Report on Marine Fisheries Climate Services Workshop

Blue-Action Case Study Nr. 4

Figure 1 Scene from stakeholder engagement workshop held with recreational fishers on January 22, 2018, in Vingsted, Denmark

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Summary for publication

Case Study Four of the Blue-Action project focuses on the identification, development and valuation of marine ecological climate services. This task takes a co-development approach, where end-users are directly involved in shaping, developing and evaluating climate services that are of direct relevance to decision making in their daily activities.

As a first step, a review of existing marine ecological forecast products was performed, and the lessons learned catalogued. A key result in this survey was the importance of including stakeholders and end-users in the development of these products from the very start, emphasising importance the co-development approach originally envisioned. It was also seen as necessary to strike a balance between what is scientifically *feasible*, on the one hand, and what is *useful* to end-users on the other hand. Importantly, the survey also highlighted that while there are multiple examples of successful forecast products elsewhere, there are no known examples in Europe.

In order to identify the potential climate services that are of greatest value, and based on the lessons from our review, a broad series of meetings with end-users were carried out to identify their needs for climate services. End-users contacted spanned three broad types 1) organisations with connections to the commercial fishing industry 2) international groups associated with the monitoring and generation of scientific advice about the management of living marine resources and 3) Non-governmental organisations and members of the general public. For each user within these groups, a series of meetings with scientists from Blue-Action was held to identify and prioritise their needs for climate services.

The main results obtained from this process are highlighted in the table below. For each end-user, a prioritisation of potential climate services that could be developed was made. Details were discussed about the technical aspects of development, and in many cases a timeline laid out and details around the presentation and communication of information developed. The prioritised climate services are as follows:

End-user	Highest Priority Potential Climate Service(s)
Pelagic Freezer Trawler Association (PFA)	Timing of spawning in Downs herring
Danish Pelagic Producers Organisation (DPPO)	1) Productivity and 2) timing of Sandeel in the North Sea
Marine Ingredients	Productivity of the portfolio of small pelagic fish stocks in the North Sea
WKPELA2018	Productivity of herring in the North Sea
WGIPS	Spatial distribution of Blue whiting spawning
ICCAT / Iceland, Greenlandic Fishing Industry	Distribution of Atlantic Bluefin tuna in the North Atlantic
Recreational Fishers / *Fangstjournal*	Timing and distribution of garfish migration

Future work within this case study over the next two years will focus on the development of climate services on these topics, in collaboration with the end-users.

Work carried out

Background and Approach Taken

End-users are critical to the design, development, implementation and ultimately the value and usefulness of climate services: without a user, a climate service is simply another piece of climate-oriented data. Today, it is widely accepted that co-development and co-production of climate services is the optimal route to ultimately ensure that they are taken up by end-users, and that they are useful to society.

The Blue-Action project has incorporated the philosophy of co-development into its project structure, and end-users are viewed as being critical to shaping and designing all of the climate services that will be developed within the project. Within Case Study 4 (Climate Services for Marine Fisheries), the initial step in the co-development process has been to survey the needs of potential end-users, from both within the Blue-Action consortium and outside it. This report details the work carried out in this regard, the results obtained, and the lessons that have been learnt as a result.

The first step in this exercise was to review the current state-of-the-art of forecasting marine ecological variables. This was done in the form of a scientific review paper lead by DTU-Aqua (Mark Payne) with around 15 co-authors from around the world with experience in the development of marine ecological forecast products (Payne *et al.*, 2017). The review examined the forecast products that are currently available, how they have been developed and what makes a successful forecast. The lessons learnt from this exercise have then been used to shape and influence the rest of the approach to developing climate services within this case study.

The review process emphasised the importance of including stakeholders and potential end-users in the development of climate services. One of the key points that became apparent as a result of this review process was the importance of personal interactions and one-on-one conversations in the successful identification of potential climate services and their ultimate development. This result, however, was in conflict with the approach originally envisaged for Blue-Action Case Study 4 during the proposal drafting phase: initial plans were for a single large stakeholder workshop to identify potential climate services that could be developed, lead by the PFA. In light of this revelation, the decision was therefore made to take a different approach to stakeholder engagement, involving a series of small meetings (1-2 individuals) with representatives of key stakeholder and end-user groups. This approach also had the added advantage of being generally more resource efficient.

