Theme session A 2021

Top predators, food webs, and ecosystem-based fisheries management (EBFM)

Conveners: Christopher Lynam (UK), Anita Gilles (Germany), Andrew Trites (PICES/Canada)

Session A received 28 presentations, including 14 from Early Career Scientists, that addressed 5 sub-topics:

1. **Foodweb modelling** to identify consumption requirements of top predators along with the production of fish prey (e.g. multispecies functional response and dynamic energy budget models) [8 presentations]
2. **Spatio-temporal empirical studies** to identify overlap between predators and prey [8 presentations]
3. **Evidence of indirect interactions** between fisheries and top predators: specifically, competition for food sources or fisheries losses (discard/slippage/offal discharge) as a food source [4 presentations]
4. **Assessment approaches** that can deliver ecosystem advice including but not limited to the extension of multi-species fisheries models to include top predators, Bayesian network analyses and risk-based models [4 presentations]
5. **Management options** that enable productive fisheries and support conservation aims, including spatial and temporal management of fishing fleets through protected areas, seasonal closures, catch restraints and effort limits [4 presentations]

The majority of presentations fell under the first two sub-topics (predator-prey interactions), but each sub-topic was addressed with highly relevant and interesting material.

One additional presentation given by the PICES co-convener A. Trites explained the derivation of recently updated equations to estimate daily prey consumption by marine mammals as a function of their cost of living. These equations were used by T. Tamura who demonstrated that survey estimates of biomass, along with residence time, for a range of cetaceans can be used to determine the prey levels that current populations of marine mammals require in the North Pacific. For the Nordic and Barents Seas, M. Skern-Mauritzen compared marine mammal consumption to removals by fisheries, and emphasized the importance to integrate these complex mammal-fisheries interactions in EBFM. However, such levels of prey must be available to the predators both temporally and spatially, including in the vertical dimension as addressed by J. Fall's study of interactions between capelin and cod in the Barents Sea.

Predator species may also compete for access to habitat and prey resources as suggested by N. Goñi's investigation on the avoidance of albacore tuna by bluefin tuna in the Bay of Biscay, while A. Dolgov noted the persistent lack of large predatory fish in the Arctic Seas. For successful foraging, prey species must also be of the appropriate size for the predator as demonstrated by A. Receveur's study of interactions between pelagic prey and predatory tuna and shearwaters in the southwest Pacific — and by A. Mulas for deep-sea elasmobranch species inhabiting the Sardinian slope. Additionally, climate change might drive alterations in abundance and body size (M. Erauskin-Extramiana). Clearly effective foraging requires a greater biomass of prey in an ecosystem than solely that needed to meet energy demands of the predator, but it is also important to note that the size and energy content of prey differs between species (as demonstrated by C. Booth for harbour porpoise diet). Diet studies, such as from A. Preti on dolphins, are key to understand spatio-temporal shifts in predator distribution but also highlight the need for more information on prey distribution. In this respect new methods, such as DNA-barcoding techniques (Lucile Ranguin/Jean-Paul Robin) are key to overcoming some limitations from hard-part analysis.

There are a number of ways in which fisheries impact top predators. For example, I. García-Barón demonstrated that Great shearwater over the Armorican slope and southern off-shore waters are at risk of bycatch by the artisanal tuna fishing fleet. In addition, fisheries can lead to indirect impacts on predators as shown by the model study of O. Paradell, who found that diets of top predators can be altered when ecosystems are fished at high or low levels. Alternatively, N. Kulatska demonstrated that natural mortality on sprat in the Baltic Sea (i.e. through predation by cod) was greater historically than mortality imposed by pelagic fisheries, but as the cod stock declined and consumption shifted towards smaller individuals, this pattern reversed. J. Burgess documented an increased mortality rate of grey seals in years with higher sandeel landings potentially linked to indirect competition with fisheries for sandeels or concomitant with change in the environment. Thus, fisheries management can have unintended consequences such as that postulated by S. Quer in her study on the potential early implications of the landing obligation on Great skua diet since a decrease in the proportion of fish prey has been observed since 2015.

