WORKING GROUP ON THE HISTORY OF FISH AND FISHERIES (WGHIST; outputs from 2023 meeting)

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Contents

i Executive summary

The ICES Working Group on History of Fish and Fisheries (WGHIST) explores how historical data (e.g., from prehistory to the last few decades) from a range of sources can help understand past human practices, how social-ecological systems have changed over time and the pressures upon them. WGHISTs four Terms of Reference consider: i) data collection and standardisation, ii) integration of different sources to obtain useful information about past ecosystem or fisheries dynamics, iii) long-term changes in social-ecological systems, and iv) utilisation of historical information for understanding social-ecological outcomes of management. In this iteration WGHIST has been encouraging discussion around inter-disciplinary working (from ecology, history, historical ecology, anthropology, archaeology, social science, palaeontology) at our annual meetings, by engaging with teams from large multidisciplinary projects, organising conference workshops and theme sessions, and completing analyses. This included considering the challenges of using mixed sources and approaches, how best to complete interdisciplinary work and how to effectively communicate across disciplinary divides. We are exploring how different disciplines interact, what language they use, what data they analyse and how. This will help integrate data and results across disparate disciplines. A huge effort standardising WGHISTs metadata has begun, including preparing guidance to help make historical data accessible to a wider community. Since 2021 WGHIST and its members have produced five peer-reviewed publications (with another two in review), two articles in newsletters, and three workshop reports. Outputs considered the potential contributions historical data can make to contemporary science and management. They included 120-year analysis of how major policy changes influenced patterns of UK seafood production, trade, and consumption; a 110-year reconstruction of Mediterranean swordfish populations; and, how seafloor functioning changed during global warming in deep time. We consider the contributions made by the late Professor Sidney Holt, an advocate for historical data, to four ongoing challenges in marine science and his successes engaging with stakeholders as well as scientists. Members showcased the historical databases they have built for European oysters can be used to inform restoration targets. Other resources highlighted included current research projects, relevant networks, new approaches, historical datasets and archives.

ii Expert group information

Expert group name	Working Group on the History of Fish and Fisheries
Expert group cycle	Multiannual fixed term
Year cycle started	2021
Reporting year in cycle	3/3
Chair(s)	Bryony Caswell, UK
	Camilla Sguotti, Italy
Meeting venue(s) and dates	21-25 June 2021, online meeting (35 participants)
	9-6 June 2022, Chioggia, Italy (34 participants)
	12-15 June 2023, Falmouth, UK (36 participants)

1 Progress towards the completion of each ToR

1.1 Collect, assemble and integrate historical data on socio-ecological systems

The first ToR aims to collect, assemble, and integrate meta-data on marine social-ecological systems through time and develop links with historical data management bodies (within and beyond ICES). This is fundamental for collaboratively develop data products to encourage the use, preservation, and maintenance of historical data and explore potential shared interests and compatibilities with other researchers and other programs. Many presentations of the members over the past meetings discussed the importance of data availability in order to carry out meaningful research. While 98 metadata records were collected in WGHIST during the last and the present iteration of the Working Group, all the data were formatted in different ways and contained a variety of information. Some data are catch per unit of effort data or landings data, which are the typical product scientists are used to working with ranging from the end of the 19th century until today (Fig. 1.1). Other data are instead prices, export, import data, but even qualitative information coming from historical books, presence/absence data or effort data. An effort to standardise all the metadata was thus initiated in order to have a better product that could be made accessible through the ICES website. Experts on data products and databases such as Leen Vandepitte from VLIZ (EUROBIS the Europe Ocean Biogeographic Information System (OBIS) node) but also John Nicholls (OBIS History node and Oceans Past Initiative) were invited to discuss methods to format and standardise the data and possible ways of formatting to make them more readily usable and include them not only in the ICES catalogue, but also in other platforms such as OBIS (Annex 3). This included the benefits of linking to other platforms, e.g. using cross referencing to locations in Marineregions.org, FAO fishing areas, and APHIA or LUSID ID for species names that will link to the WOrld Register of Marine Species (Table 1.1). Meetings with the ICES data expert Periklis Panagiotidis explored better ways in which to display the data in the ICES catalogue. During the standardisation process we realised that formatting and standardising that from such different sources is very challenging and requires clear guidelines.

Many discussions were conducted at the meetings to understand how to best format these data, where to archive them and how to make them relevant for management. The data structure design is almost complete (Table 1.1) and will be made available in the ICES catalogue in the next iteration. From these discussions, ideas also emerged that we might provide guidance on best practices for describing and handling historical data (ToR B). This guidance should resolve some important questions such as what types of historical data exist, what approaches are generally used to work with these data, are there any challenges associated, which solutions can be adopted to use historical data in a more structured way? This product should help interested scientists to dive through the complexity of historical data and to better navigate the WGHIST metadata repository, but also to better understand what the data are and how to standardise and use the data. This is a necessary step to promote accessibility and more consistent use of historical data and is an effort that will continue through the next iteration of WGHIST.

WGHIST has been promoting participation and engagement of Early Career Researchers (ECRs) as another important step towards preserving and maintaining historical data sources, but also to support continued development of marine historical ecology as well as related disciplines. We are working to develop different ways of engaging and integrating ECRs in WGHIST such as mentoring, promoting their work through our suggestions for the ICES highlights and, in the next iteration we will add and train a third chair who is an ECR. Moreover, we have promoted the work of our ECRs members to the whole ICES community through science highlights and through participation at different ToRs.

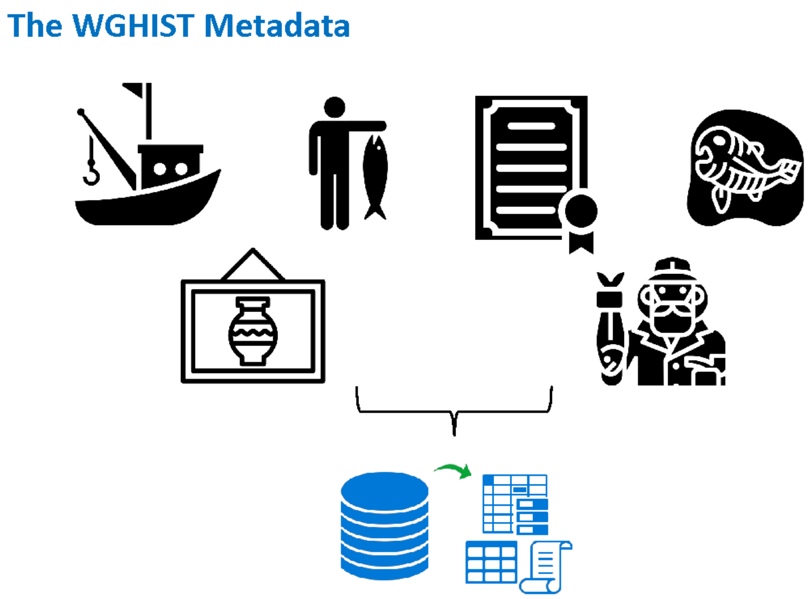

Figure 1.1 The different types of information described in the WGHIST metadata (see also Table 1.1). Looking at the variety of data (e.g., written records, fisheries data and logbooks, historical images and maps, data from oral histories and accounts, palaeontology and archaeology). It is immediately clear that synthesising these different types of information is challenging.

Across the three years a number of resources were highlighted that can be added to the WGHIST metadata catalogue (e.g. The Clodia Database, NOAA archive, Irish Marine Institute Archives, and others listed below). At our 2023 meeting we heard about data products being produced by WGHIST members and collaborators as part of historical ecology working group of the Native Oyster Restoration Alliance (https://noraeurope.eu/nora-historical-ecology-working-group/; last accessed 09/01/2024), The datasets for England are already available online (https://environment.data.gov.uk/dataset/c3c60843-e831-43ba-8bef-054437e60f7c; last accessed 09/01/2024) with those for the rest of Europe soon to follow.

Table 1.1: Table entry and criteria proposed for standardising the WGHIST metadata.

Table Entry	Cell Contents	Categories or information used
Short title	Dataset name/title, should include country, data type and temporal range	Free text entry
Region_name_unit1 (IHO,GSA)	Use general sea area (GSO) or International Hydrographic Organisation (IHO) name	Marine region name (IHO or GSA) from marineregion.org
Region_ID_unit1 (IHO,GSA)	Use general sea area (GSO) or International Hydrographic Organisation (IHO) number	Marine region ID code (IHO or GSA)
Region_name_unit2 (region, sea)	If data specify use 2nd more detailed classification (region, sea, other lower unit) name	Marine region name (region or sea) from marineregion.org
Region_ID_unit2 (region, sea)	If data specify use 2nd more detailed classification (region, sea, other lower unit) number	Marine region ID code (region or sea)
Fishing region (informal)	Name of the marine region fished/sampled	Free text entry
FAO fishing area	FAO fishing area code	FAO fishing area, subarea and division, e.g. Baltic Sea 27.1.a
Latitude	Latitude of exact port, town, fishing ground, sea, ocean or marine region	Number; Decimal. (Use the midpoint of smallest spatial unit, specify unit)
Longtitude	Longitude of exact port, town, fishing ground, sea, ocean or marine region	Number; Decimal. (Use the midpoint of smallest spatial unit, specify unit)
Species_name_latin	Latin name for species	Free text entry (binomial whenever possible, genus only if necessary)
Species_name_common	Common name for species	Free text entry
aphia_ID	Unique species naming system	Aphia ID code
LSID	Life Sciences Identifier; another unique species naming system	LSID code

Table Entry	Cell Contents	Categories or information used
Start year	Year of first observation	4 digit number (if uncertain round to nearest 5 or 10 years and add comment to notes row)
End year	Year of last observation	4 digit number (if uncertain round to nearest 5 or 10 years and add comment to notes row)
yearsSpan	Temporal range (years)	4 digit number
tempRes	Temporal resolution of the data reported	day, month, year, discrete data point
spatialRes	Finest spatial resolution at which data are reported	Harbour, basin, lat_long,
Contact	Contact information of the data owner or manager	Email address
dataOwner	Who owns the data? Name of the organisation or individual	Choose from organisation or select “individual” and add contact
Link to data owner	Link to website for data owner	URL if available
longTitle	Detailed title for the data	Free text entry
recordType	What type of record is it? This provides the context in which the information/data was collected.	Business records; Tax records; Court records; Trade records; Government statistics; Government reports; Committee minutes (e.g. council, government, fishers associations); Scientific survey or expedition reports; Fishers log books, Maritime charts; Newspapers; Technical periodicals; Fish market registers; Vessel registers; Ship-builders records/plans; Architectural plans/surveys; Port records; Medical records; Charity records; Trade Union records; Guild records; Church records; Naval records; Family/estate records; Leisure society records; Recreational periodicals; Naturalists accounts; Museum records; Local authority records; Legal records; Personal correspondence; Personal diaries/journals; Weather
dataSourceNAME	Name of the source (could be a series)	Free text entry
obsType	What information was recorded?	Landings, Catch; imports; exports; sales; taxes; Type of fish/shellfish; amounts of fish/shellfish; amount of larvae; type of larvae; fishers opinion; scientists opinion; managers opinion; non-commercial species type; non-commercial species abundance; fishers health; employment; gear types; fishing effort; vessels; Fishing grounds; Bathymetry; habitat type and extent (e.g. reef); Census; Weather.
landCountry	The country where the catch was landed (if relevant) or the country where data were collected.	A country name (current and post f geopolitical boundaries have changed in the period since the data were collected).

Table Entry	Cell Contents	Categories or information used
notes	Any additional information which gives context or provides caveats to the data.	Free text entry
Format	What is the format of information/data?	Numerical; Textual (written or typed); visual (e.g. photographs, paintings, video, carving, illustration); audio recording (including transcriptions);

Data resources highlighted for ToR A:

- CLODIA Database: https://chioggia.biologia.unipd.it/en/the-database/ (last accessed 09/01/2024)
- Irish Marine Institute archive: https://oar.marine.ie (last accessed 09/01/2024)
- NOAA oral history archive: https://voices.nmfs.noaa.gov (last accessed 09/01/2024)
- Datasets from 4OCEANS, NORFISH AND HMAP are stored on Fig-share: https://figshare.com/articles/online_resource/Online_Resource_Historical_Marine_Footprint_for_Atlantic_Europe_1500-2019/22236730 ((last accessed 09/01/2024)
- Historic distribution of native oysters in England from the historical ecology working group of the Native Oyster Restoration Alliance (https://environment.data.gov.uk/dataset/c3c60843-e831-43ba-8bef-054437e60f7c; last accessed 09/01/2024) with datasets for the rest of Europe soon to follow.
- Swordfish bycatch data from tuna traps located at four sites in Italy, 1896-2010, archived in Pangaea (https://doi.pangaea.de/10.1594/PANGAEA.928996; last accessed 09/01/2024) from MacKenzie et al. (2022), further context and supplementary information on the limitations of this data is available in MacKenzie et al. (2022).
- Ethnolinguistic Atlases, the Atlas linguistique de la culture Méditerranéenne, part of a global long-term project Atlas Linguarum Europae which has 546 items per interview (Linguistic global atlas). Used a common interview framework shared by researchers (only existing boundaries are isoglosses (no ecosystem or administrative boundaries), data is collected in a standardised way, and it is generally accessible. URL for the Atlas Linguarum Europae: https://unesdoc.unesco.org/ark:/48223/pf0000017577 ((last accessed 09/01/2024).

1.2 ToR B Explore the actual or potential synergies between different kinds of historical data

ToR B explores synergies between different types of data and information in order to facilitate its use. Historians, historical ecologists, environmental historians, archaeologists and palaeontologists and anthropologists employ a broad range of different sources, types of data and information, and by necessity these require different assumptions and there are differing constraints on their use.

We have been working to encourage awareness of the use and applications of historical data from marine social-ecological systems (ToR A) and the synergies between different kinds of data (ToR B) by highlighting its value, past applications and potential future applications. We published two articles in the Oceans Past News on WGHISTs work (Caswell and Sguotti, 2021; Caswell and Sguotti, 2022), and in 2023 we presented the WGHISTs past work on "Lessons from history for today's blue growth agenda: the Venetian lagoon a case study" (Caswell et al., 2020) at the Brussels Institute for Advanced Studies workshop on 'The past, present and future of food, climate and sustainability' (Caswell, 2023). We have engaged with new research communities and groups across disciplinary divides, e.g. contemporary ecologists through our 2022 ICES ASC theme session and through the MAF-World and Sea Unicorn Cost actions. We are actively working with archaeologists and palaeontologists through our position on the steering group for Q-MARE: Disentangling climate and pre-industrial human impacts on marine ecosystems (Agiadi et al., 2022). This is a Past Global Changes (PAGES) working group (https://pastglobalchanges.org/science/wg/q-mare/intro; last accessed 09/01/2024).

Over the last three years WGHIST has engaged with several large research projects seeking to understand past marine exploitation and the social-ecological changes (Table 1.2) being led by WGHIST members and collaborators that are exploring historical change from a range of different perspectives and approaches. Such work requires the use and understanding of diverse different data types to reconstruct a picture of social-ecological change in marine ecosystems through time. It needs experts from many different disciplines working together to achieve an integrated understanding of changes. Thus, a broad range of voices and perspectives are needed for these collaborations, spanning many disciplines and experts from both the humanities and natural sciences.

The research employs a range of different and often discrete data types, time periods and caveats, and the project deliverables range from using different data types in parallel to integrating them into one metric. A critical component of this work involves exploring how this can be done. For historic work in particular, identification of the data (what and where it is), understanding of its nature, and quality, the uncertainties around it are critical before it may be used together to answer a common research question. The 4Oceans, Seachange and Tradition (Table 1.2, Annex 3) projects are employing diverse different types of archives and data on the species exploited, how they were exploited, human diets, fishing practices, agriculture and trade, and data from the wider record of environmental (from seafloor sediments, sclerochronology, fossils) and societal change. The review elements should help to assess data availability and where knowledge is lacking. Data products and lessons should emerge from all of the projects that can contribute to ToR B.

The Fish Architecture project (Table 1.2) provides data on past fisheries that are encoded in architectural information, both how the architectural design relates to fisheries practices and vice versa (Annex 3). For instance, in Lisbon the fishing harbour is designed for trawlers and used freezing (or at least refrigeration) to process and transport the fish, this changed the landscape of food consumption and distribution (lots of little vans selling fresh fish). A characteristic feature of the cod fishery was large areas of drying mats used for drying cod in the sunshine (Tavares, Annex 3). It may provide a unique source of social-ecological information (ToR B) from the intersection between fisheries management and urban policies.

Table 1.2 Current marine historical ecology projects (Annex 3 provides project specific details and links to the project websites)

Project title	Objectives	Scope
2021-2027 4OCEANS (ERC Synergy)	Assess the importance of marine life to human societies during the last two millennia, with a focus on understanding the consequences of marine resource exploitation for societal development".	4 Oceans: Atlantic, Indian, Pacific and Arctic oceans. Data from global markets in London and Lisbon. Transects: Global North, Global South, Atlantic Ocean basin 10 taxa of environmental or economic importance: right whales, bowhead whales, sirenians, cod, walruses, fur seal, sea otters, parrot fish, herring and bluefin tuna
2019-2025 TRADITION (ERC Synergy)	Two main parts (i) investigating 6000 years of fisheries ecology, and (ii) enhancing policy, and citizen awareness of lost coastal ecosystems.	Biodiversity hotspots and LEK, threatened systems and anthropogenic history of the Southern Atlantic Ocean.
2020-2026 Seachange (ERC Synergy)	Test the scale and rate of biodiversity loss as a result of fishing and habitat destruction over the last 2,000 years in the N Sea, around Iceland, E Australia and the W Antarctic Peninsula, and N Europe transition from hunter- gatherer to farming 6,000 years ago.	5 cultural transitions: 1: North Sea shift from hunter-gatherer (Mesolithic) to farming (Neolithic) 2: Late Holocene North Sea last 2000 years 3: Queensland mid-late Holocene

		4: Northern and eastern Iceland, the last 2000 years 5: Antarctica over the last 400 years
2022-2024 Fishing Architecture: The Ecological Continuum between Buildings and Fish Species. (ERC Consolidator)	To what extent can fish produce architecture? This project traces a socioecological history of N Atlantic architecture in relation to fisheries, elucidating relationships between marine environments and terrestrial landscapes and assessing the ecological impact of fishing structures and natural resources.	5 analytical axes: (1) marine ecosystems; (2) fishing technology; (3) food processing; (4) politics; and (5) consumption habits. Case study areas: Portugal (Matosinhos), Iceland (Grindavik), UK (Grimsby, Gloucester), Norway (Vesteralen Archipelago), Newfoundland (Harbour Grace), France (Douarnenez). Fisheries: cod, hake, sardine, herring, salmon, and tuna
2018-2024 The Wadden Sea project	How did communities /populations change relative to the available habitat? Can we define guiding principles on "desired reference states" for Wadden Sea fish communities?	How can history feed into defining management and conservation targets (given shifting baselines). Causes of change, rates of change, and achievable goals. Which species have disappeared, declined and appeared and do the project goals reflect this?
2019- How does a historical perspective inform ecosystem management targets, goals, and outcomes? (Sesync, NSA, USA)	How does historical perspective inform EBM target goals and outcomes?	How have historical ecology perspectives influenced environmental management decisions? How does the metric change if historical data are integrated into targets? and what are the pathways to integrate historical data. into management?

Work by WGHIST members (MacKenzie et al., 2022) demonstrates the use of unconventional and opportunistically sourced information to reconstruct and assess species ecology (informing ToR B). For instance, they use data on bycatch from historic tuna traps in Sardinia and Sicily to derive new ecological baselines for Mediterranean swordfish. Detailed records on the bycatches included descriptions of all the species found and the amounts of each in the same locality from 1896-2010. Gear design changed very little throughout this period and so provides consistent catch data. Data on at least three properties of swordfish ecology were extracted: their abundance, size and migration phenology. This type of data could be used to provide new long-term datasets for species lacking quantitative data on pre-exploitation populations such as the swordfish. Data on the amounts of many other bycatch species can be extracted and variations in these species could be explored through time. Additionally, many other traps existed from which data could be extracted to improve the resolution.

Other work showed the importance of combining historical data with Local Ecological Knowledge (LEK; Lopez, Annex 3). Many interviews with fishers, both young and old were used to contextualise the historical landings data. Interestingly, the perspectives between old and young fishers changed, demonstrating the shifting baseline syndrome. This work showed the importance of combining different types of data to have a better understanding of the socio-ecological systems. Similar messages were conveyed from a variety of case studies (Barausse, Annex 3) using different but complementary types of historical data (time series, LEK, experimental data and models), highlighting the importance of a long term perspective to understand ecosystem changes in the northern Adriatic Sea over the last century (Barausse et al., 2011; Bartolini et al., 2013; Barausse et al., 2014). Another example from the Tradition project (Table 1.2, Annex 3) shows how biodiversity changes as perceived by public media, e.g. historical newspaper archives, revealed unprecedented information on catch composition, and perceived social and economic importance of key species over decades, which predated official national-level landing records (Herbst et al., 2023). Palaeontological data have demonstrable use for reconstructing pre-human baselines for fishes (e.g., Lueders-Dumot et al., 2018; Agiadi and Albano, 2020; Dillon et al., 2022; Annex 3) as well as from archaeological records that provide insights into past human behaviour and impacts (e.g. Dunne, Fitzhugh, West, Butler, Colonese, Rittezzo, Annex 3).

The WGHIST chairs and members co-authored a paper in the ICES Journal of Marine Science (Raicevich et al., 2021) in memoriam of the late Professor Sidney Holt who was a member of WGHIST for many years. As well as being a founding father in fisheries science he was also an advocate for historical data and the lessons it can teach us, we recount our experiences working with him in WGHIST. We considered his contributions to four ongoing challenges in marine science namely the suitability of maximum sustainable yield, the future of marine mammal conservation, implementing ecosystem-based management and the value of historical perspectives for conservation and management. The latter challenge directly addresses ToR C, but for all four challenges we consider the historical contexts of the ideas, the events that led them and Sidney's role in their development. In addition to considering scientific contributions we explored what lessons might be distilled from Sidney Holt's legacy. Finally, we considered what kind of scientist Sidney Holt was and what future marine scientists could learn from him. We proposed that he was a systemic thinker and trans-disciplinary scientist with a very broad perspective and approach across disciplines and that included scientists and non-scientists (Raicevich et al., 2021). In this way we demonstrate the value and benefits of bridging disciplinary differences in data types, application and perspectives (ToR B).

In 2022 we co-convened a theme session at the ICES Annual Science Conference in Dublin on the "Impacts of Human Activities and Pressures and on seafloor ecosystems: Past, present and future" together with WGMBRED and WGMHM where we highlighted historical resources and perspectives (ICES, 2022b; ToR B). The session consisted of 24 contributed talks or posters followed by a two hour "World Cafe" style discussion (attended by 115 people). WGHIST chairs also participated in session G "Geohistorical records of climate and anthropogenic impacts on marine biota" (13 contributions and attended by 119 people; ICES, 2022a) organised by co-chairs in Q-MARE. These theme sessions have provided important networking opportunities, engaged ECRs, highlighted historical resources (e.g., data and tools) and approaches that can be used to better understand marine social-ecological systems (ToR B). A range of approaches were demonstrated that can be used to reconstruct past species distributions, population connectivity and demographics, and trophic ecology. Different perspectives and experiences (e.g., disciplinary or cultural) were shared amongst experts during these sessions that included disciplinary norms, assumptions and expectations and in so doing stimulated discussions that bridged disciplinary differences (ToR B).

Together with the PAGES working group Q-MARE which brings together scientists from different disciplines to disentangle past climate and human-induced changes in marine ecosystems, to explore the timing and scale of human impacts on Quaternary marine ecosystems by combining paleontological, paleoclimatic, archaeological and historical data. These objectives align with those of ToR B, and WGHIST chairs have been involved in discussions about data availability and synergies when using different data to understand past marine social-ecological systems at four Q-MARE working group meetings. Additionally, in 2023 together with Q-MARE we coordinated a workshop on "Geohistorical perspectives on functional connectivity patterns" at the ICES-Sea-Unicorn Symposium on Human Impacts on Marine Functional Connectivity, Sesimbra, Portugal (https://www.ices.dk/events/symposia/ImpactsMFC/Pages/default.aspx; last accessed 09/01/2024). Support for attendance at the workshop was provided by the EC Cost Action Sea-Unicorn (CA19107 https://www.sea-unicorn.com; last accessed 09/01/2024) and Past Global Changes and included a number of ECR colleagues. During conversations with 22 colleagues from different institutions and disciplinary backgrounds (ecologists, historical ecologists, archaeologists, evolutionary biologists, geochemists and palaeontologists) we explored the different types of data and information that we each use, the assumptions and limits that accompany this data and how they might be used together (Agiadi and Caswell, 2023). In this way the work informs ToR B, by exploring synergies between different kinds of data, we also explored best practices for integrating the data. This project has produced several deliverables discussed further under ToR C.

Our annual meeting in 2023 was organised in collaboration with the historical ecology working group (WG4) of the Marine animal Forests of the world EC COST action (CA20102, https://maf-world.eu; ((last accessed 09/01/2024) to explore the historical value of and applications of non-traditional data and that from habitat-forming invertebrate communities. One such example included data products being produced as part of historical ecology working group of the Native Oyster Restoration Alliance (NORA; https://noraeurope.eu/nora-historical-ecology-working-group/; last accessed 09/01/2024) who are using historical archives, naturalist accounts, fishing records, museum collections and maps they are recreating past oyster habitat type and distribution across Europe. Historical resources such as those displaying the extent of physical structures (reefs) on maps provides a somewhat unique information that allows recreation of a valuable habitat-forming species. In order to integrate the broad range of records (1600 records from 1602-2019, from the intertidal to 80 m water depth) and information types they have developed approaches for assessing confidence by ranking records based on the amount and type of evidence available.

In 2023 Travis (Annex 3) demonstrated the applications of visual information from historic maps, that together with other information can demonstrate changes in fisheries and behaviour (Travis et al., 2023b) social narratives and cultural attitudes. This included tools from the Digital Environmental Humanities (Travis et al., 2023a) that can be used e.g. to create an Atlas of marine exploitation as the 4Oceans project intends to do (Holm, Annex 3).

Bernardi (Annex 3) showed how they were applying a range of non-conventional sources including different kinds of imagery (e.g., paintings, mosaics, personal photos, historical naturalist's representations and the photographic archives of the recreational big game fishing clubs) can convey the importance of a marine resource in a particular period, the decline or changes in species occurrences through time and can be used to understand the changing body-size for some species. They may also include information on technological innovation in the fishing activities and fishermen's behaviours. This can become an innovative instrument for understanding the changes in an overexploited basin such as the Northern Adriatic (Bernardi, Annex 3). This work shows the range of information that can be acquired from qualitative sources and some approaches for integrating different data sources.

Ongoing WGHIST work on ToR B

Part of the delivery of ToR B includes supporting the use and reuse of historical data on fish and fisheries, for this reason we are preparing a suite of resources that can advise on best practices with "non-traditional" data. We are preparing advice on how to work across-disciplines in general (manuscript in prep), for specific purposes (e.g. to look at marine functional connectivity; Agiadi et al., In Review). We are also developing materials that will support cross-disciplinary working, e.g. guidelines for good practice when working with historical data (museum collections and archives), a lexicon of terms commonly employed by practitioners working with historical data to facilitate communication. We have also completed systematic reviews of the literature that will allow us to provide a synthesis on the work completed in disciplinary fields of relevance to WGHIST, for instance on Marine Historical Ecology (Fig. 1.2). WGHIST is uniquely placed to facilitate cross-disciplinary discussions on how to overcome these challenges, and on best practices for effective integration of 'traditional' and 'non-traditional' historical data for science and management.

We have been building new, and maintaining, our existing connections with a range of projects (Table 1.1), COST Actions, and data management bodies (see also ToR A) to further collaborations, but also facilitate information exchange and improve our science. We believe these linkages are fundamental for performing quality science, keeping up to date, widening our reach, bridging disciplinary boundaries. In 2021 WGHIST heard from the Cultural Heritage Framework Programme for the UN Ocean Decade Heritage Network, the only decade action addressing cultural heritage, seeks to ensure that cultural heritage contributes to the decade vision and sustainable development. The programme objectives align well WGHIST ToRs in seeking to protect and promote historical research and the tools and data that may be used to complete such work (ToR A) and seeks to connect professionals and support actions that cross disciplinary boundaries (ToR B) to discuss cultural heritage, making sure resources are not lost and that their context is preserved. Cultural Heritage Framework resources were highlighted to members. Continued engagement with the network will help to highlight historical resources and encourage their recognition and integration into the United Nations goals and management. The ODHN have listed WGHIST on their webpages as well as including key WGHIST deliverables.

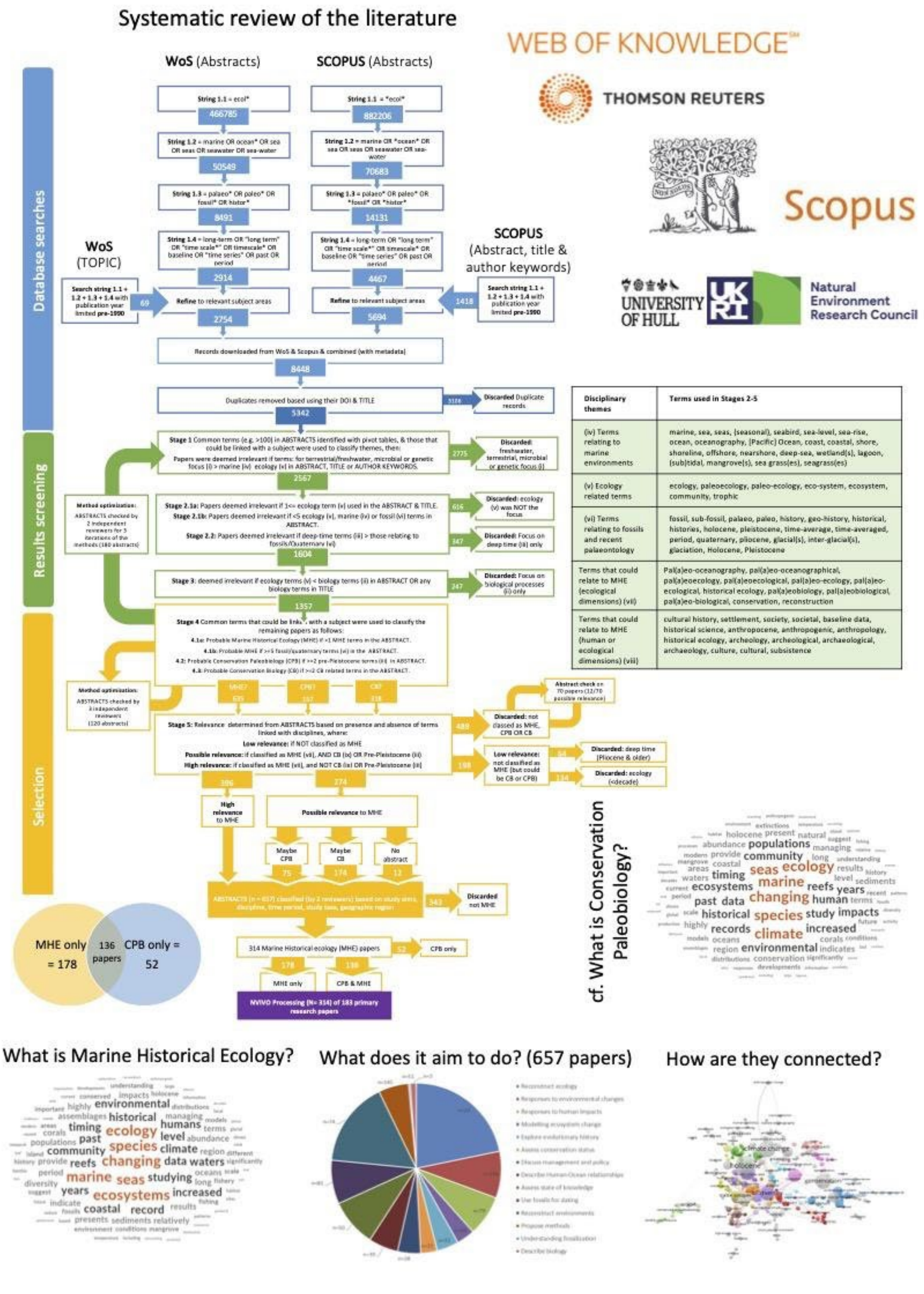

Figure. 1.2. Summary of systematic review of Marine Historical Ecology and preliminary results (Caswell et al. 2023, Annex 3). Copyright: Bryony Caswell 2024

Other resources highlighted at WGHIST meetings that inform ToR B:

- Storymap and online data: Surveying fisheries in colonial lake Malawi (David Wilson): https://storymaps.arcgis.com/stories/2974f11f7f9d4bbba8c3ef2f192d083b (last accessed 09/01/2024).
- "Routledge handbook of the digital environmental humanities", Edited by Charles Travis et al. 2023 (https://www.routledge.com/Routledge-Handbook-of-the-Digital-Environmental-Humanities/Travis-Dixon-Bergmann-Legg-Cramp-sie/p/book/9780367536633?gclid=CjwKCAiAx_GqBhBQEiwAlD-NAZk2qB9jlABWmEGR5znEfBxHUeQ5Qt44-4OxqIsVdnejFwUsX8P-QFxo-CaYcQAvD_BwE; last accessed 09/01/2024).
- "Architecture follows fish: An amphibious history of the North Atlantic" by Andre Tavares (MIT Press, 2023). URL for the book: http://www.grahamfoundation.org/grantees/6346-architecture-follows-fish (last accessed 09/01/2024)
- Past Global Changes Q-MARE working group (https://pastglobalchanges.org/science/wg/q-mare/intro; last accessed 09/01/2024)
- Past Global Changes QMARE Youtube seminar series: https://www.youtube.com/playlist?list=PLSaCdvmD4wMLGHMd-4sIEOYG6cjFLeKWu (last accessed 09/01/2024).
- Ocean Decade Heritage Network, includes membership directory, upcoming events (conferences and seminar series focussed on specific disciplines or regions), networks, trusts/foundations and research institutes, specific research programmes and projects, publications (https://www.oceandecadeheritage.org/resources/; last accessed 09/01/2024)
- Historical ecology working group of the Native Oyster Restoration Alliance (NORA)(https://noraeurope.eu/nora-historical-ecology-working-group/; last accessed 09/01/2024)
- Thurstan, R. H. et al. In Press. Historical dataset details the distribution, extent and form of lost Ostrea edulis reef ecosystems. DOI: 10.32942/X28C99. Includes an online open access dataset.
- Historical ecology working group (WG4) of the Marine animal Forests of the world EC COST action (CA20102, https://maf-world.eu; last accessed 09/01/2024)

1.3 ToR C Evaluate long-term changes within marine social-ecological systems

Marine historical ecology can help to understand how marine ecosystems have changed and how the social systems evolved over time. This can help to understand what drivers impact marine ecosystems, how the ecosystems have changed over time and which was the pristine status and how this information can be passed to managers and policy makers. Lots of members' presentations were linked to this ToR and explored how communities or ecosystems changed over time in different areas of the globe such as the North Sea, the Mediterranean, the North Atlantic, Africa etc. Apart from some studies that use long time series datasets, most of these studies showed how the integration of different data sources such as anecdotal information and more modern data such as landings or fishing surveys is fundamental to better understand how the systems change and show how profoundly ecosystems shift over time. As already explored and discussed in ToR B, the integration of these data is complex and not always standardised in a "canonical" way, but it is still important to put together these types of data (for more case studies example see Annex 3).

