ICES WGHIST REPORT 2013

SCICOM STEERING GROUP ON SUSTAINABLE USE OF ECOSYSTEMS

ICES CM 2013/SSGSUE:08

REF. SCICOM

Interim Report of the Working Group on the History of Fish and Fisheries (WGHIST)

7–11 October 2013

Panicale, Italy

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

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

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2014. Interim Report of the Working Group on the History of Fish and Fisheries (WGHIST), 7-11 October 2013, Panicale, Italy. ICES CM 2013/SSGSUE:08. 44 pp.

Contents

1 Executive summary

The ICES Working Group on the History of Fish and Fisheries (WGHIST, 2012–2014) brings together fisheries scientists, historians and marine biologists working on long term change in the marine environment. It welcomes historical marine case studies from around the world and synergizes historical fisheries datasets. Outcomes are relevant for setting baselines for management, restoration and conservation of marine resources and ecosystems. In 2013, WGHIST met in Panicale (Italy), invited by veteran scientist Sidney Holt who, unfortunately, could not attend due to sudden ill health. The workshop was opened on 7 October 18:30 and closed on 11 October 12:30. Twelve participants from Australia, Africa, North America and Europe attended. The workshop excelled as platform for discussion between scientists in different disciplines, and was structured around the following three themes:

1) *Data rescue, archiving and digitization (ToR c).* - Rescue of historical data can be costly and time-consuming. This theme encourages learning from partners' experiences in data archiving and digitization. Efforts include: Belgium's Historical Fisheries (HiFi) database; Italy's CLODIA database on Adriatic fisheries; *Trawling Through Time* database on Cefas (UK) surveys in the North Sea (1902–1971); early scientific surveys around South Africa (Univ. Cape Town); Swedish effort in the Baltic (Stockholm University). The newly digitized datasets were identified and added to the WGHIST metadatabase.

2) *Case studies documenting progress in historical fisheries research (ToR a, b).* – Several fisheries declines/collapses in different sea areas were highlighted, but also attempts to view changing fisheries and fish catches in combined ecological, socio-economic, and fisheries contexts. These included repeated collapses of sprat in the Baltic, declines in Queensland's snapper fishery, declines in elasmobranchs and other large-bodied, late-maturing fish in the Adriatic, and a decline (1936–2009) in mean trophic level of landings in South Australia. Dramatic ecosystem change in Canada's Bay of Fundy over the past 150 years was attributed to a range of diverse anthropogenic pressures. For Northeast England, shifting baselines in fishers' perceptions of fish size and abundance were reported. From 1946–1995, Belgian trawlers fishing Icelandic cod had declining catch rates and proportions of 'large' cod specimens. Historical cpue data for UK trawlers revealed distribution shifts in many North Sea fish stocks the past 100 years, not only attributable to climate change but also to (locally more concentrated) fishing *pressure.*

3) *Impact and outreach* – historical fisheries science placed in current policy context (ToR d). - Historical ecology can help guide policy advice, by placing the current state in historical context, and informing on baselines and the 'virgin' state. Historical ecology has potential to support implementation of the EU Marine Strategy Framework Directive, and the recommendation is to (1) where possible, provide data on metrics consistent with those used for MSFD indicators; (2) use spatial scales consistent with the MSFD; and (3) report on both the state of the system and the pressures it is subject to. Historical ecology may especially contribute to Descriptors 1 (Biodiversity), 3 (Commercially exploited fish), 4 (Foodwebs) and 6 (Seabed integrity).

2 Opening and closing of the meeting

The **2013 Working Group on the History of Fish and Fisheries** (WGHIST) took place at Villa Lemura, Panicale, Umbria, Italy. The locale was chosen upon invitation by veteran fisheries scientist Sidney J. Holt who however, unfortunately, could not be present due to ill health[1]. The Chairs, Georg Engelhard (Cefas, UK) and Ann-Katrien Lescrauwaet (VLIZ, Belgium), opened the meeting on Monday 7 October at 18:30 and closed it on Friday 11 October at 12:30. For the list of participants and contact details see Annex 1.

3 Adoption of the agenda

The WG met under the following Terms of Reference:

a) Provide a platform for discussion to various disciplines on history of fish and fisheries

b) Welcome historical case studies on fisheries from around the world's oceans

c) Summarize and synergise historical fisheries datasets

d) Support historical ecological baseline development

WGHIST will report on the activities of 2013 by 1 December 2013 to SSGSUE and SIBAS for SCICOM.

During this meeting, work on history of fish and fisheries was organized according to the following *themes*:

1. Data rescue, archiving and digitization (ToR c)
2. Case studies documenting progress in historical fisheries research (ToR a, b)
3. Impact and outreach – historical fisheries science placed in current policy context (ToR d)

[1] We were relieved to learn that Sidney Holt was discharged from hospital towards the end of October.

4 Updates on new developments

During this meeting, 20 presentations were given on new research developments or outcomes in historical fisheries ecological research. The titles and authors are listed below, with the name of the presenters underlined. The presentations were scheduled under each of the three themes outlined above. During the presentations, each presenter was requested:

- to summarize his/her findings as a 'one sentence key message',
- to explain how substantial the evidence is to test the working hypothesis and/or support the key findings,
- to elaborate on how the study supports current marine management.

5 Working Group contributions

The make-up of the 2013 Working Group was very different from last year's, with many new people attending but also minimum overlap with last year's attendance. As a result, and of a lack of funding, no progress was made on the three manuscripts 1–3 commenced in 2012. Work on these manuscripts will be done intersessionally and pending on funding sources. Instead, here we provide overviews of the contributions to the 2013 WG structured according to Themes (1) Data rescue, archiving and digitization; (2) Case studies; and (3) Outreach and impact.

Theme 1. Data rescue, archiving and digitization (ToR c)

- Currie, J., Attwood, C., Atkinson, L., Sink, K. Ecological change and historical baselines in South Africa's trawling grounds.
- Engelhard, G.H., Pattison, J.D., Hyder, K., Pinnegar, J.K., Bayliss-Brown, G.A., Hunter, E. *Trawling Through Time*: old data, new insights.
- Lescrauwaet A-K. Belgian fisheries: ten decades, seven seas, forty species: Historical time-series to reconstruct landings, catches, fleet and fishing areas from 1900. PhD Thesis. Ghent University (UGent): Gent. xiii, 242 pp.
- Mazzoldi M., and Fortibuoni, T. CLODIA: an open access database on the fisheries of Chioggia, Italy.
- Thurstan, R. Investigating the value of historical data: charting changes in Queensland's snapper fishery
- Alleway H. Reconstructing historical time-series and baselines in 5 case studies in Australia (King George whiting, Mean Trophic Level, *Ostrea angasi*).

Theme 2. Case studies documenting progress (ToR a, b)

- Grygiel, W. (2013) Collapses of Baltic sprat catches in Poland – on the historical examples from 1908–1914, 1937–1950 and 1979–1984.
- Engelhard, G.H., Kerby, T.K., Cheung, W.W.L., Pinnegar, J.K. (2013) Distribution shifts in the North Sea: why is life so complicated?
- Fortibuoni, T. (2013) Fishery in the Northern Adriatic Sea from the *Serenissima* fall up to the present: a historical and ecological perspective.
- Thurstan, R. (2013) Charting changes in Australia's marine environment.

- Townhill, B.L., Pinnegar, J.K. (through correspondence) Historical diets, foodweb dynamics and climate change in the Arctic.
- Alleway, H. (2013) Historical changes in the mean trophic level of South Australia's fisheries.
- Selim, S., Blanchard, J.L. (2013) Shifting baselines in coastal ecosystem provisioning: case study on Northeast England.
- Hentati-Sundberg, J. (2013) Long-term social-ecological dynamics in the Baltic Sea.
- Holm, P. (through correspondence) North Atlantic fisheries after the Second World War: environmental reprieve and repercussions.
- Orton, D., Morris, J., Locker, A., Barrett, J. (by correspondence) Detecting the origins of the Cod Trade: meta-analysis of urban archaeological remains as a tool for tracing consumption and trade over the long term.
- Verliin, A., Ojaveer, H., Kaju, K., Tammiksaar, E. (by correspondence) Quantification of the early small-scale fishery in the Northeastern Baltic Sea in the Late 17th Century.

Theme 3. Impact and outreach

In this session, the Q was raised and discussed how to reach from results and key message to the impact that is envisaged. A number of key recommendations were drawn from the discussion:

a) include dissemination and outreach activities from the beginning in the proposal

b) popular articles

c) organize local conferences or meetings to disseminate your results to your key actors

d) think/focus on the key message for each of the different key actors

- Klein, E (2013). In a dynamic world, how can we better understand complex marine systems? Bay of Fundy: a case study.
- Raicevich, S. The potential of Historical Ecology research to support implementation of the Marine Strategy Framework Directive (CE/2008/56).
- Mazzoldi, C., Sambo, A., Riginella, E. The CLODIA database as an instrument to increase stakeholders' awareness of ecological change in the Adriatic Sea.

6 Outputs from WGHIST

During 2013, three PhD theses were completed after having received support and inspiration from ICES WGHIST 2012 and previously, SGHIST 2010–2011:

Lescrauwaet, A-K. (2013) Belgian fisheries: ten decades, seven seas, forty species. PhD Diss., Univ. Ghent, Belgium, 257 pp. – Defended at University of Ghent on 6 June 2013 (public defence 5 July).

Kerby, T.K. (2013) UK fisheries, climate change and North Sea fishes: a long-term perspective. PhD Diss., Univ. East Anglia, Norwich, 129 pp. – Defended at University of East Anglia on 30 September 2013.

Klein, E. S. (2013) Change in nonlinear dynamics and spatial structure of coastal socio-ecological systems: Bay of Fundy as case study. PhD Diss., Univ. New Hampshire, Durham, NH, USA, 261 pp. – Defended at University of New Hampshire on 22 October 2013.

The following scientific papers were published or submitted in 2013 (or late 2012), as direct or indirect outcomes of ICES WGHIST 2012 and WGHIST 2013:

Engelhard, G.H. (submitted) On the need to study fishing power change: challenges and perspectives. *In:* K. Schwerdtner Mañez K, Poulsen B (eds) *Perspectives in Oceans Past: A Marine Environmental History*. Springer Publishers.

Fincham, J.I., Rijnsdorp, A.D., Engelhard, G.H. 2013. Shifts in the timing of spawning of sole linked to warming sea temperatures. *Journal of Sea Research*, 75: 69–76. doi:10.1016/j.seares.2012.07.004

Kerby, T.K., Cheung, W.W.L., van Oosterhout, C., Engelhard, G.H. 2013. Wondering about wandering whiting: distribution of North Sea whiting between the 1920s and 2000s. *Fisheries Research*, 145: 54–65. doi: 10.1016/j.fishres.2013.02.012

Kerby, T.K., Cheung, W.W.L., van Oosterhout, C., Engelhard, G.H. (2013) Entering uncharted waters: long-term dynamics of two data limited fish species, turbot and brill, in the North Sea. *Journal of Sea Research*, 84: 87–95. doi:10.1016/j.seares.2013.07.005

Lescrauwaet, A.-K., Fockedey, N., Debergh, H., Vincx, M., Mees, J. 2013. Hundred and eighty years of fleet dynamics in the Belgian sea fisheries. *Reviews in Fish Biology and Fisheries*, DOI 10.1007/s11160-012-9287-1

Lescrauwaet, A.-K.; Torreele, E.; Vincx, M.; Polet, H.; Mees, J. 2013. Invisible catch: A century of bycatch and unreported removals in sea fisheries, Belgium 1929–2010. *Fisheries Research*, 147: 161–174. hdl.handle.net/10.1016/j.fishres.2013.05.007

Lescrauwaet, A.-K. 2013. Fishing in the Past: the spatial dynamics of the Belgian sea fisheries during the 20th century, in: Lescrauwaet, A.-K. (2013). Belgian fisheries: ten decades, seven seas, forty species: Historical time-series to reconstruct landings, catches, fleet and fishing areas from 1900. pp. 94–119.

Lescrauwaet, A.-K., De Raedemaecker, F., Vincx, M., Mees, J. 2013. Flooded by herring: Downs herring fisheries in the southern North Sea during World War II, in: Lescrauwaet, A.-K. (2013). Belgian fisheries: ten decades, seven seas, forty species: Historical time-series to reconstruct landings, catches, fleet and fishing areas from 1900. pp. 164–181, and submitted.

Lescrauwaet, A.-K., Vincx, M., Vanaverbeke, J., Mees, J. 2013. '*In* Cod we trust': Trends in gadoid fisheries in Iceland 1929–1996, in: Lescrauwaet, A.-K. (2013). Belgian fisheries: ten decades, seven seas, forty species: Historical time-series to reconstruct landings, catches, fleet and fishing areas from 1900. pp. 182–197, and submitted.