A second point that became apparent was that there were a broader range of stakeholder sectors that could potentially use forecast information and climate services than initially considered. One of the most surprising results that arose from early conversations with PFA and DPPO was that they viewed the most valuable contribution that Blue-Action could make would be to development climate services that improved the quality of fisheries management systems: this would therefore reduce the associated uncertainty and ultimately feed benefits back to them in the form of increased fisheries quota. This was a surprising result for Blue-Action, but was one that has also been taken on board by expanding the scope of potential end-users. Finally, it also became apparent that both Non-Governmental Organisations and members of the general public could also benefit from climate services developed to focus on their needs, and we have engaged in a dialogue with representatives from these sectors as well.

The full list of stakeholder groups surveyed was therefore as follows:

- Commercial fishing industry
- International organisations responsible for monitoring and generating scientific advice on fisheries-management
- Members of the general public and Non-Governmental Organisations

It has clearly not been possible to cover all organisations within these sectors, given their large breadth and the limited resources within the Blue-Action project. Instead work has focused on a small set of representatives from each sector who could potentially gain value from the development of tailored climate services. The interactions with each these groups are detailed in the sections below.

Finally, given the breadth of these sectors covered, the decision was made to switch the responsibility for this task and deliverable within the Blue-Action project. In the Description of Work, the Pelagic Freezer Trawler Association (PFA) was listed as being responsible for this deliverable, D5.16: this made sense when the end-user engagement process was intended to be one-large workshop focused on commercial fisheries operators. However, the broadening of the scope meant that it made more sense for DTU-Aqua, as the primary scientific partner and common factor in the development of each of these climate services, to lead the engagement process and therefore this deliverable.

After a description of the review process, the following sections describe the dialogue held between Blue-Action and each of the stakeholder sectors. Key decisions are summarised in the section “Main Results Achieved”.

Review of Existing Marine Ecological Forecast Products

Recent years have seen a rapid expansion in the ability of earth system models to describe and predict the physical state of the ocean. Skilful forecasts ranging from seasonal (3 months) to decadal (5–10 years) time scales are now a reality. With the advance of these forecasts of ocean physics, the first generation of marine ecological forecasts has started to emerge. Such forecasts are potentially of great value in the management of living marine resources and for all of those who are dependent on the ocean for both nutrition and their livelihood; however, this is still a field in its infancy and there is little in the way of established “best-practice”

To guide out work in Blue-Action, we therefore undertook a broad literature review of the state-of-the-art of this field. We built this work on top of a theme session held at the ICES Annual Science Conference in Riga, Latvia, in October 2016, where we gathered a collection of experts in the field from around the world. We then reviewed the state of the art in this emerging field and identified the lessons that can be learnt and carried forward from these pioneering efforts to our work in Blue-Action.

The majority of this first wave of products are forecasts of spatial distributions, possibly reflecting the inherent suitability of this response variable to the task of forecasting. Promising developments are also seen in forecasting fish-stock recruitment where, despite well-recognized challenges in understanding and predicting this response, new process knowledge and model approaches that could form a basis for forecasting are becoming available. Forecasts of phenology and coral-bleaching events are also being applied to monitoring and industry decisions.

Developing marine ecological forecasts requires striking a balance between what is *feasible* and what is *useful*. We proposed a set of criteria to quickly identify such “low-hanging fruit” that can potentially be predicted; however, ensuring the usefulness of forecast products also requires close collaboration with

actively engaged end-users. Realizing the full potential of marine ecological forecasting requires bridging the gaps between marine ecology and climatology on the one-hand, and between science and end-users on the other. Nevertheless, the successes seen thus far and the potential to develop further products suggest that the field of marine ecological forecasting can be expected to flourish in the coming years.

The full manuscript describing this review has recently been published in the journal Frontiers in Marine Science (Payne *et al.*, 2017).