Through our deliverables (e.g., Raicevich et al., 2021; MacKenzie et al., 2022; Thurstan, 2022; Caswell and Herringshaw, 2023; Thurstan et al., 2023a; Agiadi et al., In Review), WGHIST have demonstrated how data and knowledge from the past can: inform conservation and management, and be used to assess the implications of human activities (Harrison et al., 2023).

All of the projects presented at WGHIST over the last iteration (Table 1.2) address or demonstrate the importance of historical data to understand long term changes in social-ecological systems and may contribute to management (ToR C). Most of the 4Oceans project deliverables (Annex 3) can inform ToR C across a broad geographic scale and may contribute to filling some previous gaps in knowledge by widening the picture outside of the North Atlantic. This project is also compiling data that can be used to build a border picture of social-ecological change (e.g., marine resource extraction that includes food and non-food items) but also non-marine trade products to contextualise relative value. The Tradition project (Annex 3) fills some much-needed gaps in appreciation of changes in social-ecological systems in the southern hemisphere prior to European arrival (e.g., Admiraal et al., 2023). Deliverables from the project examining changes in fishing practice and the effect on species functional traits over 9500 years, has shown the indigenous fisheries were overfished (Fossile et al., 2023). They also show changes in human diet (to include more maize) as a result of social changes may have alleviated millennia of pressure on fisheries, showing a broader picture of social-ecological change is important context for understanding changes in marine ecosystems and the 'shifting baselines' (Admiraal et al., 2023), but also the danger of assuming that 'prehistory' was culturally and economically static. These findings demonstrate very clearly the important contributions that history can bring to contemporary science and management (ToR C).

In 2021 we heard about the results from work reviewing the contributions from across historical ecology studies (>200 from marine and terrestrial systems) and the emerging recommendations from this work in relation to ecosystem management (Beller et al., 2020). The majority of studies reviewed (~90%) derived from North American and Europe, with forests being the focus of nearly half of all papers. These works emphasised the need to protect and restore both habitat remnants and modified ecosystems, the value of ecosystems as cultural landscapes, and the importance of adopting landscape-scale perspectives for ecosystem management. Nearly one-quarter made recommendations that challenged management status quo, underscoring the value of a historical perspective in setting management goals, strategies and targets, and strongly aligns with ToR C. McClenachan highlighted the National Science Academy Project (Table 1.2) which is asking how historical perspectives can inform EBM target goals and outcomes? By considering how historical perspectives have influenced environmental management decisions in the past, and how the metrics change if historical data are integrated into targets. They are also exploring the best pathways for integrating this data into management. This project directly informs WGHIST ToR C by exploring how historical knowledge can be applied to contemporary science and management broadly, but also specifically by considering how the targets change and how to transfer and implement use of historical knowledge. Similarly, WGHIST member's work published in Fish Biology (Thurstan, 2022) describes the range of possible applications of data from marine historical ecology for understanding human-ocean interactions, the development of methodologies and emphasises the need to work with managers and policymakers to develop mutual understanding and explore how to integrate historical data into present-day management frameworks (ToR C).

Discussions during our theme session at the Annual Science Conference in 2022 ("Impacts of Human Activities and Pressures and on seafloor ecosystems: Past, present and future"; ICES, 2022b) explored: how will human activities affect marine benthos and service delivery over the next few decades? What information do we need to anticipate changes? And what approaches can be used to synthesise this information? Discussions highlighted the areas of data deficiency, explored where further data could be acquired, and how it could be better integrated and applied to management (and be included in ICES assessments). One conclusion was that because baselines are always shifting we need to incorporate dynamics and variation within ecological baselines, e.g. by using “historical” data that captures a greater range of natural states and system variability (relating to ToR C). Furthermore, a better understanding of the characteristics that engender resilience is also needed and could be informed by historical data (ToR C).

At our 2023 convened workshop on “Geohistorical perspectives on functional connectivity patterns” at the ICES-Sea-Unicorn Symposium on Human Impacts on Marine Functional Connectivity (described as part of ToR B) we explored how data and information describing long-term changes in social-ecological systems could be applied to marine functional connectivity (Fig. 1.3) an emerging research theme (Darnaude et al., 2022). These functional connections include the movements of living organisms that facilitate the flow of matter, genes, and energy at different temporal and spatial scales. Data from Earth and human history can be instrumental for identifying baselines and deciphering long-term trends and the variability of MFC, resulting from changes in the distributions, life histories, and migration of species, which may be due to natural or anthropogenic causes and may occur across large spatial and temporal scales and during extreme change in the past (Fig. 1.3), e.g. changing ocean basin connectivity, climate change and major evolutionary transitions. Historical data has great value for tracking the pathways, rates and consequences of species distributions and movements at decadal to millennial timescales and can provide information on how human activities have contributed to functional connections and disconnections. This work informs ToR C, by illustrating the value of historical data from marine ecosystems and the unique contributions it can make to contemporary science. The results from the workshop were published in a report to Past Global Changes (Agiadi and Caswell, 2023) and has formed a Food for Thought paper which has been submitted (Agiadi et al., In Review) to the ICES special issue on marine functional connectivity being produced from the symposium (https://www.ices.dk/events/symposia/ImpactsMFC/Pages/IJMS.aspx). This article provides *Food for thought* and a research roadmap on how to use historical data (from history, ecology, archaeology and geology) to better understand marine functional connectivity. We explore the different types of data available, the resources that exist and explain how they might be used (including any constraints).

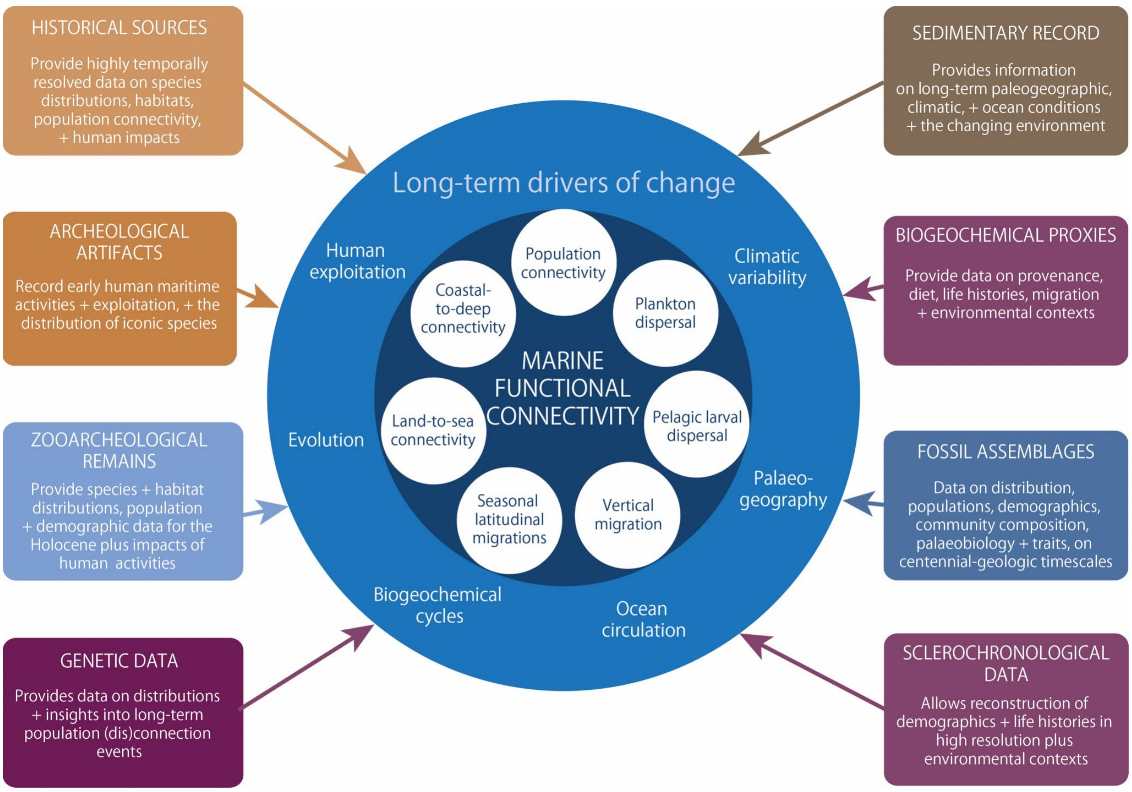

Figure 1.3. Overview of marine functional connectivity processes (white circles), their long-term drivers, and how data (boxes with arrows) from history, archaeology and palaeontology can help unravel changes in marine functional connectivity over time (modified after Agiadi and Caswell, 2023). Copyright: Agiadi and Caswell 2024.

1.3.1 Example approaches and applications of historical data presented at WGHIST meetings

A number of works were presented that show the importance of historical knowledge in relation to fishery science. MacKenzie et al. (2021) reconstructed population sizes of swordfish *Xiphias gladius* in the Mediterranean Sea (from bycatches in tuna traps) extended existing time series by up to 70 years and showed multi-annual to decadal variations in fish abundance and weight over 110 years providing ecological baseline data and improving understanding of Mediterranean swordfish ecology. Overall mean body size declined 21% and individual fecundity declined 26% between the 1940s-present as fishing intensified. This work shows how historic fisheries bycatch information can provide high quality data on natural variability in past fish populations and the effects of exploitation informing ToR C (MacKenzie 2023; Annex 3). Other works that showed the importance of having longer perspective was presented by Ojaveer (Annex 3), who showed that expanding the usual data with more historical data helped to discover the non-stationarity nature of recruitment and spawning stock biomass of spring spawning herring in the Gulf of Riga. This information can be crucial for managers and stock assessment and would not have been found without the addition of historical data. Similarly, Sturrock (2021, Annex 3) showed how using historical data on salmon helped to better understand how the populations changed, what the drove the change and to better perceive the real extent of the population collapse (more than 80% loss of the total biomass). Finally, Thorpe (2021, 2022, Annex 3) showed the importance of using a long-term perspective to inform stock assessment and multi-species modelling to see how exploited populations changed through time and to better predict how they might evolve in the future.

By sourcing and collating information and data on the nature, quality, extent and importance of native oyster reefs WGHIST members and collaborators who are part of NORA (see ToR B) will be informing targets for oyster reef restoration projects (Thurstan et al., 2023a). For instance, their new estimates show that there were more than 1.7 million ha in NW Europe (conservative estimates from historical sources) and they were probably the dominant coastal habitat type at times. The datasets for England are already available online (https://environment.data.gov.uk/dataset/c3c60843-e831-43ba-8bef-054437e60f7c; last accessed 09/01/2024) with those for the rest of Europe soon to follow (Thurstan et al., 2023b).

At our 2023 meeting zu Ermgassen described their project applying the IUCN Red Listing criteria to oyster reef habitats (Annex 3). They faced challenges defining the extent and quality of the oyster ecosystem, in particular the existing baseline data did not capture the historic spatial extent, nor depth range and complexity of past reefs. The data available suggested reefs were much smaller and more degraded compared to historically. Defining thresholds for regional collapse of the species/habitat contained considerable uncertainty due to the lack of data on historical densities. They pinpointed data deficiencies and provided guidance on completing IUCN assessments using historical data (zu Ermgassen et al., 2023). Projects collating historical data and information such as the Native Oyster Restoration Alliance (see ToR B) can provide spatially resolved data that can be used to guide assessments such as this.

Guarini proposed a possible new application for historical data in providing Environmental Impact Assessment baseline information (Guarini, Annex 3). If this could be done it would be one means of integrating historical information into environmental decision making, informing ToR C. Bernardi presented work on the use of non-conventional sources to understand the changes that occurred in shark communities of the Adriatic Sea over centuries and to show how many iconic species disappeared and community diversity declined (Bernardi, Annex 3). In order to do this information from the 17th century onwards was extracted from historical books, pictures, newspapers articles, fishing club and port and landings data. Bernardi presented suggestions on methods for integrating these data and showing the evolution of the community. Larsen (Annex 3) showed changing cultural values of the very long-lived Greenland shark, but also how their unique ecology resulted in them not being overfished and that it might be more appropriate to manage long-lived fish species like this with approaches and principles used for marine mammals. This work contributes to ToR C by showing the importance of historical data to understand changes in the ecosystem through time.

Work presented in 2022 by Dunne (Annex 3) described approaches for thinking about how humans interact with biodiversity through time. It can be used to think about how past communities used ecosystem services in pre-history and to compare them between communities, regions, marine and terrestrial resources and so on informing ToR C. The first approach reconstructed coastal food webs that included past humans in the Sanak Archipelago and explored their role within it compared to other species (Dunne et al., 2016). The second approach also assessed the societal value of natural resources based on the number of different uses humans had for a species, where both simple and more complex interactions (e.g. requiring tools) can be compared (Crabtree et al., 2019; Crabtree et al., 2021; Crabtree et al., 2023). These analyses are well-suited to archaeological as well as historical sources of information (ToR B-C). In subsequent works these authors have been modelling how environmental information is acquired and acted on by past societies and how it may inhibit sustainable practices (Crabtree et al., 2023).

Paleontological data can make a major contribution to ToR C, they have demonstrated great promise in providing pre-human baselines, e.g. for shark communities reconstructed from their denticles (Dillon et al., 2021), but also the reef ecosystem as a whole (Dillon, Annex 3) these approaches show string fidelity with modern accumulations (based on denticle shedding rates) and other data sources (Dillon et al., 2022). The application of new stable isotope techniques on fossil teleost fish otoliths can provide quantitative information on marine food webs (Lueders-Dumont, Annex 3), which are rare prior to the 20th century, validation with modern materials validate record quality and show changes in trophic position of Atlantic cod and provide benchmarks for pre-exploitation populations (Lueders-Dumot et al., 2018; Lueders-Dumont et al., 2020). Similarly, fossil fish otoliths from the Mediterranean Sea document the response of communities to Lessepsian invasion through the Suez Canal (Agiadi and Albano 2020) and so can indicate how present-day assemblages will respond to species movements whether these are driven by human vectors or changing species ranges associated with global warming (Agiadi and Albano, Annex 3).

A number of historical ecology projects are beginning to integrate data from both the terrestrial and marine realm for instance in the ERC project Tradition (Colonese, Annex 3) considers the interplay between food resources acquired by agriculture and fisheries in past societies in the Southern Atlantic (e.g., Admiraal et al., 2023). The new InTerAquAS project (Rizzetto, Annex 3) will employ archaeozoology using both biometrics and stable isotopes of terrestrial and aquatic fauna, with the aim of reconstructing past human/environment relationships and the ecological history of the NW Adriatic lagoons (ToR C). The Seachange project seeks to capture changes in marine productivity in the sea that correspond to changes in human behaviour and land use. The Fish Architecture project (Table 1.2, Annex 3) considers architecture and the urban landscape and seascape across the sea-land continuum, from fishing grounds to processing facilities and distribution. Similarly, assessments of resource use by past societies in Polynesia by Crabtree et al. (2021) included materials that were marine or terrestrial, because to reliably assess resource availability and use requires a holistic perspective (Dunne, Annex 3). In small-scale fisheries in eastern Indonesia in the 20th century government subsidies and policies in relation to agricultural practices had demonstrable effects on small-scale fisheries which would not be captured if resource use had not been considered across sectors (Ramenzoni, Annex 3).

1.3.2 On-going WGHIST work on ToR C

As part of ToR C, two scientific papers are being developed by WGHIST; the first one about the use of anecdotal sources to inform management. This study is an ongoing effort to show how anecdotal information can be integrated into management. Multiple case studies have been collected from members and scientists outside WGHIST where it is shown how pictures, Journal articles, paintings can inform modern management. One example is the case of snapper in Australia, where pictures and information from newspaper articles, coupled with fishers' interviews helped to reconstruct past abundances of this fish around Queensland (Wortmann et al., 2019). These new population estimates allowed management to adjust to the new level of collapse discovered. Case studies similar to these are being collected in order to understand what type of management implication historical data can have and also to understand how to communicate with policy makers.

Another aspect of ToR C is to understand if managers and policy makers can learn from historical ecology. Based on this we are preparing a peer-reviewed manuscript for which we are exploring whether there are examples where the principles of Ecosystem-based Management have been applied in the past (prior to the 1950s). Ecosystem-Based Management (EBM) is the new management paradigm that many countries around the world are seeking to develop and implement this approach to management. Among its most significant "innovations", is the idea of including multiple activities and their interactions within management measures, considering changes in the wider environment and ecosystems, being adaptive to change and local considerations, and to a certain degree bringing management to local communities. Although the concept seems very modern in comparison to the single stock management that has been applied since the 1950s, and in some cases is still applied today, historic records show that in some areas there are examples from the past of management practices that engender the principles of EBM. Historical records highlight how some communities applied adaptive management, considered the environment and wider habitat, and established mitigating/adaptive measures when managing components of both the ecological and societal systems. In this manuscript we are asking what principles of EBM were considered in the past, whether it shares principles with present day ideas of EBM, how it would be classified according to the types used today (e.g., was it the Ecosystem Approach to Fisheries Management, Ecosystem-Based Fisheries Management, or EBM?), why it was or was not successful and whether we can learn lessons for the implementation of EBM in the future. We are collecting case studies from different areas of the world such as Europe, USA, Africa, Chile. The paper will be finalised during the next iteration.

Finally, as part of ToR C, we are still exploring how historical knowledge can be integrated into ICES products such as Ecosystems and Fisheries Overviews. Historical ecology could help to better define the past baselines and states of ecosystems, the major impacts upon them and the fishing community. Work exploring the opportunities to integrate historical data within these ICES products will continue in the new WGHIST iteration.

1.4 ToR D The utility of historical data for understanding social-ecological outcomes of management strategies

The 120-year analysis of how major policy changes influenced patterns of UK seafood production, trade, and consumption by Harrison (Annex 3; Harrison et al., 2023) provides examples of the cultural relationships between fish and fisheries, and shows how resources are valued by people and how those may vary between social-ecological systems, but also through time. They showed that policy changes including introduction of Exclusive Economic Zones (EEZ) and the UK joining the European Union, resulted in large declines in distant-water fisheries (for large, flaky fish such as cod and haddock), that drove a mismatch between seafood produced and what the UK public ate domestically. The scale of this mismatch exceeded any observed previously (including that during both world wars). We don't like bony fish now, as Holm's work identifies Europeans in the 16th, 17th and 18th centuries (Annex 3) had a greater preference for herring. Understanding some of these relationships can help to understand human behaviour informing ToR D. Our relationships with fisheries have changed in other ways - at some stages we were more dependent on fisheries (Allaire and Holm, 2022; Admiraal et al., 2023), and perhaps were more efficient in consuming more of what we landed. Food security is not just determined by the factors that determine resource availability (e.g., environment, fishers' behaviour, social system dynamics), but also our preferences, how we value things and the historic cultural associations.

Similarly, the cultural associations with a species can indicate their value and how they were viewed as a food source. Insights on these associations may vary between cultures and through time as shown by anthropological work on the cultural associations and language used and to describe the common mussel as "peoci" or "lice" (Vianello, Annex 3), the associations and folklore associated with limpets and their role as "famine food" (Firth, Annex 3; Firth (2021)), and the evolution from food resource to emblematic protected resource as in the case of porpoise in the Bay of Biscay (Danto, Annex 3). These associations and behaviour can influence the social-ecological outcomes of management decisions (ToR D).

Heard's work exploring fish imports and exports from the UK can help to understand national behaviour and trends especially because data are often considered in some kind of discrete spatial unit (e.g., by fishing ground, port of landing, fish market) whereas the inclusion of import and export data can provide a more-complete picture of resource extraction and use. This contribution (Annex 3) shows how imports contribute to relative landings and that imports can be considerable, having exceeded landings by double in recent years (as transport has become more efficient and cost-effective). Understanding why local demands are not being met, and how the consumption of local seafood produce can be encouraged can help to create food security. These data and lines of enquiry can contribute to understanding of long term change in social-ecological systems (ToR C), but also by understanding what management intervention is needed and how this fits into broader management objectives (ToR D).

The mismatch between the fish we catch and the fish we want to eat has implications for future food security as well as environmental state. It determines which fish are considered valuable and so which stocks are fished and what happens to the fish once it is landed. This also feeds into broader management because inefficiencies in supply chains need to be considered. These dynamics directly inform ToR C in understanding long-term changes in marine social-ecological systems and this can be applied to contemporary science and management, it may also inform ToR D in understanding the outcomes of management interventions and why they succeed or fail.

Archives from international fisheries organisations were used in conjunction with records from the naval, federal institutions and companies, surveys and logbooks and ethnolinguistic atlases (Danto; Annex 3) to explore the transition from fishing to aquaculture through time and how this related to territorial dynamics in Baltic Sea states (Danto and Danto, 2021). This work shows how geopolitics and supra-national decision making can influence national management and social-ecological outcomes informing ToR D. Other work from Poulsen and Thomsen et al. (Annex 3) showed how environmental change and management decisions may have important implications for society. Changes in the Limfjord fisheries led to major changes in the dependent communities including major socio-economic implications that were disproportionate for different groups of people and resulted in large scale human migration (Poulsen. Some include examples of responsive management (Poulsen; Annex 3) in the face of disturbance. Lessons learnt from these past examples could help to anticipate the responses of social-ecological systems and their resilience to future changes resulting from similar environmental disturbances, or management decisions (ToR D).

Ramenzoni (Annex 3) investigated changes in fishing participation and per capita seafood intake in a small-scale fishery in Flores, Eastern Indonesia over 100 years due to mechanisation. By combining multiple sources of information (ethnographic, observational, nutritional, and historical) they reconstruct the story of stocks, fishing effort, and consumption of marine products, and identified long-term trends in resource use practices. Findings underlined that mechanisation and commercialization can have dire repercussions on food security and job stability within small-scale fishing sectors, especially if they are not part of comprehensive community development programs (Ramenzoni, 2017). Understanding the social-ecological outcomes of technological developments, decision-making and management (ToR D) at the fringes of more centralised systems is essential for understanding and navigating the trade-offs among poverty reduction, economic growth, and environmental degradation (Ramenzoni, Annex 3).

Work of the Cultural Heritage Framework Programme for the UN Ocean Decade aligns with ToR D, by giving context on the possible outcomes of societal activities, such as management, by looking backwards at how past societies have related to resources, the value they hold in our culture and how they contribute to cultural ecosystem services (i.e. spiritual, well-being, identity). Demonstrating the value of these services - things that can often feel intangible - is difficult for environmental economists to place a value on, and so they are more likely to be overlooked.

Finally, WGHSITs on-going work on the identification of the presence of Ecosystem-Based Management in the past (see 1.3.2) is also linked with ToR D since it can help to understand how certain management practices have led to socio-economic impacts and ecosystem consequences.

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Annex 1: List of participants

List includes meeting participants from 2021-2023.

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Annex 2: Resolutions

2020/FT/HAPISG05 The **Working Group on the History of Fish and Fisheries** (WGHIST), chaired by Bryony Caswell, UK; and Camilla Sguotti, Italy, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2021	21–25 June	Online meeting		
Year 2022	6–9 June	Chioggia, Italy		
Year 2023	12–15 June	Falmouth, UK	Final report by 15 August to SCICOM	

ToR descriptors

ToR	Description	Background	Science Plan Codes	Duration	Expected Deliverables
a	Collect, assemble, and, integrate meta-data on marine social-ecological systems through time and develop links with historical data management bodies (within and beyond ICES) to: explore shared interests and compatibilities, and collaboratively develop data products to encourage the use, preservation, and maintenance of historical data.	Data from WGHIST supports the development of tools for marine living resource management and provides a resource of historical and long-term information for the global community via the ICES Data centre. In addition, WGHIST can work with the ICES Data Centre and others to identify further opportunities for promoting and facilitating access to historical and archival resources housed by other institutions (e.g. by collating and digitizing them). WGHIST can also work with other experts to develop guidelines for best practises in using of long-term data for research and management.	6.1, 7.7	3 years	Digital products, such as indexing WGHIST metadata on the ICES Spatial Facility. Guidelines on best practice within ICES and beyond for using and/or applying historical data to contemporary advice for management.
b	Explore the actual or potential synergies between different kinds of historical data and provide tools both for communicating, and for bridging disciplinary differences	Historical data comes in many forms, and often requires an open and responsive approach to its usage. When 'traditional' (i.e. independently verifiable and/or quantitative) data is	7.7	3 years	Wiki providing resources such as: information on best practice and examples of how to understand and the overcome the challenges and

	in data usage.	missing or incomplete, it may be supplemented by 'non-traditional' (i.e. anecdotal or less easily verified) data. These non-traditional data can be more challenging to integrate into management which predominantly focuses on using modern, quantitative data. However, WGHIST is uniquely placed to facilitate cross-disciplinary discussions on how to overcome these challenges, and on best practices for effective integration of 'traditional' and 'non-traditional' historical data for science and management.			constraints of using different kinds of data; with links to other relevant resources that can help to address the integration of different data types for effective and high-quality research.
c	Evaluate long-term changes within marine social-ecological systems, and explore how this knowledge can be applied to contemporary science and management.	The interdisciplinary nature of WGHIST, with expertise in marine ecology, fisheries biology, historical ecology, palaeo-ecology, social and environmental history, offers a unique forum for conducting transdisciplinary research into marine social-ecological systems. It may therefore provide unique data and knowledge that can be leveraged to improve our understanding of social-ecological systems and their dynamics (e.g., scale, direction and drivers of change through time).	2.2, 4.5, 5.4, 7.7	3 years	Submission of (1) manuscript for peer review which might explore the origins or impacts of 'technology creep' in social-ecological systems. OR opinion/perspective piece on the applications of historical data for contemporary science. Provide knowledge that could contribute important context for the ICES fisheries and ecosystems overviews.
d	Explore the utility of historical data for understanding the social-ecological outcomes of emerging management strategies.	WGHIST is unique in bringing together specialists from very different fields who have particular interests in using unconventional resources and approaches, and interdisciplinary methodologies to interpret social-ecological trends over long (decadal to centennial) periods of time. With many new challenges becoming apparent in the 21st Century, so too are new	2.2, 2.7, 7.7	3 years	Work towards published outputs addressing the historical implications of subsidies and the political context for social-ecological change over time, and/or resource sustainability.

	ways of thinking and innovative solutions for how global society may continue to develop, and how we may in turn manage our resource use. WGHIST can provide valuable context on the possible outcomes from these strategies, in particular the response of human societies to past development. For instance, (a) attitudinal and behavioural shifts in effective resource management, and (b) changing patterns of access and use-rights.	

Summary of the Work Plan

Year 1	In Year 1, WGHIST will work with the ICES Data Centre and external bodies to explore the opportunities for developing data products that encourage use of and enhance the visibility of historical and long-term data (ToR a). Production of resources on best practice guidelines (ToRs a, b) will also commence during the Year 1 meeting, as will outlining of perspective/opinion pieces on the applications of historical data (ToR b). Potential areas of interest already identified by WGHIST members for ToRs c and d include: quantifying changes in ecosystem services over time, detailing fishing technology change and cumulative impacts upon fishing efficiency, and invoking cross- disciplinary knowledge to expand our understanding of linked social-ecological system change through time. Post-meeting work will involve soliciting contributions from the wider WGHIST membership list and continued development of manuscripts. The WGHIST 2021 meeting will discuss re-establishing links with the ICES SIHD and other WG with expertise relevant to WGHIST aims, through invitation of SIHD and WG Chairs to the WGHIST meeting, whether in person or remotely. These efforts aim to strengthen cross-disciplinary ties and enhance communication and learning among ICES WGs. Links with external groups will also be maintained (e.g. Oceans Past Initiative) and expanded (e.g. PICES, and the Ocean Biogeographic Information System) to enhance interdisciplinary learning and collaboration.
Years 2 and 3	In years 2 and 3 WGHIST will continue to develop digital tools for historical metadata, explore opportunities for improving the accessibility of historical data for use by the scientific community, and develop protocols for best practise when using historical data, potentially in collaboration with the ICES Data Centre and other WGs. While these tools will be finalised in year 3, it is our hope that progress will be ongoing throughout years 1 and 2, including the provision of digital updates to the ICES community during this time. Years 2 and 3 will also see progress on the proposed manuscripts and perspective pieces, and the WGHIST chairs will work to maintain and enhance connections with other relevant WG, and external bodies as above. Year 2 will forward manuscript and guidelines in our ToRs, specific research from WGHIST members will be used to expand this work. Deliverables will then be completed in Year 3.