7 Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	E-MAIL
Heidi Alleway	Southern Seas Ecology Laboratories, University of Adelaide North Tce., Adelaide, SA, Australia, 5000 x Department of Primary Industries and Regions South Australia 33 Flemington St., Glenside, SA, Australia, 5065	Tel. +61 (0) 438 449 096	heidi.alleway@gmail.com
Jock Currie	SAEON Egagasini Offshore Node Biological Sciences Department, University of Cape Town Cape Town, South Africa	Tel. +27 (0)78 333 7287	jock@saeon.ac.za
Georg H. Engelhard **(Chair)**	Centre for Environment, Fisheries & Aquaculture Science (Cefas) Pakefield Road, Lowestoft NR33 0HT, UK	Tel. +44 1502 527747	georg.engelhard@cefas.co.uk
Tomaso Fortibuoni	ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) Loc. Brondolo, 30015 Chioggia (Venezia) Italy	Tel. +39 0415543933, Fax +39 041.5547897, Mob. +39 3493825601	tomaso.fortibuoni@isprambiente.it www.strategiamarina.isprambiente.it, www.gap2.eu
Wlodzimierz Grygiel	National Marine Fisheries Research Institute (NMFRI) Department of Fisheries Resources ul. Kollataja 1, 81-332 Gdynia, Poland	Tel. +48-58-7356270, Fax +48-58-7356110	wlodzimierz.grygiel@mir.gdynia.pl www.nmfri.gdynia.pl
Sidney J. Holt **(Host; Apology)**	Voc. Palazzetta 68, Paciano (PG), 06060 Italy	Tel. +39 075 830 7035	sidneyholt@mac.com
Emily Klein	Natural Resources & Earth Systems Science University of New Hampshire 142 Morse Hall, 8 College Road, Durham, NH 03824, USA	Tel. +1 (603) 862-2396, Mob. +1 (435) 659-1354	emily.klein@unh.edu

Name	Address	Phone/Fax	E-mail
Ann-Katrien Lescrauwaet **(Chair)**	Flanders Marine Institute/Vlaams Instituut voor de Zee (VLIZ) Wandelaarkaai 7, 8400 Oostende, Belgium	Tel. +32 475 493452	annkatrien.lescrauwaet@vliz.be
Carlotta Mazzoldi	Department of Biology, University of Padova Via U. Bassi 58/B, 35131 Padova, Italy	Tel. +39 0498276194, Fax +39 0498276199	carlotta.mazzoldi@unipd.it www.bio.unipd.it/fish
Saša Raicevich	ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) Loc. Brondolo, 30015 Chioggia (Venezia), Italy	Tel +39 0415543933, Fax +39 0415547897, Mob. +39 3486113600	http://marinestrategy2012.dmu.dk/, www.gap2.eu
Samiya Selim	Department of Animal and Plant Sciences University of Sheffield Alfred Denny Building, Western Bank, S10 2TN, UK	Tel. +44 7783603377	bop11sas@sheffield.ac.uk
Jonas Hentati-Sundberg	Stockholm Resilience Centre, Stockholm University SE-106 91 Stockholm, Sweden Visiting Address: Kräftriket 10	Mob. +46 (0)73 938 79 69	jonas.sundberg@stockholmresilience.su.se www.stockholmresilience.org
Ruth H. Thurstan	School of Biological Sciences and ARC Centre of Excellence for Coral Reef Studies University of Queensland, St Lucia, QLD 4072, Australia	Tel. +61 (0) 450 586 263	r.thurstan@uq.edu.au www.marinepalaeoecology.org

Annex 2: Summaries

Identifying and reconstructing shifted ecological baselines in temperate marine Australia

Heidi Alleway
Southern Seas Ecology Laboratories, University of Adelaide, Adelaide, South Australia, 5000 and Department of Primary Industries and Regions South Australia, Glenside, South Australia, 5065

Introduction. – Ecological baselines are often used within Australian frameworks for Natural Resource Management (NRM) but are largely contemporary. Although the practice of reconstructing historical baselines is now more widely accepted there is limited knowledge of whether ecological baselines in southern Australia have changed over multidecadal time-scales, and how. This PhD thesis uses a case study approach to identify and quantify historical baselines in the temperate marine environment of South Australia. Current case studies are:

Case Study 1: Historical changes in mean trophic level of southern Australian fisheries

Heidi K. Alleway[A], Sean D. Connell[A], Tim Ward[B], Bronwyn M. Gillanders[A]
[A] *School of Earth and Environmental Sciences, University of Adelaide, South Australia, 5005*
[B] *South Australian Research and Development Institute (Aquatic Sciences), South Australia, 5022*

Decreases in the mean trophic level (MTL) of fish catches have been used to infer reduced abundance of high trophic level species caused by fishing pressure. Previous assessments of MTL in southern Australian fisheries have been inconclusive. This study aims at providing more accurate estimates of MTL by using disaggregated taxonomic and spatial data. We applied the model of MTL to catch statistics for the state of South Australia from 1951 to 2010 and a novel set of historical market data from 1936 to 1946. From 1951 to 2010 MTL declined by 0.16 trophic level decade^{-1}; a rate greater than the global average of 0.10 but equivalent to similar regional investigations in other areas (Table 1). The change was mainly attributable to large increases in catches of sardine, rather than reductions in catches of high trophic level species. The pattern is maintained when historical market data are included providing a time line from 1936 to 2010. Our results show a broadening of the catch of lower trophic levels and reveal care in interpretation of MTL of catches because reductions do not necessarily reflect change in high trophic level species by fishing pressure.

Table 1. Measures of patterns in MTL over time, in fisheries data (1951–2010) and with the inclusion of market data (1936-2010), R^2 values of linear trend lines, and the significance of the trend, *P*-value.

	1951–2009			1936–2009		
Analysis	Per decade TL change	Linear trend R2	P	Per decade TL change	Linear trend R2	P
All species	–0.14	0.8226	0.000	–0.11	0.6896	0.000
All species (exc tuna)	–0.18	0.8694	0.000	–0.15	0.8010	0.000
All species (exc tuna & shark)	–0.16	0.9161	0.000	–0.14	0.9027	0.000
All species (exc tuna, shark & sardine)	–0.10	0.8285	0.000	–0.09	0.8730	0.000
Species TL > 3.25	0.01	0.1307	0.007	–0.01	0.0080	0.480
Species TL > 3.25 (exc tuna or shark)	–0.01	0.0173	0.339	–0.04	0.3525	0.000

Case Study 2: Quantitatively understanding lost oyster beds using qualitative data

Heidi K. Alleway[A], Sean D. Connell[A]
[A] *School of Earth and Environmental Sciences, University of Adelaide, South Australia, 5005*

Histories of the exploitation and decline of oyster populations have been documented for many species but these assessments are largely based on historical survey data. Using the native mud oyster of southern Australia, Ostrea angasi Sowerby 1871, we investigated alternative methods for appreciating lost oyster beds where limited quantitative data are available. We collated information from fisheries correspondence and inspector diaries during the 1800s and 1900s to reconstruct: a time line of development and changes to the fishery, an understanding of the bioregions and locations where oyster beds were commercially exploited, and changes to catch and effort between 1886 and 1944. Qualitative statements on the fishery were coded to estimate perceived abundance and consider if locations were overfished prior to the collection of catch data in 1886. A model for estimating the number of oysters on beds prior to the onset of fishing was also developed. Results indicate that five of the state's eight marine bioregions previously had oyster beds used for commercial fishing. Some locations were overfished prior to the collection of catch data and the numbers of oysters on these beds were comparable to those of other Ostrea species. This work illustrates that there are alternative methods for quantifying lost oyster habitat in situations where there is limited ecological or fisheries data.

Ecological change and historical baselines in South Africa's trawling grounds

Jock Currie

South African Environmental Observation Network, Egagasini Offshore Node

Marine Research Institute, Biological Sciences, University of Cape Town

Background. – South Africa's trawling industry initiated in 1898 when the first steam trawler started fishing off the Cape. Before then, fishing had mainly been conducted from shore or on small wooden boats that could not venture far from the coast. The industry grew steadily until about 1950, after which trawl landings escalated and peaked in the 1970s, largely due to substantial effort by foreign vessels in South African waters. Stocks of the most important target species, hake, collapsed just as the first management measures were introduced, initially by the International Commission for the Southeast Atlantic Fisheries and later by the South African government, which declared an exclusive fishing zone in 1977. Although the trawl fishery has been relatively well monitored and managed since the 1980s, details of its early development and associated statistics have been buried in inaccessible, mostly forgotten historical reports or archives.

Effective policy advice on fisheries management and biodiversity conservation implicitly relies on an understanding of what our marine ecosystems looked like in the past. Historical baselines are important as they allow measurement of long-term changes and allow evaluation of management strategies. Estimates of unfished species abundances are required as inputs into fishery stock assessment models and guide the choice of baseline conditions in the rapidly growing field of ecological models. Improved historical reference points of South Africa's marine environment are a national research priority.

Fortunately, South Africa has a wealth of underutilized historical marine data, and an exceptional dataset was digitized recently. This included thousands of geo-referenced research stations surveyed during exploration of offshore fishing grounds between 1897–1904 and 1920–1949, as well as commercial landings records from harbours and trawling vessels/companies during the periods of 1897–1906 and 1921–1960. These data allow unprecedented insight into historical marine communities in South Africa and their early exploitation history, yet have not been interrogated in any detail previously.

My PhD project aims to make significant inroads into resolving the historical backdrop of trawl fisheries on the Agulhas Bank of South Africa. To do so, I have set the following objectives:

4) Examine how the distributions of selected fishery species have changed between the early 20th century and the present, interpreting such changes in light of climate change and fishery impacts.

5) Reconstruct the spatio-temporal evolution of fishing pressure in South Africa's trawl fishery.

6) Contrast the trawl-caught community structures of the early 20th century and the present, assessing how these have changed in light of anthropogenic pressures.

7) Estimate baseline biomass and relative abundances of historical fauna, to provide reference points from a period before they would have experienced significant anthropogenic pressures.

8) Share results and interpretations across a broad audience, including lay-people, resource managers and the fishing industry, with a particular emphasis on educating stakeholders and the broader public.

Methods. – Two chapters will be desktop-based and will commence prior to field surveys. The distributions of selected taxa will be mapped from historical survey and commercial landings records and compared to recent distributions. Concurrent changes in the physical environment will be investigated from oceanographic data and hind-cast simulations of global and regional ocean general circulation models. In a separate chapter, the spatial development of trawl fishing pressure over time will be reconstructed from historical records of commercial catches and vessels. These results will be compared to the distributional changes and will provide a backdrop for following chapters.

Three well-sampled sites have been identified from the historical trawl survey data of 1897-1904, which were carried out by South Africa's first steam trawler, the *Pieter Faure* (Figure x). We plan to re-survey these sites, imitating the methods, gear and trawl speeds of the early 20th century. Information within historical reports and other literature will be used to construct trawling gear that is identical in size and as close-as-possible in its functioning to the otter trawls used during the early surveys. A working visit to Cefas, Lowestoft, UK (from 14 October–8 November 2013) allowed the retrieval of relevant historical gear information from Cefas library archives.

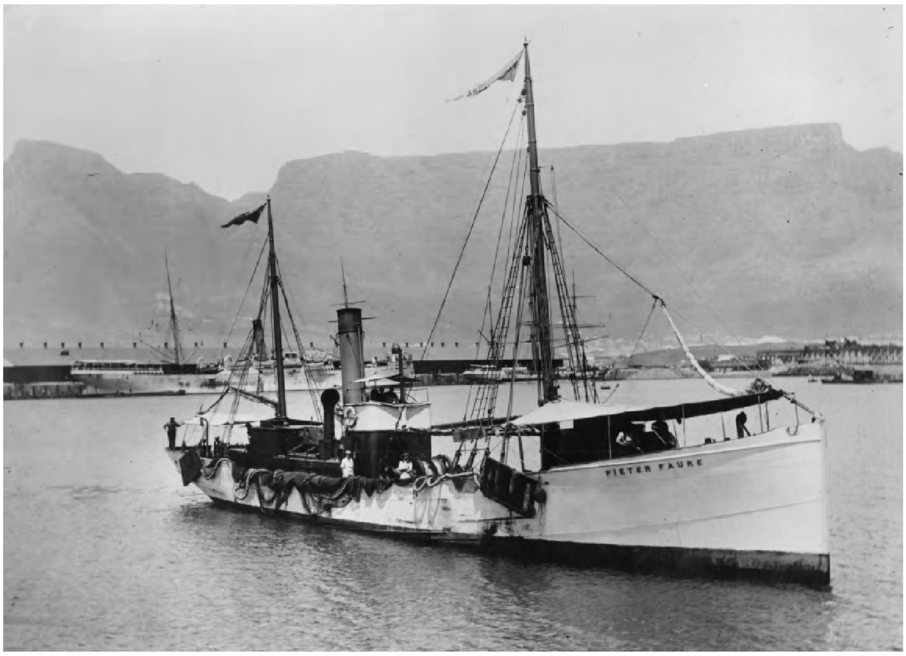


Figure x. Steam trawler *Pieter Faure*, built in Scotland and the first to extensively trawl South African waters, did exploratory fishing surveys on 'virgin' grounds near Cape Town and on the Agulhas Bank during 1897–1904. The survey data were recently digitized and are analysed as part of the PhD project. (Photo from the Department of Agriculture, Forestry and Fisheries photo library)

Using the reconstructed historical gear, repeat trawl surveys will be conducted in collaboration with current demersal trawl skippers, using an inshore commercial trawler. Once repeat surveys have been conducted, multivariate analyses will be used to compare the community structure of the vertebrate fauna between the historical surveys by SS *Pieter Faure* and our re-surveys. A further chapter will focus on comparing the abundance estimates of selected species and estimating indices of biomass between the two periods.

Collaboration with the government demersal research group and the trawl industry will be the key to achieving the fieldwork component of this project and contact has been established with them. A central focus of our project will be to develop partnerships and result-sharing across stakeholders that include government, fishery managers, industry and the public. Results will assist resource assessment scientists, will feed into ecological models and will inform the implementation of spatial protection and management in proposed offshore focus areas.

Distribution shifts in the North Sea: why is life so complicated?

Georg H. Engelhard (1), Tina K. Kerby (1,2), William W.L. Cheung (3), and John K. Pinnegar (1)

(1) Centre for Environment, Fisheries and Aquaculture Science (Cefas), Lowestoft, UK; (2) University of East Anglia, Norwich, UK; (3) University of British Columbia, Vancouver, Canada.

Abstract. – The North Sea has been termed a 'hot spot' of marine climate change and has warmed by over 1°C over the past 100 years. In accordance, several highly cited studies reported that over the past 30 years, various North Sea fish species showed an apparent northward shift in distribution, and that the whole fish assemblage has 'deepened'. In a recent project, extensive historical data on fish distribution were digitized for a timespan approaching a century, for seven North Sea fish species of key commercial significance (sole, plaice, cod, haddock, whiting, brill and turbot). A picture is emerging that distribution shifts in the North Sea cannot simply be described as 'fish moving north'. Distributions have shifted in various directions: some species have shifted northward, others southward, others remained surprisingly stable, whereas others again have mainly contracted or declined significantly over portions of their former range. Both climate change and fishing pressure are found to be important drivers leading to distribution shifts, with fishing pressure being especially important for the two species of highest commercial significance, sole and cod.