The Commercial Fishing Industry

Pelagic Freezer Trawler Association (PFA)

The Pelagic Freezer-trawler Association (PFA) is an association that represents the interests of trawler owners occupied in pelagic fishing activities for human consumption on a national, European and international level. Nine trawler companies from five EU countries are members of the PFA, each with a long history in the fishing industry: Cornelis Vrolijk's Visserij Maatschappij BV – The Netherlands, Doggerbank Seefischerei GmbH – Germany, France Pélagique s.a.r.l. – France, Interfish Ltd – United Kingdom, Jaczon BV – The Netherlands, North Atlantic Fishing Company Ltd – United Kingdom, Parlevliet & Van der Plas BV – The Netherlands, UAB Atlantic High Seas Fishing Company – Lithuania, W. van der Zwan & Zn BV – The Netherlands. These are mostly family businesses that have been active in the industry for 50 years or more, and which have grown to become fully-fledged companies operating world-wide. The Association aims to improve the transfer of knowledge on pelagic fishing activities between all those concerned, including the consumer. The members of the association employ a total work-force of around 1.500 people.

The PFA is a member of the Blue-Action project consortium, and has status within this consortium as a Small and Medium Enterprise (SME). Within the Blue-Action project, the PFA is represented by Martin Pastoors.

List of Relevant Meetings

1. 2 February 2017, ICES Headquarters, Copenhagen, Denmark (together with DPPO)
2. 15 June 2017, ICES Headquarters, Copenhagen (together with DPPO)
3. 6 December 2017, ICES Headquarters, Copenhagen, Denmark
4. 17 January 2018, Sloterdijk, Netherlands

Summary of First Meeting, 2 February 2017, ICES Headquarters, Copenhagen, Denmark

The first meeting between DTU-Aqua (Mark Payne) and the PFA (Martin Pastoors) was held together with the DPPO (Claus Sparrevohn) on the side of a fish-stock assessment meeting being attended by all parties. The meeting served primarily to introduce the Blue-Action project to the PFA and DPPO, and the current state of the art in marine ecological forecasting. The goals and objectives of the project relevant to the SME stakeholder partners were discussed. PFA and DPPO agreed to discuss with their members what could be of use to their members.

Summary of Second Meeting, 15 June 2017, ICES Headquarters, Copenhagen, Denmark

A second meeting between DTU-Aqua (Mark Payne, Anna Miesner), the PFA (Martin Pastoors) and DPPO (Claus Sparrevohn) was held in June, again on the side of a fish-stock assessment meeting being

attended by all parties. This workshop involved a more detailed discuss about the potential marine climate services that could be developed.

An important highlight of these discussions was the viewpoint that the most beneficial use of the climate services approach would be in the improvement of management advice regarding fish stocks of interest to these groups. Improvements in the scientific understanding, including the development of forecasting tools, reduce the uncertainty associated with estimates of the abundance, productivity and dynamics of a fish stock: such improvements can then be directly translated into increases in fish quota, which is of benefit to the members of the DPPO and the PFA. This was a surprising idea for the Blue-Action project, which had previously focused on the idea of developing tools that could be used directly by the members of the PFA and DPPO. It was agreed to explore some of these approaches by engaging in dialogue with the organisations and scientists responsible for monitoring fish stocks and generating scientific advice about their exploitation, while at the same time exploring the potential for tools that could be applied directly by the organisations.