Supporting information

Priority	The value of historical marine ecology and historical data for evaluating current ecosystem health has been well established in the literature. Understanding social-

	ecological change – and in particular, long-term trends in social-ecological interactions and their current impacts – has great potential for informing decision making and management of ecosystems and marine service industries in the future. **Scientific Scope:** WGHIST will continue to operationalize historical data for addressing contemporary scientific questions and future management needs. This iteration of WGHIST will prioritise the capture, assembly, and integration of data on ecosystem changes resulting from interactions between social and ecological systems over time, and it will conduct interdisciplinary research based on this data. In this way, it may inform the future management and decision-making of marine resource use.
Resource requirements	WGHIST will continue to consult with ICES Data Centre staff, as well as informally with data management experts and gatekeepers beyond ICES, in order to facilitate (and refine best-practice for) the assembly and integration of metadata within and beyond the organisation. New WGHIST Chairs will contact SIHD chairs to broaden still further the scope for intra-ICES collaboration on the collation, integration and best use of historical data in management and future decision-making. The lessons from this year's remote WGHIST meeting, and the broader lessons to be taken from the impact of COVID-19 on organisational and administrative paradigms, suggest the high value in the future of operationalising remote meetings, conferences and consultations. Any assistance that ICES can offer for supporting remote consultation and meetings would be very much appreciated.
Participants	The chairs will review, and seek to enhance, group membership early in the new iteration of WGHIST. Currently, the members include ecologists, historians, social scientists, economists, policy experts and data analysts working in or connected to historical marine ecology, and we will seek to ensure that this diversity is maintained throughout the next group iteration. Past experience predicts attendance of 8-15 group members and guests at face-to-face annual meetings. However, the experience of this year's remote meeting suggests that this core group could potentially be greatly enhanced with the further use of remote technologies – either for individual participants who are unable to attend in person, or for the organisation of the meeting as a whole.
Secretariat facilities	Standard EG support.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	WGHIST will actively seek out connections within ACOM for the application of historical ecology work into scientific advice (e.g. stock baselines, change through time, context for IEAs, etc).
Linkages to other committees or groups	Potential links to ACOM, EPDSG, HAPISG, IEASG, SIHD as well as WGBIODIV, WGBFAS, WGECO, WGMARS, WGMIXFISH, WGRMES, WGSAM, DIG, WGSEDA, WGECON and WGSOCIAL depending on interest and availability of committee and group members to join in person or remotely.
Linkages to other organizations	Participants in the Oceans Past Initiative (OPI) will be interested in our work and outcomes, and WGHIST will further enhance existing links with this group. WGHIST has an international participation beyond ICES member countries (including Australia, South Africa and Italy) and these will be maintained and, where possible, further enhanced. We intend to work together with the Ocean Biodiversity Information System (OBIS) executive to make historical data (metadata as a minimum) on fish and fisheries available through the OBIS portal.

Annex 3: Summary of work presented under ToRs A-D

A3.1 Presentations at WGHIST meetings contributing to ToR A

Firth (2021) Cultural Heritage Framework Programme” led by the Ocean Decade Heritage Network

Antony Firth, Historic England, UK

The UN Decade of Ocean Science for Sustainable Development 2021-2030 is supposed to be transformative, the vision being to conduct the science we need for the ocean we want. A recognised partner to the decade, the Cultural heritage network programme is the only decade action addressing cultural Heritage and “without cultural heritage, how can you deliver the Decade?” (ODHN 2021). It can deliver a new outcome: an inspiring and engaging ocean. Creating a network of people getting to advocate the importance of humans and marine historical ecology.

The UN is very engaged with the cultural heritage program (both intangible and tangible heritage). Cultural Heritage Framework Programme → ensures that cultural heritage contributes to sustainable developments for the UN Ocean Decade. Seeks to support actions by others to have an impact on the UN Ocean Decade. Connects projects that work with cultural heritage. Disseminate visions, organise workshops → try to reach out to people involved, also link with them to discuss and talk about ocean heritage. Mechanism for people to connect, what can we do for you and what can you do for us, can we connect, how can we connect to that? Interdisciplinary and transdisciplinary linking.

ODHN URL: www.oceandecadeheritage.org (last accessed 09/01/2024).

ODHN Cultural Heritage and Ocean Decade: info@oceandecadeheritage.org (last accessed 09/01/2024).

Link to ToRs:

Specifically, ToR A/B protecting, promoting historic works and data/tools, bridging boundaries and disciplinary differences, making sure we don’t lose resources or their context. Also, ToR D the utility of historical data for understanding social-ecological systemss, diversity and creativity of approaches, but also context on the possible outcomes of societal activities based on looking backwards to how past societies have related to resources, the value they hold in our culture and how they contribute to cultural ecoservices (ie spiritual, well-being, identity). Demonstration of their value - something that can often feel intangible and is difficult for environmental economists to place a value on - so it gets forgotten, overlooked.

Graham and Pinto (2022) The voices of oral history archive

Molly Graham & Patricia Pinto da Silva, National Oceanic and Atmosphere Administration, Washington, USA

- Collect and share oral histories and interviews, much of the data is unique to the database
- She/they also conduct interviews with NOAA staff
- 1895-, 2,200 oral history archives, 120 collections, narratives from 30 states and some from Canada and Samoa.
- Wide range of themes, institutional memories, declining or obsolete industries, landmarks, dialects, rare collections, processing workers, multigenerational fishing families, community leaders and public officials, demographics, greying of the fleet, expert testimony.
- Themes: expeditions to extreme environments, explorers, loss of loved ones at sea, extreme events, and some more recent, multicultural, multi-ethnic records, interviews from multi-gen fishing families, expert testimonies (environment, atmosphere, and marine studies).
- Polled usage and found - maximal stakeholder value - historical change 17%
- Crowd-sourced - archiving in this ways vastly improve their discoverability
- The process of being heard has great value to the orator.
- Molly and colleagues can help interested parties to access and use the resource (they also offer training and workshops, they have a best practice guide for doing oral histories). Ask Molly about their best practice guide (website links to this).
- Can listen to them online through the database, and each has a short description. An awesome database, could be analysed linguistically, interviews are both structured and contemporaneous. Described as a guided interview, with some prompts to reflect and contextualise the information.

URL for archive: https://voices.nmfs.noaa.gov (last accessed 09/01/2024).

Link to ToRs:

These archives can contribute to our meta database (or maybe be flagged from for ToR A). Guidance around use of oral histories can inform the best practice deliverables being developed for ToR B.

Mazzoldi (2022) The Clodia (Chioggia) database

Carlotta Mazzoldi, University of Padova, Italy

- Very large fishing fleet in the Mediterranean, the fish market has a very long history
- Umberto D'Ancona, formed a marine lab here because of lagoon's importance, high biodiversity etc
- Records from 1945 (paper initially), 107 categories, excel versions 1997-present. They built two databases- first databases use similar categories to 1945 records and a 2nd more advanced database with more contemporary-type data, 2011 went online, and is open access - to make data available to fishers.
- Possible to freely download data if you register so that we are able to see who uses it and how
- We can use the data to ask science questions, landings data. Can trends in landings data reflect trends/changes in abundance over time? Seems like a good correlation between CPUE and landings (but varies by species, and whether its target or bycatch).
- Nice paper by Alberto Barausse et al. 2011 using the database showing change in capacity/total landings over time - change in diversity of landings (shift to more pelagic species)
- Multivariate analysis of assemblage composition - nice evidence of shifts in comp through time (also Camilla's work on this database from 2010)

- Anglerfish and data from scallops back to 1945, scallop decline, bluefish increase. Fishermen have confirmed the shift in landings of bluefish does reflect a change in catch
- Skate and shark data also, even though they aren't abundant data can reflect changes in abundance. Shows change in seasonal use of the fishing grounds, and perhaps changes in phenology (as migration timing? Becoming later and later).
- Database is undergoing continuous updates, but of course every year new data. Expert constitutions are also increasing.

URL for CLODIA Database: https://chioggia.biologia.unipd.it/en/the-database/ (last accessed 09/01/2024).

Linked publications:

- Mazzoldi, C., Sambo, A., Riginella, E. 2014. The Clodia database: a long time series of fishery data from the Adriatic Sea. Scientific Data, 1:140018. DOI: 10.1038/sdata.2014.18
- Barausse, A., Michieli, A., Riginella, E., Palmeri, L. & Mazzoldi, C. 2011.cLong-term changes in community composition and life-history traits in a highly exploited basin (northern Adriatic Sea): the role of environment and anthropogenic pressures. J. Fish Biol. 79, 1453–1486. DOI: 10.1111/j.1095-8649.2011.03139.x

Link to ToRS:

The Clodia database can be added to our metadatabase (ToR A).

Vandepitte (2021) Databases for WGHIST historical data

Leen Vandepitte, OBIS, VLIZ

EUROBIS (European OBIS), and WORMS and marine regions hosted out of VLIZ at Flanders Marine Institute. EUROBIS seeks to centralise scattered biogeographic marine data (within Europe and that collected by European scientists outside of Europe) and make data freely and widely available, producing searchable databases on marine species distributions. "Collect once and use many times" want to protect and archive data. The sharing is voluntary, has a degree of quality control, with feedback to the provider. Within the data centre the use Darwin core, assigns a doi, plus links to Marineregions.org. They also ensure they understand the goal and context of the data (which will be quite important to historians).

Data from before 1950 is classed as historical - and 'rescue data' is that published between 1950-2000s but which only currently exist on paper. For data inputs that don't have an original data provider - identifies publication (if no provider) - scanning and OCR creates metadata and manually digitises it. Species distribution data can be linked to data on biomass, environment, animal length measurements.

Pre-1950 there are 155 datasets (14% of the total) hosted on EUROBIS, with 635,000 occurrences (2% of total). There are less details in the historic datasets, they are intending to do a historical data inventory, in collaboration with partners, and see how they can incorporate more information.

WGHIST data archived in EUROBIS will link to both OBIS and GBIF. The Lifewatch (LUSID) project species information is the backbone and builds on expert validated and literature based information, intends to facilitate standardisation of species data, and facilitates virtual integration of distributed data repositories. It may communicate with and exchange across WORMS to validate and verify species names. URL: https://www.eurobis.org (last accessed 09/01/2024).

Link to ToRs:

Mainly ToR B, exploring and overcoming the synergies and possible incompatibilities between the kinds of data the group uses, interpretation and context of historical data. Also connected with ToR A in many ways - assembling and integrating both metadata and 'data' (more *sensu stricto*) - encouraging use and preservation (and 'rescuing') data, a big challenge for historical data.

A3.2 Presentations at WGHIST meetings contributing to ToR B

Holm (2021) 4OCEANS ERC Synergy project

Poul Holm, Trinity College, Dublin, UK

4Oceans considers the human history of marine life from the last 2000 years, producing a world atlas of marine exploitation against a background of societal and political change. Research questions include: When and where was marine exploitation of major significance to society? When did we develop knowledge? What were the societal drivers of exploitation? What living resources did we extract? How did we value it? And, what were the consequences of it?

The project considers: the global south (far less well-known), North and Atlantic Basin transects, including the global marine footprint, the supply chains (particularly between London and Lisbon markets); focussing on 10 taxa of environmental and economic significance (of mammals and fish). It will employ multi-disciplinary records (cartography, zooarchaeology, history, and so on) to track key societal and environmental events, e.g. the Tambora eruption (nicely demonstrated in Herring catch boom), the values of people and the relationships with marine resources.

A number of large historical ecology projects - all transdisciplinary - are about to or have recently started, with many potential inter-connections between them. Achieving a critical mass, widening perspectives, and gathering more data will increase our power of prediction/forecast, baselines from which we can consider current challenges such as climate change.

URL for project: https://www.tcd.ie/tceh/4-oceans/ (last accessed 09/01/2024).

Toso (2021) ERC project TRADITION

Alice Toso, Krista McGrath & Andre Colonese, Universitat Autonoma de Barcelona, Spain

UN 2030 SDGs recognise the lack of data/information on the value and contribution of small-scale coastal fisheries, despite them being key to conservation. The potential contribution is large, yet there is little knowledge of change through time or the drivers of change. An initial literature review showed that very few studies consider history <10% of papers published. TRADITION will address these deficiencies and will focus on Latin American and local indigenous knowledge.

The project will:

- Look at human remains, animal remains, shell mounds (biomolecular residues), historical sources and archaeological remains (biomarkers from human possessions).
- Bridge the gap between what we know about small scale fisheries today and in the past from archaeology. Including the initial development of many fisheries.

- Data on colonial history is missing, pre-colonial there is some information, but little during and post European colonisation.
- How is Traditional Ecological Knowledge impacted by colonialism? Does TEK change? Is it preserved? Does it cross generations (does baseline shift?), what were the stressors?
- So far the data suggests that not all past activities were sustainable.
- What was the role of fisheries pre-colonisation? There is much focus on Latin American agriculture, but we think the overall story is more complex, fisheries were a major food source but were overcooked.

Project URL: https://erc-tradition.com (last accessed 09/01/2024).

Butler (2021) ERC Synergy Project SEACHANGE

Paul Butler, University of Exeter, UK

AIMS: To quantify the impacts of major cultural transitions on marine ecosystems (biodiversity and ecological functioning). Common misconceptions: we do not see the oceans so we think they are more resilient than perhaps they are, and that significant impacts are very recent. Will construct new baselines for understanding environmental changes. To assess the impact of human activities over a longer time frame. Specific cultural transitions will be considered → cessation of whaling in Antarctica, Viking settlements, Mesolithic and Neolithic North Sea over the past 1000 years.

It will use interdisciplinary methods: archives (shells, seafloor - kitchen middens, marine sediment cores), chronology, cross dating of the shell and other methods: palaeo/zooarchaeology, historical marine ecology, collecting data from historic documents. Stable isotope analysis of biotic remains, plus aDNA and eDNA, proxies from sediments themselves, and will use numerical ecosystem modelling, to discern the impact of environmental and human changes in these past marine ecosystems. Will to some extent recreate the environment and food webs. Modelling to also understand how the marine environment will change in the future? Covers a similar timeframe as 4OCEANS, but is more chemical, has a significant benthic focus, and also more from human changes point of view.

Project URL: https://seachange-erc.eu (last accessed 09/01/2024).

Links of the four projects to the ToRs:

All of the ERC projects address or demonstrate the importance of historical data to understand long term changes of the social-ecological systems and may contribute to management (ToR C). Important discussions and strategies are required about collating and storing different data and ensuring they are coherent and compatible or comparable. Each project has some initiatives to collate an online database. This is linked with ToR A where we address the importance of collecting and openly sharing metadata, protecting legacy data and methodological details. But, also ensuring they're compatible and somewhat comparable and can be used together (ToR B). Further, because projects analyse changes in social-ecological systems from different perspectives, ecological side or from the social side and different disciplinary perspective's ability to communicate across disciplinary boundaries is paramount.

Tavares (2022) Fishing Architecture: Architecture follows fish

Andres Tavares, University of Porto, Portugal

- ERC consolidator project started in September 2022 and runs for two years.
- Architecture is becoming more abstract - relationship to ecology
- Different architecture is used for different purposes/processes/species: Great image of Svolvaer, Northern Norway drying fish heads on giant teepees; or in Hastings, UK smoking sheds - unique multi-purpose form of architecture; Matosinhos Canning factories near Porto, Portugal in the 1940s (Fig. S1).
- Nice example of use of images (casa Terranoca shop in Lisbon) - with prices of different sized salted cod from different fishing grounds in 1966.
- The project is asking, how, where, why were the structures built? And are relating it to the North Atlantic history of temperature change linked to the fish caught.
- Fishing technology/processing are the two most recognised architectural dimensions that can inform consumption patterns.
- Their question is: How does the ecosystem impact architecture and vice versa?
- Maps with data on what are the structures and where? analysing its architecture can indicate how the facility relates to urban dimensions of the city (e.g. downtown Lisbon where drainage is). Also linking the population of Lisbon to food processing and the capacity to feed people, also linking the size of processing factories to likely size of gear and so stock!?!?! (certain sizes of factories became bankrupt with changes in stock…).
- Q. Where do you get your data from, is it all historic maps? (see urban maps below of Portugal) Yes, also images of architecture (and architectural archives of factory design) and to some extent reconstructing fishing/transport routes.
- Looking at Portugal (Matosinhos), Iceland (Grindavik), UK (Grimsby, Gloucetser), Norway (Vesteralen Archipelago), Newfoundland (Harbour Grace), France (Douarnenez) for cod, hake, sardine, herring, salmon, and tuna.

URL for project: https://fishingarchitecture.com (last accessed 09/01/2024).

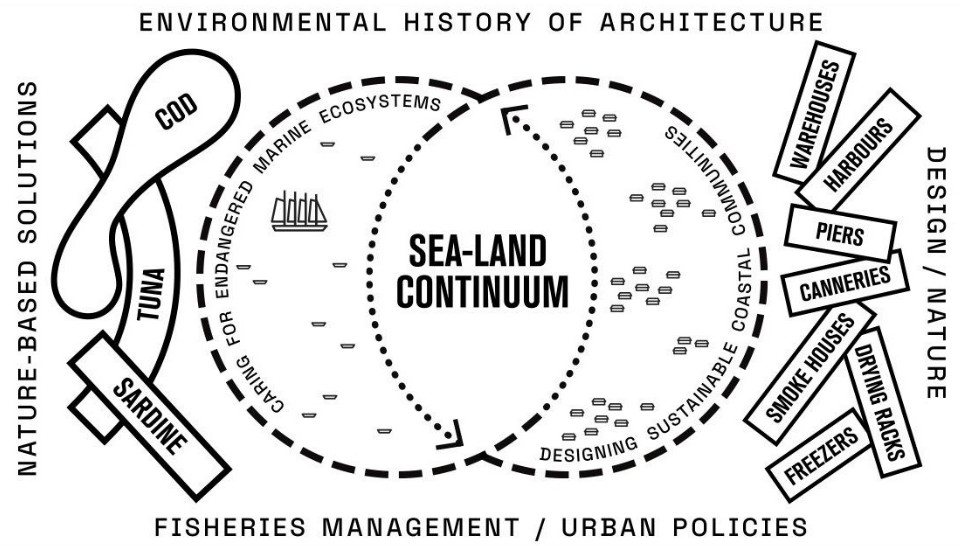

Figure A3.1. Schematic of the Fishing Architecture project. Copyright: Andre Tavares 2021.

Link to ToRs:

There could be a good case study from this for the deliverables under ToR C, spans multiple levels of industry/society, across areas with good data, connecting land and sea. Also gives some good examples of alternative data sources contributing to ToR B.

Walker (2021) The Wadden Sea Project

Paddy Walker, Andreas Dänhardt, Nederlandse Elasmobranchen, Vereniging

2010 Trilateral fish targets (Germany, Denmark, Netherlands) were developed for the Wadden Sea (world heritage site) then nothing happened for a period. 2018-2024 The Swimway vision and action programme began. Now have a trilateral WG and are looking for cooperation and collaborative projects. Focussing on the life cycle and bottle necks for mixed species. They are considering it across four pillars: Research and monitoring, policy, management, communication/education.

Highlights from the WG knowledge community, they are interested to learn about parallel projects that reach beyond their immediate community. Recognising the importance of shifting baselines and how history can feed into this (for defining management and conservation targets), which can demonstrate the causes of change, rates of change, and achievable goals. They want to include historic, present-day and recent past data (trait based, plus surveys) into future models Themes: biodiversity, what is the relevant timescale, link between Biodiversity-Ecosystem-Functioning and species diversity. They would like to know specifically which: species have disappeared, declined and appeared and do the project's goals now reflect this? They are asking: How did communities/populations change relative to the available habitat? Can we define guiding principles to define “desired reference states” for the Wadden Sea fish community? Regarding, reference states: What is realistic? Should we try to achieve something beyond this? Which measures provide adequate reference state?

Mercedes Lopez (2022) Don't leave the modeller alone: integrating time series analysis with fishers’ LEK (local ecological knowledge) to identify causes of change in coastal ecosystems

Maria Mercedes Lopez, University of Padua, Italy

The Venice Lagoon and the northern Adriatic Sea are complex, dynamic, and heterogeneous ecosystems that face multiple external pressures, both natural and artificial, which often interact, making it difficult to identify the causes of environmental changes. The project aims to integrate long-term time series and ecological knowledge of local fishermen, to reconstruct causes of emerging ecosystem change. Long-term fishery landings referring to the northern Adriatic Sea and southern Venice Lagoon (Clodia Database, 1945–2019) and northern Venice Lagoon (a novel database covering 2006–2019) were statistically analysed to identify changes in fish and macroinvertebrate communities, and then interpreted in relation to natural factors and human pressures. To reconstruct local fishers' perceptions, one-to-one questionnaires were carried out, followed by participatory group meetings. Interestingly, the perception of ecological changes was related to the employed fishing gear and the years of experience, and fishers explained changes in landings over time in terms of human pressures, climate but also socio-economic and technological factors. This comparison of LEK and ecological time series analysis highlighted advantages and limitations in both methodologies, which appear to be complementary. Their integration provided us with novel socio- ecological perspectives on the causes of change in these coastal ecosystems, contributing to the knowledge base needed to implement ecosystem-based management.

Links to ToRs:

This work links to ToR B by combining approaches using historic data on community changes as well as LEK. Interestingly data quality varied with perceptions changing depending on the audience (group and individual perspectives differed) and whether they employed traditional or modern approaches. The novel socio- ecological perspectives created can contribute to the knowledge base needed to implement ecosystem-based management informing ToR C.

Danto (2022) Bycatch of marine mammals and seabirds in the Bay of Biscay, looking back to help the future of fisheries?

Anatole Danto, La Rochelle University

Goal is to analyse the controversy surrounding the incidental capture of marine mammals and birds due to fishing. Study site: Bay of Biscay (FR, but also Spain). Project funded by French Ministry of Research, to increase marine mammals and birds bycatch in this area. But an increasing number of research projects, too => see the "Ecosystem of research projects" on bycatch in the Bay of Biscay.

New public issue, between sciences, society and policy. Ethnographic survey: coupling ethnology, history and ecology. Conducted with the actors of the communities and based on a multi-sited ethnography->Marcus, G. E. (1995). Ethnography in/of the world system: The emergence of multi-sited ethnography. Annual review of anthropology, 24(1), 95-117)

Allowing for in-depth fieldwork (Clifford Geertz's notion of "thick description"). A field preparation phase, then fieldwork phases of medium length immersion as much as possible. Conducting ethnographic field surveys sometimes collective, sometimes alone, with semi-directive interviews, participant observation, observing participation, floating observation. An in-depth ethnographic approach: Work on museum collections, production of oral archives (deposited on a secure public database), field notebooks, short ethnographic films, photographic archives.

Work on archival sources: Archives are diversified (private, public, scientific, managers, ...). A lot of work has been done on the identification of private archives and their inventory, especially of former professionals (fishermen, ...). Necessity of "maps of actors and policies". Allows to trace unknown or inaccessible time series dedicated to birds or marine mammals' bycatch.

An evolution of the resource from a "food resource" to an "emblematic protected resource":

- Porpoise hunting in Piriac-sur-mer (Loire-Atlantique): note the hunting dog on top of the captured trophy.
- Organisation of fishing communities around hunting, or "just" consumption when the catch is accidental.

XIXth – XXth century: a "fishermen" oriented national policy

- Collection of grievances by the maritime administration (Affaires maritimes): analysis of succession of laws.
- Authorisation and encouragement to kill (premiums).
- Active participation of the French Navy fleet to "regulate" the populations. When fishermen find that there are too many "porpoises" (generic term for MM during XIX-XX centuries), the army sends torpedo boats to shoot the animals, during campaigns that are

detailed in the old regional press (sources ++: old press in AD and military ships' logbooks in SHD)

- But in parallel: the emergence of questions about the origin of the strandings. Stranding of a beluga whale in Les Sables d'Olonne (Vendée), and a stranded marine mammal at Saint-Gilles-Croix-de-Vie (Vendée).
- And an emergence of "whistleblowers". Their basic tool are counting and time-series => very interesting data!
  - Implementation of automatic collection systems.
  - Structuring a network of observers.
  - Pooling of data.
  - Creation of databases.
  - And sometimes, structures become real public institutions, and not just associations.
  - Example: the Penn ar Bed NGO magazine (Brittany), or the Pelagis Observatory (French Atlantic coast).
- Until the arrival of NGO activism (more contemporary than for the seal, but the parallel is interesting). 'Murderous fishermen'' and "Pray for dolphins", in Douarnenez (one of the biggest fishing harbours in Brittany).

Linked publications:

- Réveillas, J., Cazé, C., Danto, A. 2023. La solidarité écologique: une solution juridique à la problématique des captures accidentelles dans le Golfe de Gascogne? Droit et Cultures, 84 (2). DOI: 10.4000/droitcultures.8827.
- Cazé, C., Mazé, C., Danto, A., Saeedi, H., Lear, D. et al. 2022. Co-designing marine science beyond good intentions: support stakeholders empowerment in transformative pathways. ICES Journal of Marine Science, 80 (2), 374-377. DOI: 10.1093/icesjms/fsac155.
- Mazé, C., Cherques, C., Danto, A., Réveillas, J., Cazé, C. 2022. Ocean Whistleblowers: Women's Contributions to Marine Knowledge and Conservation. Cybium, 46 (4), 349-355. DOI: 10.26028/cybium/2022-464-003.
- Cazé, C., Danto, A., Réveillas, J. 2023. Décrypter la controverse autour des captures accidentelles dans le Golfe de Gascogne. Report UMR 726. Littoral Environnement et Sociétés (LIENSs), La Rochelle, France.
- Cazé, C., Réveillas, J., Danto, A., Mazé, C. 2022. Integrating Fishers' Knowledge Contributions in Marine Science to tackle bycatch in the Bay of Biscay. Frontiers in Marine Science, 9, 1071163. DOI: 10.3389/fmars.2022.1071163.

Link to ToRs

Demonstrates use of a mixture of sources including ethnography (ToR B)

MacKenzie (2022) Neglected fishery data sources as indicators of pre-industrial ecological properties of Mediterranean swordfish (*Xiphias gladius*, Xiphiidae) swordfish fishery reconstruction)

Brian MacKenzie, Technical University of Denmark

- We investigated whether tuna traps (historic) capture bycatch species in amounts that can tell us about their ecology.
- Extracted, compiled and digitised and made available data from 4 sites. Started at a previous WGHIST meeting (EU COST platform in 2016) and visited Italy to collaborate - utilise written records from bluefin tuna trap fishery (used for centuries in coastal areas).

- Gear design didn't change for a long period so is good for comparison of trap data. Some records are quite detailed including: all species found, the amounts of each.
- Traps are very large (100’s m; See Fig) extend from the shore and were emptied several times per week. They were designed to catch bluefin tuna, but also caught other species as bycatch (including swordfish).
- More information on the methods and results (in our publication in earth system science and data - also archived in Pangea), published the dataset, and then published a paper with a time series.
- Chose to focus on swordfish because not much is known, and it is a commercial species now. There is little quantitative information about exploitation pre 1950s. Kind of pilot study because lots of trap records that could be used - we selected four. From near Sardinia and Sicily.
- 1880-2020 seasonal deployment patterns, they seemed to set them at different times, maybe linked to migrations to /from spawning sites. Mean number caught/yr ranged from 30-130. N=8000 fish(?) across the 4 areas. Also looked at the duration of trap deployment - traps that were out longest caught most fish. Mean CPUE matches this. CPUE varied through time and the pattern varied by location.
- They also looked at body size, mostly 25-30 kg fish and 2.5-4 years old (50% were mature). Overall decline in body size from 1940s-present, mean size decreased 21% since 1940s - has consequences for reproduction and stock. Individual fecundity declined 26%. All reflected a decline from 1880 - which occurred after exploitation began. Of course, we don’t know how large a spatial area body size declined over.
- High temporal resolution allows exploration of catch phenology. Can derive migration phenology percentiles and investigate climate and fishing effects on timing of migration. Mean arrival times can suggest migration from the west towards the spawning area.
- Conclusions - bycatch data can have value, and for swordfish bycatch data has been overlooked, but data look good. Showing many shifts through time – rather than a random mess.
- Many other traps existed, and the data could be used in this way - and could improve resolution. Can provide new long-term datasets - amount caught varied through time and had pattern and structure.
- At least 3 properties of swordfish ecology (can be extracted: abundance, size, and migration phenology) and so can derive new baselines from them.
- Large decreases in mean body size after the fishery began are consistent with exploitation.

Linked publication: McKenzie, B. R., Addis, P., Battaglia, P., Consoli, P., Andaloro, F., Sarà, G., Nielsen, A., Romeo, T. 2022. Neglected fishery data sources as indicators of pre-industrial ecological properties of Mediterranean swordfish (Xiphias gladius, Xiphiidae). Fish and Fisheries 23, 829-846. DOI: 10.1111/faf.12651

Link to ToRs: This work can contribute metadata to the catalogue (ToR A) and informs ToR B in using opportunistic sources of information to reconstruct and assess species ecology. It also informs ToR C by providing data on past assemblages and effects of exploitation.

Page (2022) The Transnational Urbanisation of the North Sea: Mapping the spatiotemporal Dynamics of Human Activities in an Increasingly Viscous Shelf Sea

Dean Page, University of Hull, UK

- The Liminal Cynefin framework - lessons in sense making of anthro-complexity for complex decision making - splits into "complex" "clear", "disordered/chaotic.
- Mapping a complex patchwork of human use/human footprint in three regions through time (Hull, Esbjerg). The maps of human use and interactions are complex and really interesting. Mapping fishing effort and zones,
- Will you be mapping renewables and projecting future change? Yes by the looks of it
- Using the DAPSI framework
- A lot of data - but generating a sequence of maps of different areas with multiple human pressures interacting, as a tool for management.
- Verification with interview data maybe?

Link to ToRs: Approach could be used to assess historic patterns of urbanisation and its impacts (if one can get enough historic map data), links to ToR B.

da Costa Gonzalez (2023) Once upon a time

Fiz da Costa Gonzalez, Instituto Espanol de Oceanografia, Vigo, Spain

Collaborating with NORA and is researching oysters in Murcia, Spain, in relation to water quality for bioremediation. Change in salinity, historical mining of Fe (Roman times), and from 2015 onwards phytoplankton blooms, turbidity issues killing off fish etc . He is now working with NORA to collect historical data on oyster presence from historical docs (1920s?) with the locations, quantities, habitat description, trade, place names "Ostreira", drivers of change, cultural heritage. Looking at Ostrea antantina and another Ostrea edulis, both species cohabit

Information from 45 settlements when the Romans arrived. There are archaeological traces of everything that they ate, including oysters. Afterwards there was no data until 1600 or 1700. There is data on the locations of beds, habitats, substrata, and cultural heritage of these oysters.

There was a "Flat oyster" market in Vigo? (only sold oysters) records are scattered and quality of records is very varied due to regional data collection practices being so different. Mural of the last female oyster seller.

Historical aquaculture initiative. European initiative, experts that work with oyster aquaculture to get all data (NORA) with evidence of historical aquaculture of oyster (oyster laying). There are maps of culture locations (from 1700s onwards), images of culture approaches ongoing work. Galicia generally has great interest in bivalves as food (clams, razor clams), there is historical data on other bivalve species that could be used for similar purposes (e.g. cockle and clam beds).

Link to ToRS: Historical aquaculture work informs ToR B and C using different kinds of data and sources. Also, there is an interesting story about the scale of industry historically and cultural values including archaeological records (ToR C).

Fossi (2023) Macrofauna associated with oyster reefs

Eugenio Fossi, University of Bologna, Italy

PhD student at the University of Bologna, Italy. The 1st part of his PhD is working with historical data, 2nd part will be field sampling and molecular analysis. Focussing on the northern Adriatic Sea to collect data from farmers with surveys, 30-40 farmers all around the Adriatic coast. Working to understand the level of knowledge of the farmers, and to create connection between stakeholder and farmers. Some farmers found ways to impede colonisation from other non-native species. Examining the history of introduction with species attached to oysters. Identification of species found living in oyster beds, also to detect possible invasive species that could arrive in the Mediterranean.

Marsili 1755 has locations of oyster reefs in the Adriatic, including more high-low certainty scaling - developed consistently across the NORA network. Also used terms such as "steps" and "longs". He is recreating the history of introduction of the species (the most important vector is aquaculture activity). Many oyster farmers have been doing it for 20-30 years and often are family businesses etc so there is a strong legacy of collecting. He is looking at the associated fauna that have also spread, 2 new species of Polydora (worm) come in within the oyster.

He has been collecting LEK from 30 or so farmers - they seem to be recounting the associated species, pest for some farms but not others. Mussels in Sardinia, a lot of production is from overseas (buy them from Galicia, depurify in Sardinia and then sell them as Italian products. Species are transferred with these aquaculture processes. (would make the data on landings/sales unreliable, very nuanced)

Link to TORS: Interesting angle on historical non-native invasive species (ToR C), but also the species lists within shellfish beds (with impacts for the NORA work; ToR B) will include invasives from spreading spat/seed.

