

## Theme session I

Seasonal-to-decadal prediction of marine ecosystems: opportunities, approaches, and applications

Co-sponsored by PICES

Conveners:

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In recent years we have seen a dramatic increase in both the amount of oceanographic observations available, and in particular, the development of environmental forecasts with meaningful skill on the seasonal-to-decadal (3 months - 10 years) time scales. This theme session focused on the fundamental question of marine ecosystem prediction at seasonal to decadal scales. Such forecasts are potentially of great value to the ICES community, as they mirror the timescales on which ICES generates scientific advice, and plans monitoring programs. Applications of this knowledge for the management of fisheries are now starting to emerge in other parts of the world, most notably in Australia, although such work has yet to fully emerge as a recognized discipline. The ICES community, however, is already lagging well behind other parts of the world in the development and application of such approaches. The aim of this theme session was therefore to bring together the global community of researchers working on these topics to form the core of a new research community and to inspire the development of comparable products here in Europe.

The theme session was both well-subscribed and well-attended over three sessions on the opening two days of the conference. More than thirty abstracts were received and a total of 23 presentations delivered. Interestingly, both the presenters and the audience tended to be relatively richer in researchers from North America than was seen in other theme sessions, possibly reflecting the greater awareness in this region of the predictive potential of ecosystems.

The theme session opened with three invited scene-setting talks that provided background knowledge for those not familiar with the issues at hand. Alistair Hobday (Australia, I:253) provided an overview of the work that has been done in Australia looking towards prediction of marine ecosystems in general, while Claire Spillman (Australia, I:190), via video, presented examples of seasonal forecast systems currently in operation. Daniela Matei (Germany, I:652) complimented these talks with details from a climate modelling perspective of how and why forecasting the oceans at these long time-scales is feasible - a particularly important point was that European waters and the North Atlantic are amongst the most predictable in the world with forecast horizons potentially extending beyond 10 years.

Examples of forecast products that were already in use in the USA were also presented. An overview of US stock assessments (I601) highlighted a total of 23 stocks (5%) where environmental and ecosystem knowledge is used directly in generating advice. The California sardine stock, with its strong and well-recognized physical-biological linkages, is the most prominent of these, and was addressed by two talks: one describing the problems encountered with getting forecasts acted upon (I628), and another quantifying the added-value that forecast information gives to advice (I543). Other products from the US included the Coral Reef Watch product for management of tropical coral ecosystems (I:239) and forecasts of the timing of the Gulf of Maine lobster fishery (I:527).

The remainder of the talks focused on “work-in-progress”, grouped loosely according to the environmental variable being forecast. Talks addressing the spatial distributions of species (I262, I132, I421) focused mainly on the processes driving distribution shifts: however, in two cases, for Atlantic Bluefin Tuna (I330) and blue whiting (I276), the presenters were able to take this to the next step by coupling this knowledge to oceanographic forecast models and thereby demonstrating forecast skill for these species out to 10 years into the future.

Recruitment prediction also featured strongly (I240, I242, I298, I351, I655, I272). The approach taken by most of these talks was generally empirical in nature, and was aimed at detecting environmental variables that can retroactively explain observed recruitment variation, using either traditional correlation analysis or, in one instance, more powerful techniques that claim to approach causation (I242). A notable exception to this tendency was work focusing on mechanistic drift-modelling of NE Arctic cod larvae by Kjersti Strand (I351), where the processes contributing to off-shelf advection of larvae (and thereby poor recruitment) were investigated mechanistically and drivers identified.

A notable outlier talk was presented by Alan Haynie (I654), who presented work on modelling and forecasting the distribution and behavior of fishers in relation to environmental, economic and management behavior. This talk was particularly eye-opening, as it extended into a realm not normally considered as “predictable”, but also highlighted potential avenues that may have forecast skill comparable to many biological variables.

The final part of the theme session was focused on building a research community around the topic of predicting marine ecosystems. Presentations were given by working groups from ICES (WGS2D), PICES/CLIVAR (SG-CEP) and IMBER/CLIoTOP, all of which are focused on the common task of predicting ecosystems. These groups are regionally focused, but as a result of this session have now formed a wider global network where ideas and experiences can be exchanged and developed e.g. a joint theme session at the Fourth “Effects of Climate Change on the Worlds Oceans” Symposium in 2018 has been mooted.

Manuscripts presented in this theme session are also being submitted to a “research topic” (*i.e.* a special issue) of the journal *Frontiers in Marine Science* (<http://journal.frontiersin.org/researchtopic/4484>), which will further develop the work presented and provide direction for this field. Also, an extended discussion and brainstorming exercise as part of the final session provided the input into a review article with the focus on the lessons learnt thus far, and potential future directions.

In conclusion, the theme session was well received and appears to have achieved the goals of bringing examples of operation forecasting systems for marine resources to Europe and forming a community around marine ecosystem prediction. There remains, however, much to be done. While North America and Australia are clearly leading the world in terms of applying this type of knowledge, it is still only used in a few percent of stock assessments (North America) or fisheries (Australia). The prior impression that Europe is lagging behind was reinforced, despite the fact that some of the planet's most predictable waters are on its backdoor step. Developing biological forecast systems and realizing their full potential will require moving beyond correlative understanding towards a mechanistic grounding. This theme session highlighted that forecasting biological systems is possible, and can contribute to the management of marine ecosystems: the challenge now is to accelerate the process of developing these products and to incorporate them into management.