Introduction. – The North Sea has warmed significantly over the past 100 years but is also subject to significant trawling pressure. Several authors (e.g. Perry *et al.*, 2005; Dulvy *et al.*, 2008) have indicated that the recent warming trend has coincided with a northward shift in the distribution of some fish species over the past 30 years, and that the whole fish assemblage has 'deepened'. However, closer examination of reported shifts at the individual species level has revealed many different, confusing responses with some fish moving northwards, some southwards and some hardly responding at all. Here we synthesize outcomes from new studies on spatial distribution of North Sea fish over the past 90–100 years – work that has extended the known time-span of shifts for these species by some 5–6 decades backwards, and which highlights the potential roles of both climate change and fishing pressure as drivers of shifts.

Material and methods. – Data were digitized from 'statistical charts' (catalogued in Engelhard, 2005) that were produced by the UK Ministry of Agriculture, Fisheries and Food (MAFF; now the Department for Environment, Food and Rural Affairs – Defra). These show fishing effort (hours fished) and fish landings (tonnes) by British otter trawlers (either steam or motor driven) for each ICES rectangle (0.5° latitude by 1° longitude) in the North Sea. Two projects (Defra *100 Years of Change in Fish and Fisheries* and Cefas *Trawling Through Time*) have supported this large-scale data recovery and digitization effort, which has led to a unique 100 year (1913–2012) spatial time-series of fish catch-per-unit-effort (cpue) data. These were then used to examine whether locations where peak catches of species such as cod (*Gadus morhua*), whiting (*Merlangius merlangus*), haddock (*Melanogrammus aeglefinus*), plaice (*Pleuronectes platessa*), sole (*Solea solea*), turbot (*Scophthalmus maximus*; Figure 1) and brill (*S. rhombus*) are obtained, have shifted throughout the 20th and early 21st Centuries. For full details of the methodology, see Engelhard *et al.* (2011, submitted), Skinner (2009) and Kerby *et al.* (2013a, b).

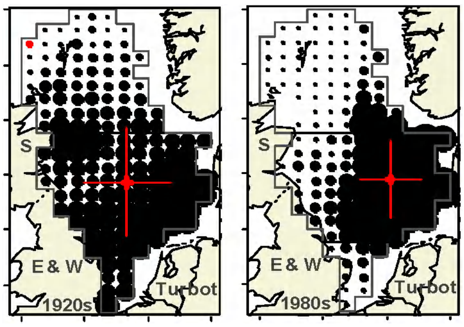


Figure 1. Distribution of turbot cpue, 1920s and 1980s (Kerby *et al.*, 2013b).

Results and Discussion. – A synopsis of century-scale distribution changes in seven North Sea fish species (Table 1) reveals that distributions have shifted in various directions: some species have shifted northward (cod, plaice, brill), others southward (sole), others remained surprisingly stable (whiting), whereas others again have mainly contracted or declined significantly over portions of their former range (turbot, cod). Whereas plaice have gradually shifted north and to deeper waters (as may be expected with climate warming), sole have shifted southward and 'shallowing' response (possibly attributable to better survival in shallow waters in recent, milder winters; Engelhard *et al.*, 2011). Statistical analyses of changing spatial distributions suggested that shifts in the 'centre of gravity' of cod, haddock, sole and plaice distribution could, wholly or partly, be attributed to climatic variables (such as SST, NAO and AMO). On top of climate change, it was found that fishing pressure was an especially important driver for the two species of highest commercial significance, sole and cod. Historical data suggested, moreover, that turbot has been largely depleted from an area off Scotland where it was formerly fished in rather large numbers. This ground still bears the name *Turbot Bank* – but turbot have only been caught sporadically here since the 1960s (Figure 1).

Globally, distributions of many fish stocks are shifting, and the role of climate change is increasingly appreciated. We highlight the significance of fishing pressure as a potential additional driver in range shifts. We encourage that the question is paid more attention, given that many commercial fish stocks are subject to intensive exploitation pressure, and also given that fishing effort is often highly concentrated in specific regions within a stock's distribution range.

Table 1. Overview of distribution shifts in seven North Sea fish species with attributed cause and references.

Species	Shift	Attributed cause of shift	Source
Cod	N, E, deepening	N and deepening to climate change, E to fishing pressure	Engelhard *et al.* submitted
Whiting	Fairly stable apart from W shift from late 1940s–1960s	No clear relationships	Kerby *et al.* 2013a
Haddock	N shift of southern range boundary	Climate change	Skinner, 2009
Plaice	N, W, deepening	Climate change	Engelhard *et al.*, 2011
Sole	S, W, shallowing	Fishing pressure, climate change	Engelhard *et al.*, 2011
Turbot	Contraction away from N, now mainly in C and S North Sea	Depletion in N, or fewer large fish migrating from S to N	Kerby *et al.*, 2013b
Brill	Stable in S and C, some expansion in C	Unclear	Kerby *et al.* 2013b

References

Dulvy, N.K., Rogers, S.I., Jennings, S., Stelzenmüller, V., Dye, S.R., and Skjoldal, H.R. 2008. Climate change and deepening of the North Sea fish assemblage: a biotic indicator of warming seas. Journal of Applied Ecology, 45: 1029–1039.

Engelhard, G.H. 2005. Catalogue of Defra historical catch and effort charts: six decades of detailed spatial statistics for British fisheries. Science Series Technical Report, Cefas Lowestoft, 128: 42 pp.

Engelhard, G.H., Pinnegar, J.K., Kell, L.T., and Rijnsdorp, A.D. 2011. Nine decades of North Sea sole and plaice distribution. ICES J. Mar. Sci. 68: 1090–1104.

Engelhard, G.H., Righton, D.A., and Pinnegar, J.K. (submitted) Climate change and fishing: a century of shifting distribution in North Sea cod.

Kerby, T.K., Cheung, W.W.L., van Oosterhout, C., and Engelhard, G.H. 2013a. Wondering about wandering whiting: distribution of North Sea whiting between the 1920s and 2000s. Fisheries Research, 145: 54–65.

Kerby, T.K., Cheung, W.W.L., van Oosterhout, C., and Engelhard, G.H. 2013b. Entering uncharted waters: long-term dynamics of two data limited fish species, turbot and brill, in the North Sea. Journal of Sea Research, 84 : 87–95.

Perry, A.L., Low, P.J., Ellis, J.R., Reynolds, J.D. 2005. Climate change and distribution shifts in marine fishes. Science, 308: 1912–1915.

Skinner, J.A. 2009. The changing distribution of haddock *Melanogrammus aeglefinus* in the North Sea: effects of fishing effort and environmental variation over the last century. MSc Thesis, Univ. East Anglia, UK.

Fishery in the Northern Adriatic Sea from the *Serenissima* fall up to the present: a historical and ecological perspective

Tomaso Fortibuoni

Istituto Superiore per la Ricerca e la Protezione Ambientale (ISPRA), Chioggia, Italy.

Introduction. – Fisheries have been described as the major driving force altering fish communities, and chronologically, have done so for longer than any other human impacts, including pollution, eutrophication and anthropogenic climate change. Marine ecosystems have been severely altered for centuries, but management policies for marine resources are typically based on recent (few decades) observations only. This could lead to an underestimation of ecosystems' productive capacity and biodiversity, the well-known 'shifting baseline syndrome'. Therefore, the recovery and analysis of historical data are now at the forefront of fishery science, which is trying to reconsider past baselines to better understand ecosystem dynamics and set targets for restoration and management. A major challenge, however, is the collection and analysis of proxy data: although there is much qualitative information on the past abundance of marine organisms, quantitative data are often lacking.

The Northern Adriatic Sea provides a valuable case study, owing to its rich historical sources on fish fauna and fishing activities, and owing to its ecological value, derived from the high primary and secondary productivity, making it one of the Mediterranean's most heavily exploited basins. Key objectives of this work were (1) to describe the development of fishing capacity between 1800 and 2000 in the Northern Adriatic Sea; and (2) to study long-term (2 centuries) changes in the fish community through naturalists' accounts and landings statistics. This was done through extensive surveys (from January 2007–March 2008) of libraries and archives in Venice, Padua, Rome, Trieste, and Chioggia (Italy) and Split (Croatia), to collect reports, books and scientific publications dealing with fishery and fish fauna in the Northern Adriatic. Some 500 documents were examined, of which around 300 were acquired. Documents included both scientific and humanistic sources, such as naturalists' descriptions of fish fauna, grey literature on fishing activities in the area, landings statistics, and official government reports on the fishery and fishing fleets.

Results and discussion. – The period between the second half of the 19th Century and the First World War was characterized by increases in numbers of fishing vessels and fishers. After the Second World War, a real revolution of fishing methods took place, with the introduction of engine propellers and several other technological devices, including the acoustic fish finder and the use of synthetic fibres (Figure 1).

The intercalibration and integration of naturalists' descriptions of fish fauna and landings allowed constructing a semi-quantitative, 2-centuries time-series of species "perceived abundance" (Figure 2). Temporal trends of fish community structure indicators highlighted a long-term 'fishing down' process. Declines in relative biomass of Chondrichthyes, large demersals, as well as late-maturing fish species indicated significant, long-term changes in the fish community structure (Figure 3).

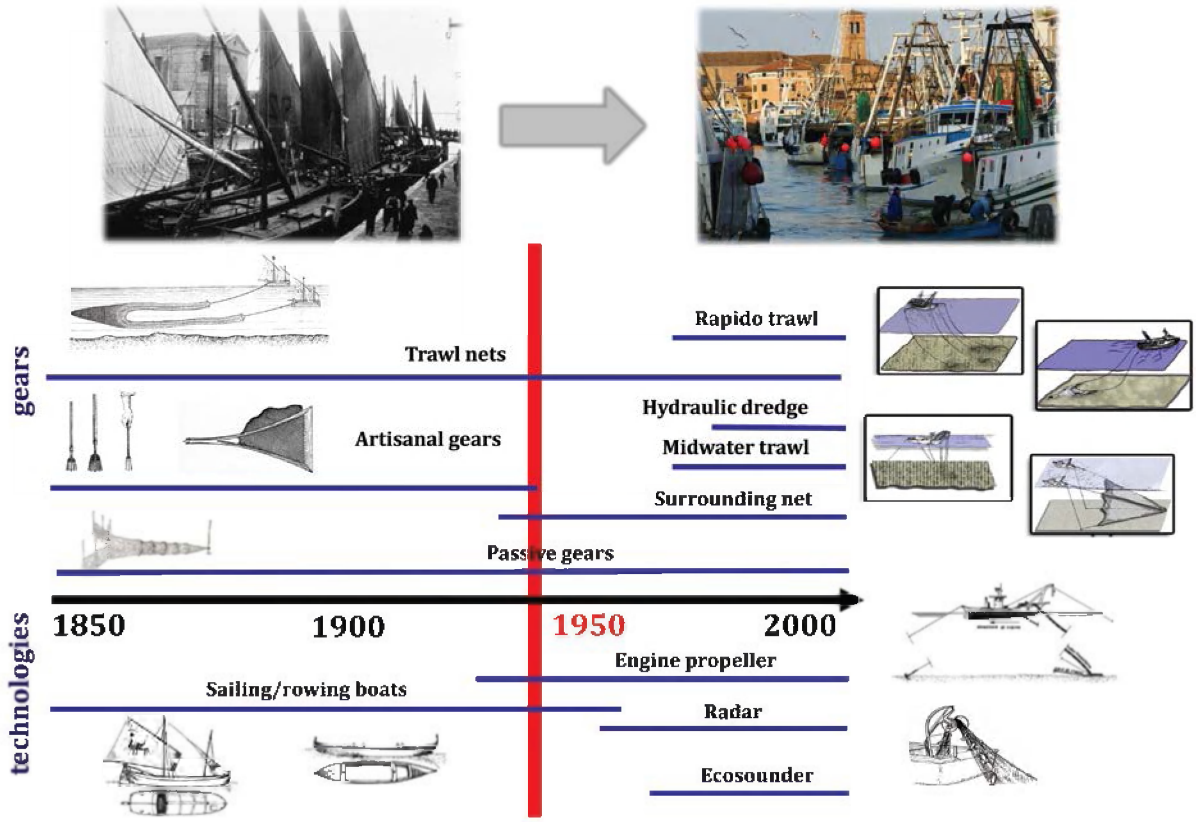


Figure x.1. Conceptual map of changes in fishing gears and technology in the Adriatic Sea (west coast fisheries) from 1850–2000. After World War II, traditional sailing boats were abandoned due to the adoption of engine propellers. New technological devices (e.g. radar, echosounder) and fishing gears (e.g. midwater pelagic trawl, rapido trawl, hydraulic dredges) increased the catchability of target species.

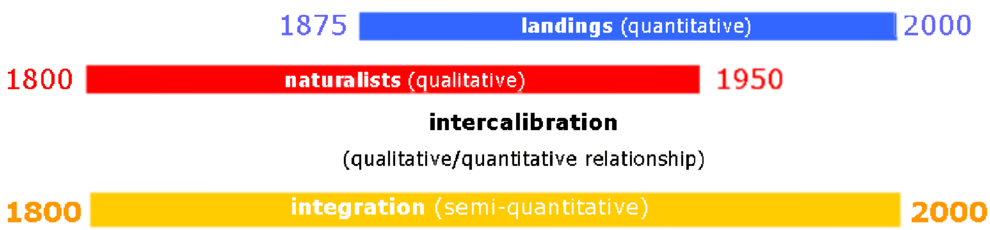


Figure 2. Intercalibration method that allows quantification of naturalists' qualitative descriptions of fish "perceived abundance". Naturalists' classes of "perceived abundance" were given a set of numerical weights based on landings proportions. Furthermore, it allowed to define class limits to convert landings for the periods 1951–1975 and 1976–2000 (for which naturalists' descriptions were not available) into classes of "perceived abundance". This resulted in the description of species "perceived abundance" with the same semi-quantitative metric over the entire period from 1800–2000.