Fisheries and predators are able to coexist as demonstrated by P. Breen in her study of the common scoter and razor clam fishery in the Irish Sea. The qualitative modelling approach of L. Clavareau demonstrated clearly that depredating species can be tolerated by a fishery if fishers are more successful in capturing fish than depredating species are at removing their catch from fishing gear when stocks are sustainably managed.

Potential foodweb effects linked to commercial fishing were demonstrated by A. Fariñas-Bermejo whose study on top-predators in the Celtic Sea ecosystem found that a high abundance of the sprat stock was linked to the occurrence of fin whales, while humpback whales and minke whales were in higher abundance when herring dominated. Similarly, S. Surma demonstrated the Norwegian spring spawning herring were key in the diet of minke whales, harp seals and killer whales—and fisheries could have competed with top predators historically (1960-70s) when over half of herring production was harvested annually. Environmental variability and zooplankton productivity at the base of the foodweb is important also as demonstrated by the large-scale movements of baleen whales in the mid-Atlantic Ocean by S. Pérez-Jorge. Similarly, G. Pierce highlighted, in their study of persistent organic pollutants in small cetaceans in European waters, that human impact can arise through other activities. A fuller understanding of the impacts of contaminant and pathogen flow through marine foodwebs is required within EBFM.

From a foodweb perspective, areas of resilience can be identified from traits-based analyses as shown by L. Flensborg, which can inform spatial management to maintain ecosystem functioning. Marine Spatial Planning and management (MPAs) were considered key to the successful development of extensive wind farms offshore. One means to evaluate the trade-offs this poses for fisheries and conservation is to use spatial modelling through Ecopath with Ecosim (EwE) and the extension Ecospace as demonstrated by M. Püts.

M. Coll gave an overview of a programme of work addressing EBFM in the Mediterranean Sea. She addressed a significant body of work on the ecological and socio-economic consequences of the changes in small pelagic fish populations on fisheries, iconic predator species, and ecosystem-wide dynamics; and provided a robust means to evaluate future management options.

X. Corrales communicated the development of an EwE Ecospace model for the Bay of Biscay to inform Integrated Ecosystem Assessments enabling interactions between climate change and fishing strategies to be investigated. D. Chagaris similarly demonstrated that models of intermediate complexity, using the EwE framework, had been used successfully to deliver management advice for "Ecological reference points" for Atlantic menhaden.

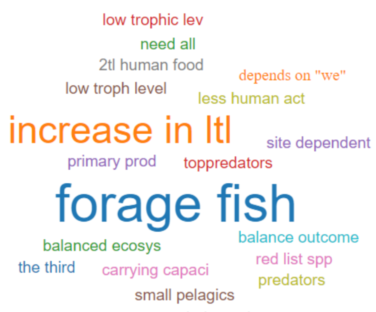
J. Thayer's presentation "Implementing Ecosystem Considerations in California Current Fisheries" was particularly noteworthy as she demonstrated the wealth of studies required and the framework needed to integrate available information into management outcomes. In addition to identifying prey needs of predators through empirical diet studies and meta-analyses, they also quantified needs through modelling to determine predator productivity thresholds of prey abundance. The key fishery – predator interactions were then documented in ecosystem assessments to highlight trade-offs between forage fishing and predators, and the spatial overlap between fishery and predator hotspots. Assessment approaches to deliver ecosystem advice used both quantitative predictions for fish stocks and qualitative forecasts for impacts on predators. In order to develop effective options EBFM, precautionary legislation was of utmost importance, and fishery management plans were needed that incorporated ecosystem considerations. As a result, spatial management (including MPAs) and harvest guidelines to avoid harm to predators have been possible.

