Ojaveer, H. 2007. Fisheries of the Gulf of Riga (Baltic Sea) in the late 17th century. Fisheries Research 87, 120–125

Lajus, J., Ojaveer, H., Tammiksaar, E. 2007. Fisheries on the northeast coast of the Baltic Sea in the first half of the 19th century: what can be learned from the archives of Karl Ernst von Baer. Fisheries Research 87, 126–136.

MacKenzie, B.R., Bager, M., Ojaveer, H., Awebro, K., Heino, U., Holm, P., Must, A. 2007a. Multi-decadal scale variability in the eastern Baltic cod fishery 1550–1860–evidence and causes. Fish. Res., 87, 106–119.

Ojaveer, H., Awebro, K., Karlsdottir, H. M., MacKenzie, B. R. 2007. Swedish Baltic Sea fisheries during 1868–1913: spatio-temporal dynamics of catch and fishing effort. Fisheries Research 87, 137–145

Mediterranean Sea

There is an ongoing project titled "Recovery Scenarios for the Northwestern Mediterranean Marine Ecosystem: motivating policy action on an ecosystem basis". The project is funded by the Oak Foundation and the Lenfest Ocean Program and it is based off the University of New Hampshire, Dalhousie University, Stanford University, CSIC Blanes with collaboration with many Mediterranean partners.

A first goal is to describe the development of fishing fleets, technology and fishing effort over the past 100 years in Italy, France, Spain and former Yugoslavia. This information will be used to determine the fishing pressure exerted on the stocks over time and space.

The second goal is to reconstruct the changes in biomass of important commercial and non commercial species in different areas of the NW Mediterranean. This is being achieved by analyzing landings, commercial cpue's and data originating from multiple scientific surveys and commercial scouting over the past 60 years. We will use statistical methodologies, appropriate to the data, ranging from Generalized Linear Models to Time Series analysis and meta-analysis.

The third goal is to understand how biodiversity has changed over time and space in relation to fishing impacts. This is important as biodiversity has been linked to ecosystem services and to ecosystem recovery potential (Worm *et al.*, 2006). Understanding the effects of top predator removals on ecosystem stability will be an important part of the ecological analysis.

The last part of this project will be to construct recovery scenarios for the main commercial demersal species. Life history attributes and population models will be used to make predictions and scenarios that will incorporate different levels of fishing mortality. Data and scenarios will be made available to the scientific community and policy makers.

In the Mediterranean there is also an ongoing HMAP project since 2004.

References

B. Worm, E. B. Barbier, N. Beaumont, J. E. Duffy, C. Folke, B. S. Halpern, J. B. C. Jackson, H. K. Lotze, F. Micheli,S. R. Palumbi, E. Sala, K. A. Selkoe, J. J. Stachowicz, and R. Watson, "Impacts of Biodiversity Loss on Ocean Ecosystem Services," Science, vol. 314, no. 5800, pp. 787–790, 2006.

Northwest Atlantic

There are two ongoing research projects on the history of the Northwest Atlantic:

1) The Gulf of Maine ecosystem assessment through collection and analysis of total removals of fish, catch rate standardization, 1850–1950 (Gulf of Maine Cod Project, University of New Hampshire).

2) Time series analysis of Gulf of Maine fisheries, environmental drivers, and anthropogenic impacts, 1870–2007. Preliminary work involved Atlantic herring (*Clupea harengus*), SST, salinity, and particular socio-economic and industry events. Further work will address bluefin tuna, cod, other small pelagics (e.g. mackerel and anadromous herrings), and additional external environmental and anthropogenic drivers.

It is expected that these two projects are going to provide a substantial input to the understanding of long-term dynamics in these systems.

Annex 1: List of participants

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Annex 2: SGHIST terms of reference for the next meeting

The **Study Group on the History of Fish and Fisheries** [SGHIST] (Co-Chairs: Bo Poulsen* and Martin Pastoors*, The Netherlands) will be established and will meet in [Vlaardingen, The Netherlands] for four days in August 2009 to:

a) update the inventory of historical data on marine fisheries and resources in the North Atlantic
b) coordinate data recovery programs for historical data
c) propose data-storage solutions that will allow access to recovered historical data.
d) initiate studies on the history of fishing technologies and fishing power
e) develop methods that can be applied to historical data in order to estimate long-term dynamics.
f) carry out cross-regional comparisons of fish and fisheries in the North Atlantic.