Other ideas discussed as potential climate services included

- Prediction of the timing of herring spawning in the English channel
- Generation of survey quality information (e.g. proportion of fish stock covered by a survey in a given year) for use in developing management plans and performing stock assessments
- Spatial distribution and productivity of North Atlantic blue whiting fish-stock
- Providing environmental information, including short-term forecasts, as a tool for fishers to choose where to fish.
- Forecasts of “bycatch” rates i.e. catches of undesirable species, including protected species or those for which the fisher does not have quota, together with the target species. Hake was identified as one species in particular that creates bycatch problems for pelagic species. However, developing such forecasts may be technically challenging, it would require forecasts of the distribution of both multiple species.
- Distribution of mackerel spawning, particularly in relation to the Mackerel Egg Survey (MEGS) that monitors the distribution and abundance of this stock. Such forecasts could be used to ensure that the survey has covered the entire stock, to investigate the timing of spawning, and to aid in the planning of this survey.
- Distribution of mackerel during the summer feeding period, particularly in the Norwegian Sea and in the waters around Greenland and Iceland, where there have been recent dramatic expansions in the distribution, resulting in international conflicts over fishing rights. An improved understanding of these processes may be useful to develop an early-warning system of such shifts.

It was agreed to meet again later in the year to focus in on the most relevant of these suggestions.

Summary of Third Meeting, 6 December 2017, Copenhagen, Denmark

The third meeting between DTU-Aqua (Mark Payne) and the PFA (Martin Pastoors) was held on the side of the WKPELA meeting in ICES (see below). This meeting focused on narrowing down the scope of potential climate services to one or two specific suggestions for climate services that could then be used to move forward with.

The timing of spawning of herring in the English Channel quickly emerged as a potentially valuable climate service for the PFA. During the six months since the last meeting, Martin Pastoors, representing the PFA, had collected relevant data spanning the last 10 years from a member fishing vessel. This data

showed the proportion of fish biomass made up by the gonads and how it varies through the spawning season: clear inter-annual variability in the timing of spawning is present, and the skippers have a strong impression that this is linked to the temperatures experience by the spawning fish. Such temperatures in the North Sea are highly predictable on the seasonal time-scale. Furthermore, other data sources could potentially be brought in bear on this topic, particularly based on data from the International Herring Larval Survey (IHLS) that is performed annually on this population during the spawning period. Both parties agreed that this example is highly promising as a candidate for developing a Climate Service and they will explore it further together.

Summary of the Fourth Meeting, 17 January 2018, Sloterdijk, The Netherlands

The fourth meeting between DTU-Aqua (Mark Payne) and the PFA (Martin Pastoors) was held in Sloterdijk, Netherlands, while Mark Payne was travelling to present Blue-Action work at the WGIPS meeting (see below). This meeting expanded on the previous meeting and discussed the practicalities, time frame and goals for developing a climate service around the timing of spawning of “Downs” herring in the English Channel.

The meeting started with a presentation of recent work by DTU-Aqua on the development of a climate service for the distribution of blue whiting spawning habitat (see notes in relation to WGIPS). This served as an excellent source of inspiration to illustrate what could be done.

The details of how a climate service for the timing of spawning of Downs herring might look like were discussed. This fishery is performed primarily during December and January, with a break over Christmas.The minimum lead time for the forecast product was viewed as being around six weeks (i.e. forecast ready at end of October). Eggs from fish caught in the fishery are extracted and sold to the Japanese market for consumption as roe. A lot of information is available from commercial fisheries fishing on this stock and the PFA is prepared to share this information with DTU-Aqua in the interests of developing the climate service. In addition, observations from the IHLS survey can provide a long time series (back to 1972), that can put the recent variability in perspective. Two hypotheses were discussed for what determines spawning (gonadal maturation rates vs waiting for an optimal temperature) and these will be investigated in the course of developing this product.

A number of other potential climate services of interested were discussed again as back-up plans, in case it was not possible to develop sufficient predictive skill for the timing of spawning to be of use. These included

- Distribution and productivity of Blue whiting, and the timing of spawning
- Distribution and migration patterns of Mackerel
- Regime shifts in the productivity of demersal fish stocks

Opportunities for further collaboration meetings were discussed, and a timeframe developed for preliminary analyses in relation to these meetings. It is intended to have preliminary analyses ready in time for the annual science meeting held by members of the PFA in May / June, with the goal of having the first forecast product ready for the 2018 season (ie December 2018).