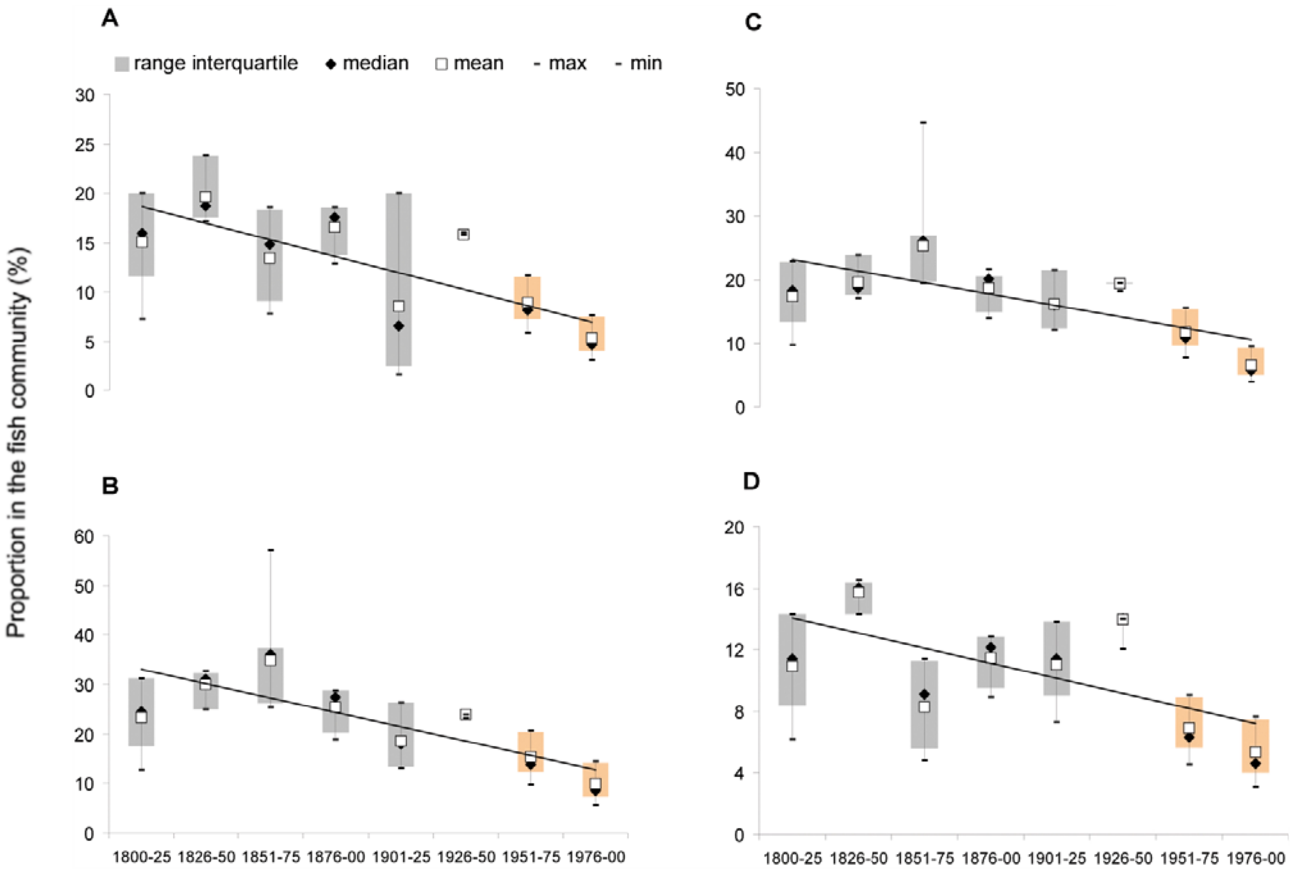


Figure 3. Temporal trends of fish community structure indicators in the period 1800–2000 (N = 87 species/groups of species). Grey boxes indicate the naturalists' observations of species' perceived abundance, and orange boxes indicate the observed relative composition transformed into classes of perceived abundance. (a) Chondrichthyes; (b) large demersals; (c) species with a maximum body length between 120 and 250 cm; (d) species that reach sexual maturity between the 4th and 6th years of life (from Fortibuoni, T., Libralato, S., Raicevich, S., Giovanardi, O., Solidoro, C. (2010) Coding Early Naturalists' Accounts into Long-Term Fish Community Changes in the Adriatic Sea (1800–2000). PLoS ONE 5(11): e15502. doi:10.1371/journal.pone.0015502).

Collapses of Baltic sprat catches in Poland – on the historical examples from 1908–1914, 1937–1950 and 1979–1984

Wlodzimierz Grygiel
National Marine Fisheries Research Institute (NMFRI), Gdynia, Poland

Key message. – Dramatic, long-term collapses of the Polish commercial catches of Baltic sprat were observed in 1908–14, 1937–1950 and 1979–1984 and likely resulted from significant changes in the fishing pattern (high fishing pressure on resources) and some biological-hydrological changes.

How substantial is the evidence. – Based on papers by Polish (and some German) scientists, on sprat catches in the Gulf of Gdańsk during 1905–1938; on ICES Secretariat sprat catch statistics and market values from 1913–1945; and on ICES Bulletin Statistiques 1948, WGBFAS/2011, and WGBFAS/2013 Reports.

Support of current marine management. – Each of the three sprat collapses in Polish waters (1908–1914, 1937–1950, 1979–1984) followed short periods of very intense fishing effort and high landings. Similar situation is repeated in current years in the Baltic. Insights from the history of Polish sprat catches in the Gulf of Gdańsk can provide explanations and advice to current specialists on Baltic sprat stock assessment.

Abstract

The presentation synthesized published data sources, available literature, and ICES fisheries statistics on Baltic sprat with focus on the Polish fisheries, and with special reference to the marked stock collapses that were observed during 1908–1914, 1937–1950, 1979–1984.

First historical, sudden and long-term collapse of sprat catches in "Poland" (1908–1914)

In autumn–winter 1907/1908, record-high catches were taken in the Gulf of Gdańsk by some 200 fishing vessels, using only passive fishing gears, i.e. moored and drifted gillnets and trapnets (Dixon, 1937). Sprat landings collapsed from 10 538 to 8 t; the crisis lasted 7 years (1908–1914), and the mean market price increased from 6 to 41 German Marks per 125 kg (Ropelewski, 1963).

Attributed causes:

- The commercial "disappearance" of sprat was accompanied by the appearance of large numbers of grey seals in the Puck Bay (Ropelewski, 1963; Wultańska 1971).
- Instead of sprat, exploitation switched to flatfish grey seal hunting, which was intensively developed in 1907–1920 near the Peninsula of Hel (Ropelewski, 1963).

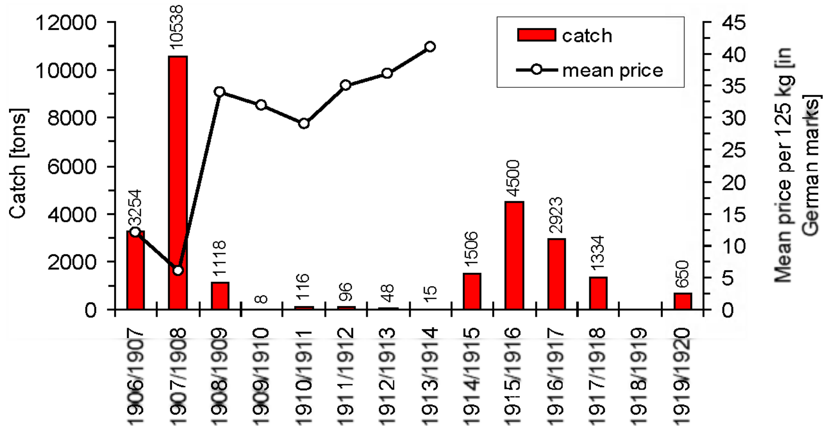


Figure 1. Baltic sprat catches in the Gulf of Gdańsk (bars) and mean market price of sprat (circles)

Second historical, sudden and long-term collapse of sprat catches in Poland (1930s)

In 1936, some 30 000 t sprat were landed from the Baltic and neighbouring waters, of which 80% originated from the Gulf of Gdańsk and Prussian Pomerania coasts (Dixon 1937, 1938). The combined, international landings of sprat from the Baltic were two times higher than those taken from the North Sea (Figure 2).

In 1934–1936 (Poland), the "harvest sprat" changed into an abundance-calamity owing to flooding of the market, leading to a fall in the price of sprat from 40 to 2 grosz's kg^{-1} (Ropelewski, 1963). Distribution of landed sprat was poorly organized, and much was used in agriculture as fertilizer.

In 1936–1938 Baltic sprat landings in Poland decreased significantly, from 15 081 to 50 t (Mulicki, 1948). After 1936, the lack of industrial concentrations of Baltic sprat lead to 12 (15) years collapse of the Polish fishery; recovery began in 1950 (Mulicki, 1948; Elwertowski, 1957).

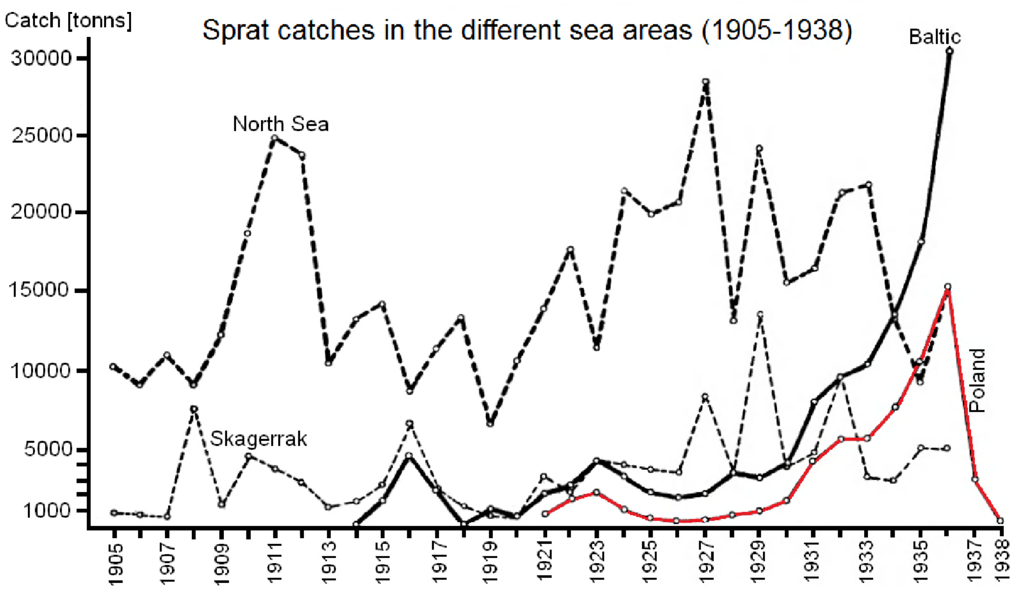


Figure 2. Sprat catches in different sea areas.

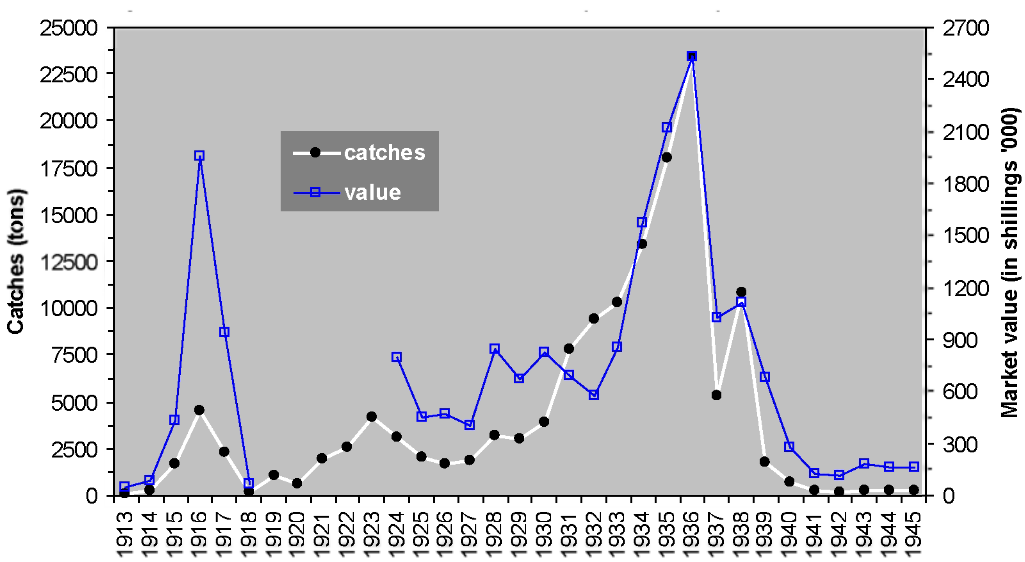


Figure 3. Sprat catches in the whole Baltic Sea (1913–1945) vs. market value.

Attributed causes:

- Overexploitation before 1937, as a result of fishing methods changing to less selective and more efficient, active gears (large pair bottom trawls), and of significant increases in numbers of vessels and fishing effort in the Gulf of Gdańsk, with high concentration of effort in a small area of the Puck Bay and near the Peninsula of Hel (Demel, 1946; Ropelewski, 1963; Dunin-Kwinta and Wawrzyniak, 2011). Moreover, high preference to sprat at a local fish market, and a lack of transparent fishing regulations (Dixon 1937, 1938, 1950, Siedlecki, 1947, Dixon and Mulicki, 1948)
- Collapse of the sprat fishery after 1936, acc. to Meyer (1942) is not the effect of the pressure of the large pair bottom trawls on fish resources, but resulted from the high sensibility of sprat eggs and larvae on the environmental factors. The intensive use of bottom trawls led to substantial reduction of abundance of clupeids recruiting year-classes (Meyer, 1942, Elwertowski, 1957)
- After 1937, a series of the inclement winters with strong winds from the coast modified sprat migrations, and decrease of abundance of recruiting year-classes (Siedlecki, 1947).
- Before WWII, in the Baltic fishery in force was an informal rule: „Catch-as-catch-can" (Ropelewski, 1976). After 1936, Dixon (1937, 1938) and others postulated for the implementation of a ban on sprat catches by Polish fisheries on Saturdays from April 1st, and an international ban on sprat catches by bottom pair trawls, the implementation of regulation concerns size of the sprat bottom trawls.
- From 1936–1947, no strong year-class of sprat recruited (Elwertowski, 1957b, Birjukov, 1971; 1980), partly resulting from weak effectiveness of spawning in the Gdańsk Basin in 1936 because of occurrence of unfavourable conditions at spawning areas (Mańkowski, 1951; Bogucki cited by El-

wertowski, 1957a) and considerable depletion of zooplanktonic food resources for sprat (Żarnecki, cited in Elwertowski, 1964).