Holm (2023) 4OCEANS ERC Synergy project: update since 2021

Poul Holm, Trinity College, Dublin

Project covers 4 Oceans: the Atlantic, Indian, Pacific and Arctic oceans (excluding the Southern Ocean because of lower exploitation there at this time). They are looking at data from 2 global markets (London and Lisbon), 3 transects (Global North, Global South, Atlantic Ocean basin), and 10 taxa of environmental or economic importance (Fig. S2). They authored a paper on "New Challenges for the human oceans' past agenda" published on open Research Europe. Systematic versus a "learning" driven review and because much information is not accessible this has led to the expert review (URL for questionnaire https://arcgis/yKDaD0; last accessed 09/01/2024).

The project has published 30 publications so far, and a major deliverable will be a "World Atlas of marine exploitation". They have established new research labs (stable isotopes) with ERC funding and have been field sampling for whale remains in Europe. They have identified a "Fish event horizon", different cultural events at different times in different places, and acceleration as seen in the 16th century and 19th centuries. Future fieldwork is planned in the global south (Colombia, Cape Verde, Belize, Mozambique, Chile and Brazil) looking at global sirenians, pinnipeds and whales.

They are asking questions such as: how does fishing fit within the broader questions of food sustainability? And what were the consequences of marine exploitation for societal development and the oceans. Using Japanese famine data (1700-1868), and population size, they are asking who had access to marine resources? Based on 10,000 disruptions to agricultural records in local chronologies.

They are asking when did the human footprint appear in the marine environment? Per capita seafood consumption from 1500 to 2019 in Europe, declined in the Nordic countries over this period, but it changed everywhere in 1900 (increased in all except Nordic countries). Non-food consumption shifts earlier in the 1820s (whaling) followed by fishmeal production in the 1960s - shows a real shift so we need to include non-food components which is substantial. They have used this to construct a human marine footprint from 1500 of fish for consumption and major non-consumption products (whaling and fishmeal), which peaked in 1960 (for the Atlantic).

But, how do we disaggregate natural and human change? They are looking at the Newfoundland cod catch from 1676-1827 as a proxy and the effects of volcanic eruptions on marine production. For cod catches increase in years before (-1,-3) and after (+6, +10 and +13 years) the eruptions and for herring 5 and 7 years after the eruption– suggesting an ecological impact on cod and herring, but they don't yet know what the mechanism is (perhaps zooplankton peak with lagged effect on fish diet).

Key archives they are using to explore global trade are coming from the Dutch East India Co and the English East India Company since 1602, French archives d'Outremer (a company state with quasi-governmental powers). These archives are key and need to be combined with indigenous data and knowledge. They are also contextualised the marine resource data with data on other resource extraction/production e.g. metal, sugar, skins, and have found that fish had considerable value compared to the others. Project data is being published online, with some materials online at figshare.com so far. They will make a "History of the world in ten taxa".

URL for project: https://www.tcd.ie/tceh/projects/4-oceans/

URL for review paper: https://open-research-europe.ec.europa.eu/articles/2-114/v1(last accessed 09/01/2024).

Link to ToRs: Most of the 4Oceans project deliverables can inform ToR C with a broad geographic scope fulfilling some previous gaps in knowledge, e.g. from the southern hemisphere, and widening the picture. The data products can inform ToR B and lessons from the project should be able to contribute to ToR B. The review parts of the project identified a range of data that are inaccessible and knowledge that is needed, and data that should be considered to complete the picture (e.g. non-food marine resource extraction) but also non-marine trade products to contextualise relative value.

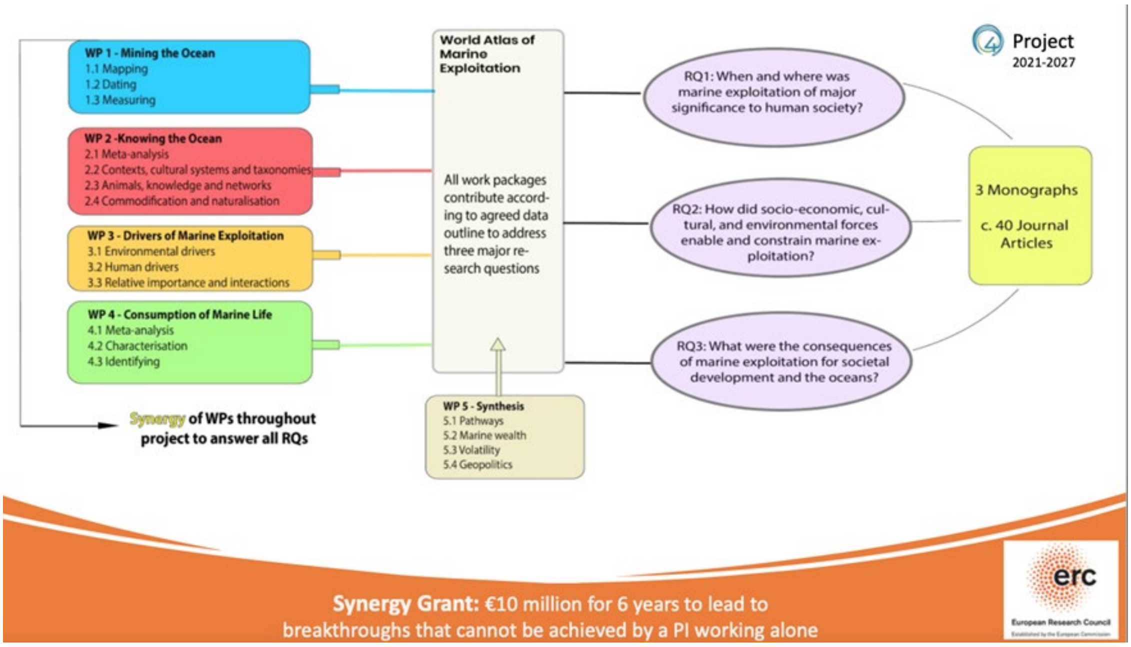

Figure A3.2. **Schematic of the Fishing Architecture project. Copyright: Andre Tavares 2021.**

Tavares (2023) Fish Architecture ERC Consolidator grant: update since 2021

Andre Tavares, University of Porto, Portugal

The project will reconfigure the way we speak about buildings. The project considers the sea-land continuum, what is the impact on the sea of constructions and also how species can impact architecture. Looking at four species sardine, tuna and cod, hake and salmon at seven different locations (Portugal, France, England, Norway, Iceland, Newfoundland, USA). 1830s-1950s, specifically pre-industrial to fully industrialised fisheries. It explores marine ecosystems, fishing technology, food processing, politics and consumption habits. The history of architecture through species, the environmental history of architecture and the intersection between fisheries management and urban policies.

Separated information into 5 components: marine ecosystems, fish tech, fish processing, politics, consumption habits. Connects the scale of the fish processing facilities e.g. with catch. One challenge is connecting these different layers. They have found a greater impact on fish populations occurs when we have more industrialised buildings. So far they have focussed on cod, sardines and tuna - with all of the associated architecture.

Project URL: https://fishingarchitecture.com/page/about (last accessed 09/01/2024).

Andre has published a book in Portuguese "Arquitectura do Bacalhau" (A Faculdade de Arquitectura da Universidade do Porto, 2022) and so gave us an overview. It has chapters on *Gadus morhua* (Bacalhau), *Thunnus thynnus* (Atun), hake (Pescada), *Sardinia pilchardis* (Sardinha) and

Octopus vulgaris (Polvo) - it is possible to write a history of architecture through these species. Different landscapes and seafloor affect the types of infrastructure that has developed - architectural problems within this landscape. For example, with sardines, seines and brineries are needed and can build fragile wooden structures, and some boats "seiners" require different types of harbours, sizes and type. For tuna the S Portugal fisheries relied on very fragile structures (made of reeds/grasses) in the sand dunes and then more sophisticated industrial facilities, but they used the same gear. Lisbon fishing harbour (designed for trawlers) used freezing (or at least refrigeration) to process the fish - also changed the landscape of food consumption - and food distribution network – lots of little vans selling fresh fish. A characteristic feature of the cod fishery was large areas of drying mats used for drying cod in the sunshine (e.g. photos from Morraceria). The labour force was majority female and was a community endeavour. "Architectural footprints" can indicate the type of building could link to the amount of fish caught and processed, so maybe link to ecological impact? URL: https://dafne.pt/livro/arquitectura-do-bacalhau-e-outras-especies/ (last accessed 09/01/2024).

Told us about and MSc project on "Maritime backyards, Povoza de Varzim, Portugal" by Marta Labastida and Jose Pedro Fernandes in 2020/21 (URL for publication: https://doi.org/10.7480/spool.2020.2.5037; last accessed 09/01/2024). An offshoot from the fishing architecture project, it looked at how fishermen developed special methods and procedures for organising their maritime territory. The paper describes the processes used in the fishing community of Povoza de Varzim, NE Portugal. The fishing families developed mental maps of the sea, which they named producing an intangible heritage. Now the sea is mapped digitally and is divided up based on the gear used (referred to as "maritime backyards), this paper compared traditional maps and contemporary maps.

Andre's new book coming soon, in English "Architecture follows fish: An amphibious history of the North Atlantic" (MIT Press, 2023). Synopsis from the book: "To what extent can a fish produce architecture? The objects of this book are the leftovers of historical commercial fisheries, their coastal settlements, and industrial facilities. Its gaze is focused on architecture's ecological impact and how construction its intertwined with natural resources and the environment. Certain buildings exist because of the presence of nearby fishing grounds, and their existence puts pressure on fish populations. What are the relationships between marine ecology and architecture? Architecture Follows Fish sets out a hypothesis to tackle these dynamic relationships. It takes cod as an example covering the whole North Atlantic region, with the same fish connecting different practices from both sides of the ocean. The research looks through several lenses: marine ecosystems; fishing technology; food processing; politics; consumption habits. The outcome aims to trace a socio-ecological history of architecture, overcoming the nostalgia for industrial heritage and raising awareness of the environmental effects of architecture." URL for the book: http://www.grahamfoundation.org/grantees/6346-architecture-follows-fish (last accessed 09/01/2024).

Link to ToRs: Excellent span of data from multiple levels of industry/society, across areas with good data, connecting land and sea informs TORs B-C. Also demonstrates the value of novel information from architectural plans and urban development. Some of the case studies directly inform deliverables for ToR C.

Colonese (2023) ERC TRADITION: Update since 2021

Andre Colonese, Universitat Autònoma de Barcelona, Spain

Started in September 2019, and so there are 2 years left (completes in August 2025).

Two main parts (i) investigating 6000 years of fisheries ecology, and (ii) enhancing policy, and citizen awareness of lost coastal ecosystems. They are looking at Biodiversity hotspots and LEK, threatened systems and anthropogenic history of the Southern Atlantic Ocean.

Very little is known about anthropogenic activity in this region, there are a variety of threats today, but know very little about the impacts here as yet. Records date back 8000 years, and have to use pre-European archaeology because there are no written records. (good point, interesting is this unique to this region?)

Shifts from subsistence-based, to community-based activity and local-regional exploitation. Consists of a very multi-disciplinary team, important results so far that can be used to inform conservation policies:

- Marine biodiversity changes as perceived by public media over 180 years (Herbst et al. 2023)
- Size decrease of the whitemouth croaker in Southern Brazil, important for food security in small scale fisheries (Fossile et al. 2023). Isotopes suggest ecological conditions were not different, but fish size is very different. 50% decrease in size, possibly due to overfishing in the last 200 years.
- Decrease dietary fish intake in Brazil predates European arrival (Admiraal et al. 2023)

Commoditization of marine resources has dramatically increased anthropogenic footprints on coastal and ocean systems, but the scale of these impacts remains unclear due to a pervasive lack of historical baselines.

Herbst et al. (2023) reviewed newspapers tracking species diversity, market demands and impacts, publications spanned 1840-2019 and >20,000 articles. The paper explores changes in marine animals (vertebrates and invertebrates) targeted by historical fisheries in southern Brazil since the late 19th century. The investigation of historical newspaper archives revealed unprecedented information on catch composition, and perceived social and economic importance of key species over decades, predating official national-level landing records (Fig. A3.3). We show that several economically and culturally important species have been under persistent fishing pressure at least since the first national-scale subsidies were introduced for commercial fisheries in Brazil in the late 19th and early 20th centuries. Our work expands the current knowledge on historical fish catch compositions in the southwestern Atlantic Ocean, while advocating for the integration of historical data in ocean sustainability initiatives.

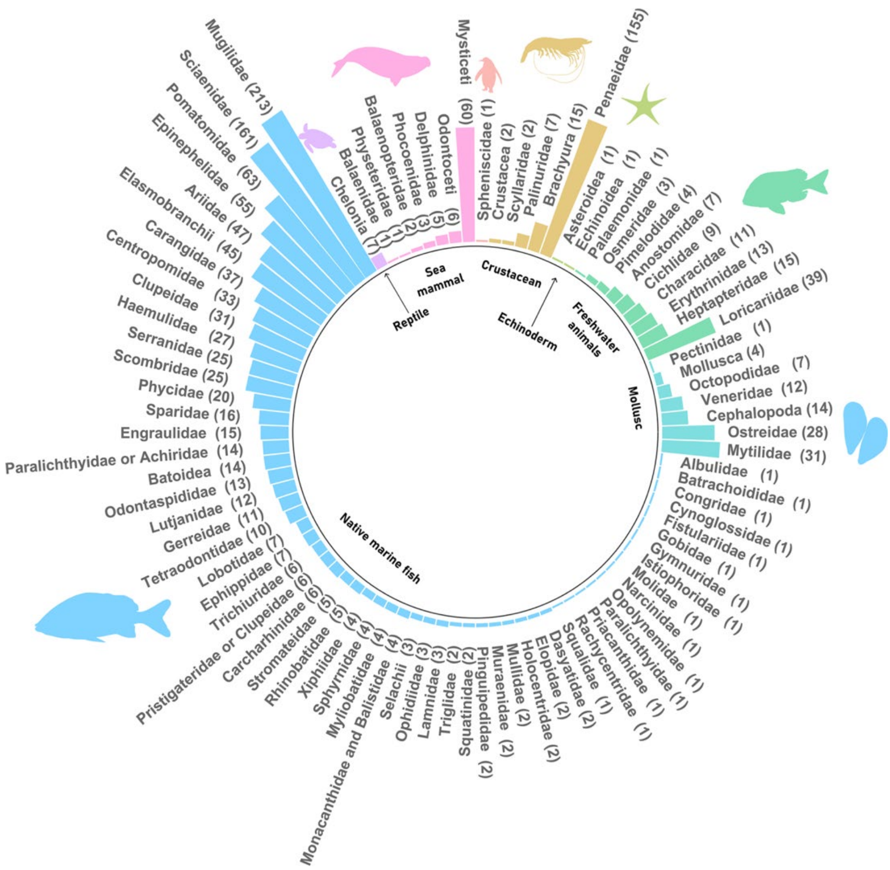

Figure A3.3. **Abundance of marine species (number in parentheses) by family reported in historical newspapers between 1840 and 2019 for locally exploited reptiles, mammals, crustaceans, echinoderms, freshwater animals, molluscs and native marine fish. Reproduced from Herbst et al. (2023). Copyright: Herbst et al. 2023.**

Coming up with indices and approaches for turning qualitative into quantitative data, it is very important to consider these different perspectives. In the 1950s there is an increase, changes in trophic positions - increasing articles on fish at lower trophic positions. They hindcasted with data on catches shows the Brazilian industrial revolution from 1930-45, there was a big investment in fisheries, including subsidies and public investment. Most ecologists now look from the 1960s when there was investment - but miss the information on the subsidies from the 1930s. There are archaeological records of intensive fishing, and historical evidence of European colonisation. Before the European contact there was no record, that is why archaeology can provide important information. 6000% increase in smuggling(?) of fish in Brazil, subsidies also create social impacts → favelas (shantytowns).

Another paper from the project reviewed published data on Middle and Late Holocene marine fish remains along the southern coast of Brazil. This region preserves archaeological sites that are unique archives of past socio-ecological systems and pre-European biological diversity. We assessed snapshots of species compositions and relative abundances spanning the last 9500 years, and modelled differences in species' functional traits between archaeological and modern fisheries. We found evidence for both generalist and specialist fishing practices in pre-European times, with large body size and body mass caught regularly over hundreds of years. Comparison with modern catches revealed a significant decline in these functional traits, possibly associated with overfishing and escalating human impacts in recent times. *Micropogonias furnieri* (white-mouth croaker) emerged as the most abundant and broadly captured species, representing 33% of the identified remains, and occurring in 70% (n = 37) of the archaeological sites. There was not much variability in the ecological conditions, but size decreases abruptly (by 50%). So demonstrates a really strong impact from overfishing.

A recent paper from the project (Admiraal et al., 2023) considers Guarani groups reached the southern Brazilian coast at around 1000 years ago (as part of one of South America's largest diasporas). Their impact on the long-standing coastal economy is unknown, due to poor preservation of organic remains. For this research a total of 224 samples were analysed, originating from 11 archaeological sites (3 of which containing Taquara-Itararé pottery, and 8 of which containing Guarani pottery). Isotopic data from organic residues on pottery show a split in diet from mostly fish to more plant-based diets prior to European arrival, and from 1700-1850 mixed fish and plants. More recently everyone eats maize (even those living on the coast) – a very clear separation of diet that corresponds with social change (arrival of the Guarini). This shift may have alleviated the considerable pressure on fisheries.

URL for project: https://erc-tradition.com/ (last accessed 09/01/2024).

Linked publications:

- Herbst DF, Rampon J, Baleeiro B, Silva LG, Fossile T, Colonese AC. 2023. 180 years of marine animal diversity as perceived by public media in southern Brazil. PLoS ONE 18(6): e0284024. DOI: 10.1371/journal.pone.0284024
- Admiraal, M., Colonese, A.C., Milheira, R.G. et al. 2023. Chemical analysis of pottery reveals the transition from a maritime to a plant-based economy in pre-colonial coastal Brazil. Sci Rep 13, 16771 (2023). DOI: 10.1038/s41598-023-42662-5
- Fossile T, Herbst DF, McGrath K, Toso A, Giannini PCF, Milheira RG. 2023 Bridging archaeology and marine conservation in the Neotropics. PLoS ONE 18(5): e0285951. DOI: 10.1371/journal.pone.0285951

Link to ToRs: The TRADITION project fills some much-needed gaps in appreciation of changes in social-ecological systems in the southern hemisphere prior to European arrival. Many aspects of this project can contribute to the WGHIST ToRs, notably showing how newspaper archives can help to reconstruct catch composition, evaluate social value of different resources and especially where these predate formal records: demonstrating the value of an integrated approach (ToR B). Further, it seeks to develop approaches for using qualitative and quantitative data together thus also informs ToR B. Deliverables from the project are contributing to ToR C, e.g. by looking at changes in fishing practice and the effect on species functional traits over 9500 years, the indigenous fisheries were overfished. They also show changes in diet (inclusion of more maize) as a result of social-ecological systems change that may have alleviated millennia of pressure on fisheries, showing a broader picture of social change is necessary context for understanding changes in social-ecological systems and the 'shifting baselines' and danger of assuming that 'prehistory' was culturally and economically static (ToR C).

Butler (2023) ERC SEACHANGE: Update since 2021

Paul Butler, University of Exeter, UK

Impact of major human transitions on marine ecosystems - shifting baseline challenges. Five cultural transitions (6 WPs, final one being data based).

Cultural transition 1: 8-6 kcal BP shift from hunter-gatherer (Mesolithic) to farming (neolithic) around the North Sea Changes in biodiversity and ecological functioning across transition to agriculture: examining specific middens and marine sedimentary sequences from Denmark Orkney and Shetland. Using eDNA from sediments from archaeological sites.

Cultural transition 2: In the Late Holocene North Sea (AD950), fish event horizon from Orkney and Denmark, sclerochronological time series from sediment cores. Those from the Skaggerak, Fladen ground shells (100-500 years BP), looking at N-isotopes as well as eDNA to identify species and capture changes in primary production and commensurate changes on land. Compound specific isotope analyses show some protein spikes and they are figuring out how it links to changes in diet/behaviour.

Cultural transition 3: in Australia both pre and post EU colonisation AD1000, sites near to Queensland and the Great Barrier Reef. Slower progress on this WP due to ethics

Cultural transition 4: Northern and eastern Iceland over the last 2000 years, from the 1st settlement of Iceland in AD 874. Identifying 1st use of fertilisers in Iceland in the 1920s from Arctica islandica shells.

Cultural Transition 5: Antarctica over the last 400 years, mostly whaling – looking at species richness through time from 3 sites - with different patterns at each site (spanning slightly different temporal range 50 years and the other was 130 years).

In order to cross-calibrate data, the temporal ranges needed to overlap and can still be hard to confidently match them. So, they're using rangefinder dating (with amino acid racemisation) – allowing them to confidently separate out the ages.

Link to project: https://www.exeter.ac.uk/news/featurednews/title_757765_en.html (last accessed 09/01/2024).

Link to ToRs: Projects addresses importance of historical data to understand long-term changes in social-ecological systems. Using a range of approaches and data types this is linked with ToR B where we address the importance of collecting and openly sharing metadata. Link to ToR C/D analysing changes in social-ecological systems from different perspectives, whether they come from the ecology or from the social sciences.

Caswell (2023) The PAGES working group QMARE

Bryony Caswell, University of Hull, UK

The project addresses interdisciplinary challenges of different types of data. Data needs to have a legacy→ need to guarantee the future for the data. Which one is the suitable archive for everyone with different types of data? Big data. What big data means and what historical ecology means to it! Multiplicity of various data sources enabling the whole to be more than the parts. So different types of data. Metadata format that is always constant. There is also flexibility for its own data format. So actually, historical qualitative data are really having a breakthrough! Narrowing of the consumption species to understand what was being consumed. It should be possible to interrogate databases for text talking about something (state papers) VOC database (millions of texts). Species info/Human responses and technologies (Fig. S4).

URL for QMARE project: https://pastglobalchanges.org/science/wg/q-mare/intro (last accessed 09/01/2024).

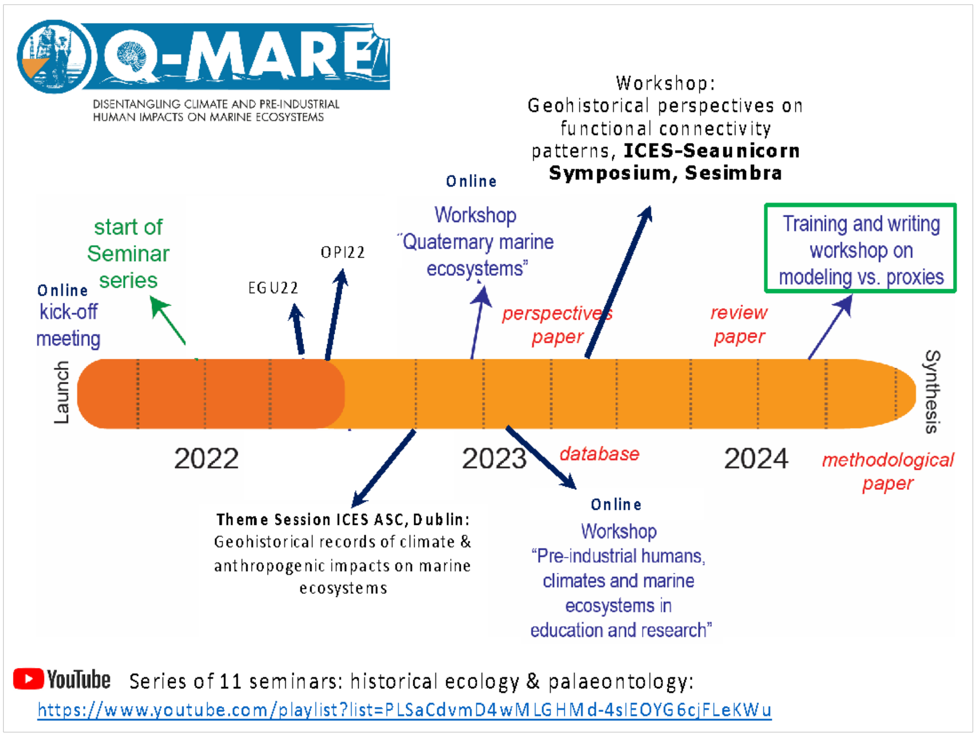

Figure A3.4. Schematic of progress of the Past Global Changes working group Q-MARE since late 2021. Copyright: Konstantina Agiadi 2024.

Link to ToRs: The deliverables of Q-MARE link to ToR B, exploring the synergies between palaeontological, archaeological, historical and ecological data). Some of the aims also align with ToR C to evaluate long-term change in social-ecological systems.

Thurstan (2023) Evidencing Europe's lost oyster reefs

Ruth Thurstan, University of Exeter, UK

This work is part of NORA and has been ongoing through a number of projects. Ostrea edulis is functionally extinct and is a target for restoration actions.

Why use historical data, to understand: long-term dynamics, survival, and past distribution (potential niche) to inform restoration goals. Using written archives (bills, commissions, fishermen's journals, maps, museum collections, some archaeology but less so as less habitat based). There are very good French records from surveys 1907-1910. They were commercially important (food, trade as food), using extraction areas and amounts as a proxy for substantial oyster habitats in Europe. They have 1600 records from 1602-2019 (published records but exploited over a much longer period), from the intertidal to 80 m water depth (often recorded as "Steps" 1.75 m).

Historically the oysters were very widespread – they ranked their records for confidence based on the amount and type of evidence. Reported reef size, showed that many more than 1 ha in area (300 records of area or length). Estimates of location but also habitat extension, so they can estimate the areas likely a dominant habitat type on the coastlines. New estimates show that there were more than 1.7 million ha in NW Europe (conservative estimates from historical sources) and they were probably the dominant coastal habitat type at times.

They are looking at the Mobius 1883 descriptions of associated fauna, "sea hands". The description of associated communities, even contains lists of species (up to 190 species) → could also look at biodiversity that oyster communities produced? Also, with birds and communities outside. Actually, also shallow area reefs (lower intertidal), that we do not have now. The associated faunas were distinct with a range of trophic guilds present. "Oyster catcher's" - today we think they don't eat them (rather mussels) despite their name, but historical sources show that they did!!! Also looking at data from Buckland and Walpole 1879 for Newhaven and Jersey, can tell us about oyster movement – of spat transplantation from Jersey to Whitstable. Recreation of images of old oyster reefs by Maria Eggertsen.

Link to ToRs: A resource for ToR A, lessons, approaches and data compatibility for ToR B

Link to publications in review:

- Thurstan, R. H. et al. 2023. 'European native oyster reef ecosystems are universally Collapsed', DOI: 10.32942/X2HP52, 07/12/2023, preprint: not peer reviewed.
- Thurstan, R. H. et al. 2023. 'The world was our oyster: Records reveal the vast historical extent of European oyster reef ecosystems', DOI: 10.32942/X20W43, 07/12/2023, preprint: not peer reviewed. Includes online open access dataset.

Caswell (2023) What is marine historical ecology: A review

Bryony Caswell, Felicitas ten Brink, Aimee Buck, University of Hull, UK

Preliminary results from our systematic review of the literature on marine historical ecology (MHE) and closely-related disciplines.

- We found 5342 unique abstracts that used : *ecol* AND (marine OR *ocean* OR sea OR seas OR seawater OR sea-water) AND (paleo* OR palaeo* OR *fossil* OR *histor*) AND (long-term OR "long term" OR "time scale*" OR timescale* OR baseline OR "time series" OR past OR period) (Fig. S5).
- Screening & selection of abstracts, title, and author keywords for key terms (automatically) produced 2567 with a marine ecology focus, further sorting showed -> 1357 relevant to the Quaternary.
- Automated & manual sorting -> 657 papers of possible/high relevance to MHE: Spanned 10 disciplines (mean of >2 each) -> c.24% "palaeontology", 18% MHE, 17% palaeo-oceanography, 11% conservation palaeobiology, remaining 6 disciplines <7%
- 20% deep time (64 +347 papers discarded in earlier stages also deep time), 25% Pleistocene, 30% "Holocene", 25% is last 6000 years (15% 20th C) – technically all latter are Holocene (66%).Database contains 314 "marine historical ecology" papers: Most papers were also palaeontology (27%), CPB (20%) or palaeoceanography (19%); anthropology, archaeology or CB <10% each (Fig. S5).
- Majority (50%) considered invertebrates, 25% vertebrates, 25% primary producers, 15%? Human
- 25% Pleistocene, 40% "Holocene" & 30% last 6000 years (with 15% 20th C), 1-2% deep time
- Regions: 50% papers from Temp N Atlantic, followed by Temp N Pacific then, Tropical Atlantic; then W Indo Pacific = Arctic = CIP

- Aims: 25% reconstruct ecology; 30% response to env change, human impacts, & reconstruct environments*; 10% human-ocean interactions* (*different from CPB)

Conservation PalaeoBiology (CPB; 188 papers): most work also considered MHE (27%) or palaeontology (25%) or palaeoceanography (18%) – CPB has more in common with MHE than vice versa. Aims: 35% reconstruct ecology* & response to env change*, 10% human impacts & 10% reconstruct environments*; 5% human-ocean interactions* (* different from MHE)

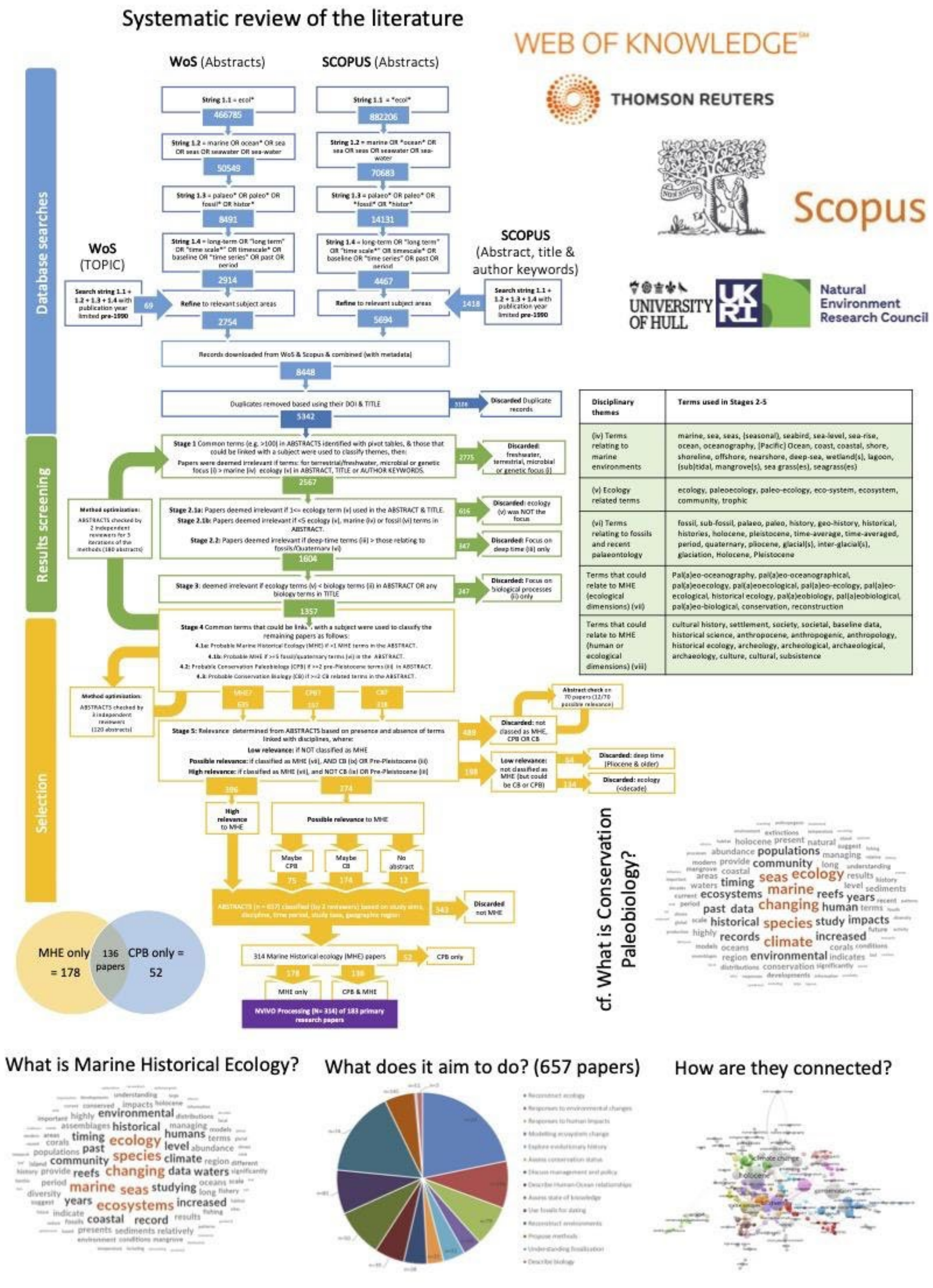

Figure A3.5. **Systematic review on the research considered marine historical ecology, approach and pre-liminary results. Copyright: Bryony Caswell 2024.**

A3.3 Presentations at WGHIST meetings contributing to ToR C

Thorpe (2021) Why we need a historical perspective to understand fisheries biology

Robert Thorpe, Centre for the Environment Fisheries and Aquaculture Science, Lowestoft, UK

Climate models give very different perspectives from the past, fisheries, when there were no fisheries? What baseline do we use? We need to establish a baseline and uncertainty associated with the different models and the different mechanisms. Is what we know enough to understand the future, and project it? What would happen if there were no fishing? (ecosystems are in it? or just fishing models?)