Danish Pelagic Producers’ Organisation (DPPO)

Representing the 12 largest Danish pelagic vessels, the Danish Pelagic Producers’ Organisation (DPPO) is a key player and stakeholder in the management of fisheries, fish stocks and the marine environment. The DPPO-vessels account for more than one third of the total turnover in Danish fisheries and their

target species include herring, mackerel and horse mackerel for the human consumption market, together with sandeel, sprat, blue whiting, Norway pout, and boarfish for fish-meal and -oil. Since most pelagic species are regulated through an ITQ system and the pelagic vessels target a range of different species; sustainability is crucial for their businesses. Hence a key objective of the DPPO is to enable a management, e.g. by providing alternative data sources, which will help secure a maximum sustainable yield (catches and economics) in the long term.

The DPPO is a member of the Blue-Action project consortium, and has status within this consortium as a Small and Medium Enterprise (SME). Within the Blue-Action project, the PFA is represented by Claus Sparrevohn.

List of Relevant Meetings

1. 2 February 2017, ICES Headquarters, Copenhagen, Denmark (together with PFA)
2. 15 June 2017, ICES Headquarters, Copenhagen (together with PFA)
3. 15 January 2018, DPPO Offices, Copenhagen, Denmark

Summary of First Meeting, 2 February 2017, ICES Headquarters, Copenhagen, Denmark

See summary in first meeting with PFA above, which was also attended by the DPPO.

Summary of Second Meeting, 15 June 2017, ICES Headquarters, Copenhagen, Denmark

See summary in second meeting with PFA above, which was also attended by the DPPO.

Summary of Third Meeting, 15 January 2018, DPPO Offices, Copenhagen, Denmark

The third meeting between DTU-Aqua (Mark Payne) and DPPO (Claus Sparrevohn) was held at the offices of the DPPO in Copenhagen in mid-January. This meeting focused on narrowing down the scope of potential climate services to one or two specific suggestions for climate services that could then be used to move forward with.

Sandeel was quickly identified as the main species of interest to the DPPO in the context of climate services, due to the high degree of variability that the stock exhibits between years, and its commercial importance to members of the organisation. All aspects of sandeel biology were seen as important, and climate services could be envisaged that predict the following aspects:

- Recruitment: the size of individual cohorts varies greatly between years and has direct consequences for the quota that the DPPO is allowed to catch. A number of mechanisms have been proposed, including circulation patterns in the North Sea basin and the effects of temperature and Zooplankton abundance (van Deurs *et al.*, 2009; Lindegren *et al.*, 2017). Recruitment prediction could take the form of indicators of good / bad years. A forecast with around four months lead time (August to November) would be sufficient for decision making in the fishery, and potentially in management as well.
- Phenology: the timing of key events in the lifecycle of this species, such as emergence of hibernation is of critical importance for the planning of the fishery, and is thought to be closely linked to temperature.
- Growth: Growth rates are seen as an underappreciated aspect of the fishery and can vary by up to 20% per year and have a direct consequence on the number of fish that are actually extracted from the population (as quota is set by mass, rather than numbers of individuals), and

can therefore lead to under/overfishing. The supply of key zooplankton species and temperature are thought to be important in this regard.

- Maturation rates: potentially seen as a "dark horse" that is poor understood but that has important consequences for fishing quota.

In addition, a number of other potential climate services were discussed that could serve as back-up options, in the case that none of these options proved to be feasible. These included:

- Spawning of herring in the North Sea, and particularly in the Downs area. This is the same topic as is being developed in conjunction with the PFA (see above), and the DPPO is also interested in taking up such forecasts if developed successfully.
- Conditions for sprat fishing. Sprat catch rates in autumn are significantly influenced by weather conditions, with optimal conditions coinciding with high air pressure, wind from the north and the phase of the moon. A climate service that provides information about the number of days of favourable weather per month covering the autumn fishing season could be of value to the fishers performing this fishery.
- Mixing of herring in the Skagerrak and Kattegat regions. Herring in the waters around Denmark comprise of two distinct populations (so-called "IIIa" and "NSAS" herring) that mix in this region. However, the quotas for these stocks are set separately, which can create problems for both management and prosecution of the fishery in this region alike. A better understanding, and potential predictability of the mixing process would be of great value.
- Mackerel distribution and migration, particularly with regards to the southwards migration and coverage of the Mackerel Egg Survey (MEGS – see also above discussion with PFA on this topic).
- Bycatch in pelagic fisheries, particularly of spurdog and saithe, and of juvenile herring in the sprat fishery.