SGHIST will report by 15 September 2009 to the attention of the ICES Scientific Committee.

Supporting Information

PRIORITY:	The activities of this Group will improve the understanding of long-term changes in fish stocks productivity and changes in the ecosystems. Consequently these activities are considered to have a high priority.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	There is growing interest in historical data on fish and fisheries. The interest is on the discovery, recovery, digitization and analysis of historical data. The analysis of historical data is expected to give insight in long-term historical trends in fish stocks and fisheries which can be related to long-term changes in environmental indicators. The work links to the History of Marine Animal Populations project that is funded under the Census of Marine Life and which aims to discover historical data sources. Several fisheries research institutes in Europe have started to make inventories of historical information and the workshop is intended to bring these initiatives together. WKHIST 2008 has recommended that a project should be set up to recover the historical information that has been collected by marine research institutions and zoological museums around the North Atlantic and the Mediterranean. SGHIST will oversee that project. SGHIST will link with methodological experts to advance the methodologies for analyzing historical data including methods for using meta-information from different areas.
RESOURCE REQUIREMENTS:	No specific requirements
PARTICIPANTS:	The Group is expected to attract approx 15 participants
SECRETARIAT FACILITIES:	None.
FINANCIAL:	No financial implications.
LINKAGES TO ADVISORY COMMITTEES:	ACOM
LINKAGES TO OTHER COMMITTEES OR GROUPS:	Linked to ICES proposal proposal for the digitization, analysis and interpretation of plankton data for pre-1914 ices sampling in the north sea and adjacent waters
LINKAGES TO OTHER ORGANIZATIONS:	Census of Marine Life / History of Marine Animal Populations

Secretariat marginal cost share:	

Annex 3: Theme Session 2010

Theme session 2010: "Linking the history to the present: understanding the history of fish, fisheries and management."

Convenors (still to be confirmed, selected): Andy Rosenberg, Martin Pastoors, Henn Ojaveer, Max Cardinale, Bo Poulsen

The theme session would follow-on from the HMAP conference on Oceans Past (26–28 May 2009, Vancouver. http://hmapcoml.org/oceanspast/). The theme session would link the results from the historical studies with the work carried out in several of the advisory functions of ICES. It would also provide a common interface where historical scientists, ecosystem scientist and fisheries scientists could meet to exchange results that can improve the understanding of the long-term dynamics of marine ecosystems.

Annex 4: Recommendations

RECOMMENDATION	ACTION
1. Encourage the understanding of historical fisheries more holistically. To do so, collaborations are promoted that link across species, time, and field, e.g. history, statistics, climate and social science. This includes promoting interdisciplinary research where historians and scientists can evaluate the historical and socio-cultural context in the analysis of fisheries related datasets. Such research can be further discussed at multidisciplinary symposia, workshops, and theme sessions at international meetings.	
2. Encourage a multinational effort for the identification and maintenance of original historical records. This includes announcement of possible removals or destruction, inventory of data type and location, and encouraging access to data for others. Countries should review their archival holdings and develop a plan to preserve the historical fisheries records.	
3. Understand and encourage awareness of various archiving policies across different marine research institutions.	
4. Along with maintaining the original documents, a comprehensive multinational effort should be put in place to digitize the paper records. Such effort should include online archiving of documents images (Tiff and pdf formats) and the keying of the data into databases.	
5. Ensure that the work done by HMAP and INCOFISH is continued and encouraged, especially the connection of this work with current science and management. Expand this work to a wider context regarding species, locations, disciplines, ecosystems, and statistical approaches for analysis.	
6. Promote the application of historical data, such as their crucial importance to climate change research, and the use of new analytical approaches – expand awareness of possible avenues to do so to the wider scientific community.	
7. Encourage outreach to the public and additional disciplines regarding the relevance and applicability of historical analysis, in addition to information on the locations and accessibility of historical data.	