Forecasting fish distribution and abundance in the Atlantic Ocean: The challenge of balancing exploitation and sustainability

- POLICY BRIEF -

ABOUT

This briefing document was produced for the Science-Policy Discussion on 'Forecasting fish distribution and abundance in the Atlantic Ocean: The challenge of balancing exploitation and sustainability' organised by three Horizon 2020 projects, Blue-Action, TRIATLAS and MISSION ATLANTIC, with the support of the European Parliament Intergroup on Climate Change, Biodiversity & Sustainable Development on 3 December 2020 as an online event.

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Suggested citation: Payne, M. R., Keenlyside, N., et al. (2020): Forecasting fish distribution and abundance in the Atlantic Ocean: The challenge of balancing exploitation and sustainability, Blue-Action policy briefing, DOI: https://www.zenodo.org/record/4289935

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The Atlantic must be considered in its entirety. The circulation of the ocean and atmosphere connects the Atlantic from pole-to-pole and from the tropics to the high-latitudes. The heat and moisture transported by ocean and atmosphere is important to determine the climate in our northern latitudes, and also the habitats for marine ecosystems. This interconnectivity must be captured by our observing and prediction systems. The effects of climate change and other stressors on the marine ecosystem act across the Atlantic basin, and are also economically interconnected. The European Union has recognized the importance of this perspective in its recent programmes and through supporting the Galway and Belém Statements, and in driving the All-Atlantic Ocean Research Forum. The European Union is investing further in the development of predictive systems, or the Earth Digital Twin, through its new funding programmes. These systems will be important tools to help Europe and the world to respond to the climate and ecological emergency.

WHAT ARE WE ABLE TO DO AND WHAT DO WE NEED TO DO?

- Ecosystem Based Fisheries Management in Atlantic Upwelling Regions needs adequate indices to monitor changes in an integrated manner and to identify appropriate links between environment, climate, and fisheries. Existing knowledge provides a framework within which to use the novel data and tools, such as fish forecasts, to help address the most urgent issues for a sustainable future: life in the oceans is under pressure from multiple directions. Resilience and sustainability should be central to management decisions with respect to all timescales.

- Long-term sustained observations in the Atlantic Ocean are critical for understanding and monitoring the ocean to improve predictions of weather and climate in the future, and to better understand and predict how climate change could affect marine ecosystems. We must continue to pursue trans-national research that links physical and biogeochemical oceanography, marine ecosystems, climate and atmospheric sciences.

- A multitude of ocean observation data products that can be used for fisheries forecasting are already available, but funding is intermittent, not all necessary variables are covered nor being harmonized or integrated, and not all data are open. In particular, biogeochemical and ecosystem parameters are still in their infancy in terms of systematic global observations.

- Climate predictions provide a reliable outlook on conditions in years to come. Climate based prediction of marine ecosystems requires combining climate prediction and numerical marine ecosystem models. New integrated observations of physical and ecological systems are needed to improve our understanding and capability to model climate-ecosystem interactions and better resolve interactions between weather and climate. Climate services translate these into valuable and actionable knowledge for citizens, businesses and government.

- The development and production of marine ecological forecasts requires continuous focus and funding to achieve their full potential in supporting sustainable management of the Atlantic Ocean. In particular, awareness of these forecasts needs to be raised amongst potential end-users and stakeholders. End-users and forecast developers need to work

- closely together to ensure that the forecasts that are developed match the decision making needs of society.

WHY IS THIS IMPORTANT?

In 2018, total world fisheries reached a record of 96.4 million tonnes, including catches from inland fisheries of 12 million tonnes[1]. Globally, only 6.2 percent of fish stocks are underexploited[2]. Currently, fisheries in the EU is an important source of employment and nutrition. The EU fleet shows good economic performance and there are clear and important signs of improvement in the North-East Atlantic Ocean and Baltic Sea. Globally, 59.5 million people work in the fisheries and aquaculture sector and 3.3 billion people rely on fish for at least 20 percent of their protein. However, fisheries cannot meet the nutritional demand of a growing global population with diminishing resources, and marine ecosystems are endangered by pollution and unsustainable production practices.[3]

Fishing vessel. Credits: The Scottish Association for Marine Science.

Fish populations are highly variable and changes in both their distribution and abundance present a tremendous challenge to fisheries and management, and for the communities and businesses that depend upon them. In some cases, this variability has given rise to international conflicts, as has been seen in the case of the international conflict over access to Mackerel in recent years. Furthermore, this situation is expected to worsen under a changing climate, as species move across international boundaries in search of cooler waters. In addition, the changes in management structures associated with the United Kingdom leaving the EU (Brexit) will create new boundaries in the ocean, furthering uncertainty and the potential for conflict.