- By contrast, two strong herring year-classes were born in 1936 and 1937 in the Baltic Proper, likely competing for prey resources with sprat (Popiel, 1955; Ojaveer, 1962a; 1962b).
- Substantial increases in cod abundance in the southern Baltic during the second half of the 1930s, leading to increased predation pressure on sprat, which forms a main component of cod diet (Elwertowski, 1957b; Mańkowski, 1959; Wultańska, 1971; Popiel *et al.*, 1985).
- Several influxes of saline water from the North Sea into the Baltic and cooling of Baltic waters in 1937–1939, stimulating productivity of cod but reducing sprat food resources (Grauman *et al.*, 1987).
- In 1930s, growing population of harbour porpoises, adding additional predation pressure on reduced sprat resources in the Gulf of Gdańsk (Dunin-Kwinta and Wawrzyniak, 2011).
- Unfavourable climatic conditions in the Gulf of Gdańsk after 1936: lack of strong ocean-winds (northwesterly), which stimulate sprat shoals shifting to the area of wintering in the gulf, and predominance of strong mainland winds (southeasterly), which shift sprat shoals from traditional fishing grounds to deeper parts of the Baltic (Demel, 1937, 1938a, 1938b, Wultańska, 1971, Popiel, *et al.*, 1985).

Third gradual, short-term collapse of Polish sprat catches (1979–1984)

In 1977–1983, the Polish landings of Baltic sprat significantly decreased from 38 800 to 7 100 t (5.5 times) and the international landings decreased 4.9 times. In 1977–1983, the Polish landings of Baltic cod increased from 47 700 to 123 500 t (2.6 times; from WGBFAS/2011 Report).

Attributed causes:

- Baltic sprat SSB decreased from 916 000 to 223 000 t (4.1 times)
- Baltic cod total-stock biomass increased from 533 503 to 1 057 369 t (2 times; WGBFAS/2011 Report)
- High internal competition in the large Baltic cod stock for food, i.e. primarily sprat
- In 1979–1986, sprat fishing mortality ($F_{3\text{–}5}$) fluctuated from 0.123 to 0.267, and cod fishing mortality ($F_{4\text{–}7}$) was 3–4 times higher and varied from 0.495 do 1.094 (WGBFAS/2011 Report)
- Commercial interest of Baltic fishing fleet was steered principally to cod. In the first half of 1980s the price per kg of cod was 12 times higher than that of sprat
- Low abundance of Baltic sprat recruiting year-classes 1976–1990 (with the exception of 1982), well below long-term average of 80.3 billion (after ICES – WGBFAS/2013 Report).

Conclusions

1) Spectacular, long-term collapses of Baltic sprat commercial catches in Poland occurred in 1908–1914, 1937–1950 and again in 1979–1984, but now on a smaller scale.
2) Sprat collapses followed short periods with intensive exploitation and high landings.

3) Significant changes in two main factors, i.e. the biological-hydrological and fishing origin, provoked the negative results in sprat stable and efficient catches, however, the high fishing pressure on resources, prevailed in this "mutual competition".

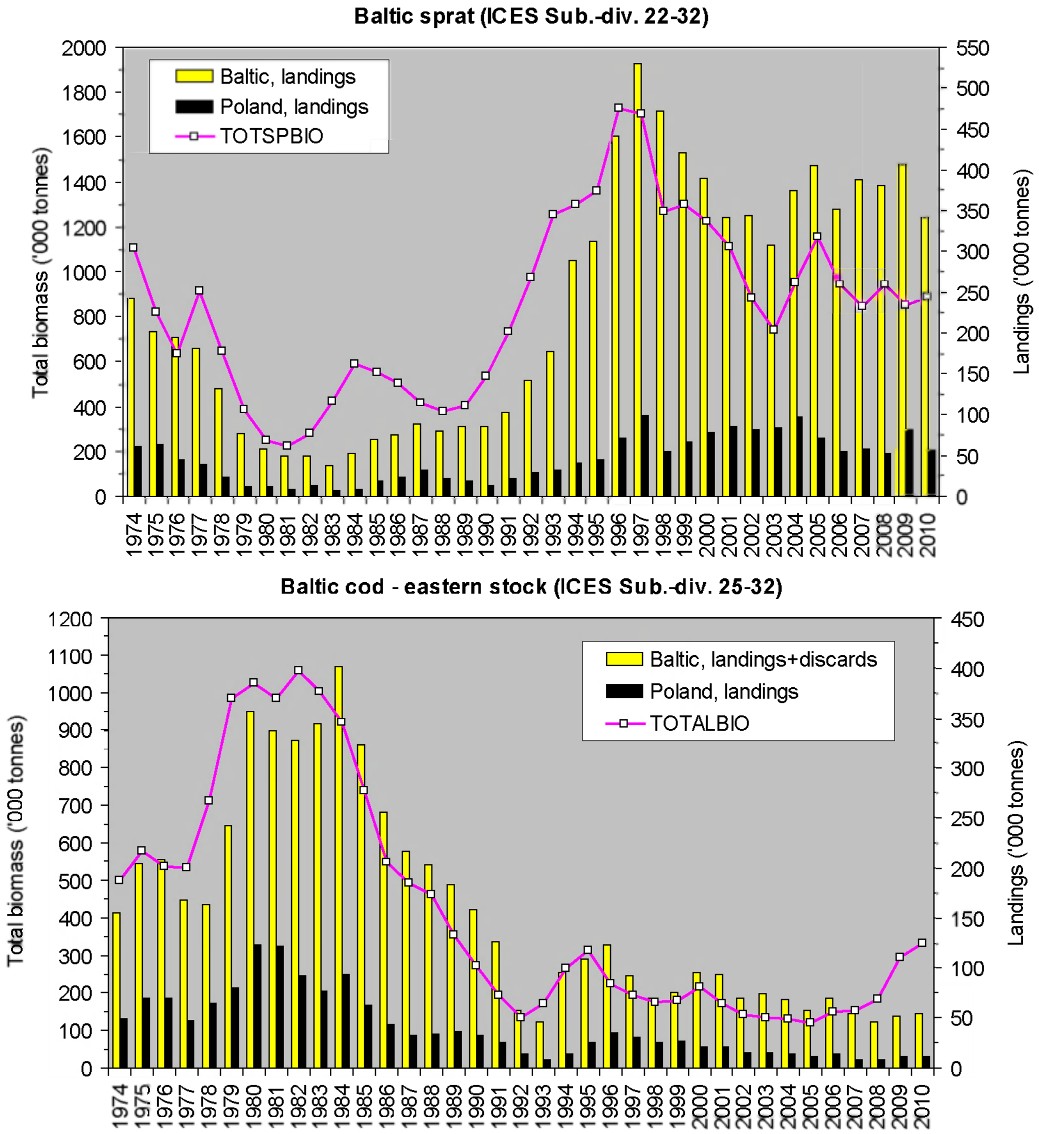


Figure 4. ***Top:*** **Baltic sprat international landings (yellow), Polish landings (black) and SSB (circles).** ***Bottom:*** **Baltic cod international catches (yellow), polish landings (black) and total-stock biomass (open circles).**

Long-term social-ecological dynamics in the Baltic Sea

Jonas Hentati-Sundberg

Stockholm Resilience Center, Stockholm University

Sustainable governance of natural resources is challenged by poor understanding of complex human–nature couplings. Advances in resilience theory, acknowledging the importance of social-ecological linkages and the self-organizing capacity of social-ecological systems, provide a new perspective in sustainability science. Yet, limitations in methods and data for integrated studies of social-ecological systems hamper progress in science and management. My PhD project aims to generate and test specific hypotheses building on social-ecological systems theory using a variety of methods and a long-term, multidimensional empirical dataset of the Baltic Sea social-ecological fisheries system.

In one strand of research, I have asked which factors have impacted change in fisheries patterns in the Baltic Sea over a 15 year period, 1995–2009. I conclude that the responses of fishers are largely driven by top–down management regulations, which have favoured increasing scale of operations and specialization, and that the capacity of fishers to engage in ecosystem stewardship is low. Resilience could be enhanced through an increased focus on governance actions that can stimulate the self-organising capacity of the system.

A second research strand focuses on one particular fishery, whose long-term dynamics have been strongly driven by an ecological regime-shift in the Baltic Sea. High potential profits and weak control has raised suspicions of widespread misreporting in this fishery. By developing a new method for reconstructing catches, we suggest that underreporting has been significant, and was likely driven by high economic incentives created by ill-designed policy. This misreporting risks contributing to a negative feedback that substantially alters the management cycle, and thereby constitutes a part of a social-ecological trap in this fishery.

The project outcomes so far indicate that there are good prospects for using the Baltic Sea as case for integrated social-ecological studies, aiming at informing resilience theory. Of particular interest are social-ecological changes over longer time periods than in the previous fisheries research related to the Baltic Sea (~100 yr). A database has been set up on historical fishing effort, fishing methods, catches and prices for the Swedish Baltic Sea fishery. This work will be conducted in tight alignment with other ongoing historical work on the ecological and biogeochemical aspects of the Baltic Sea.

CLODIA: an open access database on the fisheries of Chioggia, Italy

Carlotta Mazzoldi, Andrea Sambo, Emilio Riginella

Hydrobiological Station "Umberto D'Ancona", Department of Biology, University of Padova, Italy

Since 1945, the fish market of Chioggia is collecting all the official landings data. The seafood products are registered at the fish market according to their origin: local; national imported; foreign imported. The local products are landed by Chioggia's fishing fleet, representing the major fishing fleet of the area and one of the major of the entire Mediterranean Sea. The fleet operates in the northern-central Adriatic Sea, including the Venetian lagoon.

Starting from the data on local seafood products landed at the fish market, we developed an open-access database (Clodia database: http://chioggia.scienze.unipd.it/DB/database_landing.htm) including the monthly landings statistics. The construction of the database included the rescue and digitization of all the statistics, present only in paper form from 1945 to 1996. A second step included the interpretation of the statistics, since seafood products were registered with generic, common or sometimes even dialectal names in the first decades. Therefore we reconstructed the composition of each registration category, through interviews with fishers and employees of the fish market. According to this reconstruction, the database includes 114 categories, comprising one or more species, for a total of 187 estimated species. From 1997 registration procedures were improved, leading to more detailed records (126 categories, 180 species). To maintain the available details, we built a second time-series, from 1997 to present, with the more detailed registration process. To make the database accessible also to non-expert users, we chose a user-friendly interface that allows the users to choose species, categories and time period, and that allows easy visualization of the data through line or histogram plots. Each category is provided with a card that gives to the users all details needed (species composition, pictures, and any information useful for data interpretation). All data are freely downloadable.

Landings data are affected by several biases, for instance they do not include discards, nor unreported landings. Even if it is not possible to validate all data, we evaluated the reliability of landings data in depicting changes in abundances of species through comparison with scientific surveys or landings data from other fishing fleets. In general we found a fairly good match between data, supporting the usefulness of this remarkably long time-series.

To provide information also on Chioggia's fishing fleet, we built a database starting from the data included in the European Register of Marine Fleet. Using an interface similar that used for landings data, the characteristics (GT, length over all, engine power, year of construction, fishing gears allowed to be employed) of the fishing fleet from 1991 onwards are provided.

Up to now, the database has been used for different purposes, in the fields of fishery biology, ecology and climate change. The changes in landings data from 1945 to 2010 were analysed in relation to human and environmental factors, showing the role of fishery, seawater temperature, river run-off and nutrients in driving remarkable changes in landings composition (Barausse *et al.*, 2011). The analyses of specific categories grouping all the elasmobranchs highlighted the marked decline of these species, in particular of skates and catsharks. Yearly landings data allowed also to highlight the occurrence of periodic fluctuations in particular in skates (Barausse *et al.,* in press). The analyses of landings data coupled with life history traits allowed to depict the status of the Atlantic mackerel, *Scomber scombrus*, in the Adriatic Sea (Meneghesso *et al.,* 2013). Finally, the analyses of landings data for the crab species, Carcinus aestuarii, in relation to seawater temperature, coupled with physiological data on adult and eggs, allowed to depict the role of climate changes in driving the abundance of this species (Bartolini *et al.,* 2013). Moreover the database is regularly visited by non-experts and employed in practicals in the curses of marine biology.

References

Barausse, A., Michieli, A., Riginella, E., Palmeri, L., and Mazzoldi C. 2011. Long-term changes in community composition and life-history traits in a highly exploited basin (northern Adriatic Sea): the role of environment and anthropogenic pressures. Journal of Fish Biology, 79 : 1453–1486.

Barausse, A., Correale, V, Curkovic, A., Finotto, L., Riginella, E., Visentin, E., and Mazzoldi, C. in press. The role of fisheries and the environment in driving the decline of elasmobranchs in the northern Adriatic Sea. ICES Journal of Marine Science.

Bartolini, F., Barausse, A., Pörtner, H.O., and Giomi, F. 2013. Climate change reduces offspring fitness in littoral spawners: a study integrating organismic response and long-term time-series. Global Change Biology, 19 : 373-386.

Meneghesso, C., Riginella, E., La Mesa, M., Donato, F., Mazzoldi, C. 2013. Life history traits and population decline of the Atlantic mackerel, *Scomber scombrus* in the Adriatic Sea. Journal of Fish Biology, 83 : 1249-1267.