Multispecies models - mechanisms where the same for all the different ecosystems which are in different states from pristine to severely damaged?

My previous assessment → prediction of reference points, new projected reference points quite optimistically. But there was no agreement between the different models, very different results.

So, why have we failed in determining reference points? Fishing mortality (F) is most important, food webs not so important, mortality of large fish, what is it that kills the large fish apart from F?

How can you build a baseline for a system that is completely changed? Productivity, mortality, recruitment, dynamic of resource depletion, and the environment differed, fishing lower!

Link to ToRS: Changing coding techniques and the nuances of analytical approaches and models need to be captured as well as the actual data collection (ToR B). Previously it was the physical media that changed (paper, VHS, cassette tapes, CDs etc, now it is a type of digital record - which is also susceptible to loss, misinterpretation or changing context). The fisheries models relate to ToR C, the application of historical data to management problems, and consider how we model future fisheries. The main issue being we don't yet have suitable 'scenarios' for the future although they must exist in history (little ice age, other changes in glacials/interglacials, sudden events Tambora, Laki; Palaeocene-Eocene Thermal Maximum and further back). We see the baselines and reference points as something static, but instead they are dynamic and have been changing for centuries. Historical data can be used to look at a wider range of conditions for ToR C and D.

Holm (2021) Accelerated Extractions of North Atlantic Cod and Herring, 1520-1790

Poul Holm, John Nicholls, Patrick W. Hayes, Josh Ivinson, Bernard Allaire, Trinity College Dublin, UK.

We propose the concept of Accelerated Marine Extraction to signify two periods when rapidly increasing cod and herring fisheries, c.1540-1600 and c. 1730-1790 exceeded human demographic growth. Total landings vastly exceeded previous assessments and more than doubled between 1520 and 1620 from about 220,000 metric tonnes (t) to 460,000 t. Supplies of cod and herring to the European market peaked in 1788 at more than 1 million t before the unrest connected with the French Revolution brought many fisheries to a temporary halt. Accelerated Marine

Extractions increased European food security at times of human demographic growth by almost doubling the supplies of fish protein per capita. While herring was the most important species in the early sixteenth century, cod dominated through the early modern period, and the trajectories of cod and herring extractions differed significantly. Cod landings increased almost tenfold through the period, driven by strong and sustained landings in the Northwest Atlantic. Herring landings remained stable through the 16th century but declined severely through the next 150 years. However, from 1750, herring landings quadrupled, largely because of Swedish west coast fisheries. The results fundamentally shifts our understanding of the scale of Atlantic fisheries in the past and underlines the role of marine resources for European societies.

Subsequently published as: Holm, P., Nicholls, J., Hayes, P. W., Ivinson, J., Allaire, B. 2022. Accelerated Extractions of North Atlantic Cod and Herring, 1520-1790. Fish and Fisheries 23 54-72. DOI: 10.1111/faf.12598

Link to ToRS: Links to ToR C since it talks about long term changes of two very important fisheries. It also links partially to ToR D since it shows how extraction of these resources corresponded to an increase in human population, so shows a clear service of the resources to humans. Interesting point is that revised catches in the past might also change the way we actually manage the stocks now. Another interesting point is that technology creep did not reflect an increase (or change) in cod fishery, maybe we could use it as one of the examples for the technology creep paper.

Agiadi (2021) Holocene fish assemblages provide baseline data for the rapidly changing eastern Mediterranean

Agiadi, K. and Albano, P., University of Vienna, Austria

The eastern Mediterranean marine ecosystem is undergoing massive modification due to biological invasions, overfishing, habitat deterioration, and climate warming. Our ability to quantify these changes is severely hindered by the lack of an appropriate baseline; most ecological datasets date back a few decades only and show already strong signatures of impact. Surficial death assemblages (DAs) offer an alternative data source that provides baseline information on community structure and composition. In this study, we reconstruct the marine fish fauna of the southern shallow Israeli shelf before the opening of the Suez Canal based on fish otoliths. We quantify the age of the otolith DAs by radiocarbon dating, and describe its taxonomic composition, geographic affinity, and trophic structure. Additionally, we test by radiocarbon dating the hypothesis that Bregmaceros, a presumed Lessepsian invader with continuous presence in the Mediterranean throughout the late Cenozoic, is a relict species. The otolith DA date back to the mid-Holocene because 75% of the dated otoliths of the native species are older than the opening of the Suez Canal in 1869, suggesting that the DA is a proper baseline for quantifying modern impacts. Consistently, 97% of the otoliths and 88% of the species we collected belong to native Mediterranean species. The native anchovy Engraulis encrasicolus dominates the DAs, although gobiids are the most diverse group (14 species, 28%). The DAs show similar trophic structure to present-day pristine Mediterranean coastal fish assemblages. Two non-indigenous species are recorded here for the first time in the Mediterranean Sea, Amblygobius albimaculatus and Callogobius sp., highlighting the importance of DAs for detecting non-indigenous species. Finally, Bregmaceros otoliths are modern, not supporting the previous hypothesis that the taxon is a Pleistocene relict.

Introduced the new Past Global Changes working group Q-MARE: https://pastglobalchanges.org/science/wg/q-mare/intro (last accessed 09/01/2024).

Published in: Agiadi, K. and Albano, P. 2020. Holocene fish assemblages provide baseline data for the rapidly changing eastern Mediterranean. The Holocene, 30 (10), 1438-1450. DOI: 10.1177/0959683620932969

Link to ToRs: Links to ToR C, can help to understand the origin of biological invasions and which are the species that were resident in the Med Sea against species that enter afterwards. Also, fish assemblage itself provides a baseline for this area (ToR C), and potentially shows the early impacts of fishing (needs archaeological investigation to confirm this), specifically on demersal taxa. Interesting to explore biodiversity in the past and see how it changes, and maybe even find drivers. Potential to help understand invasion dynamics - what are the longer-term implications when a new species arrives, can help to predict the impacts of species range shifts and identify timing of key events (greater marine connection: Suez Canal, mixing of water masses and species assemblages).

Sturrock (2021) A short history of freshwater and salmon management in California

Anna Sturrock, Essex University, UK

Salmon shows considerable trait diversity, and their evolutionary history in California with a very variable climate – shows very variable timing of salmon migration (adults and juveniles). This leads to the question: How are we (humans) going to live in an increasingly variable future climate

Problem 1: There is an imbalance between hydrology and where we live, in drought years it is very difficult because of the links with agriculture. Many engineering solutions are used, such as physically moving water and fish. Not simply a case of adding a salmon ladder. In 1929 Clark commented on "walking across streams of salmon", this is just some evidence for the diminishing size of salmon, dwindling in both the spring and fall runs.

Problem 2 - Much of the spawning habitat has been lost (>60%), the many salmon canneries and overfishing in 1860s-1890s that corresponded with the Gold Rush. What is the solution? A lot of hatchery propagation was attempted and released into the system in the wild.

Problem 3: Why is the survival rate so low? Alison Whipple's work on maps shows how the delta has changed, it is less diffuse, all it really does now is direct water, it has lost complexity and habitat, plus there are problems with runoff problems (plus pollution, issues with striped bass).

They tried physically moving the salmon by truck, many trucks. We looked at the history of its development, documented spatiotemporal trends (did the georeferencing, but location information was vague), modelled factors influencing straying rates of hatchery fish in return (Fig. S6). Initially fish were released at one site, now more clustered around the estuary and there are some issues with the timing of release (one place, one time? more risk if doing it all in one place) is affecting recruitment. There are several problems, drought, further you move them more of a problem (maladapted gene flow). Can they find their way back home? They have lost their olfactory map. There are very large dams, and they are very numerous (e.g. 42 on one river), having a major effect on peak flow – both geomorphology, and fish behaviour (flow magnitude matters, in drier years far far fewer juveniles plus carrying capacity). If releasing fish at the wrong time of year, big swings in cycles of salmon numbers linked to river flows when juveniles are at the edge of species range (Fig. A3.6). Water wars, needs of farming etc versus needs of salmon etc. They are now also looking at ancient salmon otoliths (pre-damming) and comparing these with today. She wants to look at the UK now, and how they've evolved through time in NZ in a completely novel habitat (NIS equivalence).

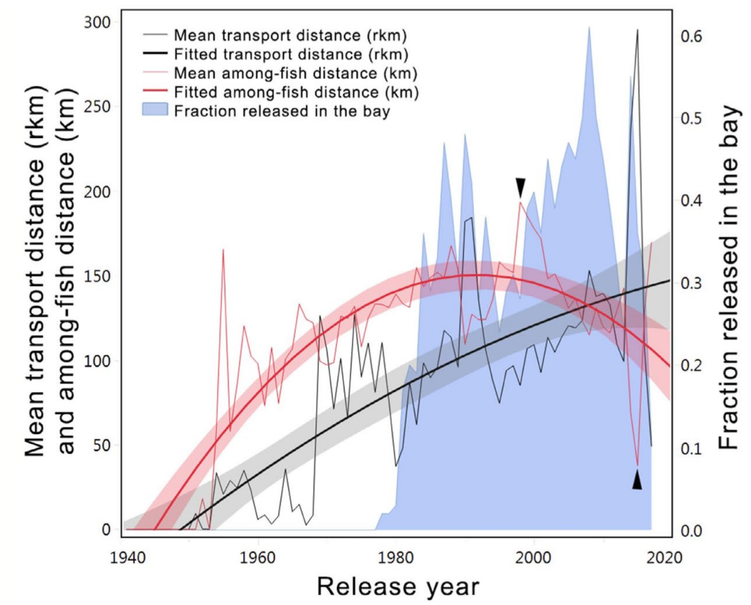

Figure A3.6. **Historical distances salmon were transported and the fraction released in the bay. Reproduced from Sturrock et al. (2019). Copyright: Sturrock et al. 2019.**

Linked publications: Sturrock, A.M., Satterthwaite, W. H., Cervantes-Yoshida, K. M., Huber, E. R., Sturrock, H. J .W., Nusslé, S., Carlson, S. M. 2019. Eight Decades of Hatchery Salmon Releases in the California Central Valley: Factors Influencing Straying and Resilience. Fisheries Magazine, 44 (9), 389-456. DOI: 10.1002/fsh.10267

Link to ToRs: Link to ToR C, long term changes in a resource and drivers. Interesting to see the 80% loss of areas of salmon and how the practice of the fishery completely changed and transformed now.

Ojaveer (2021) Spawning Stock Biomass modulation of environment-recruitment relationship in a marginal spring spawning herring population

Henn Ojaveer, University of Tartu, Estonia

Small but important herring population in the Baltic Sea (Gulf of Riga), the self-sustaining population does not migrate far (spring spawning population can be discriminated by otolith shape, managed as a separate stock by ICES). Scientific interest in the dynamics of fish recruitment date back to the beginning of the 20th century. Since then, several studies have shown that the environment may have a stronger effect on recruitment (R) compared to that of the spawning stock biomass (SSB). By combining a suite of methods designed to detect the nonlinear, nonstationary, and interactive relationships, we have re-evaluated the potential drivers and their interactions responsible for the multiannual dynamics of the recruitment dynamics of the Gulf of Riga (Baltic

Sea) spring spawning herring (Clupea harengus membras) population at the longest timespan to date (1958–2015) allowing coverage of variable ecosystem conditions. R was affected significantly by prey density (copepods) and the severity of the first winter. Although SSB was not a good predictor of R, adding interaction with SSB significantly improved the model, hence the effect of the two environmental variables on R was modulated by SSB. While temporal changes in the environment–R relationship were generally gradual, several abrupt changes were evident in the strength of these relationships. More abundant prey led to higher recruitment (linear response), but for winter severity response was unimodal. Added SSB interaction and recruitment was highest when SSB was high AND the abundance of prey was high. R was highest at lowest SSB and intermediate winter severity. The unimodal response shifted in more recent years becoming more linear. Sliding window models: relationship with SSB up to mid 90s, R and prey abundance always positive, R and winter severity mostly negative. Prey density matters, but different from other recent studies in showing that it was the early copepod stages (IV-V) that mattered and the severity of the first winter, SSB was not a good predictor of R adding SSB improved model though - density dependency and SSB modulates the interactions between the environment and recruitment. Non-stationary and nonlinear relationships need consideration.

URL for paper: Ojaveer, H., Klais-Peets, R., Einberg, H., Rubene, G. 2021. Spawning stock biomass modulation of environment–recruitment relationship in a marginal spring spawning herring (Clupea harengus membras) population. Canadian Journal of Fisheries and Aquatic Sciences, 78 (12), 1805-1815. DOI: 10.1139/cjfas-2021-0018

Link to ToRS: ToR C, how long-term data can help maybe partially improve management. Using longer time series allows one to better understand the relationship between environment, SSB and recruitment and see that this relationship was non-stationary. This can therefore help the stock assessment groups to better understand recruitment dynamics, directly linked with populations model and management.

McClenachan (2021) Sesync project on historical ecology and “Past forward: recommendations from historical ecology for ecosystem management”

Loren McClenachan , Colby College, Maine, USA

In the context of accelerating environmental change, there is an urgent need to identify ecosystem conservation, restoration, and management strategies likely to support bio- diverse and adaptive ecosystems into the future. The field of historical ecology has generated a substantial body of recommendations for ecosystem management, yet these insights have never been synthesised. We reviewed >200 historical ecology studies and analysed recommendations for ecosystem management emerging from the field. Most studies (~90%) derived from North American and Europe, with forests being the focus of nearly half (48%) of all papers (Fig. S7). Papers emphasised the need to protect and restore both habitat remnants and modified ecosystems in management, the value of ecosystems as cultural landscapes, and the importance of adopting a landscape-scale perspective for ecosystem management. Nearly one-quarter contained a recommendation that challenged status quo management, underscoring the value of a historical perspective in setting management goals, strategies, and targets. Fewer than 12% of papers contained recommendations that explicitly addressed ongoing or projected climate change, suggesting opportunities to integrate findings from historical ecology with other perspectives to create forward-looking management strategies that are rooted in place and past (Fig. A3.7).

Sesync Project: How does historical perspective inform EBM target goals and outcomes? Because historical data are relevant for restoration, our goal is to consider this across different systems. The project will ask how have historical ecology perspectives influenced environmental management decisions? How does the metric change if historical data is integrated into targets? and what are the pathways to integrate historical data. into management? **URL for project:** https://www.sesync.org/research/historical-ecology (last accessed 09/01/2024).

Published in: Beller, E., McClenahan, L., Zavaleta, E. S., Larsen, L. G. 2020. Past forward: Recommendations from historical ecology for ecosystem management. Global Ecology and Conservation, 21, e00836. DOI: 10.1016/j.gecco.2019.e00836

Link to ToRs: Link to ToR C, especially how historical ecology can help developing management. Importance of terrestrial historical ecology. Important note, very few works on historical ecology include climate change.

Figure A3.7. Recommendations for ecosystem based management from historical ecology literature, aggregated by type) with the proportion of articles and examples for each. Reproduced from Beller et al. (2020). Copyright: Beller et al. 2019.

Ramenzoni (2021) Reconstructing the History and the Effects of Mechanization in a Small-Scale Fishery of Flores, Eastern Indonesia (1917–2014)

Victoria Ramenzoni, Rutgers University, New Jersey, USA

The number of studies on small-scale fishing communities has grown considerably over the past 30 years. Evidence on how the process of mechanisation and technological expansion has affected traditional small-scale fishers in peripheral regions, however, is less abundant. For areas like Eastern Indonesia that are now facing important challenges in governance and resource degradation, lack of information impairs the design of long-term environmental solutions. This article explores the changes in fishing participation and per capita seafood intake in a small-scale fishery in Flores, Eastern Indonesia over the past 100 years (1917–2014). By combining multiple sources of information (ethnographic, observational, nutritional, and historical) to reconstruct the story of stocks, fishing effort, and consumption of marine products, long-term trajectories, and trends in resource use practices are identified. Findings underline that mechanisation and commercialization can have dire repercussions on food security and job stability within small-scale fishing sectors, especially if these processes are not part of comprehensive community development programs. The article concludes that understanding the outcomes of mechanisation at the fringes of more centralised systems is essential to navigate the trade-offs among poverty reduction, economic growth, and environmental degradation.

Published in: Ramenzoni, V. 2017. Reconstructing the History and the Effects of Mechanization in a Small-Scale Fishery of Flores, Eastern Indonesia (1917–2014). Frontiers in Marine Science, 4. Sec. Marine Fisheries, Aquaculture and Living Resources. DOI: 10.3389/fmars.2017.00065

Link to ToRs: Strong links to ToR C, a great addition because it brings to a southern hemisphere/SIS/subsistence example. Lots of interesting points about the influence of subsidies and government policy, and links between land-based exploitation and marine. Interest in fisheries really slowed as agriculture expanded (government driven). Important points about scale (including both fishing centres and periphery, plus looking across land and sea, plus extrinsic global events like WW2). Importance of historical activities (also for herring above) and dynamics that may engender resilience. Also, a nice mix of different data sources for deliverables for ToR B.

Raicevich and Fortibuoni (2022) Venice Lagoon: its natural resources and the historical roots for its exploitation

Sasa Raicevich and Tomaso Fortibuoni, Instituto Superiore per la Ricerca e la Protezione Ambientale

- The evolution of exploitation, quality of information, past challenges and successes, and lessons for the future
- The largest single lagoon in Mediterranean (550km2), situated in the NW Adriatic Sea, the city of Venice and its lagoon were declared a UNESCO World Heritage site in 1987.
- Formed 6000-7000 years ago, mostly shallow waters (<1m mean depth) with a few deep ship channels c.20m deep with three inlets connecting to the Adriatic.
- 1000s of years of human interaction, wide range of habitats and biodiversity, but also hydraulic modifications (a particular challenge is delivery of suspended sediments to the lagoon)
- 1961-1971 mean sea level was 172.1cm and for 1992-2202 was 173.9cm, this was a 23.56cm rise since 1897. The area being eroded has gotten much larger and spans a greater depth range than in the past; with a history of eutrophic events and high nutrient loading.
- Long history and interplay of human factors, modification, direct and indirect; plus associated environmental changes (e.g., eutrophication), and invasive species such as *Ruditapes*.
- Exploitation of living resources dates back several hundred years, and was based on LEK of fish behaviour, life cycles, efficiency.
- The fishing gears are very specific to the lagoon, nets, traps, even boats (flat bottomed); a high variety of specialised gear targeting different species.
- When ponds became concentrated in the ponds - closed ponds and allowed fish to grow, wild juveniles were caught outside of the lagoon.

- The Venetian Lagoon is the most important "nursery area" for the N Adriatic Sea. Juveniles (Bass, Cuttlefish, Gilthead bream) enter the lagoon mainly between winter and spring where they find high availability of food and refuge from predation in the inner sections of the lagoon.
- Venetian fishermen have historically exploited these migrations using fishponds – closing the ponds with removable reed barriers and nests to trap the fry then in fall catch the fish when trying to return to sea. There are also some capture-based aquaculture where they are on-grown in captivity until reaching marketable size.
- Venice is said to be "wed to the sea", with many laws and restrictions "Republica Serenissima" and Fraglie.
- Different ecological patterns by species, some use as nursery, some are estuarine residents, and some are migratory. Target fishing species vary by season.
- Management history of the lagoon probably reflects its great value as a food source (both in the open lagoon and the fishponds), and for salt extraction.
- Long and varied history of fishing, management, and modification of the lagoon

Link to ToRs: Historic fisheries activities in the Venetian lagoon inform ToR C, the historic fish farming and lagoon engineering modification could further inform ToR C deliverables such as those looking for evidence of EBM principles from the past.

Barausse (2022) Different methodological approaches to understand the role of human pressures and natural factors in the changes in the northern Adriatic Sea ecosystem over the past century

Alberto Barausse, University of Padova, Italy

A question for management and conservation: how do human stressors and natural variability influence coastal aquatic ecosystems?

- Examples in the northern Adriatic coastal area (incl. Venice Lagoon; mainly from my research)
- Hierarchical approaches: population, community, and ecosystem level
- Comparison of methodologies

1. **Population** responses to anthropogenic stressors and natural variability: shore crabs

- Uses data from the Clodia Database going back to 1945, it has a distinctive larval stage and so is well documented.
- An apparently tolerant species can be strongly affected by climate impacts on vulnerable life stages (*ontogenetic bottlenecks*)
- Extreme events (heat waves) can be important for population dynamics.
- Time series give long term perspectives.
- Lab experiments suggest thermal stress responses have a 1-2 year lag.
- Laboratory + (simple) statistical models allow mechanistic interpretation of time series and scaling up responses to climate from physiology to population.

2. **Community** responses to anthropogenic stressors and natural variability

- Correlations suggest bottom-up pressures (temperature, nutrients) as key drivers of change in Adriatic communities…… but also show selective effects of fishing pressure on predators
- Life history traits support interpretation: shift from k to r-selected organisms (long-term exploitation)

- The role of changes in predation pressure (trophic interactions) is hard to test with time series analysis (feedbacks)

3. **Ecosystem** responses to anthropogenic stressors and natural variability

- Elasmobranch landings: –80% from 1945-2012
- Fishing capacity increased: CPUE –89%
- All elasmobranch categories decreased.
- Fish market surveys: elasmobranchs mostly landed sexually immature (females 60-83%, males 21-71%, n. 11,900)
- Correlations: hydro-climatic changes are not an explanation, overfishing is the most probable cause
- Population dynamics models to explore the role of fishing.
- (Food web models to quantify the impact of elasmobranch loss and potential restoration on the ecosystem and fisheries)

Conclusions

Adriatic Sea: different methodologies provide a consistent picture:

- Key role of bottom-up forcing (and low-medium trophic levels)
- Upper trophic levels depleted by human pressures (fishing)

Different methodologies work complementary:

- Long-term time series and other historical records: highlight changes, suggest causes, inform models.
- Models: show emerging interactions, testing causes of change (process-based), generate new questions
- Lab experiments and LEK: bring complementary perspectives on ecological changes, support process-based understanding.

Linked publications:

- Barausse, A. Michilei, A., Riginella, E., Palmeri, L., 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. DOI: 10.1111/j.1095-8649.2011.03139.x
- Bartolini, F., Barausse, A., Portner, H.-O., Giomi, F. 2013. Climate change reduces offspring fitness in littoral spawners: as study integrating organismic response and long term time-series. Global Change Biology, 19, 378-386. DOI: 10.1111/gcb.12050
- Barausse, A. et al. 2014. The role of fisheries and the environment in driving the decline of elasmobranchs in the northern Adriatic Sea. ICES Journal of Marine Science, 71(7), 1593-1603. DOI: https://doi.org/10.1093/icesjms/fst222

Link to ToRs: A mixed approach shows value added by long-term time series and other historical records (ToR B), can highlight changes, suggest causes and be used to inform ecosystem models (ToR C).

Dunne (2022) The role functions and impacts of humans in complex ecological networks

Jennifer Dunne, Santa Fe Institute, USA

Dunne et al. 2016 explored the roles and impacts of human hunter gatherers in North Pacific marine food webs, they compared the effects of human foragers on the feeding of other species.

Sanak Archipelago case study – ice free for 16,000 years, they integrated archaeological, ecological and social data. It was the first highly resolved reconstructed model of humans within the food web. 96% of species were within two trophic links of humans, and humans fed on ¼ of the species present. Feeding direction(?) was exponential, this is typical of all food webs she has modelled it. Humans were super generalists with lots of prey, short food chain lengths and were highly omnivorous. Used hunting technologies to improve efficiency. They did a lot more hunting than gathering (Fig. A3.8).

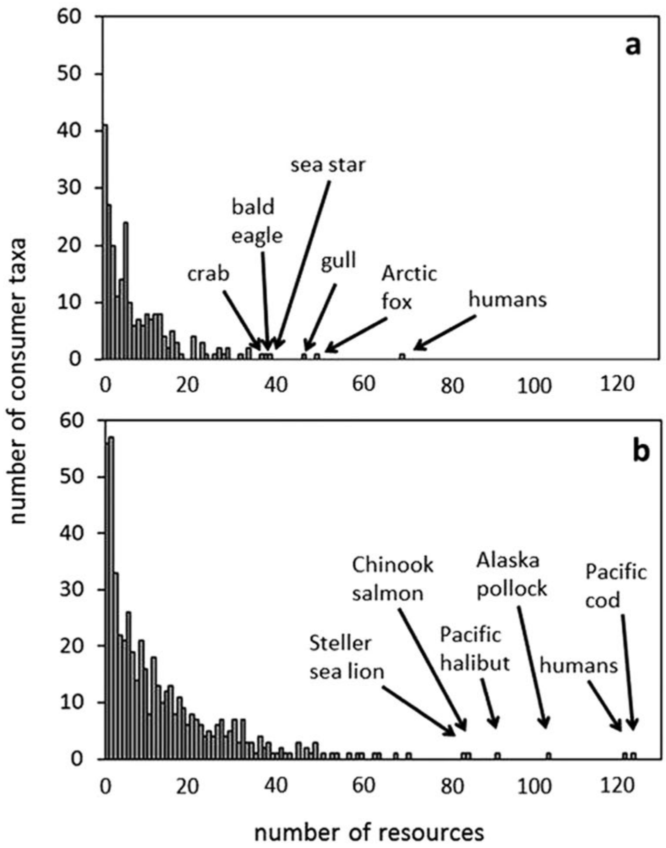

Figure A3.8. **Number of consumer taxa and number of prey resources for (a) the Sanak intertidal and (b) the Sanak nearshore foodweb. Six generalist taxa are annotated. Reproduced from Dunne et al. 2016 under Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/). Copyright: Dunne et al. 2016.**

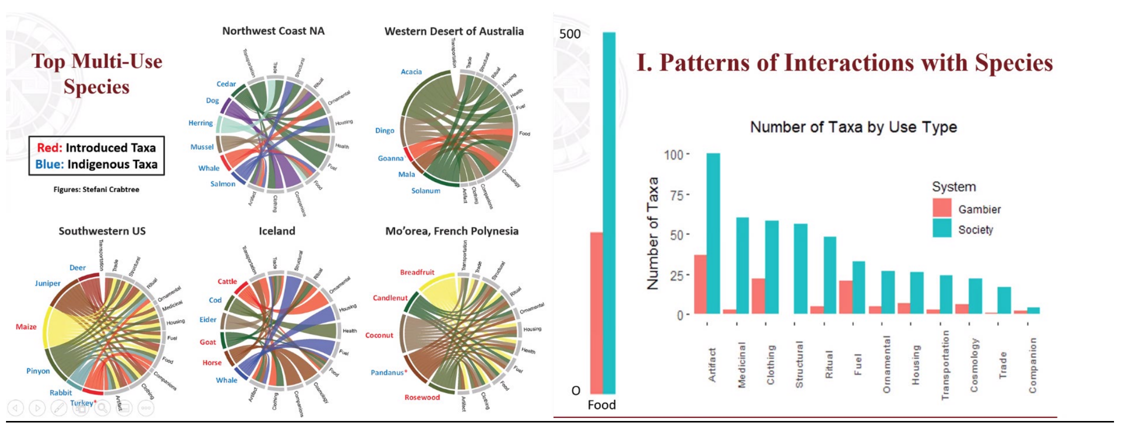

Figure A3.9. **Left: Circle plots showing the top multi-use species (introduced and indigenous) marine and terrestrial taxa at six locations Right: patterns of interactions of humans with living resources for different purposes on the Gambler and Society islands. Copyright: Jennifer Dunne 2022.**

Socio-ecosystem dynamics of natural human networks in Polynesia. 3500 years ago, Polynesians moved across and occupied the North and South Pacific, and they brought various species with them (crop, livestock and their hitchhikers) and technology for fishing and hunting. They invaded and settled all the islands leaving archaeological traces in caves or rock shelters etc. Middens contain information on the number of specimens of fish taxa. NISP? Asked questions about human behaviour and how they interacted with other species. The histograms show how many taxa humans have interacted, the use and type (Fig. A3.9). Data are split into the "gambler" and "society" islands. It demonstrates how one species can be used in multiple different ways. Looked at the top multi-use species (pies) and compared whether they were native or introduced and found both simple and complex interactions. Some resources being used directly as they are eaten by humans. Others were more complex, e.g. bread fruit is much more complex and requires technology to process and other species – needs a network of interactions (more technology, tools and knowledge and so are increasingly sophisticated). It can thus give an indication of the relative value or resources. More sophisticated uses are dependent on tools etc (Fig. A3.9).

Another example: humans using whales. Shows that all of the different species exploited, and the technology required (from both terrestrial and marine resources). A really nice way to compare communities' use of resources and how it varies between regions, communities, and the marine and terrestrial realm.

The ArchaeoEcology Project (TAEP): Explores how human interactions with biodiversity are shaped by and have impacts in ecology, environment and culture And beyond, food webs can ask how humans interact with biodiversity through space and time.

Linked publications:

- Dunne, J.A., H. Maschner, M.W. Betts, N. Huntly, R. Russell, R.J. Williams, S.A. Wood. 2016. The roles and impacts of human hunter-gatherers in North Pacific marine food webs. Scientific Reports 6: 21179. DOI: 10.1038/srep21179
- Crabtree, S.A., Bird, D.W., Bird, R.B. 2019. Subsistence Transitions and the Simplification of Ecological Networks in the Western Desert of Australia. Human Ecology, 47, 165-177. DOI: 10.1007/s10745-019-0053-z

- Crabtree, S.A., Dunne, J.A., Wood, S. A. 2021. Ecological networks and archaeology. Antiquity, 95(381), 812-825. DOI: 10.15184/aqy.2021.38

Link to ToRs: This is a nice approach for thinking about how humans interact with biodiversity through time. It can be used to think about how past communities used ecosystem services historically and in pre-history and compare them between communities, regions, marine and terrestrial resources etc (ToR C). The value of resources can be assessed based on how the number of different uses of a species and to compare both simple and complex interactions that are more sophisticated (requiring tools).