Advances in state-of-the-art modelling and assessments are starting to provide robust forecasts of the ocean on timescales up to a decade into the future. In cooperation with fishing communities, scientists and modellers have started to create the first generation of fish forecasting products. Already, in the North Atlantic, variables such as sea-surface temperature can be predicted five or more years in advance. Integrating these climate forecasts with ongoing work in fisheries research is leading to the development of systems that can forecast fish stock distribution and abundance years in advance.

The use of potentially very valuable information from these forecasting systems needs to be discussed. The societal, economic, and policy implications of fish forecasting products in the Atlantic Ocean need to be balanced and good practices for exploiting and protecting fish stocks found. Fish forecasting products are a contribution to national, European as well as international policy frameworks, agreements and regulation, including the European Green Deal, pan-Atlantic Galway and Belém Statements, and the United Nation Decade of Ocean Science for Sustainable Development (2021-2030).

[1] FAO. 2020. The State of World Fisheries and Aquaculture 2020.
[2] 2.5 - 87.5 percent of stocks meet at least one of the good environmental status criteria in these regions. (EEA. 2019. Status of marine fish and shellfish stocks in European seas. Accessed on 6 July 2020.)
[3] FAO 2020, Ibid.

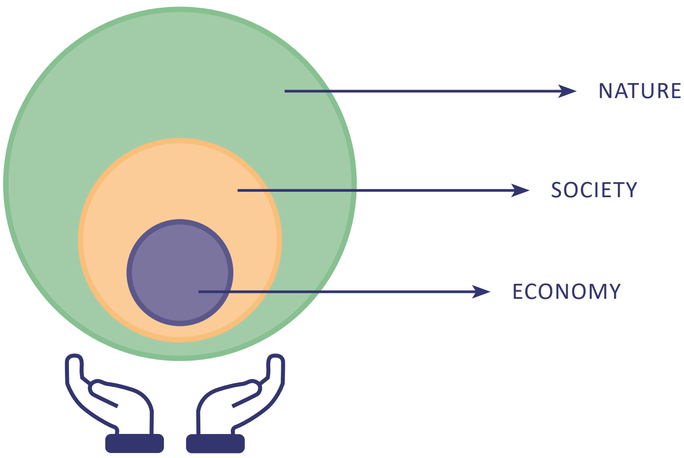
THE CHALLENGES

Climate change has a direct impact on marine species by altering their abundance, diversity and distribution and affecting their feeding, development and reproduction, as well as relations between species. Climate change is having a very clear impact on the oceans, too, given that heat is stored to a greater extent in the water. Fisheries is the marine sector most affected by climate change and climate change[4] has a significant impact on the availability of and trade in fish products. The implementation of the Paris Agreement is essential to achieving the United Nations Sustainable Development Goals by 2030. A fixed long-term objective is crucial to contribute to economic transformation, growth, and the achievement of the Sustainable Development Goals. The Commission has, in the European Green Deal communication, set out a new growth strategy that aims to transform the Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where economic growth is decoupled from resource use. The Union's and the Member States' climate action aims to protect people and the planet, including the integrity of ecosystems and biodiversity against the threat of climate change, in the context of the 2030 agenda for sustainable development and in pursuit of the objectives of the Paris Agreement, and reduce vulnerability to climate change.

Societal relevance of ecosystem based management for fisheries policies

Marine systems can be best understood as coupled social-ecological systems. Human activities are a part of these systems and affect the natural elements of marine ecosystems in multiple and cumulative ways. The sustainable management of these human activities therefore needs to consider the interlinked effects of different human activities as well as natural interactions and variability. One of the largest drivers that cannot be directly managed, is climate change. It drives productivity and distribution of species and habitats, including the living marine resources and thus needs to be explicitly considered in management.

Figure 1: The three pillars of sustainability (Daly 1996, Griggs et al. 2013). Ecosystem Approach to Fisheries Management, taking into account knowledge and uncertainty of abiotic, biotic and human components and their interactions, balancing diverse societal objectives (FAO Ecosystem Approach to Fisheries 2003). Credits: Joern Schmidt.