Change in non-linear dynamics and spatial structure of coastal socio-ecological systems: the Bay of Fundy as case study

Emily Klein

Natural Resources & Earth Systems Science, University of New Hampshire, Durham, USA

While there is growing consensus for ecosystem-based management of the oceans, it is critical to avoid isolating marine systems in time. As contemporary research demonstrates, the past is integral to comprehending long-term change in these environments. Furthermore, if system health is a goal for the future, appreciation of conditions prior to intense anthropogenic pressures can offer unique insight into ecosystem structure, function, and dynamics. This dissertation addressed the dynamics, spatial structure, and resilience of an ecologically and economically critical coastal marine ecosystem, the Bay of Fundy in Canada (Klein, 2013). In addition to analytical results, greater socio-economic context was determined from historical accounts of the ecosystem and reliant fishing communities. It focused on nine species of finfish: alewives (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*), collectively referred to as gaspereau, American shad (*A. sapidissima*), smelt (*Osmerus mordax*), Atlantic salmon (*Salmo salar*), Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*), Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*).

Historical marine ecology is providing increasing investigation on the past, yet this research has been limited to equilibrium and linear views. Other work is increasingly demonstrating the prevalence of non-linear behaviour in the oceans, and challenging conventional assumptions of linearity and equilibrium. In addition to understanding the Bay of Fundy through time, this doctoral research is the first to explore non-linearity in an ecologically and economically vibrant, less degraded ecosystem of the past. Doing so explores whether non-linear dynamics are induced by human impacts, or can be signals in natural systems.

Investigations combined qualitative narratives, novel analytical approaches, and historical data (ca. 1870–1920) to expand knowledge of ecosystem dynamics, spatial structure, and resilience for the Bay of Fundy. First, work developed narratives about the Bay during the late 19th and early 20th century from qualitative historical sources, providing descriptions of the system through the eyes of the fishers and managers that relied on it for their livelihoods. Findings indicate the Bay of Fundy during this time was productive, especially in the nearshore, and that this production was driven by a diverse and prolific suite of forage fish. Spatially, the Bay ecosystem was structured locally, with areas distinct due to local environmental and physical conditions. In addition, early fishers and managers agreed on local substocks for all of the species studied. These aspects were consistent with the Bay prior to the late 1800s, and may have supported population persistence and system resilience.

Analysis of quantitative catch statistics used nonparametric time-series modelling that applied both a linear and non-linear model, and then assesses the forecast skill of each. This skill, also termed predictability, was the ability of the model to predict observations one step ahead. Results determined persistent and predictable dynamic structure in catch of the nine finfish species studied here. The dynamics were also generally (>60%) non-linear. In addition, comparison with similar catch from more modern fisheries (1960-2002) showed a loss of predictable signals (decline from ~80% to ~50%) and a chance in non-linearity.

Research also applied multivariate modelling where non-target time-series are used to predict a target series. The approach established analogous dynamics between variables. This approach provided evidence of substocks with differential local forcing across the Bay of Fundy, as well as similar dynamics between species, again locally forced. These results indicate substocks in all species, as well as provided evidence of the small-scale spatial structure of the Bay.

Anadromous species were found to be most directly impacted by local forcing, as their dynamics were dominated by local non-linearity. This is because the non-linear dynamics for the anadromous species disappear when time-series are aggregated at higher spatial scales. In contrasts, non-anadromous fish had non-linear signals at varying spatial scales. These findings, along with their clear importance for the system from qualitative results, suggest that anadromous fish could have driven the local non-linearity found in other species. A basic Lotka-Volterra model simulation demonstrated that, indeed, non-linearity can be transferred via predator–prey relationships. The model also further showed aggregation can mask non-linear behaviour.

Findings suggest the previous Bay ecosystem was highly non-linear and locally diverse, yet interconnected with local substocks and potential subsystems. This structure may have been critical for population persistence and system resilience. Finally, although human influence clearly affected species abundance and distribution, it also shifted from local to regional scales. These spatial impacts likely caused similar change in the ecosystem, fundamentally undermining system resilience that had previously supported the Bay during centuries of human use.

References

Klein, E.S. 2013. Change in nonlinear dynamics and spatial structure of coastal socio-ecological systems: Bay of Fundy as case study. PhD Diss., Univ. New Hampshire, Durham, NH, USA, 261 pp. – Defended at University of New Hampshire on 22 October 2013.

Belgian fisheries: ten decades, seven seas, forty species: Historical time-series to reconstruct landings, catches, fleet and fishing areas from 1900

Ann-Katrien Lescrauwaet

Flanders Marine Institute/Vlaams Instituut voor de Zee (VLIZ), Ostend, Belgium

Historical data can contribute in explaining underlying cause–effect relations in changes in the ecosystems, potentially reveal information and knowledge from past conditions (Jackson *et al.*, 2001), and help defining reference conditions and achievable targets for environmental management today. The present thesis focuses on quantitative data to extend the time frame of current analyses on fisheries (landings, fleet dynamics, spatial dynamics, indexes of productivity of the fleet and impact of fishing) and on the reconstruction of historical time-series to expand our knowledge of historical references for the Belgian sea fisheries. In achieving this, it intends to counter the concept of 'Shifting Baselines' applied to the Belgian Sea fisheries.

The 'Historical Fisheries Database' (HiFiDatabase) is a product of this thesis. It is the result of a thorough search, rescue, inventory, standardization and integration of data for Belgium's sea fisheries that were not available before in the public domain or were not available before in the appropriate format for redistribution. It is documented and stored in the Marine Data Archive of Flanders Marine Institute and is freely available for end-users. It contains a unique and substantial collection of time-series with standardized species names, reporting units, fishing areas and ports of landing (Lescrauwaet *et al.*, 2010b). It is a 'living' product in the sense that new, relevant, quality-controlled time-series can be added as they are discovered or produced. Considering the relative size of the fleet, the short coastline and the limited number of fish auctions and fishing ports in Belgium, it is fair to say that the present reconstruction of Belgian sea fisheries depicts a relatively complete picture of historical volume, value and composition of landings, fleet dynamics, fishing effort and spatial dynamics. The project and its methodology offer a blueprint for similar reconstructions in other countries.

The reconstructed time-series indicate that, since the onset of systematic reporting mechanisms in Belgium in 1929, landings reported by the Belgian sea fisheries both in foreign and in Belgian ports amounted to 3.3 million tonnes (t). After a maximum of 80,000 t in 1947, annual landings declined steadily to only 26% of this peak by 2008 (Lescrauwaet *et al.*, 2010a). The most important species over the observed period in terms of landings were cod (17% of all landings) and herring (16%), closely followed by plaice (14%), sole (8%), whiting (6%) and rays (6%). In terms of economic value and based on values corrected for inflation, sole (31%) and cod (15%) were the most valuable, closely followed by plaice (11%), brown shrimp (5%), rays (5%) and turbot (3%). Near to 73% of all landings originated from 5 of the 31 fishing areas. Twenty percent of all landings originated from the 'coastal waters', while these waters contributed nearly 60% of all landed pelagic species and 55% of all landed 'molluscs and crustaceans'. The North Sea (south) and the Iceland Sea were next in importance with 17% and 16% of all landings respectively. The eastern and western part of the central North Sea, contributed each with approximately 10% of the total landings (Lescrauwaet *et al.*, 2010a).

The Belgian fisheries have followed a development of 3 major successive exploitation phases in which 3 major target species or target species groups were exploited until events or processes triggered a transition to a new phase: a 'herring' period between

1929 and 1950, a 'cod' (and other gadoid and roundfish) period between 1950 and 1980 and a period marked by plaice/sole between 1980 and 2000 (and after). This successive exploitation of targeted species was also associated with exploited fishing grounds, successively the Coastal waters for herring, the Icelandic Sea for cod, the North Sea south and the North Sea central (east and west) for sole/plaice, later also complemented by the 'western waters' (English Channel, Bristol Channel, Irish Sea) for the flatfish fisheries.

To understand and interpret the trends in landings and changes in target species (groups), it is crucial to look at trends and changes in the fishing fleet and the fishing sector inserted in a wider socio-economic and political context. In the present thesis work, a reconstruction was made of the fleet size (from 1830), tonnage (from 1842) and engine power (kW from 1912) of the Belgian sea fisheries fleet. The time-series show an 85% decrease in fleet size and a 5% decrease in overall engine power (kW) since WWII. This decrease was compensated by a tenfold increase in average tonnage (GT) per vessel and a sixfold increase in average engine power (kW) per vessel.

In only 10 years' time after WWII, the fleet size decreased from approximately 550 to 450 vessels in 1955 (Lescrauwaet *et al.*, 2012). Between 1955 and 1970 major structural changes took place in the Belgian sea fisheries fleet. These changes were driven first by the shift in the main fishing activities towards Icelandic waters in the 1950s and in the early 1960s by the governmental subsidies for the purchase of new steel hulled medium-sized motor trawlers and the introduction of the beam trawl (Poppe, 1977, Lescrauwaet *et al.*, 2012). This led to less but more powerful vessels: between 1960 and 1975 the fleet size declined from 430 to approximately 250 vessels (-42%). The decline in fleet size was exacerbated when Iceland demarcated its territorial waters from 12 nm to 50 nm in 1972 and when the presence of Belgian fishers within the declared 200 nm EEZ of Icelandic waters became subject to a 'phase-out' in 1975 (Lescrauwaet *et al.* under review). As a consequence of the loss of the Icelandic waters towards 1980, Belgian vessels shifted their activities again towards the central part of the North Sea (Omey, 1982) and - to a lesser extent - towards the English Channel, Bristol Channel, South and West Ireland and the Irish Sea. From 2000 onwards specific programmes were oriented to the decommissioning of ships with the aim to reduce fleet capacity. In 2012, the Belgian commercial sea fishing fleet counted 86 ships, with a total engine capacity of 49,135 kW and gross tonnage of 15,326 GT (Roegiers *et al.*, 2013).

The reconstructed time-series suggest that total landings decreased with total fleet size and with total fishing effort. At the level of the Belgian fleet, the total number of days spent at sea decreased from approximately 91,800 days in 1938 to 15,100 days in 2010 (-84%). The landings (kg) per vessel per day at sea or per day fishing have doubled between 1938 and 2010. The time-series shows at least 4 successive events: a first event (1939–1945) marked by WWII and the increased landings of herring in coastal waters. The exceptionally high landings per unit of effort are partly explained by the cessation of large-scale herring fisheries in the North Sea during WWII combined with the effects of two strong year classes. The second period is situated in 1951–1955 and coincides with the steep increase in landings from Icelandic waters. Thirdly, an increase in landings is observed between 1960 and 1967, which coincides with the state subsidies to introduce the beam trawl first in shrimp vessels (1959-1960) and later for flatfish fisheries. A final conspicuous event concerns the period of increased levels of landings per vessel per day between 1977 and 1986. After standardization as landings per unit of installed power (LPUP) to account for the average increase (x6) of engine power per vessel, the landings have decreased by 74% from an average 1,3 t

/installed kW in 1944-1947 to 0,38 t /installed kW in 2009-2010. Interestingly, the average price of landings (all species, all areas, all fisheries aggregated) is negatively correlated with the decreasing fishing effort and decrease in overall landings. This suggests that the Belgian sea fisheries compensated for the losses by targeting species that achieve better market prices. Although the LPUP are illustrative of the changes in the productivity of fisheries, they cannot be interpreted as a proxy of change in biomass of commercial fish stocks, because the Belgian fisheries have targeted different species and fishing areas over time. Trend analysis to study change in fish stocks must be conducted at the level of different métiers or fisheries, taking into account issues such as specificity and selectivity of gear, environmental conditions in the targeted fishing area, seasonality of fishing and behaviour of target species.

In the thesis, a closer look was taken at the impact of sea fisheries. In a first part, a quantitative approach was taken to reconstruct total removals by Belgian sea fisheries by including the unreported and misreported landings of commercial and recreational fishing, as well as an estimation of discards. The methodology applied in this reconstruction can serve as a blueprint for similar reconstructions in other countries. The results are useful to inform current policy issues and societal challenges. This reconstruction covers 6 fisheries with historical or current importance for Belgium (Lescrauwaet *et al.,* 2013). Total reconstructed removals were estimated at 5.2 million t or 42% higher than the 3.7 million t publicly reported over this period. Unreported landings and discards were estimated to represent respectively 3.5% (0.2 million t) and 26% (1.3 million t) of these total reconstructed removals. During the WWII, the Belgian fisheries benefited a tenfold increase in catches and fivefold increase in LPUE of North Sea 'Downs' herring. In the present thesis, these increased catches were explained by the combined effects of a major increase in catch power after WWI, the effects of the cessation of large-scale herring fisheries in the central part of the North Sea and by the effects of strong pre-WWII year classes (Lescrauwaet *et al.* revised manuscript under review). A third subchapter focused on the otter trawl fishery in Icelandic waters targeting cod. This fishery was of great economic importance in Belgium but decreased with the 'cod wars' (1958 and 1972) coming finally to a complete end in 1996. While the decline in total landings from Icelandic waters started after Iceland expanded its EEZ in 1958, the fishing effort of the Belgian fleet continued to increase until a peak was reached in 1963. The results show that the decline in the Iceland cod stock was visible at different levels; the decrease in the proportional importance of cod in the overall landings, the 75% decrease in the LPUE (1946-1983), the decline in the proportion of 'large' fish, and finally the decline or shift in the definition of a 'large' specimen.

As a result of this thesis, unique data are presented on the trends in volume and composition of landings for the Belgian part of the North Sea (BNS). The waters of the BNS are considered as the most important fishing area in terms of source of food for local population, but also as the most stable provider of food. The BNS and in particular the ecosystem of shallow underwater sandbanks is also important as (post)spawning and nursery area (Leloup and Gilis, 1961; Gilis, 1961; Leloup and Gilis, 1965; Rabaut *et.al.*, 2007).

The HiFiDatabase broadens the historical view on fisheries and serves as a basis for a range of potential research, management applications, and in support of policy-making. In particular, the time-series provide unique historical reference conditions of fishing in the Belgian part of the North Sea and a potential baseline for fisheries management in territorial waters or for the coastal fisheries. The latter is useful in the context of the EU Marine Strategy Framework Directive, the EU Habitat Directive and the proposal for Maritime Spatial Planning on the Belgian part of the North Sea. Finally in the present thesis work, important efforts were dedicated to approach the history of fisheries from different disciplines of work. The results underline the importance of collecting economic data, inventorying historical archives and historical legislation, historical economy and politics, in order to improve the interpretation and analysis of results. As advocated by the current integrated policies for the marine environment, both the challenge of the task and the richness of the results rely on a multidisciplinary approach.