Thurstan (2022) Evidencing Europe's lost biogenic oyster reefs

Ruth Thurstan, University of Exeter, UK

- Come and join OPI this year, will also be hybrid (including arctic and subarctic seas - discounts for virtual attendance and ECRs)
- Working to evidence Europe's lost oyster habitat (collaborative project with NORA) - from multiple countries. Research questions: what did the seabed look like? Looking at the benefits to humans, when did they change, where and to what extent?
- The native oyster is very different from other oyster species.
- Historical perspectives can aid planning for policy today - can use as a tool for engagement. Previous work suggested a huge decline in oyster habitat - but the extent of past native oyster habitats remaining unclear
- More research questions: What forms did native oyster habitat take? (their abundance, density, vertical relief), where did it occur (location and depth) and when did we lose our native oysters. Clearly this information can feed into restoration goals
- The historical sources interrogated included books, nautical guides, maps, philosophical transactions, magazines like "the shellfish supplier".
- We have accumulated a lot of data - this talk focuses on the descriptive and spatial data. So, descriptions of habitat, locations of habitat. 1400 data-points documenting oyster habitats/fisheries (from 1100-1930), some were just fishery descriptions - in this case we assumed that there was oyster habitat.
- What did a native oyster bed look like? *Ostrea edulis* >5 m^2 - quite low, is that a goal for recovery? Also, it was patchy/clumpy with 8-10 together and formed more of a crust, and it tended to get broken up - we don't get a lot of information on vertical relief, but this helps.
- How extensive were the reefs? People had boundaries in mind, could be a few hundred metres, but some were miles (80 miles long x 25 miles wide) - steam trawlers were around, but avoided them because they got snagged and ruined nets. THAT all changed 10 years later.
- Descriptions of the associated species, trying to work out what "tree like…" were (epizootic on oysters/reef inhabitants)
- Map of fisheries/habitat recorded from historical sources - maps become out of date very quickly, we are still digitising records, and mapping Floris Bennema's North Sea data on top.
- We have good maps in coastal areas, but it becomes far more uncertain as you move offshore in the North Sea
- There are very few places in the UK where oysters now persist - but we know there once was extensive habitat. We are only interested in areas where there were considerable numbers - not just occurrences.
- Conclusions - historical perspectives for planning - nice to validate/verify challenges.

Link to ToRs: Provides an idea of past ecosystem extent and complexity using a mixture of different data sources together, this can allow us to understand the value of the past habitats and provide targets for restoration (ToR C).

Link to article: https://noraeurope.eu/environment-agency-england-launch-data-layer-of-historical-native-oyster-reefs/ (last accessed 09/01/2024).

Bernardi (2022) The use of photographs and images as a new frontier in the historical ecology of the Northern Adriatic Sea

Jacopo Bernardi, Department of Biology, University of Padova, Italy

Photos, paintings and figures are unconventional data that can cover relatively large temporal and spatial scales and can provide large amounts of information about the changes in marine communities and in the fishing activities. Unfortunately, the use of images as a different tool to understand the marine communities' changes is still an unexplored study field for the Northern Adriatic area (Fig. A3.10). My research uses different kinds of sources such as paintings, mosaics from archaeological sites, personal photos of commercial fishing, local history books, historical naturalist's representation and the photographic archives of the recreational big game fishing clubs. Images can give us an idea of the importance of a marine resource in a particular period and show the decline and the occurrence of a species through the years and could be used to understand the changing in size for some species. Furthermore, photos and paintings show us the technological innovation in the fishing activities and how some traditions remain the same in fishermen's behaviours. The collaboration between researchers could solve the difficulty for the data collection in this new field of study, which can become an innovative instrument to understand the changes of an overexploited basin as the Northern Adriatic Sea.

Link to ToRS: Gives information on different types and quality of sources, and what can be extracted (ToR B). Some of these results could contribute to deliverables on qualitative resources for ToR C and D if combined with other Venetian Lagoon data from the Austro-Hungarian empire. Iconographic representation of shark teeth in fishermen's manuals can also help understand which species were present in N Adriatic and at which time (ToR B).

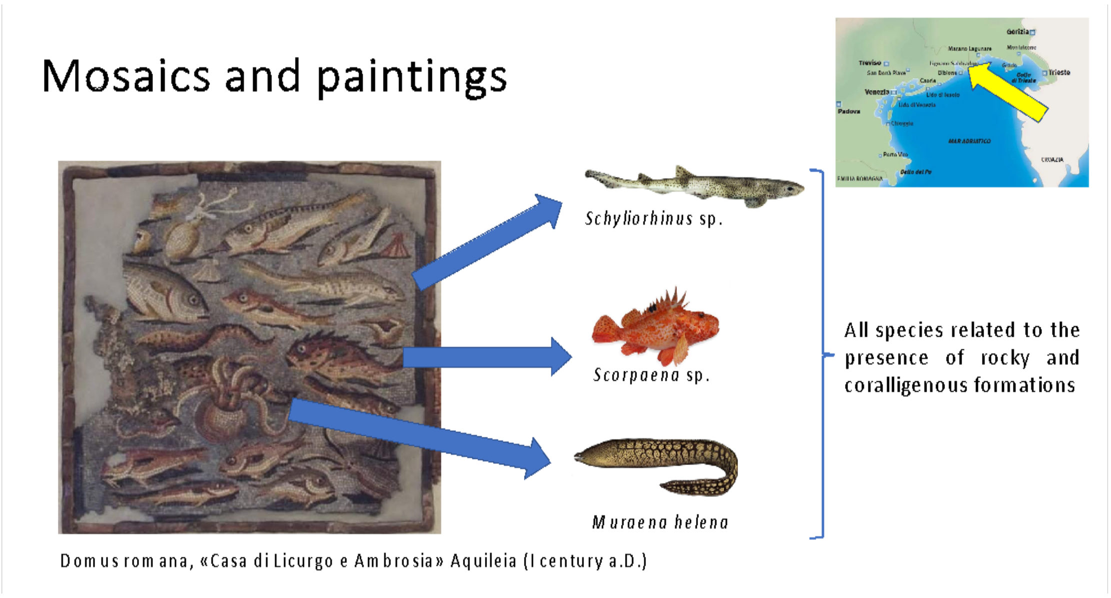

Figure A3.10. Example of information on Adriatic fish species that can be extracted from Roman mosaics. Copyright: Jacopo Bernardi 2022.

Engelhard (2022) The [R]evolution in fisheries science

Georg Engelhard, Cefas, UK

- Documenting the collaboration between Sidney Holt and Ray Beverton.
- Here we see the two working on their magnus opus - the dynamics of exploited fish populations, and understanding their dynamics and quantifying them.
- Both had quite different career pathways and directions in terms of objectives and interests, Beverton at Cefas and Sidney got quite interested in whale conservation. Later in life both reflected on the development of the discipline - and we have compiled their narrative.
- Beverton highlighted need for transdisciplinary work and conversations in the Bev lectures
- Chioggia talk in 2016 - we have the transcript form the talk which we started to explore, and we are using these two sources to reconstruct a dialogue between the two men.
- Runs us through paradigms 1 and 2
- Took us through 6 paradigm shifts we have discerned - and the evidence for them.
- We see the paradigm shifts as - a seed being planted - the idea gathering momentum - eventually it becomes widely accepted
- We need to recognise that paradigms will continue to shift.

Link to ToRs: History of policy and practice and the different paradigms of understanding can inform ToR C and D.

Thorpe (2022) Using reconstructed fishing mortality in the North Sea from 1880 to improve understanding of foodweb dynamics

Robert Thorpe, Cefas, UK

- Advice timescales - multispecies models (of foodwebs), challenge for timescales for advice, can look at model fit, hindcasts were improved - reference points - do we want to manage to pristine state - what would it look like and what would multispecies MSY look like.
- 9 versions of the Mizer model - they failed but why have they failed?
- In the recent past high fish mortality - when is it high/low? Rest of food web interactions become important - we cannot tell from the past how it might change in future because all largest fish are removed over time.
- Report efficiency key driver of early-life density dependence can help (is it recruitment?)
- If you do it statistically might not be reliable in the future - but if it's a mechanistic understanding it doesn't date in the same way…?
- Simulating 20th century - shows big change in effort over the period - during WW1 and WW2 fleet effort was low, past contains info about dynamics.
- F estimates (mortality; ICES and POPE) - we'd like to be able to estimate these for all stocks - but limited coverage in time, few snippets only - but how do we fill the gaps?
- Mixed fishery and choke points - keep going until all stocks are "choked" - one total quota and switch between stocks. Focussed on an average choke. Seems to be what most past management has done, split up the fleet into segments and west-east North Sea
- Assumptions F=E (effort) was equal to 2002-2013 average across all fleets, fleets can change effort through time, but not internal relative catchability.
- Compared different estimates of effort and how they fit with each other.
- Reconstructed Thurstan fit better (although just UK, and should be adjusted for all fleets in all waters).
- Best matches use fleet dynamic trajectories - suggest higher F - estimates could be reconciled if F does not = E.

Link to ToRs: Verification of models with historic data can inform ToR C.

West (2022) The Pacific Cod Project: Historical Ecology and Alaska Fisheries Management

Catherine West, Boston University, USA

- The blob- in 2015 a hot water mass developed (heat wave) in N Pacific, Gulf of Alaska, salmon and cod suffered terribly under such conditions - a lot of interest today in applied archaeology, what I appreciate about this working group is doing the embedding.
- Pacific cod fishery - they have been fishing for millennia, they achieved a rich understanding of the fish [one of the top grossing fisheries Pacific cod in N America today].
- The N Pacific ecosystem is asking us to recalibrate our understanding.
- Recently hosted a symposium (with Loren McClenachan) that assembled historical ecologists, climatologists, resource managers, archaeologists to consider cod in context of climate change - blob has given us an opportunity to ask some important research questions. How can reference points inform management? We all agreed, lack of long-term data is a real problem - 1977-2021 (fisheries managed from baselines from the 1970s) - female spawning biomass vs total catch. Rapid stock increase in 1977 then 1987-89, then declined until heat wave (2015) when it crashed.

- You can appreciate this doesn't capture the full variability we might expect to see over the long-term, regime shifts, climate events, etc, natural variability. Certainly, did not capture the blob and the other more extreme and expected future climate events.
- Rich records and proxies across Gulf of Alaska
- There are several ways to connect these data across time, age length, otoliths - relatively good for skeletal elements and can be used to interpret feeding apparatus to fish size in archaeology as well as modern biology.
- So, we can ask has cod body size changed through time.
- Assembling data across Atlantic and Pacific (West et al. 2020).
- Indigenous people fished with hand-held longlines, also used pots, and catch fish of different sizes so to compare ancient and modern focussed on one gear (longlines) - compared data from across Aleutian Islands and Gulf of Alaska - estimated body-size for 6000 specimens over 6000 years. And got data from 200,000 fish from modern day. At multiple locations across the N Pacific.
- In both cases the biggest fish in the Aleutian Islands (west side of Pacific) - so consistent difference over 6000 years. In both cases no statistically significant difference among largest fish caught - there was no evidence for change through time except in commercial fisheries today in the mid-Pacific compared with ancient (smaller fish in this area - pressure/stress). The results are mentioned in the recent Pacific cod stock assessment.
- Of course, with heat waves increasing in frequency and magnitude it will push them to the extreme

Link to ToRs: Could inform deliverables for ToR C and D by exploring past fishing practices and management, and how reference points can inform current management. Also, can advise on developing relationships and working with stock assessors.

Linked publications: West, C. F., Etnier, M. A., Barbeaux, S., Partlow, M. A. and Orlov, A. M. (2022) "Size distribution of Pacific cod (Gadus macrocephalus) in the North Pacific Ocean over 6 millennia," Quaternary Research. Cambridge University Press, 108, pp. 43–63. DOI: 10.1017/qua.2020.70

Dillon (2022) Reconstructing shark communities on coral reefs over millennia using fossil dermal denticle assemblages

Erin Dillon Uni. California, Santa Barbara, USA

- Using the fossil record to ask: How long sharks have inhabited the Caribbean?
- They (sharks/predators) are very important for structuring food webs. Despite their importance they have been lost from many reefs worldwide. Many populations of sharks have declined over the last half century (1970 - 70% decline - from overfishing - same study documented an 80% increase in fishing - and sharks are especially vulnerable due to their repro life histories).
- Most survey efforts are recent and so information is limited, and so historical data are needed. We don't know how abundance varied before fishing. Data from fossils can help us figure out what is natural in terms of abundance and function. We can use this to build baselines for sharks - how variable were they? What was the scale of decline? And, what impact does this decline have on ecosystems?
- This fits into "conservation palaeobiology" (e.g., Fig. A3.11)
- The fossil record of denticles (100um-1mm) is less well known than teeth - but they are more numerous (denticles are more abundant than human teeth). They can give us a time averaged picture of change in assemblages through time. They are made from calcium

phosphate and so preserve well. Those preserved within a reef matrix may have better stratigraphic control because there is less mixing of remains e.g., than in seafloor sediments.

- Nice summary of how the fossils that can help to recreate - denticle shape and thickness varies with traits of species (Fig. A3.12). She has several papers on how to recover denticles – use lab methods to extract, but also how to interpret body morphology from denticle form (nice figure)
- Also measured denticle shedding rates. And tested in a modern setting how realistically denticles describe the modern assemblage - generally they were correlated. This work has allowed us to start asking ecological questions.
- Caribbean case study - how sharky it was before the advent of commercial shark exploitation? Why do some reefs support more sharks? Compared Mid -Holocene reefs with present day (adjacent reefs) that predate human settlements but has similar environmental conditions there as it does today (Fig. A3.12).
- They made location specific baselines - mean denticle accumulation rate was 3x higher in the Holocene. And the abundance of different denticle forms showed that they were mostly demersal sharks (with high abrasion strength). Also, visible shifts in multivariate assemblage data as well as denticle abundance. Fits with exploitation effects
- To explore the timing of change she looked at other data (e.g., shark sightings). Habitat modification and fishing were important factors.
- Next steps are to explore drivers more and look at links between different trophic components.

Figure A3.11. Ecological and biological information that can be conveyed by fossil elements with examples of studies. Copyright: Erin Dillon 2022.

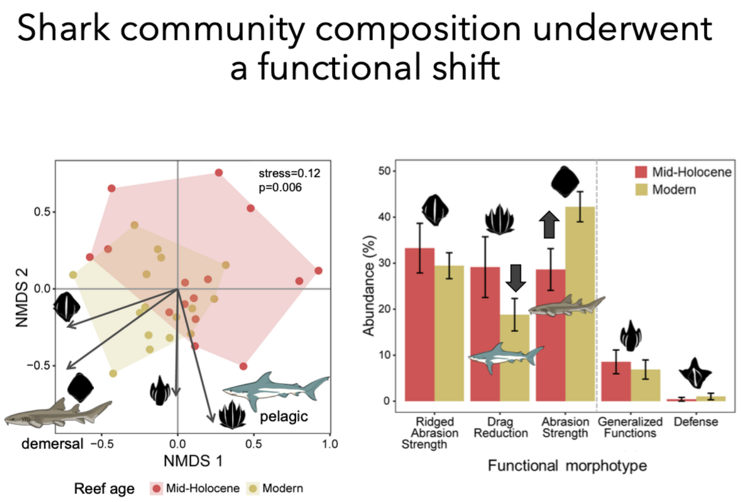

Figure A3.12. **Comparison of mid-Holocene (n = 183) and modern (n = 389) shark assemblages from Carib-bean coral reefs. Left: non-metric multidimensional scaling ordination of denticle composi-tion for sharks with different living hab-its. Right: abundance of denticles with different mor-phological traits (pictured) that are indicative of the different life habits. Reproduced from Dillon et al. 2022. Copyright: Erin Dillon et al. 2021.**

Linked publications:

- Dillon, E., McCauley, D. J., Morales-Saldana, J. M., Leonard, N. D., Zhao, J., O'Dea, A. 2021. Fossil dermal denticles reveal the pre-exploitation baseline of a Caribbean coral reef shark community. PNAS, 118 (29), 1-9. DOI: 10.1073/pnas.2017735118
- Dillon, E., Bagla, A., Plioplys, K. D., McCauley, D. J., Lafferty, K. D., O'Dea, A. 2022. Dermal denticle shedding rates vary between two captive shark species. Marine Ecology Progress Series 682, 153-167. DOI: 10.3354/meps13936

Link to ToRs: In allowing us to reconstruct shark abundance and natural variations the work can contribute to ToR C, it may also help us to understand long-term changes (magnitude and rate) in shark populations due to exploitation. Ultimately it can be used to understand change in the wider reef ecosystem. As a unique form of data and approach it may also contribute to ToR B.

Lueders-Dumont (2022) Reconstructing ecological baselines in fish assemblages using nitrogen isotopes in otoliths

Jess Lueders-Dumont, Smithsonian Institution Marine GEO postdoctoral fellow, Smithsonian Tropical Research Institute & UC Berkeley Department of Integrative Biology

Anthropogenic impacts on marine ecosystems today are compounded by centuries to millennia of human disturbance. Quantitative records of marine food webs are rare prior to the 20th century. My research uses the isotopic composition of fossil and modern otoliths (calcium carbonate ear stones in Teleost fishes) to investigate changes in food web structure, using trophic level as a metric to quantify and understand ecosystem alteration in modern and past marine systems. I find that the nitrogen isotopic composition (δ15N) of otolith organic matter is a robust indicator of fish diet. Using paired otolith and tissue samples from laboratory-reared fish and from wild fishes, I provide validation of the otolith method. Through a case study focused on trophic level variations in Atlantic cod, an economically and culturally important fish species in the North Atlantic, I demonstrate the potential for reconstructing past food webs using modern, sub-fossil, and fossil otoliths (Fig. A3.13). Otolith-bound measurements of trophic level show great potential for investigating patterns and processes in food webs prior to observational records. In future and ongoing studies, otolith δ15N will be used to identify quantitative benchmarks from pre-disturbance ecosystems, benchmarks that will be useful for conservation and management of marine ecosystems.

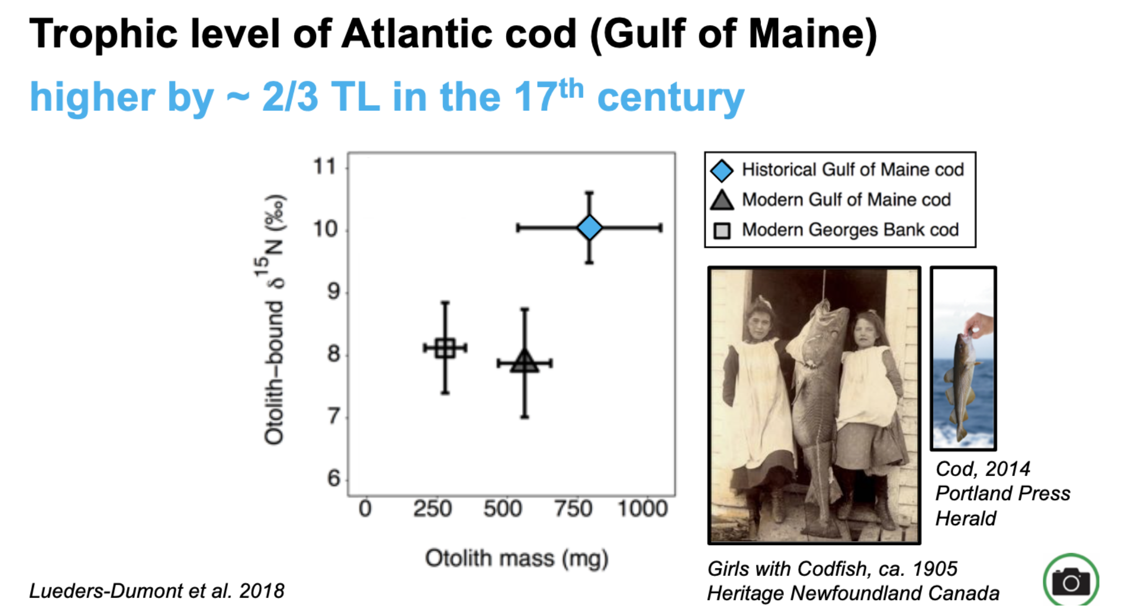

Figure A3.13. **[Text] Comparison of modern and historical (c. 1700) Atlantic cod otolith chemistry from the Gulf of Maine. Otolith mass and otolith bound N-isotope composition. Copyright: Jessica Leuders-Dumont et al. 2021. See also Leuders-Dumont et al. (2018).**

Linked publications:

- Leuders-Dumot, J.A., Wang, X. T., Jensen, O. P., Sigman, D. M. Ward, B. B. 2018. Nitrogen isotopic analysis of carbonate-bound organic matter in modern and fossil fish otoliths. Geochimica et Cosmochimica Acta, 224, 200-222. DOI: 10.1016/j.gca.2018.01.001
- Lueders-Dumont, J.A., Sigman, D.M., Johnson, B.J., Jensen, O.P., Oleynik, S., Ward, B.B. 2020. Comparison of the isotopic composition of fish otolith-bound organic N with host tissue. Canadian Journal of Fisheries and Aquatic Sciences. 77(2): 264-275. DOI: 10.1139/cjfas-2018-0360

Link to ToRS: Shows that nitrogen isotopic composition (δ15N) of otolith organic matter is a robust indicator of fish diet for cod. Quantitative records of marine food webs are rare prior to the 20th century. Otolith-bound measurements of trophic level can be used to describe the nature of food webs prior to observational records and human exploitation. In this way it informs ToR C. As a unique form of data and approach it may also contribute to ToR B.

zu Ermgassen (2023) IUCN ecosystem red listing assessment for Europe's reefs

Philine zu Ermgassen, University of Edinburgh, UK

Completed for oysters in Australia and was a very useful exercise - these are the global standard for conservation status assessment. Applied the red listing criteria to oyster reefs, defined the "ecosystem" and defined "collapse", history was very important here. It is more than just species distribution, it's the type of habitat (collective oysters) and so requires slightly different data - current day extent (required some thought) - habitat more than 20m^2?

Because today oysters are quite impoverished, but also the form they take can be quite different between species (American examples - look across a range of habitats and densities, it can vary). How to apply IUCN criteria: requires us to exactly clarify where the ecosystem collapsed.

What makes an oyster reef a habitat? Previously could be considered a habitat based on extent, but not today really, 85% of historic reefs were 1-100 ha in extent (50% of this >10 ha) the dominant size of the "ecosystem" historically -> this informed our definition of oyster reef as an "ecosystem". Oyster reef ecosystems are areas with high densities (multiple size classes), shell dominated, patches/clumps that create 3D complexity. It has value as a habitat today, but based on this can it really be considered an ecosystem anymore?

An oyster ecosystem is: resilient, biogenic (complex mixture of habitats within), should be assessed on the scale of km. Collapse thresholds are tricky because they do not have historical densities. 50 oysters m2 is an average number, and the threshold is less than 20 oysters. It does not span its natural depth range potential. Comparisons can be made between habitats, but sometimes the species were described in already depleted habitat.

Results of the assessment showed: It had collapsed across its entire range, despite still having a wide distribution. The remaining reef was important for biodiversity, a biological tipping point can be defined. Data were deficient for the abiotic parts of the ecosystem (aside from culch? Shell debris).

URL for NORA project: https://noraeurope.eu/ (last accessed 09/01/2024).

Linked publication: Zu Ermgassen et al. 2023. 'European native oyster reef ecosystems are universally Collapsed', DOI: 10.32942/X2HP52, 07/12/2023, preprint: not yet peer reviewed.

Link to ToRs: Nice example of an application of historical data or "interpretation" from within an existing conservation framework (IUCN red listing): informs ToR C. The IUCN assessment framework is great and very flexible, and she thinks it could be applied more widely, works well with qualitative data and distribution can be sufficient - lots of historical data has this (speaks to ToR B).

Rizzetto (2023) Introducing InTer AquAS: human-animal-environment relationships in the Roman & mediaeval NW Adriatic lagoons

Mauro Rizzetto, Ca' Foscari University, Venice, Italy

The Interaquas project is integrating terrestrial and aquatic archaeozoological studies with the aim of reconstructing human/environment relationships. Fall of the western Roman empire, lagoons in the Byzantine. There were many lagoons around the Roman period. Connected Ravenna to Aquileia. The lagoons became major areas of settlement (offered protection and supported trade). What can human animal use can tell us about changes in settlement? How it contributed to everyday life and trade. They are also considering the ecological history of the lagoons, and using isotopes to learn what they ate, what they feed on, and the environment.

Looking across animal groups, including fish, shellfish, waterfowl etc, also will look at body sizes and trophic position of taxa from Antiquity to The Early Middle Ages. NW Adriatic Lagoon, zooarchaeology study of terrestrial and aquatic fauna, using both biometrics and isotopes. The Roman-Mediaeval transition includes climate change in Late Antiquity, the little ice age, reduced the quality and quantity of cultivated areas - negatively impacted agricultural production. Organising a session at the next EAA (acronym for) on the Venice lagoons and Comacchio lagoon

URL for project (Marie Curie) description: https://doi.org/10.3030/101064161 (last accessed 09/01/2024).

Link to ToRS: Taking a long-term view on the Venice lagoon (a system we know to have an interesting exploitation and management history) can contribute to ToR C, the inclusion of data on terrestrial food production provides interesting parallels and informs wider questions about overexploitation and food security. It can provide guidance on how this might be done (ToR B).

Bernardi (2023) Historical presence of large pelagics in the Northern Adriatic Sea

Jacopo Bernardi, University of Padua, Italy

A new study of large pelagics, from which they are trying to extract the assemblage data, and today he is presenting the preliminary results. The Adriatic Basin is the most productive region in the Mediterranean. Targeted samplings on these species have never been made and most of the large pelagics in the Mediterranean Sea are increasingly rare, and probably regionally extinct in the Adriatic Sea.

There are lots of data on demersal species from bottom trawl surveys from WWII onwards (e.g., from HVAR 1948-1949, Santi Medici 1972, GRUND 1982-2007, and MEIDTS 1994 onwards) and fish market landings. They are using unconventional resources to fill gaps in presence data, but also information on assemblage composition. There are some limitations of this data though. They used local history books and naturalists' descriptions (see pictures), and data from some big fishing clubs. The data include information about use of space and seasonality. During the Austro-Hungarian era (1872-1905) there was a bounty system because these species were thought to be a danger to humans/fisheries. The fish market landings data are from Chioggia, Trieste and Venice, including the common thresher, bull and eagle ray reconstructions and the Clodia Database (with official monthly statistics of fish and seafood catches landed at Chioggia market since 1945). The Big game fishing club archives span the 1980-90s and document the spread of recreational big game fishing (for threshers, swordfish and bluefin tuna) – and this can be used to understand the decline of sharks in 1980s-2000s (Fig. A3.14).

Figure A3.14. **Visualisations of big game fisheries in the Adriatic, including images, maps, data sources and timeline from 1800 to 2000s. Copyright: Jacopo Bernardi 2023.**

They are reconstructing the large pelagic assemblage of the Northern Adriatic Sea and the species life history traits in order to: understand the importance of the Adriatic for these species and the causes of the decline and whether it coincides with the environmental changes in the basin over the centuries (Fig. A3.14).

They have recreated the CPUE value per year of the catches for the two main sport fishing clubs using 50-year temporal bins. Many of these species are endangered or critically endangered and some species disappeared in the 1950s (e.g., hammerheads; Fig. A3.15). He is still trying to standardise some of the sources and is thinking about how to use them, his next steps are thinking about life history traits. Need help from you, how can we integrate the different sources?

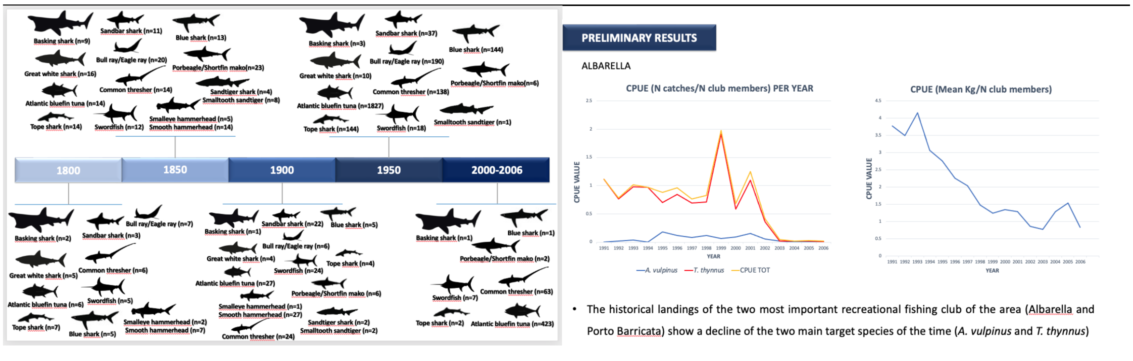

Figure A3.15. **Visualisations of the Adriatic shark assemblages from 1800 to 2006 and CPUE for A. vulpinus and T. thynnus from 1991-2006. Copyright: Jacopo Bernardi 2023.**

Also, he is interested in collaborating on collections of landings and photographs from the big game fishing clubs from other countries, do you know of any clubs where this might be done? E.g. found info on historic clubs, shark angling club of Great Britain and big game tunny fishing club.

Link to ToRs: This work although ongoing feeds into deliverables for ToR B and C using qualitative data in management. Resources highlighted can contribute metadata for ToR A, and developing approaches that integrate multiple different data sources (ToR B). Some are unique to large pelagic fish, plus can be used to evaluate long-term change in social-ecological systems (ToR C).

Guarini (2023) "Exploring ecological predictability by using historical ecology in a non-traditional way"

Jennifer Guarini, Entangled Bank Laboratory, Brest and /banyuls-sur-Mer, France

Going to talk about the overall picture of her research using historical ecology in a non-traditional way, particularly interested in scientific laws.

La pourpre Tyrian or royal purple pigments on Crete, a valuable product in antiquity, oldest examples of dyed fabric from the early bronze age (until end of Roman empire) and one of few animal pigments, pigment forms when exposed to sunlight. Much interest from pharmaceutical and nanotech companies today. Question: Could intense coastal harvesting cause local extinction events? To know the efficiency of a passive trapping method, study how individuals behave toward the bait (food resource). A behavioural model of interaction between animals and bait provides local estimates of distributions (Fig. A3.16). The approach makes it possible to estimate past exploitation pressures from archaeological inventories of shell remains.

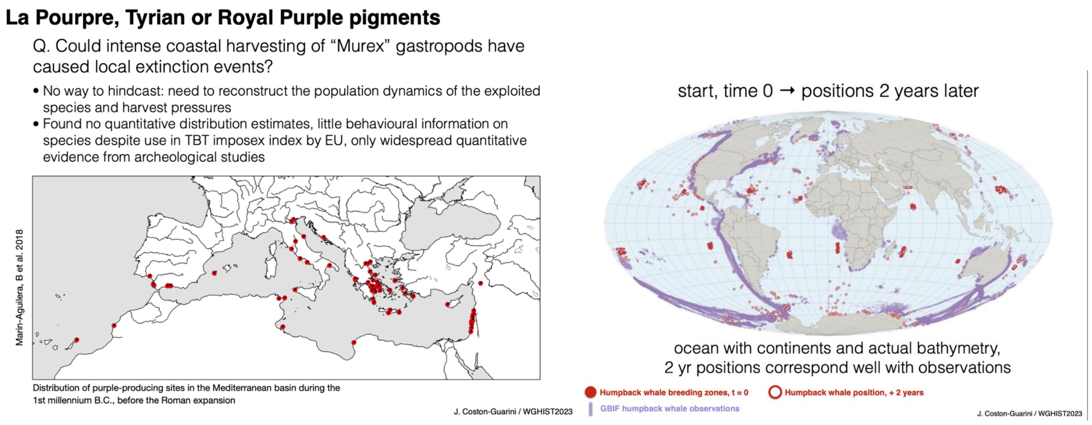

Figure A3.16. Visualisations of harvesting of snailless for la pourpre pigments (left) and individual based models of humpback whale distributions (right). Copyright: Jennifer Guarini 2023.

Usual practice has a problem, an average individual has no meaning in biology, ecology smears out variability. How can we include more variability in ecological studies at the same time as capturing and modelling variability - thinks ecology should be done at individual level? Most people focussed on population-based approaches, but Gleason…wanted to move away from representative populations and instead representative groups of individuals subjected to environmental factors.

Question 1 How to reconstruct knowledge about the past conditions of ecological systems that we did not study*? *By "study", I mean some observations may exist, but they were not collected to test a hypothesis. EIA is a forecasting process - it uses a modelled response of the designated impact receptor(s), evaluated relative to any available background (or baseline) information. The aim is to estimate how a set of potentially impacted organisms may respond to any disturbance created by the project, and only within the project area. Environmental Impact Assessment (EIA) is a regulatory approach to evaluate the impact(s) of economic development projects. It is part of decision-making systems in most countries today.

Question 2 What historical data do we have that can contribute to better predict* the future state of ecological systems? EIA is the first-time prediction was a stated goal of ecology.

Question 3: Has historical ecology spent too much time gathering data and not enough time testing* the theoretical frameworks that the data is supposed to support?