[4] European Parliament, Committee on Fisheries, Draft report, 2019/2163(INI)

Integrated ocean observation and networks to understand our ocean

Observations are crucial both to understanding interaction and variability in the ocean and underpin accurate forecasting of both weather and climate. The ocean varies on a range of time scales, from daily cycles to several decades. This is particularly true for the North Atlantic Ocean, where the variability in Sea Surface Temperature (SST) is especially large. SST observations are some of the longest records in oceanography, going back to about 1850. From these records we know that North Atlantic SST varies substantially due to both global warming and of its own accord. These oceanic signals are reproduced in climate models and contribute to forecast skill in this area. We also know from other observational records that this variability is not limited to SST but also affects Arctic sea-ice, glacier melt, and Atlantic ecosystems There are several challenges to understanding how these systems will develop under climate change and to making skillful forecasts relevant on a more regional scale.

Firstly, long observational time series are needed to discern the slower climate change trend from natural variability. This requires a long-term view of observational systems and funding. Secondly, better spatial coverage is needed to investigate regional changes. For example, small changes in ocean conditions can take a fish habitat into or out of territorial waters. Thirdly, the existing long records of measurements of physical properties need to be augmented with biogeochemical and ecosystem observations to understand the impact of environmental changes on ecosystems. Finally, these multidisciplinary observations need to be integrated into data products and models as well as predictive systems that can be used for decision making. In turn, **systematic observations of the ocean will inform us about the effectiveness of the implementation of decisions made, from global agreements on emission reduction to local fishery measures, and inform us about next steps to take.**

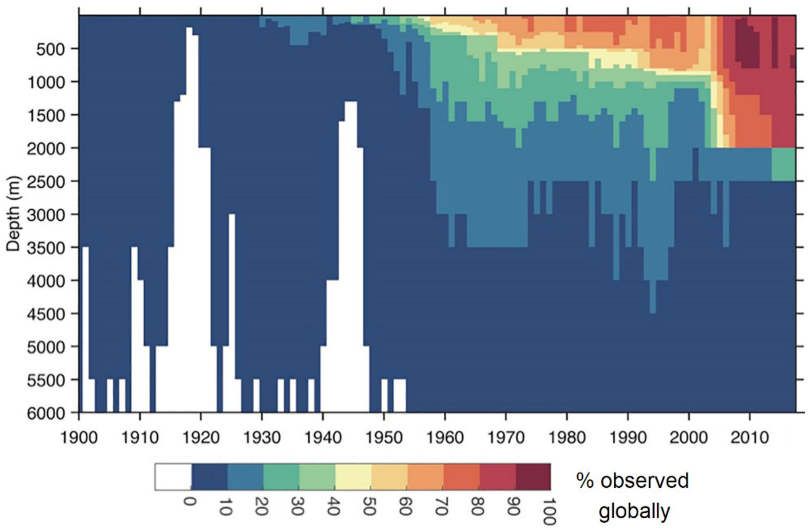


Figure 2: Increase in systematic temperature observations through time, per 3°longitude x 3° latitude box. Credits: Meyssignac et al., 2019.

Combining climate models and ocean observations for reliable long-term predictions

Climate predictions for the near-term have improved to the extent that operational services are now becoming available. **Near-term** climate prediction focuses on predicting changes from one to ten years into the future. The prediction systems combine climate models as used for **long-term** climate change with current observations and therefore resolve both the observed variations and long-term global warming. In this manner, we are able to more accurately predict the evolution of climate over the next few years. This approach is rather analogous to weather forecasting. **Very exciting recent**

results have shown that North Atlantic Climate is far more predictable than we had ever imagined: we can now predict more than 50% of the multi-year changes in North Atlantic climate ten years in advance. However, model deficiencies are a challenge, with unreasonably large numbers of numerical simulations having to be performed to extract the prediction skill.

Fish forecasts and operational climate services in the Atlantic

While many fields, most notably meteorology, have been developing and regularly producing forecasts for decades, marine science has yet to fully develop a comparable predictive capacity. Nevertheless, the last decade has seen the emergence of the first marine ecological forecasts and climate services to support decision making in the ocean. These forecasts span the full range of biological behaviours, including forecasts of where fish are found, how productive a population will be, and when key events (e.g. migration to an area) will occur. In several cases, studies have shown that the **potential use of such forecast products would significantly improve the sustainability of the fishery.**