References

Lescrauwaet, A.-K. 2013. Belgian fisheries: ten decades, seven seas, forty species: Historical time-series to reconstruct landings, catches, fleet and fishing areas from 1900. PhD Thesis. Ghent University.

The potential of Historical Ecology Research to support implementation of the Marine Strategy Framework Directive (CE/2008/56)

Saša Raicevich

Istituto Superiore per la Ricerca e la Protezione Ambientale (ISPRA), Chioggia, Italy

Abstract. – The Marine Strategy Framework Directive (MSFD, CE/2008/56) is a legislative process enforced by the EU in the context of an ecosystem approach, requiring each Member State to achieve Good Environmental Status (GES) in their national marine waters by 2020. The emerging key concept is GES: this does not represent the pristine state of the environment, but the state where human pressures are considered sustainable since they do not irreversibility hamper biodiversity and recoverability potential of ecosystem components. GES needs to be assessed according to a set of indicators and criteria established under Commission Decision 2010/477/EU according to a wide range of descriptors (virtually almost every ecosystem component/pressure). The descriptors include, among others, "Commercial fish and shellfish" (Descriptor 3), "Biodiversity" (Descriptor 1), "Seabed integrity" (Descriptor 6), which in turn are described by a suite of more than 100 indicators (or families of indicators). These descriptors represent, among others, typical themes that are dealt with by marine historical ecology research (HER). The current developmental stage of the MSFD does not allow a detailed analysis of the real impact of historical ecology in contributing to the MSFD implementation, due to the complexity of reporting and the limited availability of detailed reports. However, a general analysis of its potential could be put forward, and thus inform the scientific community on how HER has been approached to inform current management into the MSFD. This analysis is restricted, at the time being, to the context of GES definition. In particular in the report "Common Understanding of (Initial) Assessment, Determination of GES & establishment of environmental targets" (WGGES, 2011), that provides guidance to MS for the MSFD interpretation and implementation. In the report, three different methods for setting baselines in relation to GES definition were proposes and discussed : a) baseline as a state at which the anthropogenic influences are considered to be negligible; b) baseline set in the past; c) current baseline.

Both methods a and b relate, to some extent, to the approach applied in HER depending on whether analysis allowed to describe pristine states or historical baselines where human impact was reduced compared to the current impact. However concerns were posed in relation to the use of both approaches, in reference to the "quality and quantity of the available data" and "expert judgement used in the interpretation of that data", the "transparency of the approach", and the fact that some historical baselines may not be appropriate to GES determination "if one does not know how strong the impact at the beginning of the time-series was". Moreover, informal information obtained from MS delegates suggests that historical baselines were little used in GES determination, unless data were readily available and consolidated; instead, it was preferred to use data based on very short time-series but with a better match with the geographical scale to be addressed.

The above allows some general consideration on how to foster a major influence of HER on marine environment management, like in the case of the MSFD, and in particular:

- HER should, where possible, provide data for metrics that are consistent with those used for indicators adopted in the MSFD implementation;

- HER should focus on spatial scales consistent with those considered in the MSFD;
- HER should include information on both the status of ecosystem components and the degree of pressures (sustainable vs. unsustainable) these were subjected to.

However it is worth noting that, where historical data were available at a scale consistent with MSFD regions, baselines based on historical data were adopted, as in the case of the Large Fish Indicator proposed by Greenstreet *et al.* (2012) for Descriptor 4 on Marine Foodwebs.

A key question that should be acknowledged by HER to further support their use in current management is related to whether or not a reduction in pressures could allow ecosystem components to recover to historical levels. This issue, which could be tackled by studying the pressure-state relationship and may help in understanding the recoverability potential of ecosystem components, is fundamental, because it relates to the need of establishing environmental targets that are ecologically meaningful and practically reachable.

Despite the still limited practical use of HE in first step of MSFD implementation, it is worth noting that the influence of such studies is becoming increasingly relevant and influential, for instance in allowing to update the list of threatened species and inspiring the public audience by showing that the sea we are experiencing is the shadow of what it was used to be few decades/centuries ago (Pauly, 1995).

Thus, if the scientific community will better focus their HER objectives in relation to current management schemes, it is envisaged that HER will play a major role in supporting marine environment management in the near future.

References

Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive; Text with EEA relevance)

2010/477/EU: Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (notified under document C(2010) 5956) Text with EEA relevance

Greenstreet, S. P. R., Rogers, S. I., Rice, J. C., Piet, G. J., Guirey, E. J., Fraser, H. M., and Fryer, R. J. 2012. A reassessment of trends in the North Sea Large Fish Indicator and a re-evaluation of earlier conclusions. – ICES Journal of Marine Science, 69: 343–345.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution, 10(10):430.

WGGES. 2011. Common Understanding of (Initial) Assessment, Determination of Good Environmental Status (GES) and Establishment of Environmental Targets (Art. 8, 9 and 10 MSFD).

Shifting baselines in coastal ecosystem service provision

Samiya Selim

University of Sheffield, UK

We depend on the marine environment for a range of vital ecosystem services, at global (e.g. climate regulation), regional (e.g. commercial fisheries) and local scales (e.g. coastal defence, recreation). At the same time, exploitation of marine ecosystems goes back centuries and many systems today are under stress from multiple sources. Scientists and policy-makers are now looking at these issues in a more holistic way aiming to incorporate all aspects – social, economic and ecological – in ecosystem management. However, the knowledge and understanding of marine ecosystems before exploitation is very limited and goes back only a few decades.

My PhD research utilizes a historic approach to assess how the final delivery of marine ecosystem services to coastal communities is influenced by the direct and indirect effects of changes in ecosystem processes brought about by climate and human impacts. We used the northeast coast of England as a case study and collected historical data on both biological and socio-economic records related to the North Sea. We used a modelling approach to assess how both natural and anthropogenic drivers have affected ecosystem processes and in turn ecosystem services. We also used social scientific methods to obtain information on different stakeholder's perspective on changes in ecosystem services in the study region.

We have completed the first two strands of the research. We used Partial Least Square Path Modelling (PLS-PM) to explore the potential relationships between drivers of change, marine ecosystem processes and services using historical fisheries data. We created a simple conceptual model with four variables – climate, fishing effort, ecosystem process, and ecosystem services and applied the model to partial ecosystem data from historic time-series spanning 1924-2010 to identify the multiple pathways that might exist. This part of the research highlighted how path analysis could be used for analysing long-term temporal links between ecosystem processes and services following a simplified pathway.

We have also carried out social surveys with fishers in this region using semi-structured questionnaires. We have completed 30 interviews to date and have another 40 interviews to be completed by December 2014. Preliminary results show that fishermen's perspective and knowledge of North Sea fisheries match the trends from long term scientific surveys and with fish landings data. However the fishermen's perspective seemed to be linked to their age and length of time fishing, indicating that there might be issues of 'shifting baseline' in their perception of abundance and size of commercial fish.

Charting changes in Australia's marine environment

Ruth H. Thurstan

School of Biological Sciences, University of Queensland

Australian Research Council's Centre of Excellence for Coral Reef Studies

Introduction. – Fisheries throughout the world are facing unprecedented challenges due to increasing levels of exploitation, destructive fishing practises, pollution and coastal development. Yet our understanding of the magnitude of change occurring to fisheries, and thus our ability to effectively mitigate for this is impaired because managers rarely have detailed information (e.g. catch and effort statistics) that span more than three or four decades (Jackson *et al.*, 2001). In the absence of long-term data it is often assumed that Australia's fisheries are in good health, yet the few long-term studies that have taken place reveal that major changes have occurred over the past two centuries (e.g. Edgar and Samson, 2004; Klaer, 2004; Lotze *et al.*, 2006). Snapper (*Pagrus auratus*) is a commercially important sparid that is widely distributed throughout subtropical and temperate southern oceans. It forms a significant commercial fishery in Australia and is an iconic fish species for many anglers. In Queensland, state landings of snapper collected since 1946 provide the historical framework for contemporary stock assessment models, yet anecdotal data suggests that snapper were targeted in offshore waters many decades prior to this. Using previously neglected popular media sources we compiled historical records of catch and effort on the Queensland snapper fishery back to 1871, extending the temporal frame of reference for fisheries management by seven decades.

Methods. – We examined archival fishery reports, early fishing publications, digitized newspaper articles and line fishing surveys, extracting quantitative and qualitative data from each individual archival record. Because not all records provided complete catch rate data, missing values were inferred using multivariate imputation by chained equations (R package MICE 2.9, van Buuren and Groothuis-Oudshoorn 2011), a technique where missing values are replaced *n* times by simulated values to form *n* simulated complete datasets (Schafer, 1999). Historical data were compared with contemporary (1993–2002) catch rate data collected from a selection of southeast Queensland charter fishing vessels. Just the top 5% of contemporary catch rates were included to account for potential upward reporting bias in the historical data.

Table 1. Examples of early snapper fishing trips, with catch rate data highlighted in bold.

Source	Description
The Queensländer 24 May 1879	*"At a little before 7 [am] we steamed up to the Boat Rock, down went about twenty-four lines [...]. For* ***four hours and a quarter*** *the sport was sustained [...]. We were found to have lessened that particular tribe of schnapper by about 735 individuals..."*
The Queenslander 13 Jun 1885	*"The Lady Musgrave left Brisbane on Saturday evening [...] the party comprised* ***thirty gentlemen*** *[...]. Flat Rock was reached at 9.30 [am] [...] fish were hauled over the side with tremendous speed until about half-past 1 o'clock, when the fishermen ceased their labours. On heads being counted, it was found that* ***901 fish*** *– chiefly schnapper, and several gropers, had been taken in* ***four hours."***
The Brisbane Courier 16 Aug 1889	*"…reaching the fishing ground at* ***7 am yesterday****. The sport then began in real earnest and continued up till* ***1 o'clock,*** *when a start was made for home. Although only* ***8 lines*** *were out no less than* ***210 fine large fish*** *were caught."*

Results and discussion. – Table 1 provides examples of the archival records collated, showing quantitative information used to construct catch rates highlighted in bold. In total, 307 individual archival records provided quantitative data on fishing parties targeting snapper, spanning a period of 68 years from 1871–1939. Although the parties that travelled to the snapper grounds were not always regular fishers it was rare for snapper fishing parties to arrive back in port with less than 200 fish (Marine Department Report 1905). Catches of 500 or more fish were common and occasionally, phenomenal hauls of over 1000 fish were caught in a matter of hours (Marine Department Report 1905). A slight, although significant declining trend in catch rate was observed between 1871–1939 (Figure 1), although the rapid expansion of fishing grounds likely masked declines in local fishing grounds during this period. A significant decline in catch rate is also observed when historic and contemporary catch rates are compared (Figure 1).

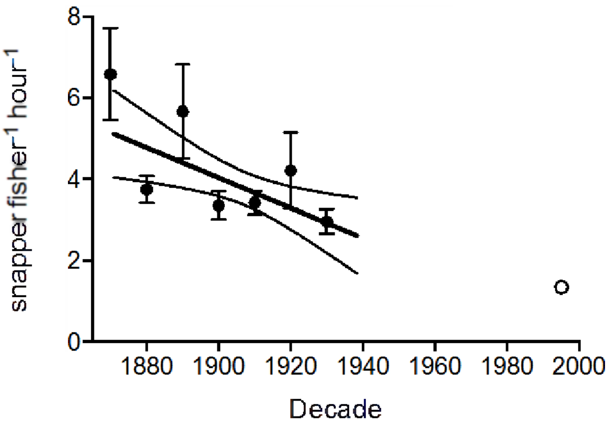


Figure 1. Snapper fisher^{-1} hour^{-1}. Closed circles show historic catch rates by decade, whereas the open circle shows the top 5% of snapper catch rates derived from contemporary charter boat data, with standard errors.

Historic catch rates show a significant declining trend over time ($R^2 = 0.02$; $p = 0.008$). A significant decline is also observed over the whole time period (regression line not shown, $R^2 = 0.15$; $p < 0.001$).

Snapper has a long exploitation history in southern temperate and subtropical oceans. Whereas assessments vary from stock to stock, snapper populations are considered to have markedly declined along the east coast of Australia as a result of exploitation. However, quantitative data on the early history of these fisheries is lacking. Such data on the *Pagrus auratus* fishery have never been examined in detail before and provide some of the earliest catch rate data globally for this species and for Australian fisheries in general.

References

Edgar, G.J., and Samson, C.R. 2004. Catastrophic decline in mollusc diversity in eastern Tasmania and its concurrence with shellfish fisheries. Conservation Biology, 18: 1579–1588.

Jackson, J.B.C., Kirby, M.X., Berger, W.H. *et al.* 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629–638.