The dominant theoretical framework in ecology today: Species populations represented by an "average individual" living under a set of environmental conditions. The dominant theoretical framework in ecology today (Fig. A3.17), has focussed on statistical explanations about the coexistence of populations of average individual species.

OBSERVATION: Ecological interactions occur between individuals, not populations (Fig. A3.17) - Maybe ecological theories should be evaluated at the individual and not the population level?

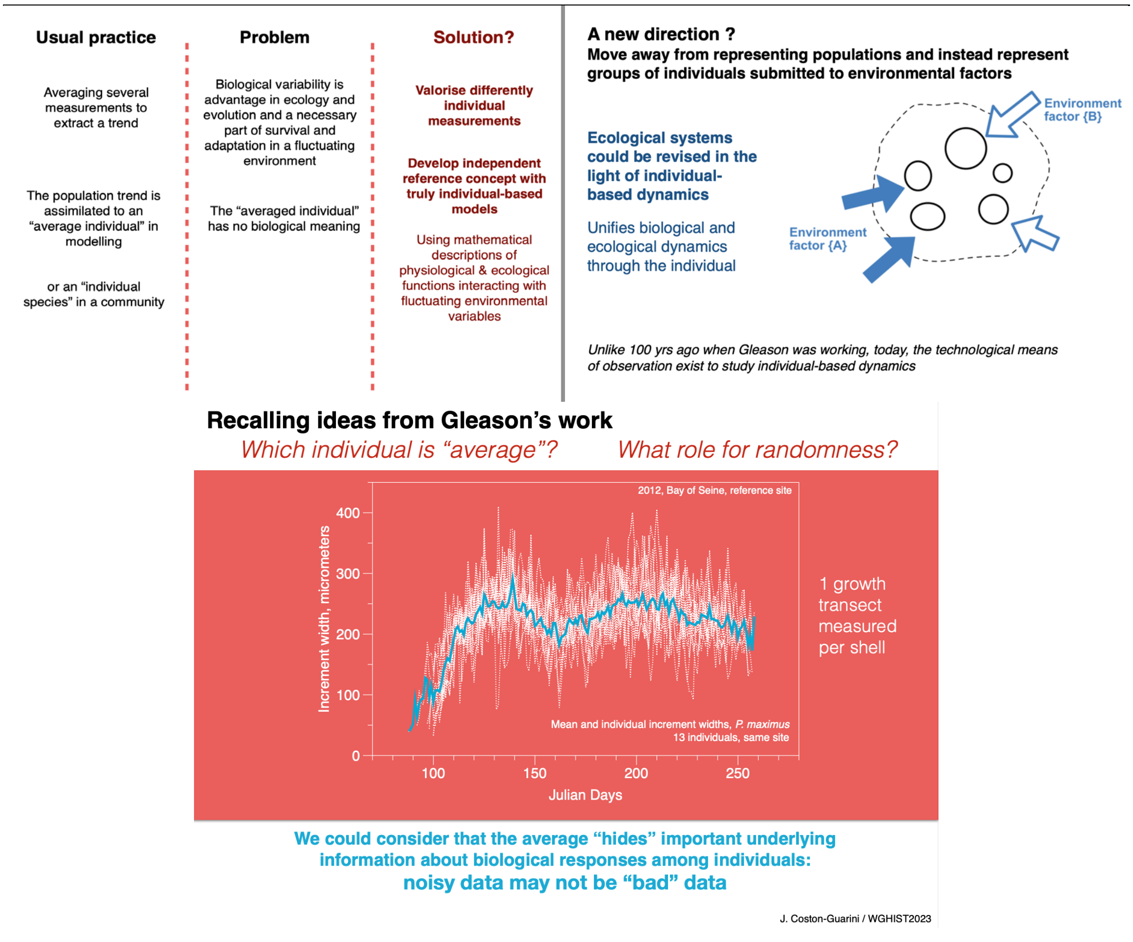

Figure A3.17. Visualisations of the principles underlying approaches to individual-based dynamics, including individual and average Pecten maximus growth rates. Copyright: Jennifer Guarini 2023.

First, build a model of the organism by describing interactions between the individuals and its environment. Ecological data about individuals are non- traditional source of information in historical ecology because most ecology is/was population-based. Models of individual behaviours permit new types of ecological experiments to be accomplished. Datasets are replaced with parameters that drive behavioural and physiological interactions, then simulations are compared to observations. An interesting test is to simulate the individual growth records of mollusc shells exploited in sclerochronological studies.

Is individual-based model simulated data a new source of information for historical ecology? What if two transects measured on the same shell are different? Challenge: Represent how individuals respond to environmental change during growth (Fig. A3.17) to produce a reference (baseline) morphology?

Models of individual behaviours permit new types of ecological experiments to be accomplished. Datasets are replaced with parameters that drive behavioural and physiological interactions, then simulations are compared to observations. Another interesting test is to use a species, like whales, to see if we can reproduce patterns at a planetary scale from local individual interactions. Simulated trajectories of individual humpback whales in the global ocean by combining a physiological and behavioural model with environmental drivers (Guarini and Coston-Guarini 2022; Fig. A3.16).

We submitted an article (Coston-Guarini et al., In Review) testing the use of a hybrid dynamic model to predict species outbreak episodes for the serpulid worm *Ditrupa arietina*. The modeling emphasises the role of demographic processes, instead of the usual biogeochemical control on ecological systems evoked for marine species outbreaks. It also turned out to be a case where the limits of the historical ecology approach were tested. In the article we elected to use a species that has/had no particular interest. The historical information available on past occurrences of the species could not be used because observations could not be confirmed, and they were too infrequent to be able to confirm past outbreak events. Hence this is also an example of the types of information gaps we can expect when trying to reconstruct past ecosystem states and the roles of ignored or overlooked species in them.

In parallel, we also went back to re-evaluate the paradigm of alternative stable states which is often invoked as an explanation of changes in ecological systems (Guarini and Coston-Guarini, 2024). We added a spatial distribution which means we can avoid introducing a special function, the Hill function, that all other articles use to generate alternative stable states in their systems. In our new formulation we demonstrate that the declaration of alternate stable states can only be assessed in very simple 2 species systems. Therefore, no alternative stable states or so-called "regime shifts" can be expected to be observed or distinguished from chaotic behaviour in the complex multivariable systems of field sites, or even in most experiments. We show that this paradigm of tipping points and regime shifts is only metaphorical and not mathematically valid, in agreement with what was originally suggested by Robert May in his 1977 article. We suggest that this terminology be abandoned.

Interrogating historical sources generates a diversity of views and observations, absent from modern literature. Everything we have done thus far, leads us to think that ecological systems should be revised in the light of individual-based dynamics. We conclude there is a need for a reference state as fulfilled by the mathematical model of the individual organism and which could be thought of as a digital holotype.

Linked publications:

- Guarini, J.-M., Coston-Guarini, J.A. 2022. First Individual-Based Model to Simulate Humpback Whale (*Megaptera novaeangliae*) Migrations at the Scale of the Global Ocean. Journal of *Marine Science and Engineering*, *10*(10), 1412. DOI: 10.3390/jmse10101412.
- Coston-Guarini, J, Charles, F, and Guarini, J-M. In Review. Modelling the hybrid dynamics of an outbreak species: the case of *Ditrupa arietina* (O.F. Müller), Gulf of Lions, NW Mediterranean Sea.
- Guarini, J-M., Coston-Guarini, J. 2024. Alternate stable states theory: Critical evaluation and its relevance to marine conservation. *Journal of Marine Science and Engineering*, *12*, 261. DOI: 10.3390/jmse12020261.

Link to ToRS: This work demonstrates a new application for historical data in providing baseline information for EIA and so informs ToR C and would require bridging different data types and exploring differing disciplinary usage (ToR B). It also asks questions about the practices/thinking underlying current paradigms in ecology (ToR B).

Clarke (2023) Re-constructing the historical record of catches, biological parameters, populations and advice for policy makers: ongoing work in the Irish Marine Institute

Maurice Clarke, Marine Institute, Ireland

They have interests in fish biology in terms of historic spawning grounds for herring, mackerel migration routes and their spawning and nursery areas. Reconstructing herring populations for stick assessment. The extent of benthic habitats e.g., oyster restoration. The evolution of fisheries advice and policy plus preserving their corporate memory. Seeking to digitise the marine Institutes digital collection.

Arthur Went (ICES president) - published an early history of ICES and Irish practices e.g., Went, Arthur EJ. 1946. "Irish fishing weirs. I. Notes on some ancient examples fished in tidal waters." The Journal of the Royal Society of Antiquaries of Ireland 76.4: 176-194.

George P. Farran (Irish Department of Fisheries, 1920s-1940s) worked on the Herring Atlas for the NE Atlantic. Demographics plus response to climate. Farran (1930) produced an analysis of herring data showing the same pattern of recruitment as in Clarke et al. 2011. The very high catches in the first decade of the 20th century were surely associated with exceptional recruitment, and Clarke et al. 2011 subsequently showed that the strong herring recruitments/fisheries correspond with cooler temperatures (Fig. A3.18).

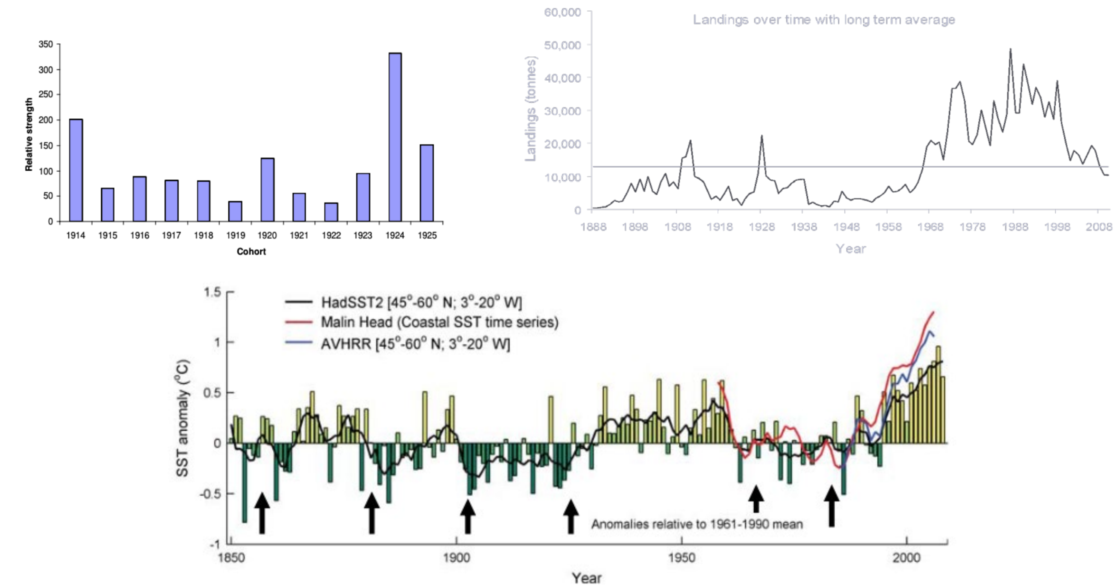

Figure A3.18. **Relative strength of herring cohorts hatched from 1914-1925 (data from Farran 1930), SST change (arrows indicate historic instances of high recruitment and/or large fisheries), and Irish herring landings over time from 1888 to 2010 (in regions VIaS and VIIbc). Reproduced from Clarke et al. 2011. Copyright: Maurice Clarke 2011.**

Best estimate of international catch (tonnes) since 1888 for herring in the area corresponding to VIaS and VIIbc. Long term average catch indicated (Fig. A3.18).

They are also investigating the loss of Mackerel migration routes. It was suggested the mackerel population was exterminated, today North Sea stock is moribund so could be true. But more work is needed. Oyster restoration - several initiatives to rebuild, inspector of Irish fisheries reports shows where they were. Semi-natural but does give a historic baseline for oyster distribution.

John Molloy, preserving corporate memory of the scientific analysis on the stocks - found this to be a useful way of harvesting corporate memory. Also, investigating the evolution of the science/policy interface - ices vs national advice on stocks from 1991-recent. Asking was the advice followed, was national advice followed more, and how did management evolve in response? (e.g., for elasmobranchs). Most of the archive is digitised, containing historical landings and stock data.

Linked publications:

Clarke et al. (2011) Long term trends in the population dynamics of northwestern Ireland herring revealed by data archaeology. ICES CM 2011/D:04. Available from: https://www.researchgate.net/publication/257327387_Long_term_trends_in_population_dynamics_of_NW_Ireland_herring_revealed_by_data_archaeology#fullTextFileContent (last accessed 09/01/2024).

URL for archive: https://www.marine.ie/site-area/research-funding/marine-research-ireland/national-marine-research-database

Link to ToRs: The Irish Marine Institute database can be incorporated into ToR A, work on the policy science interface on what advice was received, what decisions were made and why is of interest to ToR D. Work on fisheries and oyster restoration projects may contribute to understanding social-ecological systems change over time (ToR C).

Travis (2023) Seachange: Navigating Marine History with the Digital Environmental Humanities

Charles Travis, Trinity College, Dublin and University of Texas, Arlington

Charles is part of the 4Oceans project with Poul Holm, was involved in the Norfish project. Model of how the Grand Banks were mapped. Looked at cartographical archives and at charts and fishery symbolism - extracted 83 charts - identified three phases of charting: Early Pistolary 1504-1556, Shakespearean 16-00-1700, Atlantic systems 1765-1786. Developed from scribbles to mapping fisheries themselves and then incorporated them as part of the system (Fig. A3.19).

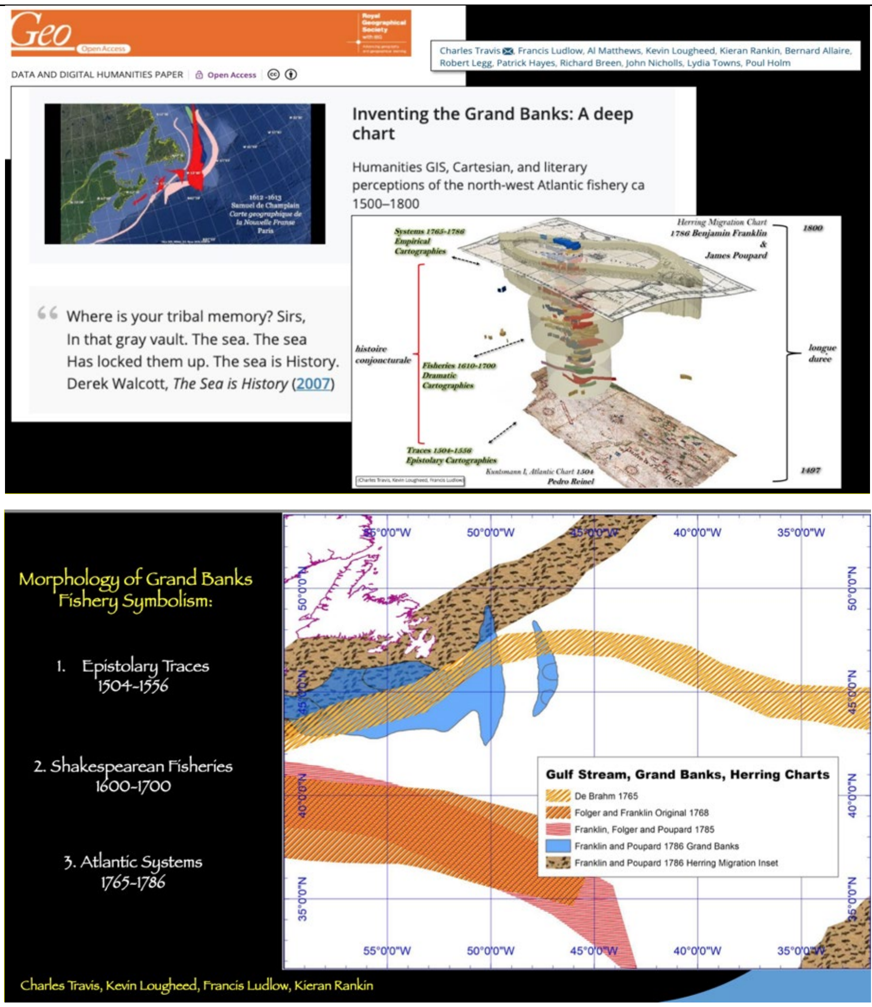

Figure A3.19. **Charts and morphology of the Grand Banks through time. Copyright: Charles Travis et al. 2023.**

Demonstrates changes in understanding of the extent of the fisheries system, and developments of cartographic technologies. The Tempest in 1610, frequency distribution of London cod vertebrae by year – Shakespearean sites and fish bone sites and Atlantic sites. Previously decided probably magical island in the Tempest was Cyprus. Took a propaganda map of Newfoundland surrounded by the French fleet, put fisheries on top, French captured Newfoundland then British again later (Fig. S20). While The Tempest was playing in London. Herring migration chart was an accidental supplement to Franklin and Pollards map of the Gulf Stream in 1786 (Fig. A3.20).

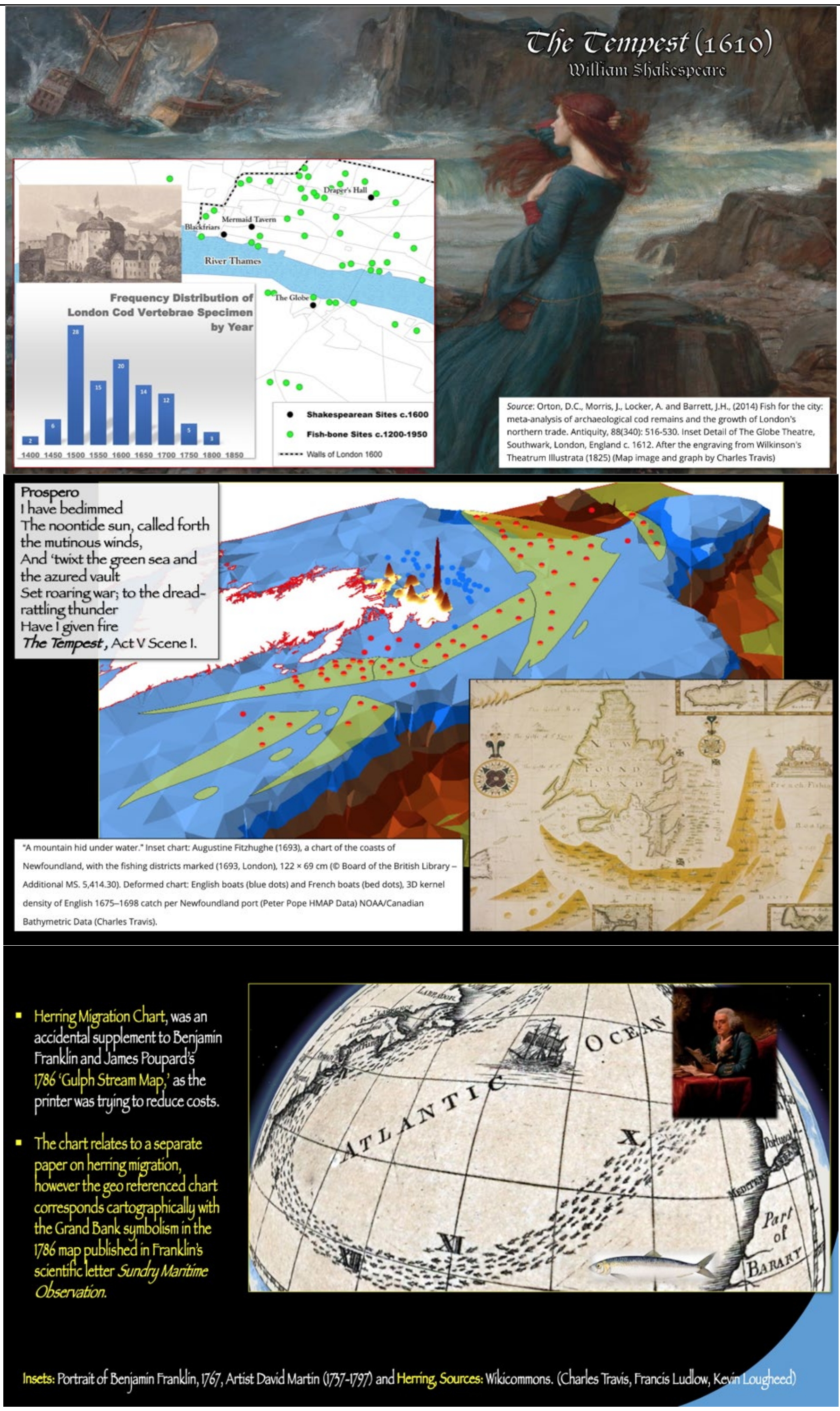

Figure A3.20. **Infographics on the distribution of cod vertebrae in London c. 1200-1950; English and French boat positions off of Newfoundland with kernel density on English cod catches 1675-1698; and the herring migration chart of Benjamin Franklin. Copyright: Charles Travis et al. 2023**

Charles has published the "Routledge handbook of the digital environmental humanities" this year. "Employing historical, philosophical, linguistic, literary, and cultural lenses, this handbook explores how the digital environmental humanities (DEH), as an emerging field, recognises its convergence with the environmental humanities. As such, it is empirically, critically, and ethically engaged in exploring digitally mediated, visualised, and parsed framings of past, present, and future environments, landscapes, and cultures. Essential reading for those interested in the use of digital tools in the study of the environment from a wide range of disciplines and for those working in the environmental humanities more generally. "Chapter 1 Cowboys, cod, climate and conflict may be of interest."

He is working with Poul to produce the 4Oceans atlas of historical marine extractions – an interactive atlas, dashboard online, for visualising different findings in a dynamic environment.

Linked publications: Cowboys, Cod, Climate, and Conflict Navigations in the Digital Environmental Humanities. In: Travis, C. et al. (eds) Routledge Handbook of the digital environmental humanities. Routledge, London. Pp. 556.

URL for the Handbook: https://www.routledge.com/Routledge-Handbook-of-the-Digital-Environmental-Humanities/Travis-Dixon-Bergmann-Legg-Crampsie/p/book/9780367536633?gclid=CjwKCAiAx_GqBhBQEiwAlDNAZk2qB9jlABWmEGR5znEfBxHUeQ5Qt44-4OxqIsVdnejFwUsX8P-QfxoCaYcQAvD_BwE

Link to ToRS: The digital atlas will be a useful tool for highlighting knowledge from the past social-ecological systems (ToR C). Understanding the cultural roots of ideas, attitudes and practices can inform ToRC. New tools for utilising historic cultural and visual information and the approaches for doing so can inform ToR B.

Wilson (2023) Histories of Colonialism & Fisheries Governance in Africa: Perspectives from Ghana and Lake Malawi

David Wilson, University of Strathclyde, UK

Looked through a lens of legal and scientific history. Prior to the imposition of colonial regulations, the lakeshore leaders held the ultimate authority and power to regulate fisheries, negotiating with neighbouring communities when any conflict occurred. It was not until the 1930s, following the expansion of non-African fishing efforts, that significant enough conflict arose to prompt the first interventions of the colonial government into the fishing industry.

Throughout Lake Malawi, fishing methods have long been tailored according to fishers' long-term observations and established knowledge of fish behaviour, local geography, and currents. In the northern part of the lake, they used "chilimila", an open water seine and a gill net called a "matchela". In the southern part of Lake Malawi used large beach seine called Makoka (50-400 yards long) and in rivers they used weirs and traps to catch fish from runs. In the southern part of the lake where fishing was concentrated on nets worked from beaches, lakeshore leaders who controlled those beaches could, in turn, control the fishing occurring therein and demand tribute in the form of a portion of fish caught. When non-African fishers started to make use of makoka in the 1930s, it was noted that these fishers had to come to personal arrangements with the relevant lakeshore authority to gain the right to access and use their beach. Colonial intervention in the fisheries of Lake Malawi first began in the 1930s after European and Indian fishers began operating in the south-east arm of the lake where they conflicted with long established African fisheries who held rights over rivers and fishing beaches. Fisheries intensified in the south-east arm, where African and non-African fishers concentrated on the use of seine nets operated from the sloping fishing beaches between Fort Johnstone and Mtimbuka village. Using this method both grounds targeted Chambo (tilapia), the main commercial fish in the lake.

Introduction of new sea fisheries nets on what was perceived to be depleting stock, lasted for 23 years, and the colonial government became arbiter over sea fisheries as it hadn't before. Disregarded fisher's knowledge and expertise of the resource. They were afraid that larger and more destructive nets would ruin the fishery – there were several attempts by fishers to restrict use. Prohibitions were introduced and appealed directly to colonial authorities. Net supporters found easy allies among the British.

By 1939, African fishers reported that their catches had declined in both the north and south of the lake, blaming the expansion of non-African fishers. Several attempts by the community to introduce byelaws failed, colonists insisted they were not damaging, "best fishing net is the one that catches the most fish" said colonial secretary of the Gold Coast colony in 1921. They assumed the nets used were the same as those used in the UK, and insisted fishing doesn't affect fish. Colony fisheries declined over 30 years. Conflict over the use of traps and weirs and accessing the fish runs of the Shire River in the early 30s, some fishers began using motorised boats to set purse, ring and gill nets in the lake.

The fisher's knowledge was dismissed. It was also, at a time when understanding of fish'ries and policies was new, and the idea of an inexhaustible sea prevailed. Intensive expansion of the non-African firms who began exporting fish to feed plantation labourers in Nyasaland and the surrounding colonies, led to concerns by the colonial government that the non-African fisheries were redirecting an important economic and food source away from local markets and even away from the colony. Non-African fisheries in the lakes compromised local rights. The colonial government passed fishing rules in 1930, 1931, 1937 it required non-Africans to acquire a permit non-Africans were prohibited from fishing for the purposes of trade or commerce unless they first obtained a permit from the colonial government. Permit holders were restricted to specific sites, fishing nets utilised were regulated, and the fishing firms had to submit monthly returns surrounding the level of fishing effort and the volume of fish caught. The colonial government directed fisheries. They completed a series of surveys, three main ones in the 1950s, and decided they needed more. Predicated on commercial development vs preservation (of stock and African fishers).

Sampling and monitoring today, with a 4-month closed season and other management is working, water quality etc is ok so not impacted by these. There is a growing faith in science against the colonial legacies of legal hierarchies, disconnections, and dispossessions. Hierarchies effect fish governance today. Since the 1990s and 2000s there has been a shift to co-management, from the 1920s onwards they have implemented a new structure more similar to local management regimes, but because it was destroyed, they now try to restart. The co-management schemes are not yet working fantastically well, fishers feel excluded and dispossessed.

Data is available on the project website here: https://storymaps.arcgis.com/stories/2974f11f7f9d4bbba8c3ef2f192d083b (last accessed 09/01/2024).

Link to ToRS: This contribution demonstrates changes in behaviour over time with colonialism but also shifts in behaviour and the need for adaptive management when social-ecological systems change (ToR C) arrival of Europeans and changes in practices, partly due to bringing new and inappropriate gear and LEK is dismissed. It demonstrates that food security can be a strong motivation for management intervention, which in this case was successful (ToR D).

Ojaveer (2023) Drivers affecting individual growth of recruitment: Gulf of Riga (Baltic Sea) spring spawning herring case study 1961-2020

Henn Ojaveer, University of Tartu, Estonia

Baltic sea spring spawning herring, they have 60 years of data. The Gulf of Riga is enclosed, very shallow, with ice cover in winter, low salinity 6-7, it is eutrophic, with a local well-defined population of herring that can be discriminated by otolith shape. It is a slow growing species that matures at 2 years. The spawning stock biomass (SSB) is between 20 and 160 KT (from 1961-2020) and the maximum catch is 40 KT y^{-1}.

They have been modelling stock dynamics (recruitment abundance I, SSB, plus weight at age after 1 year) over time from 1961-2020, separating the data before and after the regime shift in 1988/89. They have a paper in preparation with a new analysis to explore what affects the growth and productivity of 1 year old fish. They have been including all life stages of different copepods, winter severity summer SST, recruitment and SSB to assess: how important are density dependent processes over the environment?

Model 3 including all terms and interactions was the strongest. In some models the terms were combined (e.g., SSB and R as both separate and combined variables). There was a partial effect of zooplankton and feeding period temperature in interaction with SSB on fish weight R2= 0.51, the interactive effect of R and zooplankton on fish weight was R2=0.48. These were all General Additive Models. They also used a “sliding window approach” to test stepwise changes and strength of linear relationships between mean weight of herring at one year and SSB, R and mean feeding period temperature. A second sliding window was used to look at the abundance of Acartia spp. and E. affinis affinis in August and May. Also considered the data from before and after the 1988/89 regime shi–t - analysed the two time periods separately and found R2 higher (0.6-0.7) than from previous models.

There were partial effects of zooplankton and winter severity. Interaction of R and SSB was important (R2= 0.66) for fish weight from 1961-1988 and for the years after 1988 but this was weaker (R2=0.51). There were also partial effects from zooplankton both in 1961-1988 (R2=0.66) and after 1988 (R2=0.51). So, overall food abundance was important, temperature was minor, and the interactions with SSB and R improved the predictive power indicating that there was density-dependence. The relationships were stronger when the two regimes were considered separately.

Link to ToRs: Directly demonstrates the use of historical data for understanding the drivers of fisheries change (ToR C).

A3.4 Presentations at WGHIST meetings contributing to ToR D

Poulsen (2021) Living on the edge: spatial aspects of historical exploitation of eel resources in Limfjord Denmark (c.1760-1850)

Bo Poulsen, Aalborg University, Denmark

The Limfjord is situated between the Kattegat and North Sea, and it is separated from North Sea by a sandy isthmus has changed through time to open up (breached in 1825) and in turn is affected by local weather, going from being a freshwater fjord to a saltwater strait. The isthmus has moved up to 1-2 km to the east. Work by a PhD Student shows how people lived on such a volatile stretch of land.

Part of the success of these societies was the "pluriactive" lifestyle. The community used the eel resources, historically the eel were a very important part of the diet and culture in W Europe. The Limfjord eel fishery was amongst top 3 most important in EU at the time. Eel were fished using the Dutch seine, not very efficient compared to today, and they used large clubs to make noises (a pulse seine) that scared the "eel offspring" into the nets (they weren't aware at this time that they reproduced in the Sargasso Sea).

Fishermen were perceived at the time as suffering living on the isthmus (in the harsh conditions). 200 fishermen were seasonally migrating, >90% went to one parish during their career and got along very well with the local population in general. Living together with local farmers, some migrated for >40 years (long career). However," Brawls" were documented, in one large one 24 North Sea fishermen attacked 9 resident fishermen (at Tissig vig, Island of Mors) provoked by North Sea fishermen fishing with pulse seine. Locals heard noises and went to investigate. There was a court case, and it was covered in the local news. The North Sea fishermen were sentenced and fined, for fishing off season and provoking conflict. The defence claimed they were good men, but with difficult lives, the purse seine regulations were unfair, and they claimed jellyfish were the problem (not being accounted for by fishing laws). Resources were much more important at this time, life and death, growth in the fishery and human populations corresponded with other parts of Europe

Published in: Poulsen, B. 2021. Between Adaptation and Mitigation: The Nineteenth-century North Sea Storm Surges and the Entangled Socio-Natural Transformation of the Limfjord Region, Denmark. Journal for the history of Environment and Society, 6, 129-157.DOI: 10.1484/J.JHES.5.128582

Link to ToRs: This work uses social and ecological data together (ToR C), it gives an example of long-term change in social-ecological systems responding to past management regimes (ToR D). And this was complex in the past too, humans were at the centre, and there was conflict. Management actions can provide good historical records (for ToR D). It contains a nice example for coping with natural disasters, adapting, deeply rooted eel culture in these populations and interesting management approach Link to ToR C and D. Potentially an example of EBM principles in the past, it shows some adaptation strategies they had at that time to cope with disasters, e.g., differentiating the activities, bending the rules, inventing new technologies. It demonstrates the need for legislation to be flexible in adapting to natural disasters. The ability to switch to different resources was important. Could be one example of past management and EBM and so could contribute to deliverables for ToR D.