The various aspects of the sandeel fishery noted above were viewed as being the most important of these ideas and ones that could benefit from forecast information provided by climate services. It was therefore agreed to focus on these response in the first instance. However, there are important issues relating to data and knowledge limitations that may prevent the development of one or more of these services. It was therefore agreed to perform a set of exploratory analyses and literature reviews within the next six months to a year to identify which of these could be developed all the way through to fully mature climate services, and then further focus and prioritise the development and refinement of these products at that stage.

Marine Ingredients (MI)

Marine Ingredients represents producers of fish meal and fish-oil within Denmark. The Danish fish-meal industry is clearly the largest in Europe with an export value of over €400 million annually and is ranked seventh globally. The organisation represents three production units within Denmark and one on the Farore islands. The sector is important for fisheries in this region, where the catches of short-lived species such as sandeel, sprat and Norway pout make up an important proportion of the value of the total Danish fishing industry. Sandeel has been the largest fishery in Denmark for many years, whilst sprat is typically in third or fourth place. The sector contributes to growth and develop in coastal communities in Denmark and the production of fish-meal and oil creates the base for Danish exports of fish-feed and know-how in the aquaculture sector. The organisation has many of the same interests as the Danish Pelagic Producers' Organisation (DPPO), as fish caught by the DPPO vessels are often handled in processing plants represented by MI.

Summary of Meeting, 15 January 2018, ICES Headquarters, Copenhagen, Denmark

A meeting between Blue-Action (Mark Payne) and Marine Ingredients (Søren Anker Pedersen) was held at the offices of Marine Ingredients in Copenhagen in mid-January. This meeting focused on identifying potential climate services that could be of interest to Marine Ingredients, and how these interests align the closely related activities with the PFA and DPPO.

In general, there was good agreement between the issues raised from the fishers perspective by the PFA and DPPO, and those seen as important by the fish processes by Marine Ingredients. Sandeel was again identified as an important and interesting fish stock who's exploitation could greatly benefit from the development of predictive climate services: recruitment and phenology were identified as important response variables. Similarly, the recruitment of blue whiting was also identified as being of interest, as this is also a major input to many of these processing plants.

There were, however, two interesting and surprising topics raised that had not been raised previously. The first was that of recruitment synchrony and regime shifts amongst the fish stocks of interest. Søren Pedersen highlighted a recent publication (Clausen *et al.*, 2017) that has shown a high degree of synchrony in the productivity dynamics (recruitment and growth) of five important small-pelagic fish stocks in the North Sea (two sandeel stock, herring, Norway pout and sprat), with a systematic regime shift occurring around the early 1990s that resulted in reduced productivity. The mechanisms underpinning such changes have not been thoroughly investigated, but there are at least some indications that these are related to environmental change and variability in this region (Payne *et al.*, 2009; Clausen *et al.*, 2017; Pecuchet *et al.*, 2017). A climate-service that looks at productivity across such a portfolio of stocks (rather than focusing on a single stock) could be of interest to Marine Ingredients, whose plants also process a portfolio of species.

Secondly, the effect of near-term climate change was discussed, and the potential for forecasting the appearance and survival of new species in the North Sea. Recent changes in the North Sea environment as a result of climate warming have brought new species to the area (Beare *et al.*, 2004), and with them new fishing opportunities: notable new species include anchovy (Petitgas *et al.*, 2012) and red mullet (Beare *et al.*, 2005), the later of which now supports a commercial fishery. However, these species are also at the extreme of their thermal tolerance and in the case of anchovy, the outbreak in the late 2000s was stopped by a succession of severe winters in 2009 and 2010. Such conditions may well be predictable on the multi-annual to decadal scale, and could therefore be used to provide forecasts of the likelihood of anchovy abundance increasing again in the near future, and possibly supporting a fishery.