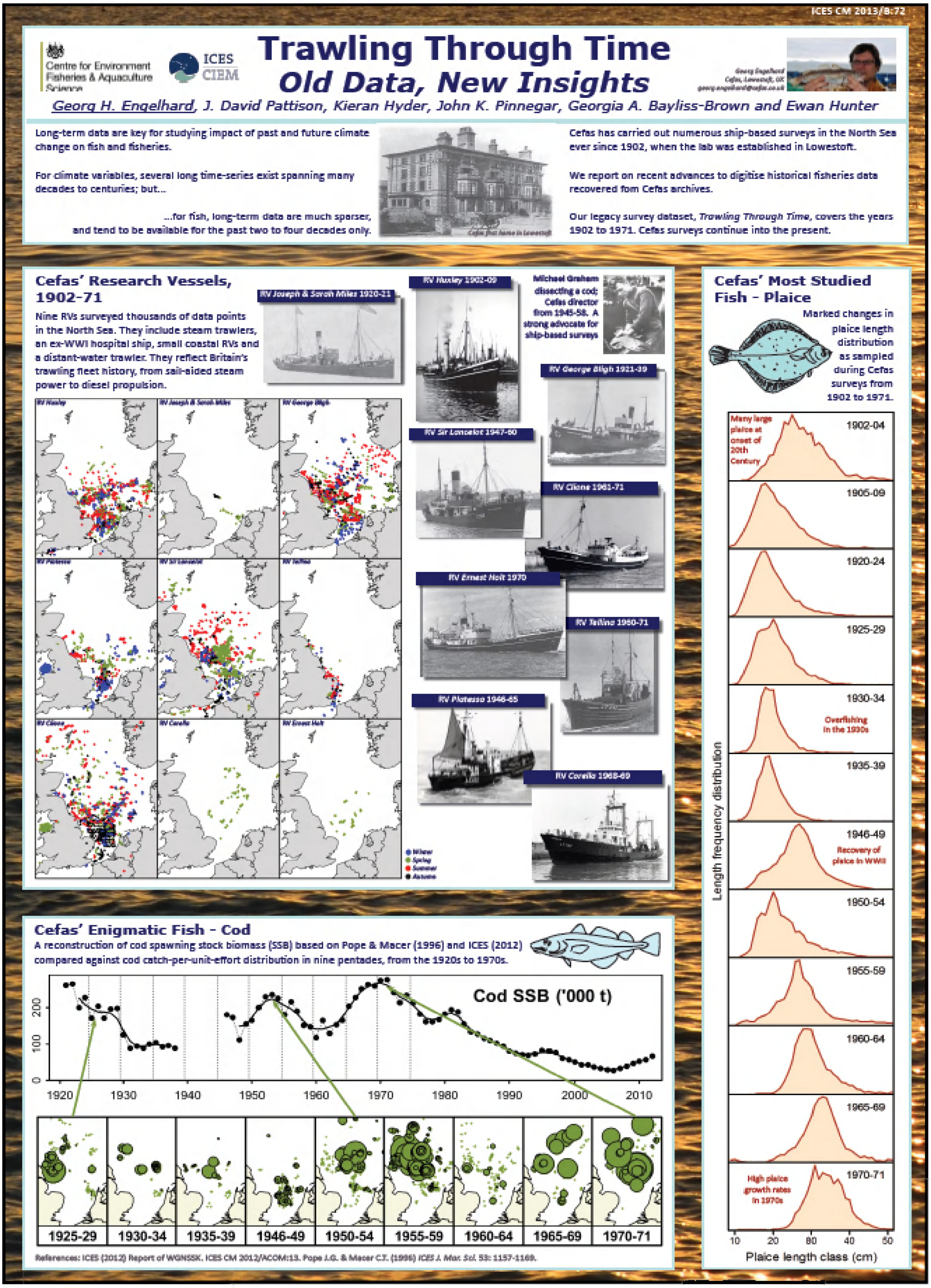
Klaer, N.L. 2001. Steam trawl catches from south-eastern Australia from 1918 to 1957: trends in catch rates and species composition. Marine and Freshwater Research, 52: 399–410.

Lotze, H.K., Lenihan, H.S., Bourque, B.J. *et al.* 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science 312, 1806–1809.

Marine Department Report. 1905. Report on the Marine Department for the Year 1904–1905. Queensland Government, Brisbane.

Schafer, J.L. 1999. Multiple imputation: a primer. Statistical Methods in Medical Research 8, 3–15.

van Buuren, S., and Groothuis-Oudshoorn, K. 2011. Mice: Multivariate Imputation by Chained Equations in R. Journal of Statistical Software, 45: 3.


ICES CM 2013/B:72
Centre for Environment Fisheries & Aquaculture Science
ICES CIEM
Trawling Through Time
Old Data, New Insights
Georg H. Engelhard, J. David Pattison, Kieran Hyder, John K. Pinnegar, Georgia A. Bayliss-Brown and Ewan Hunter
Long-term data are key for studying impact of past and future climate change on fish and fisheries.
For climate variables, several long time-series exist spanning many decades to centuries; but...
...for fish, long-term data are much sparser, and tend to be available for the past two to four decades only.
Cefas has carried out numerous ship-based surveys in the North Sea ever since 1902, when the lab was established in Lowestoft.
We report on recent advances to digitise historical fisheries data recovered fom Cefas archives.
Our legacy survey dataset, Trawling Through Time, covers the years 1902 to 1971. Cefas surveys continue into the present.
Cefas' Research Vessels, 1902–71
Nine RVs surveyed thousands of data points in the North Sea. They include steam trawlers, an ex-WWI hospital ship, small coastal RVs and a distant-water trawler. They reflect Britain's trawling fleet history, from sail-aided steam power to diesel propulsion.
RV Joseph & Sarah Miles 1920-21
RV Huxley 1902-09
Michael Graham dissecting a cod; Cefas director from 1945-58. A strong advocate for ship-based surveys
RV George Bligh 1921-39
RV Sir Lancelot 1947-60
RV Clione 1961-71
RV Ernest Holt 1970
RV Tellina 1960-71
RV Platessa 1946-65
RV Corella 1968-69
Winter
Spring
Summer
Autumn
Cefas' Most Studied Fish – Plaice
Marked changes in plaice length distribution as sampled during Cefas surveys from 1902 to 1971.
Many large plaice at onset of 20th Century
1902-04
1905-09
1920-24
1925-29
1930-34
Overfishing in the 1930s
1935-39
1946-49
Recovery of plaice in WWII
1950-54
1955-59
1960-64
1965-69
1970-71
High plaice growth rates in 1970s
Length frequency distribution
10 20 30 40 50
Plaice length class (cm)
Cefas' Enigmatic Fish – Cod
A reconstruction of cod spawning stock biomass (SSB) based on Pope & Macer (1996) and ICES (2012) compared against cod catch-per-unit-effort distribution in nine pentades, from the 1920s to 1970s.
Cod SSB ('000 t)
0 100 200
1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
1925-29
1930-34
1935-39
1946-49
1950-54
1955-59
1960-64
1965-69
1970-71
References: ICES (2012) Report of WGNSSK. ICES CM 2012/ACOM:13. Pope J.G. & Macer C.T. (1996) ICES J. Mar. Sci. 53: 1157-1169.

Annex 3: WGHIST 2013 poster announcement

Annex 4: 2014 WGHIST Terms of Reference

The Third year meeting of the **Working Group on the History of Fish and Fisheries** (WGHIST), chaired by Georg Engelhard, UK, and Ann-Katrien Lescrauwaet, Belgium, will meet at a **location to be decided during autumn** 2014 to:

a) Provide a platform for multidisciplinary discussion to scientists from a variety of disciplines and institutions working on the history of fish and fisheries

b) Present case studies on fish and fisheries using historical or recovered data from both sides of the Atlantic, the Mediterranean and elsewhere, from an ecosystem perspective

c) Provide metadata description to the ICES Data Centre of historical datasets in the ICES region that are potentially useful for establishing population and biodiversity baselines for the Marine Strategy Framework Directive (MSFD)

d) Support historical ecological baseline development in the context of the MSFD including indicators of Good Environmental Status (GES) and aim at primary publications resulting from such analyses.

WGHIST will report on the activities of 2014 by 1 December 2014 to SSGSUE and SIBAS for SCICOM.

2011/2/SSGSUE12 The **Study Group on the History of Fish and Fisheries (SGHIST),** will be renamed the **Working Group on the History of Fish and Fisheries (WGHIST),** chaired by Georg Engelhard, UK, and Ann-Katrien Lescrauwaet, Belgium, will meet in Oostende, Belgium, from 5–7 September 2012 in the first of three meetings to work on ToRs and generate deliverables as listed in the Table below.

WGHIST will report on the activities of 2012 (the first year) by 15 October 2012 (via SSGSUE and SIBAS) for the attention of SCICOM.

The second year meeting of the **Working Group on the History of Fish and Fisheries** (WGHIST), chaired by Georg Engelhard, UK and Ann-Katrien Lescrauwaet, Belgium will be held at Panicale, Italy, 7–11 October 2013.

The Third year meeting of the Working Group on the History of Fish and Fisheries (WGHIST), chaired by Georg Engelhard, UK, and Ann-Katrien Lescrauwaet, Belgium, will meet at a location to be decided during autumn **2014 to:**

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Present case studies on fish and fisheries using historical or recovered data from both sides of the Atlantic, the Mediterranean and elsewhere from an ecosystem perspective, with a view of preparing peer-review publications and synthesis papers	Science: Analysise of deviations in current population and community levels cannot be put in context without historical data to show conditions under pre-industrial exploitation levels. WGHIST can provide some of these historical baselines. Advisory: Increasingly, historical baselines for current ecosystem approaches demanded in national legislation are required. WGHIST can provide these data and analysis to in many cases to meet some of these demands. Other EGs: groups such as WGECO should find good use in the data and particulary analysis coming from WGHIST to	HPT 1, point 2, in that it seeks to provide data that can be used to assess the historical health of marine ecosystems which can be used as baselines for evaluation of current ecosystem health. HPT 1, point 44: WGHIST seeks to provide historical data, some of which would be surveys that are not readily available and make metadata descriptions, and in some cases data, available via the ICES data centre. HPT 2, point 1: Through making historical data available and providing analyses on these data, impacts of fishing on marine ecosystems can be assessed. HPT 3, point 1: making data and meta data descriptions openly available provides a tool to inform others of possibilities for analysis especially along the lines of historical baselines.	all years, culiminating in Year 3.	Primary publications in year 3. No ICES recipient except during self evaluation to SCICOM in year 3

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
		establish historical levels for populaution and ecosystem phenomena.			
b	Provide a platform for multidisciplinary discussion to scientists from a variety of disciplines and institutions working on the history of fish and fisheries	TOR b) As in a, this groups needs to be a forum for common work wherever it is done as so few of the fora exist. Through the explication of case studies, from different regions, a common perspective and learning from other analyses can help guide the group's work.		All years	No deliverable
c	Provide metadata description to the ICES Data Centre of historical datasets in the ICES region that are potentially useful for establishing population and biodiversity baselines for the Marine Strategy Framework Directive (MSFD);	Is related to the HPT on marine living resource management tool development and provides data to the global community via the ICES data centre.	HPT 1, point 2, in that it seeks to provide data that can be used to assess the historical health of marine ecosystems which can be used as baselines for evaluation of current ecosystem health. HPT 1, point 44: WGHIST seeks to provide historical data, some of which would be surveys that are not readily available and make metadata descriptions, and in some cases data, available via the ICES data centre. HPT 2, point 1: Through making historical data available and providing analyses on these data, impacts of fishing on marine ecosystems can be assessed. HPT 3, point 1: making data and meta data descriptions openly available provides a tool to inform others of	Year 3	Data to ICES data centre

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
			possibilities for analysis especially along the lines of historical baselines.		

Summary of the Work Plan

Year 1	1st year: an inventory of data describing the length of time series, spatial coverage and types of data, location where the data are stored and in what format, details of pertinent contacts for the data, an evaluation of the ease with which it can be accessed and used including important caveats, strengths and weaknesses of the datasets. Results of contacts to potential analyst participants and their interest in working towards TOR (d).
Year 2	2nd year: bring together historical data in a standard format in consultation with the ICES data centre and make the data generally available through the ICES data centre. Provide descriptions of methods and results of some calculations which consider strengths and weaknesses in the data sets which could potentially be used as MSFD baseline descriptors.
Year 3	3rd year: Finalised analysis of MSFD descriptor baselines in internally consistent chapters that should directly translate into publications. A self evaluation and recommendations for this group should be provided as part of the final report of the group.

Supporting information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem effects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority. **Scientific scope** The precursor study group (SGHIST) to the presently proposed group managed to bring together historians as well as some data keepers in a unique way in ICES but analyses of data were not often possible during the short duration of the meeting and also because there were not so many analysts with the levels of experience necessary to make usable products. Logically, including analysts to support the development of baselines from these historical data for application in the MSFD is priority work in relation to ToR d. Historical data often have difficulties in terms of partial spatial and temporal coverage and selective reporting by species and port. As such, these data contain significant biases if interpreted in the same manner as modern data collected under rigid protocols. It is therefore necessary to have both the data analysts and data historians working jointly on analysis to create a robust and applicable product to aid the development of good environmental status standards under the MSFD. Metadata descriptions and standardised historical data products if made available via the ICES data centre should encourage more historical studies both within government laboratories and universities thus providing a legacy of important work. Additionally, data recovery in this means is essential to prevent data loss especially as staff that have transitioned between the paper and electronic archive world are now retiring and risk of data loss is increasing as a result.

Justification of venue (in non-ICES Member Country	We are planning to hold the 2013 ICES Working Group on the History of Fish and Fisheries, 2013, Italy, upon invitation by veteran fisheries scientist Dr. Sidney Holt, associated for many years with FAO (Rome), and before that with Cefas, UK. The classic textbook authored by Dr. Holt and Dr. Beverton, On the Dynamics of Exploited Fish Populations (1957) has been important to WG participants in developing historical analysis of fishing power changes in fishing fleets, and his feedback has been key in bringing the WG forward in this and other areas. Italy has previously participated with expertise at several ICES meetings and study groups together with ICES members. The area of interest to the study group is global and includes the Mediterranean, and this region is relevant owing to its importance in early development of fishing technologies. We expect visiting scientists from at least two other institutions in Italy (Centro Intruniversitario di Biologia Marina, Livorno; Instituto Superiore per la Proteziona e la Ricerca Ambientale [ISPRA]) and the location will facilitate attendance by scientists from the Mediterranean. The location can be easily reached through Rome Airport and there will be no large additional costs to the ICES participants; costs of accommodations and facilities will be comparable to, or lower than in Copenhagen.
Resource requirements	Consultation with ICES Data Centre should be ongoing and partial attendance by data centre staff would be an asset to the group and to ICES.
Participants	The Group should be attended by 15-20 members and guests. Participants must include data historians, ecologists, data keepers and analysts who can interpret and calculate quantitative indicators of MSFD descriptors.
Secretariat facilities	None in 2012. 2013 and 2014 are uncertain.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There would be some linkages to WGECO especially in how that ACOM group has tasked itself with many issues concerning ecosystem interpretations and analyses under the MSFD.
Linkages to other committees or groups	SIBAS, WGBIODIV.
Linkages to other organizations	Clearly, there would be an interest from the European Commission for its relevance to MSFD baseline development. Participants in the fomer History of Marine Animal Populations (HMAP) have an interest in keep work of this nature going. Should an HMAP type project be resurrected, the work done by WGHIST as well as products produced for the ICES data centre would prove key for its success.