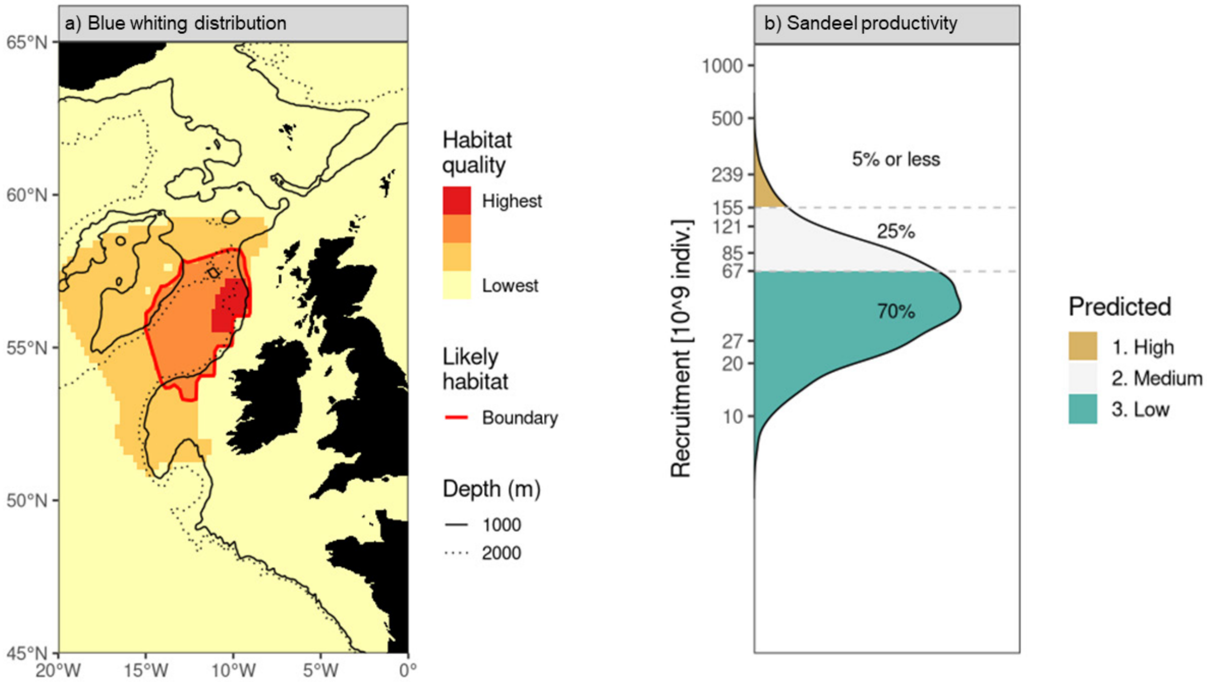


Figure 3: Examples of fish forecasts for 2021. a) Forecast distribution of spawning habitat of blue whiting in March 2021. b) Forecast number of young fish (recruitment) for Sandeel in the North Sea in 2021. Details for each of these forecasts are available through the website http://fishforecasts.dtu.dk. Credits: Mark Payne.

However, while the proof-of-concept has been demonstrated, fish-forecasts have yet to make a broad impact on the management of marine fisheries and their sustainability. Several key barriers can be identified. Foremost amongst these is the **lack of awareness** around this technology, particularly outside of the scientific community that has, thus far, been the main drivers of the development process. There is therefore a clear need to raise the profile of marine ecological forecasting and for it to be recognised as a potentially valuable tool to support sustainable management of the oceans.

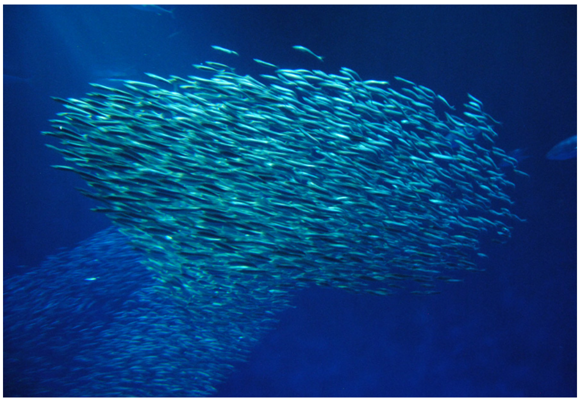
A second, and closely related, challenge is **engaging with the users of forecasts.** A good forecast product is one that is used to make decisions. Developing a good forecast therefore requires striking a balance between what is scientifically feasible, on the one hand, and what is useful to decision makers on the other: only when a forecast ís both scientifically valid and answers a specific need can the true value of the technology be realised. Overcoming this challenge therefore requires a close collaboration between the decision makers and product developers to design and produce a product that works within the limitations of the science while meeting the needs of society.

Realising the potential of fish-forecasting therefore requires a greatly increased focus on the scientific value chain from observations to societally-relevant forecasts. In particular, it is the **"last-mile" of this service delivery, the operationalisation of the service, where scientific data is translated into information to support decision-making, that is currently the bottleneck.**

Dedicated funding to apply the Climate Services approach to the ocean is therefore one clear way for this technology to be operationalised and thus realise its full potential.