It was agreed to continue the dialogue about the development of climate services that are of relevance to Marine Ingredients. Much of the work proposed with DPPO and PFA aligns closely with the interests of MI. Furthermore, it was agreed that DTU-Aqua would perform a set of literature reviews and basic exploratory analyses to assess the feasibility of developing climate services for MI around recruitment synchrony, and the potential for new fish stocks.

Scientific Advisory and Monitoring Bodies

The International Council for the Exploration of the Sea (ICES)

The International Council for the Exploration of the Sea (ICES) is the world's oldest intergovernmental scientific organisation. Founded in 1902 in Copenhagen, Denmark, ICES aims "to advance the scientific understanding of marine ecosystems, and provide information, knowledge, and advice on the

sustainable management of human activities affecting, and affected by, marine ecosystems." The organisation has four main pillars, consisting of the Science committee, primarily focused on scientific expert groups, the Advisory Committee, focused on the generation of advice and information needed by decision makers, Data and Information Services, responsible for coordinating data flows between ICES groups and member states, and the Secretariat, who support the activities of the ICES communities.

With respect to the use of climate services, it is work performed by the Advisory Committee (ACOM) and the expert groups under it that could make the most use of ecological forecast information. ACOM delivers scientific advice to the European Commission and associated coastal states regarding the sustainable management of living marine resources in the North Atlantic, including the adjacent Baltic and North Seas (although excluding the Mediterranean). This advice forms the scientific basis for management regulations set by the relevant international agencies such as the European commission and the North East Atlantic Fisheries Commission.

Work in these groups is performed by members of the scientific community nominated by ICES member states. As the interest in these groups is in taking advantage of the best scientifically-supported knowledge available at the moment, there is an opening for the direct incorporation of forecast products into the management of these living marine resources, and such forecasts have been employed in the past.

Summary of Meeting, 15 January 2018, ICES Headquarters, Copenhagen, Denmark

Blue-Action held a meeting with members of the ICES secretariat in conjunction with an ICES working group, WGS2D (Working Group on Season-to-Decadal Prediction of Marine Ecosystems). Four members of the ICES secretariat that support advice groups were able to participate and provided valuable insights about the potential applications of forecasts of the physical environment within the context of ICES work, and how this work could be applied to both advice generation and monitoring activities.

The secretariat was generally positive and supportive of the idea of developing forecast products for use in advice generation within the ICES area. Several concrete suggestions about where forecasts could be developed and applied were discussed e.g. distribution of widely-distributed species such as Mackerel and by-catch species such as Hake. The design of surveys by ICES monitoring groups was also viewed as a potentially productive avenue for the uptake of forecast information.

Contacting relevant working groups directly and in person was viewed as a useful way to development and uptake of forecast products, but it was suggested that having relevant demonstration products in hand first would greatly facilitate this process. It was suggested that it might be more productive, at least to start with, to focus on the so-called "Benchmark Workshops", rather than the standard advice-generating expert groups. In contrast to the standard "update" stock assessments performed regularly by ICES expert groups, benchmark workshops occur every three to seven years for a given stock and involve an intensive evaluation and development of the methods used to assess and give advice on the state of a fish stock: once consensus amongst participants about the appropriate protocols for the assessment of a given fish stock is achieved, the protocols remain (relatively) fixed until then next benchmark. These meetings therefore represent the primary opportunity to incorporate new knowledge into the advice generation process: furthermore, as participants are focused on developing and improving the assessment methodology, there is much more time and energy for new ideas compared to standard update assessments, which have routine work to do.

Based on these discussions, it was therefore agreed to pursue, in the first instance, ICES expert groups responsible for the monitoring of fish stocks, and benchmark assessment workshops, as potential end-users of marine ecological climate services.

ICES WKREDFISH Benchmark Workshop

As noted above, ICES benchmark workshops are held relatively infrequently and there were only five planned for the 2017/2018 assessment cycle. Of these, only three were held before the submission of this deliverable (31 January 2018) at the ICES headquarters in Copenhagen (where they are readily accessible to researchers from DTU-Aqua). Blue-Action took up contact with two of these meetings – the third, the Benchmark Workshop on North Sea stocks, did not appear to have any fish stocks that might harbor potential predictability.