Five polls were asked of the session attendees, and the responses provided useful information. Clearly a range of outcomes from EBFM was desired, but overall respondents considered that a healthy prey base of generally low trophic level forage fish for predators was key. Notably, the role of jellyfish in marine ecosystems was considered important to understand the prey distribution of top-predators [40 respondents]. In terms of integrative modelling approaches that are able to support effective ecosystem-based management actions, Ecopath with Ecosim and End-2-End models were considered the main options available currently**.** The best-known examples of EBFM (including top predators) in practice were considered to be enacted by the USA for the California Current Ecosystem and by Norway [25 respondents]. In response to the question, “*Which parameters and processes are critical to test the impact of closed areas for highly migratory species?*”, the majority of 25 respondents considered movement in/out of MPAs the most important. However, respondents mentioned that the spatio-temporal response of fishing fleets and their impact on spawning/nursery habitat quality should be considered also.

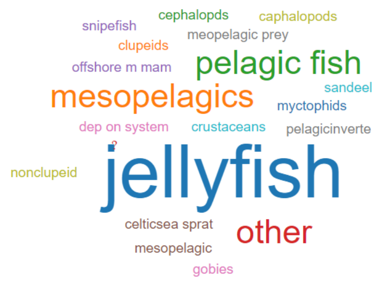
Conclusions

The area of Ecosystem Based Fisheries Management was clearly of broad interest (with over 200 participants attending the session). However, the scientists working in this area are often working in silos relevant to their ecosystem component and/or key pressure. To improve ICES science and advice in this area, we as a community need to continue to connect people, not least biologists with ecologists, modellers and social scientists both within government institutes/agencies and wider academia. Currently, there is a broad range of working groups within ICES that touch on this area. To further the collective need and desire to improve ecosystem-based fisheries management, we recommend that ICES and PICES hold a workshop on EBFM that brings together its wealth of scientists from a range of Expert Groups.

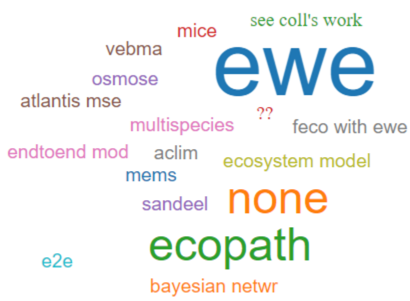
WHAT DO WE WANT MOST? INCREASE IN ALL TOP PREDATORS OR IUCN RED LIST SPECIES, PLENTIFUL FORAGE FISH FOR FISHERIES OR FOR AQUACULTURE FEED, INCREASE IN LOW TROPHIC LEVEL SPECIES AS FOOD FOR PREDATORS? [32 ANSWERS]



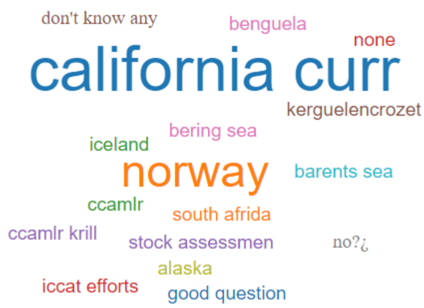
WHICH ARE THE KEY PREY SPECIES FOR WHICH MORE DATA IS REQUIRED TO UNDERSTAND THEIR BIOMASS/DISTRIBUTION: GOBIES, GURNARDS, CEPHALOPODS, JELLYFISH, OTHER? [40 ANSWERS]



WHICH INTEGRATIVE MODELLING APPROACHES ARE CURRENTLY ABLE TO SUPPORT EFFECTIVE ECOSYSTEM-BASED MANAGEMENT ACTIONS (INCLUDING HUMAN, STOCK AND DEPREDATING SPECIES)? [25 ANSWERS]



WHERE ARE GREAT EXAMPLES OF EBFM INCORPORATING TOP PREDATORS? [20 ANSWERS]



Polls downloaded 15 Sep. 2021