Support for sound policy decisions to address pressing global challenges

Life in the oceans is under unprecedented pressure, and devel oping observation networks and more sophisticated predictive models can help identify actions to address some of the most urgent global issues: the biodiversity crisis intertwined with the climate crisis, jeopardizing health and food security of people worldwide.



Credits: Kristin Werner.

Existing knowledge provides a framework within which to use the novel data and tools to help address the most urgent issues for a sustainable future: life in the oceans is under pressure from multiple directions. Resilience and sustainability should be central to management decisions with respect to all timescales. Advances in predictive models can be used to support management plans to secure good population status, but fisheries management decisions need to take much greater account of scientific advice and the uncertainties. Within the European Union, a large share of catch limits are set higher than suggested by scientific advice, despite agreed objectives. The core objective of EU fisheries management should go beyond maximizing yield, to allow fish populations to recover to levels that allow them to fulfil their role in marine ecosystems.

The EU Biodiversity Strategy sets an objective to protect 30% of EU marine areas by 2030, following scientific recommendation to create a global network of fully or highly protected marine reserves. Designing such protected area networks can make use of many types of information - and the more accurate the information, the better are the recommendations based on those tools. An example of this is a global marine reserve network study, *30x30: A Blueprint for Ocean Protection*, which combines biological, oceanographic, biogeographical and socioeconomic data to suggest combinations of areas that best capture the biological diversity present in our oceans.
Forecasting ocean life could support regional and local conservation and management decisions to protect fish populations in the places that are most suitable for them.

Sound policy decisions should make use of advances in science. There is ample evidence on the urgency of the biodiversity and climate crisis, and the main solutions to address them are available to support the decisions that need to be taken today.

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About the projects
BLUE-ACTION, TRIATLAS AND MISSION ATLANTIC

The following projects have received funding from the European Union's Horizon 2020 research and innovation programme. They all address topics touched by this policy briefing.

Blue-Action: Arctic Impact on Weather and Climate (2016-2021)

We are all facing a changing climate. Businesses, policymakers, and local communities need to access reliable weather and climate information to safeguard human health, wellbeing, economic growth, and environmental sustainability. However, important changes in climate variability and extreme weather events are difficult to pinpoint and account for in existing modelling and forecasting tools. Moreover, many changes in the global climate are linked to the Arctic, where climate change is occurring rapidly, making weather and climate prediction a considerable challenge. Blue-Action evaluates the impact of Arctic warming on the northern hemisphere and develops new techniques to improve forecast accuracy at sub-seasonal to decadal scales. Blue-Action specifically works to understand and simulate the linkages between the Arctic and the global climate system, and the Arctic's role in generating weather patterns associated with hazardous conditions and climatic extremes. In doing so, Blue-Action aims to improve the safety and wellbeing of people in the Arctic and across the Northern Hemisphere, to reduce the risks associated with Arctic operations and resource exploitation, and to support evidence-based decision-making by policymakers worldwide.

TRIATLAS: Tropical and South Atlantic climate-based marine ecosystem predictions for sustainable management (2019-2023)

Human activities such as intense fishing and coastal development are altering the marine eco-systems around the South and Tropical Atlantic. The TRIATLAS project aims to assess the current situation of the Atlantic Ocean's marine ecosystems and predict future changes. A range of African, European, and South American institutions specialised in climate change, oceanography and social sciences, as well as local stakeholders work together in the project to address this challenge. TRIATLAS is also working closely with relevant European Commission services. The project observes the impact of pollution and climate change on the marine ecosystem to present the first prog-nosis for the next 40 years for the whole Atlantic. This will aid in sustainable management of human activities in the region.

MISSION ATLANTIC: Towards the Sustainable Development of the Atlantic Ocean: Mapping and Assessing the present and future status of Atlantic marine ecosystems under the influence of climate change and exploitation (2020-2025)

How do drivers of change (climate, acidification and societal development) and other pressures (exploitation and pollution) impact the state and resilience of the Atlantic Ocean ecosystems? How do they alter the distribution and sustainability of services provided to humans? To answer these questions, the MISSION ATLANTIC project brings together scientists, managers and stakeholders from Brazil, South Africa, North America and the EU. Applying the Atlantic Integrated Ecosystem Assessments (IEAs), which are developed at basin and regional scales, the project identifies ecosystem components most at risk from natural hazards and the consequences of human activities.
To support these assessments, the project maps, models and assesses Atlantic Ocean ecosystems, including their resilience and response to cumulative pressures.

The Blue-Action, TRIATLAS and MISSION ATLANTIC projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 727852, 817578 and 862428 respectively.