Harrison (2021) The widening gap between UK fisheries landings, trade and consumption habits: a 120-year analysis

Harrison, L.O.J[1], Engelhard, G.[2], Thurstan, R. H.[3], Sturrock, A.[1]

[1]University of Essex, [2]Centre for the Environment Fisheries and Aquaculture Science, Lowestoft, [3]University of Exeter

The world is becoming increasingly dependent on international trade to meet fish requirements, which may not be environmentally or economically sustainable. The contributing factors include local depletion of fish stocks, distribution shifts due to climate change, and globalisation. With the UK becoming an independent coastal state following Brexit, we explored the sustainability of UK fish trade and consumption habits over a 120-year time span. Specifically, we analysed trends in landings, imports, and exports, and how each of these meet consumption requirements. Over the last 50 years, there has been an increasingly wider gap between the fish landed, and those consumed. In 1913 and 1970, processed landings accounted for 100% and 65% of the recommended intake respectively, whereas in 2019 this had dropped to 18%. This has economic implications, as the UK is spending increasingly more on imports than is being generated from landings and exports. After adjusting for inflation, the UK lost £408 million in 2019, in contrast to gains of £218 million in 1970. This gap has widened particularly since the introduction of Exclusive Economic Zones and the UK joining the Common Fisheries Policy in the 1970s. Currently, the UK population is consuming more fish than it lands, which has important implications for Brexit and the associated impacts on international trade. As climate change continues and countries increasingly rely on international trade to meet their fish requirements, governments should consider the health, environmental, and economic impacts both on a local and global level.

Subsequently published as: Harrison, L.O.J, Engelhard, G., Thurstan, R. H., Sturrock, A. 2023. The widening mismatch between UK seafood production and consumer demand: a 120-year perspective. Reviews in Fish Biology and Fisheries, 33, 1387-1408. DOI: 10.1007/s11160-023-09776-5

Link to ToRs: This contribution links to ToR D by providing examples of the cultural relationships with fish and fisheries, how resources are valued and how those vary between social-ecological systems, but also through time. We don't like bony fish n–w - as Poul Holm identifies Europeans in the 16th, 17th and 18th centuries had more preference for herring. We export some of the things we don't have a taste for (but is there also a disconnect between fisheri–s - do we export local fish but then import the same fish from overseas?). Our relationship with fisheries has changed in other wa–s - at some points we were more dependent on fisheries and perhaps were more efficient in consuming more of what we landed. (See also Poul Holm's talk about the potato weakening correlations of human demographics with fisheries). Food security is not just determined by the factors determining resource availability (environment, fishers' behaviour, social system dynamics), but also our preferences, how we value things and the historic cultural associations. The mismatch between the fish we catch and the fish we want to eat has implications for future food security as well as environmental state. It determines which fish are considered valuable and so which stocks are fished and what happens to the fish once landed. This also feeds into broader management because inefficiencies in supply chains need to be considered. These dynamics directly inform ToR C in understanding long-term changes in marine social-ecological systems and this can be applied to contemporary science and management, it may also inform ToR D in understanding the outcomes of management interventions.

Thomsen et al. (2021) Societal impact of a collapse in 1830 of Denmark's largest fishery, the Limfjord herring fishery

Lasse Thomsen, Johannes Rom Dahl, Bo Poulsen, Aalborg University, Denmark

At some point in time, a sub-population of herring had begun spawning in the eastern half of the Limfjord on the shallow stretches of the estuary mainly between the towns of Løgstør and Nibe. In some periods over the past millennium, the amount of herring in the fjord provided work for several thousand people, fishing for herring with beach seines, pound nets, and gill nets. Others found work in the supply chain as coopers, net makers, salters or merchants selling the finished product, salted herring in barrels to faraway places such as present-day Germany and Poland. The work was very specialised. With the herring rush (1820s) lots of people went to Nibe, and it was the second most populous town in Northern Denmark due to the herring fisheries, 1550 people were employed as fishermen, and was also important for the crown.

1829 witnessed a mere one tenth of the catches in the previous year. 1830 was even worse, and merchants and fishermen alike lost appetite for placing new investments in the failing industry. Some had substantial capital investments, which were lost, while most of the active fishermen and people occupied in the ancillary industries went into other businesses. Market town of Nibe experienced a strong population decline after collapse of the herring fishery, human population declined in Nibe (by c. 400 people between 1824 and 1840) while towns in the rest of Denmark at that time populatio91ncreaseeased. Information from "departure lists" and the Danish Parish books from 1834 (which contains information on the names, ages, employment, and household composition). They mapped the mobility of people, and many moved to nearby towns (see Table, particularly Thisted, Nykobing Mors, Aalborg). Comparing employment records before 1818 and after 1834, they found before 1818 many were employed as fishermen and salters, with many domestic staff being employed in fishermen's homes and this was not the case after 1834.

Our expectation was that the people moving were mostly fishermen (and male), but more migrants were female than male, and were servants or maids. The employment of domestic staff in fishermen's houses really declined a lot after the collapse of the fishery. A lot of social mobility was observed, with fewer fishermen moving but those fishermen that did move migrated further than the average migrating away from the Limfjord and re-settling in the fjords and bays of the Kattegat Sea on the east coast of the Jutland peninsula (Hjorring, Frederikshavn) and many moved as far as Copenhagen (Fig. A3.21).

The fishery collapse was attributed to the North Sea flow into the Kattegat, but the herring fisheries increased substantially over the 1820-30s. Overfishing was likely the main driver of collapse. Nibe as a community was not resilient to these changes since they were too specialised, population growth had been so rapid and perhaps due to a lack of equity the fishery profits were held by a few individuals.

Census – rapid growth and decline

	År 1801	År 1834	År 1840	År 1845
Nibe	1044	1429	1193	1203
Nykøbing Mors	651	1097	1168	1259
Thisted	1088	1599	1814	2145
Løgstør	463	790	791	831
Hjørring	744	1386	1556	1751
Frederikshavn	463	1163	1247	1332
Aalborg	5579	7048	7192	7477

Source: Danmarks statistik.
*** In 1824 a census made locally by a magistrate states that Nibe had 1550 inhabitants**

Figure A3.21. **Information from the Danish census from 1824 until 1845. Copyright: Lasse Thomsen, Johan-nes Rom Dahl, Bo Poulsen 2022.**

Link to ToRs: Closely aligns with ToR D as it explores what happens when a fishery collapses both directly and indirectly (through direct and indirect employment patterns) would be interesting to ask did the social-ecological systems become more resilient over time - did repeated collapses have the same effects, were they cumulative, did societal response vary. Or were other stocks exploited - did this add resilience? or was it provided through employment in other industries. Really significant implications for local demographics and the movement of people. Also, alluded to inequity - a system whereby most of the profit/business is in the hands of a few can lead to different SE outcomes than if it is more equitably distributed.

Larsen (2021) The Danish Fishery of the Greenland Shark: a study of the historical fishery in Greenland with focus on its development and mutual relationship between society and nature

Camilla B Larsen, Bo Poulsen, Aalborg University, Denmark

This master's thesis investigates the historical fishery of the Greenland shark (Somniosus microcephalus) in Greenland which took place in the 19th and 20th centuries. The investigation is based upon the interdisciplinary research tradition of marine environmental history which com- bines the two sciences of history and marine biology. The focus of the thesis is the development of the shark fishery with regards to its size and the used technology along with the environment's role in the same regard. Furthermore, the thesis will discuss how knowledge of the historical fishery can contribute to knowledge about the biology and behaviour of the Greenland shark. Much mystery revolves around the species and many questions concerning its biology, behaviour, and distribution still need to be answered. Because of the lack of knowledge, it is uncertain whether the shark should be considered an endangered species, which is why an understanding of the historical circumstances is necessary to better understand the present conditions of the Greenland shark population.

The exploitation of the Greenland shark began because of the high amount of train oil that could be extracted from its liver. The train oil was mainly used in the production of lamp- and machine oil and became a very important export product to the Royal Greenland Trade Department. By studying 18th century diaries, registers of catch numbers, and registers of purchased liver, the thesis has put forward a timeline of the development of the fishery from its early be- ginning throughout its growth, whereby a starting point of the commercial shark fishery has been presented. The first systematic fishery began in 1786, but it was not until the middle of the 19th century that the fishery began to grow. From 1862 the catch numbers grew rapidly with 16.436 sharks caught. Compared to the period 1786-1790 where 102 sharks were caught and 1845-1849 where the number reached 2.000, there is little doubt that the commercial shark fishery began around 1862. Among the main reasons for the growth was the introduction of a new fishing technology to replace the old, unproductive shark beam fishery: fishery through holes in the ice. This technology was both effective and cheap, but because of the importance of the ice in the fishery, some colonies were better suited for shark fishery than others. Thus, the shark fishery became a predominantly Northern Greenland initiative, and a co-dependent relationship between the fishermen and the natural environment was created.

By investigating the weekly catch numbers and the state of the ice in the 19th century, this thesis has presented the theory that while the ice was of great importance to the fishery, the presence of the sharks was the essential factor for which time of year the shark fishery season occurred. Interestingly, the shark fishery in all the northern colonies peaked during spring or summer where the ice was less secure than during winter times. Furthermore, the investigation showed that the peak in the different colonies appeared within a month's interval starting in April in the northernmost colony Upernavik. Going south, the peak in the fishery in Umanak (Uum- mannaq) appeared in May-June, Jakobshavn (Ilulissat) in June-July, and Christianshaab (Qasigiannguit) in July and again in September-October. Thus, a south-moving pattern occurs which could reflect a migration pattern among the sharks as it certainly does not reflect the best times for ice-fishing.

The thesis' study of the fishing technology has identified three phases in technology shifts: the shark beam fishery, the ice fishery, and deep-sea fishery with long-lines and motor vessels. The latter was introduced in the 1930's where a "revival" of the shark fishery as a supplement to the cod fishery was attempted, but without success. By 1948 the demand for shark liver oil had been reduced greatly due to the invention of synthetic oil, and by the 1960's the Greenland shark fishery had ceased completely. What remains, though, is the question whether the historical fishery has affected the shark population. Therefore, the final part of the thesis dis- cusses the potential consequences of the shark fishery. By comparing liver sizes, statements regarding the sizes of the sharks, technology, and new scientific observations, the thesis has put forward the possibility of a selective fishery that caught more sharks belonging to the older and sexually mature part of the population. Since the Greenland shark reaches sexual maturity at a very high age (possibly when it is 134 years old), this could explain why no pregnant Greenland sharks have been observed in the last 60 years, as the fishermen thus mostly caught sharks that would constitute the sexually mature part of the population today.

URL for thesis: https://www.aau.dk/study-of-the-historical-fishing-of-the-greenland-shark-near-greenland-focuses-on-interdisciplinary-cooperation-n61275 (last accessed 09/01/2024).

Link to ToRs: Again, another really nice example of cultural relations (links to ToR D), Greenlanders didn't fish the sharks due to tradition (ammonia, flavour, toxicity) of feeding them to dogs (or did that happen later?), how unique ways of fermenting to preserving/treating/storing (Hákarl) make them a national delicacy (national dish of Iceland) and so part of their food culture today. Also, of great interest for ToR C, from a management point of view - their ecology has really saved them, we need to understand fisheries with very different life histories. They can't all be managed the same way - might be more apt to apply principles/approaches used for mammals to some longer-lived fish species. Also, could feed directly into conservation lessons/targets. As for Indonesia, important points about scale (including extrinsic events; arrival of the Dutch with different culture and gear?). Interesting from a technological innovation angle too, some very different approaches that were variably effective, plus complication of ice - and as the Dutch arrived fishing grew where previously not substantial due to historic practice and values. Could contribute to our deliverables for ToRs C-D.

Firth (2021) What have limpets ever done for us? On the past and present provisioning and cultural services of limpets"

Louise B. Firth, School of Biological and Marine Sciences, University of Plymouth, UK

Limpets are one of the most abundant and familiar rocky shore organisms globally. They are perhaps most famous for their ability to cling onto rocks, but they are also well known for their grazing activity, which has an important structuring function. Limpets are celebrated for their tenacity. Their ability to cling to rocks and other hard surfaces has made them synonymous with persistence and determination. This trait was recognised by Aristotle (350 BCE) who noted 'even the limpet releases its hold in order to search for food'. In contrast to other molluscs, such as oysters and mussels, which are celebrated for their gastronomic and cultural importance, little is known about the provisioning and cultural services of the humble limpet, and they are often referred to as 'famine food'. Using an interdisciplinary approach, this paper describes the importance of limpets in the diets and cultures of humans globally. Not only were limpets often the dominant shellfish eaten by early modern humans, but also, they sustained the poor during times of famine and destitution. Today, they are considered a delicacy in many cultures. They are popular as bait and their shells have been used for a wide variety of uses, including tools, currency, offerings, traditional medicine, jewellery, and artworks. They have important spiritual and religious relevance, featuring in myriad traditions, superstitions, and folklore. Whilst limpets are not exploited on a global scale, there are many regions where populations are vulnerable to overexploitation and possible extinction. Appropriate management is required if we are to protect these underappreciated animals. This comprehensive review rectifies the limpet's reputation as 'famine food' and attests to the important role that limpets played in past and present coastal cultural heritage and food culture.

Published in: Firth, L. 2021. What have limpets ever done for us? On the past and present provisioning and cultural services of limpets. In: Beattie, J. (ed.) International Review of Environmental history, 7 (2), 5-45. ANU Press, Canberra. Australia. https://t.co/zlVs8Ypza6 (last accessed 09/01/2024).

Link to ToRs: Some interesting examples here of cultural links to resources (expressions, language, stories especially in Scotland), a seemingly common one and how the perceived value of a resource varies between societies (Ireland, Scotland, England, France). Curiously not eaten in England could this be linked to extent of habitat (ie rocky shore). Makes a very interesting comparison with oysters, and how it is related to abundance of the stock, ease of collection (when abundant and common are perceived to have less value). Does perceived value vary through time as well? Links to ToR C and D: Links to ecosystem services from shellfish, might play an interesting role as an alternative food source during times of shortage, political upheaval, establishment of new societies - link to BG potential, presents a degree of "back-up" food source.

Fitzhugh (2022) Historical ecology in North Pacific Fisheries: A retrospective analysis of the evolution of Indigenous fisheries management on Kodiak, Alaska

Ben Fitzhugh, University of Washington, USA

- Colonial Era Alaska, serious blue resource extraction
- 18th – 19th centuries – Sea otters overharvested for Russian-American commodities extraction. 1867 – U.S. purchase and expansion of other extractive fisheries: 1890 commercial fisheries (salmon, herring cod, pollock, etc), unregulated for the next 35 years
- Major resource extraction - huge salmon fish traps (peak catches 1936) -collapse in 60s
- 1924 White Act (salmon harvest to 50% of total pop, poorly enforced and lobbied; 1959 establishment of Alaska as independent state assumes control of fisheries
- (1960s) Science based management (escapement) - to ensure "fair" allocation and conservation.
- Indigenous people being told how and where to fish.
- Federal and state model ignores sustainable indigenous fisheries. Indigenous communities have their own traditional ways of managing - territorial control, innovative, sustainable harvesting, habitat management.
- Indigenous management based on social and cultural values, spiritual connection and reciprocity with other living beings, social and moral reps, waste nothing, preserve the resource. "Salmon boy a Tingit story" - lesson on respect for food and how to treat salmon.
- Indigenous management is far more than just biology and management techniques, it's an attitude. Some very nice examples of indigenous management approaches, open access/equity.

- Ben's teams project on the Kodiak Archipelago seeks to track the development of these practices in the archaeological record and to answer the question: where did this knowledge come from? Native Sugpiaq people must have learned it - suggests intimate knowledge of resource (indigenous science), assessing & determining when interventions might be needed.
- Unpublished evidence from >2000 years ago suggests key salmon declines at 4800 ya, 3800 ya, 2000 ya. Link between human and fish populations? If highly resource dependent on one stock
- Learnt the hard lessons – these would have been times to develop adaptive management strategies.
- Examples of marine mammals as well, also evidence of indigenous overfishing, but only before 5000 BP (Kopperl, 2003. PhD Thesis, D. Anthropology, University of Washington. ProCite Dissertations.)
- Look for evidence of conservation in the past - expect to see this correlated with resource depletion and human population decline. E.g., weirs/trap use back to 4500 years or so; predict translocated fish to reseed streams to increase production evident in palaeogenetics at pinch periods.
- Reconstructing from fish bones, but also gear? Or community diet, genetic evidence
- Recent research comparing prehistoric and commercial cod size distributions show no impact of fishing on cod size for 6000 years prior to last 100 years (West et al, 2022. Quaternary Research, 108, pp.43-63.)

Links to ToRs: Could be applied to deliverables under ToR D, it could provide information on EBM, EABM or EBFM examples. Also, human conflict issues and data. Some similarities with the Venetian lagoon, very specific and detailed management.

Vianello (2022) The importance of qualitative research: a historical-anthropological perspective on mussel farming in the Venice lagoon

Rita Vianello, University Ca Foscari, Venice, Italy

- Anthropologist working on mussels.
- Material culture: the visible and concrete aspects of a culture (artefacts and tools of daily life and productive activities).
- Intangible culture: practices, representations, expressions, knowledge, skills.
- The methodology: How are cultures investigated? Field research and interviews
- Fishing uses material objects to capture the intangible. The culture cannot be measured or quantified and doesn't respond to any law and can give voice to those who don't have one.
- Conducted interviews with mussel farmers and collected testimonies.
- Fishing requires specialist ecological and environmental knowledge (LEK)
- Alfredo Gilebbi, from the Marche region, launched the first mussel-farming in the lagoon in 1939: it is a new human use of mussels. This event has given rise to what can be defined as a "foundation myth" of lagoon mussel-farming. Mussel farming was an annual practice.
- Until the 1950s, the fishers of the island of Pellestrina, on the southern side of the Venice Lagoon, considered them inedible and called them *peòci,* lice
- If we consult the naturalists of the past (for example Linneus, the French Buffon D'Aubenton, De Roissy, the Venetians Chiereghin and Olivi, and the ancients Aristotle, Pliny the Elder, Aelian), we find a "dubious" perception of this mollusk throughout Europe: mussels were considered poisonous and carriers of disease.

- During the Roman era, mussels are mentioned in the *Naturalis Historia* of Pliny the Elder (23-79 A.D.). He speaks of the mussels using the word "louse": *pediculus* in Latin. It is interesting to observe that still today, Venetians call the mussels *peòci,* that means lice. In his work, which dates to about 77 A.D., Pliny gives several descriptions of the beliefs and superstitions prevalent among the people of the time.
- Why in the regions of the Northern Adriatic does this habit of naming mussels after somewhat repulsive parasites persist? Is it a linguistic fossil inherited from the Romans or is it another reason?
- Linguists and anthropologists explain that the colloquial names for marine animals appear to be drawn mainly from the vast repertoire of terrestrial names, which is what people knew best.
- Anthropomorphic vision: Creation of linguistic models based on human behaviour. When the fishers became mussel farmers: they began to develop new metaphors based on the plant and animal world, enriching local knowledge.
- Farmers perceive the mussels as delicate children with an umbilical cord, to care for and protect as they grow, but when they refer to them as a commercial product, their perception changes and they use the generic term "stuff".
- Mussel-farmers say: "When it's really hot and when it's really cold, mussels and bivalves have milk".
- Two dimensions of knowledge coexist: scientific (fishers rarely accept) and fishers' local knowledge (often defined as a set of beliefs or folklore). Fishers see prevarication and feel ignored, they think science is from books not observation.
- A social will is acquired by the entire community. The language used to describe the mussels changed to "small babies" rather than "lice".

Link to ToRs: good example of using multiple data sources synergistically (ToR B) and perhaps ToR D.

Danto (2022) Socialist fisheries in the Adriatic and central Mediterranean: the case of tuna fishing. Original sources and originality of the sources

Anatole Danto, La Rochelle University

Initially, a project on access to quantitative and qualitative data produced by:

- Former fishing kolkhozes; former fishing and aquaculture sovkhozes; Socialist scientific work on fisheries. The question was quite simple. With the collapse of the USSR and satellites, where is the data (?) to answer: How has "collectivization of production" homogenised (or not) practices? How were borders managed?
- The work initially focused on the Baltic and Caspian Seas. We are now starting to extend it to the Yugoslavian Adriatic (Socialist Federal Republic of Yugoslavia, SFRY), and we have chosen tuna fishing for different reasons:
  - emblematic character of this fishery
  - management of stocks by ICCAT (international policy)
  - numerous French-speaking sources
  - "straddling" stock, which logically poses issues of categories and borders

We identified sources and began to work on them:

- Archives of the International Organisation dedicated to EBFM for tuna in the Atlantic and neighbour seas: ICCAT archives (in Madrid and online): International Commission for the Conservation of Atlantic Tunas – created in 1966.

- Online "Collective Volumes of Scientific Papers" (Col.Vol.Sci.Pap. ICCAT)
- Scientific advice, Quantitative data, Mapping, Management policies inside
- Archives in ethno- and eco-linguistic, coming from Geneviève Massignon (French ethnolinguistic scientist, CNRS). She conducted research in the Mediterranean Sea on tuna fishing.
- Lots of archives, oral and written (recordings of surveys, and field notebooks), finally accessible at the BnF after 2 years!
- Geneviève Massignon (1921-1966): Part of her work was in fact a part of a larger regional ethnolinguistic atlas (LRA, Linguistic regional atlas: ALM = Atlas linguistique de la culture Méditerranéenne), part of a global long-term project Atlas Linguarum Europae (ALE) – 546 items per interview (Linguistic global atlas). Massignons' survey < ALM (LRA) < ALE (LGA)
- LRA Atlas Ethnolinguistic atlases are an extraordinary source of data: A common interview framework shared by researchers. The only existing boundaries are isoglosses (no ecosystem or administrative boundaries). The data is collected in a standardised way, and it is generally accessible. And above all: these atlases are "permanent". They are generally still in progress (diachronic aspect), which makes it possible to carry out longitudinal monitoring (diachronic anthropology).
- This also makes it possible to: decipher local links to nature (species, habitats), changes in identity (disinterest in fishing, homogenisation of practices by supranational regulations, ICCAT, USSR, etc.), but also to collect vernacular terminology (dedicated in particular to fauna, flora and toponymy, useful for textual research in environmental history and historical ecology); and, finally, to collect local and traditional ecological knowledge and to work at the micro-local scale (a port, a single people).

Documents coming from the Socialism era (SFRY) (original sources of fishing management and issues)?

- What's about Federal institutions' archives now (management of fishing institutions, marine stations of Academies of sciences, ...)?
- What about multi-harbours, firm archives (sovkhozes, canneries, ...)?
- What about local kolkhozes archives (still exist or not? Are they private or public now?)?

Documents coming from a more ancient time (Fig. A3.22): French (short) era in Adriatic?

- Beginning of a work on the French navy division of Adriatic (Division Navale de l'Adriatique). Archives in French SHD: MV SS B (Vincennes), and maybe Toulon (''Levant'' fleet head harbour).
- But also, contemporary information coming from the French fleet dedicated to control of Tuna fishing in Med Sea (SHD – Brest, Toulon, Vincennes) But secret archives during 50 or 100 years.
- Atlas of the Language of the Sea in Dalmatia and Kvarner: The JAPRK Project
  ® Contact the researchers who are leading this project (Vuletić, N., & Skračić, V. (2016).

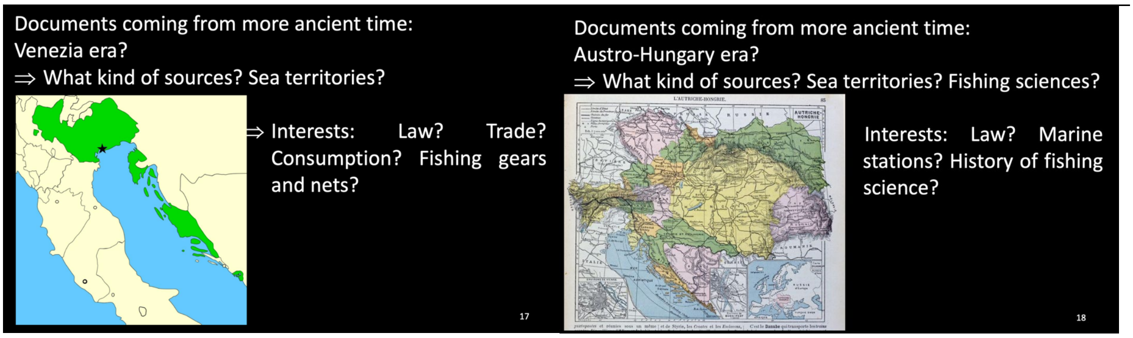

Figure A3.22. **Maps and sources of information used to extract data and information on the Adriatic and central Mediterranean tuna fisheries. Copyright Anatole Danto 2022.**

Linked publications:

Anatole Danto, Jules Danto. Traditional and emerging territorial functionalities in a (post-) socialist context: the case of fisheries-aquaculture transition. Dynamiques Environnementales - Journal international des géosciences et de l'environnement, 2022, Varia, 48, pp.64-100. DOI: 10.4000/dynenviron.5979

Link to TORS: Demonstrates use of a mixture of sources including those from anthropology especially linguistics (ToR D).

Heard (2023) British Seafood Consumer Footprint through time: quantifying seafood trade flows to and from the UK

Zoe Heard, University Exeter, UK

Doing her PhD with Ruth, Callum Roberts and Seachange.

Research questions:

- Where is our seafood coming from, and how has this changed through time?
- What are the potential ecological impacts of our global reach for seafood products on exporting countries?
- This study marks the first attempt to look at the evolution of commercial international seafood trade in the UK from 1890.

Source of data: UK Sea Fisheries Statistics Annual Reports (1890-2020).

Data extracted:

- Landings into the UK, inc. from foreign vessels (total)
- Seafood exports (total)
- Seafood imports (total)
- Country specific imports (total tonnes of seafood products coming from exporting countries into UK)
- Product specific imports (inc. fish/marine mammal products, e.g., whale/fish oil, fish meal/flours, whale bone, shells)

Sampling strategy:

- To show a snapshot through time, data was collected for the decades: 1890-1900, 1920-1930, 1950-1960, 1980-1990, 2010-2020.
- 3 years from each decade (e.g., 1893, 1895, 1897) were averaged.

Hope with this data to be able to infer ecological impacts of fishing in exporting countries to meet our demand. Whale and fish products (oils/meals/flours) were key species throughout as well as cod and to a lesser extent, salmon.

- Found that 63% of imports came from other countries, with large volumes from Canada and N America (1890-1900).
- 1920-30 Importing a lot more, from Norway Germany, Australia, Russia, India Japan, Canada
- 1950-60s doesn't record non-food products nor distinguish deep sea fisheries.
- 1980-90 imports peaked with 47% from other countries, still a lot from N America and Canada.
- 2010-2020 6% came from other countries China and Germany plus the others.

The number of countries importing from have increased through time, the top 10 most imported species were cod, haddock, we import fish oil and meals, whale oil production dropped off (from Norway, Spain and Holland; Fig. A3.23). Ecological impact of these fisheries imports was euro-centric in 1923, diminishing whale, cod and herring populations in Europe, in 2017, our global reach was much further, leading to potential overfishing of tuna in Seychelles, Ghana, Mauritius and Ecuador, and destruction of mangroves for shrimp farms in India and Vietnam.

We asked, how much do imports contribute to relative landings? In the 1950s imports exceed exports, by 1985 imports exceeded UK landings. We imported nearly double the amount of sea-food we landed into UK in the last decade suggesting a heavy reliance on seafood from abroad (Fig. A3.24). Especially pertinent now that we are trying to reach net zero in the UK by 2050, important to start eating local. We need to start asking the question: why can’t we meet local demand, what do we need to do to restore our own fish stocks, and how can we encourage local seafood produce?

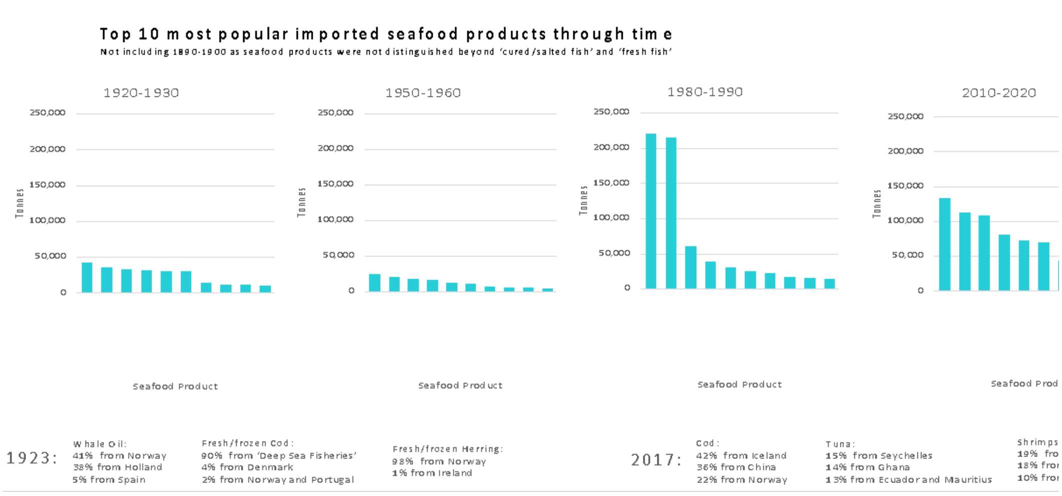

Figure A3.23. Top 10 most imported seafood products in the UK from 1920-2020. Copyright: Zoe Heard 2023.

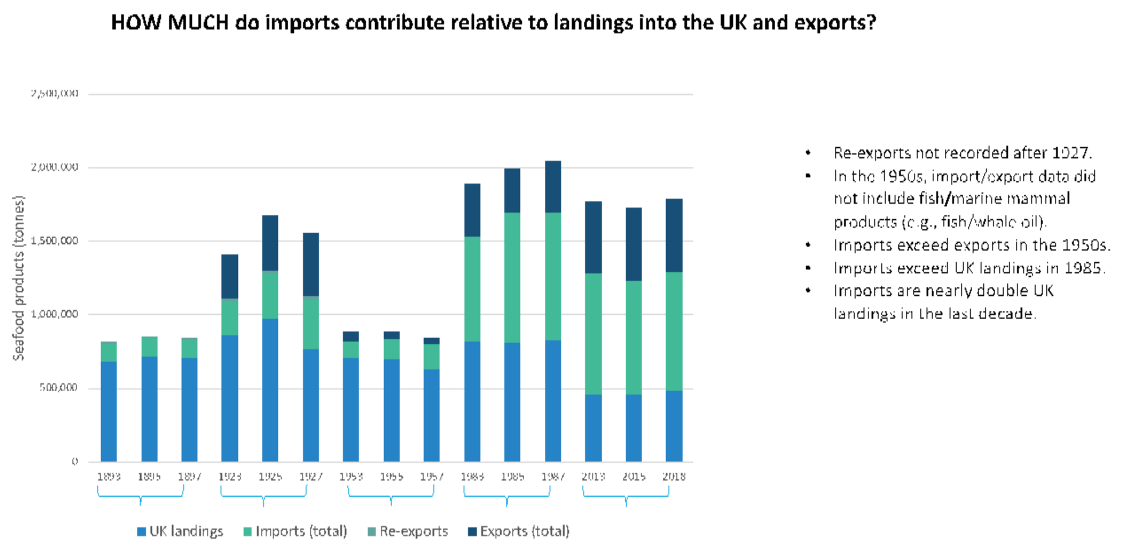

Figure A3.24. UK imports of seafood products compared with landings and exports from 1803 to 2018. Copyright: Zoe Heard 2023.

Link to ToRS: This contribution links to ToR C and D by providing examples of the cultural relationships with fish and fisheries, understanding how resources are valued and how that varies through time. It can help to understand national behaviour and trends especially because data is often considered discreetly in some kind of spatial unit (by fishing ground, port of landing, fish market). Inclusion of imports and exports are needed to get the full picture of resource extraction and use. Luke Harrison and Poul Holm's contributions shows that tastes change through time), we export some of the things we don't have a taste for. This contribution shows how imports contribute to relative landings and that imports can be considerable exceeding landings by up to double in recent years (as transport has become more efficient and cost-effective). It creates problems of food security but also in terms of reaching net zero. We need determine why we can't we meet local demand, and how can we encourage consumption of local seafood produce. These data and lines of enquiry contribute to both ToR C and D, understanding long term social-ecological systems behaviour and understanding what management intervention is needed and how these fit into broader management.