The first of these was the ICES WKREDFISH Benchmark Workshop on Redfish in the Northeast Arctic waters. This workshop aimed to establish new assessment protocols for beaked redfish and golden redfish in the Northeast Arctic. Redfish stocks in this area have shown substantial declines in productivity in recent decades, and some propose that this decline is related to environment changes. If this hypothesis held up, it would therefore make these stocks well suited to the development of climate services.

Summary of Dialogue, December 2017

Plans were initially made for Blue-Action (Mark Payne) to meet with the leaders of the WKREDFISH workshop (Benjamin Planque and Daniel Howell) to discuss potential climate services. Unfortunately, this meeting had to be cancelled due to sickness, and discussions were held electronically instead.

The dialogue between the two groups was informative and gave a much clearer picture of the current state of understanding about the understanding of the effects of physical variables on these stocks. In particular, as redfish are long-lived species, the effect of interannual variations in recruitment to the stock is relatively minor, as the fishery exploits many year classes and it takes many years before fish mature and enter the fishery. Furthermore, the chairs of the workshop expressed skepticism about the linkages to the physical environment and about the concept of predicting the productivity of fish stocks in general.

Other potential forecast variables were also discussed. Growth and survival rates were considered, but again the long-life spans of these stocks mean that growth is extremely slow, and what variability there is generally on a very long time-scale. The use of forecast information in developing management rules was discussed as a potentially useful application, but it was agreed that while it might be possible to forecast environmental variability on the decadal scale, the biological understanding necessary to assess the implications of this variability was lacking.

It was therefore concluded that there was little scope for incorporating forecast information and climate services into this assessment process, and it was not pursued further.

ICES WKPELA2018 Benchmark Workshop

The second benchmark workshop approached by Blue-Action was WKPELA2018, the Benchmark Workshop on pelagic stocks. This workshop focused on refining stock assessments for i) herring in the Skagerrak, Kattegat and western Baltic ii) herring the North Sea iii) herring in the Celtic Sea, Irish Sea and southwest of Ireland and iv) Anchovy in Atlantic Iberian waters. These stocks are also well known for the

strong influence that environmental variability has on their productivity, and could therefore be potential users of climate services.

Summary of Meeting, 6 December 2018, ICES Headquarters, Copenhagen, Denmark

Blue-Action (Mark Payne) presented its work and the idea of developing marine ecological forecast products in a plenary session to approximately twenty scientists covering all four of the stocks being benchmarked: in addition, four stakeholder representatives from the fishing industry were also present. The presentation was well received and prompted productive and broad discussions about where forecast information could potentially be used in the assessment process. Two main points were discussed:

- Growth is often overlooked as a potentially predictable variable in marine science, but for many species, particularly the short-lived species being assessed at this meeting, growth can be as important for the fishing industry as other more "traditional" responses such as recruitment. The potential for predicting the growth of these stocks was discussed.
- Recent reports (Clausen *et al.*, 2017) of regime shifts across the entire ensemble of small pelagic fish in the North Sea were highlighted: species included were Norway Pout, Sprat Herring and Sandeel. The question was therefore raised as to whether this could be linked to temperature and is therefore a potentially predictable variable, similar to the question raised by Marine Ingredients above. However, the drivers for this shift appear unclear, and work would be required to narrow this down before developing a potential climate service.

Following the plenary, a more focused discussion was held between Blue-Action and the lead scientist (Niels Hintzen) responsible for the refinement of the North Sea herring assessment. Previous work has identified substantial variability in the recruitment to this stock (Payne *et al.*, 2009) and temperature has at least some role to play in the growth (Payne *et al.*, 2013) and mortality (Fässler *et al.*, 2011) of larval herring in this region, possibly via a starvation mechanism (Hufnagl *et al.*, 2015). Such direct linkages between the physical environment and a biological response of direct relevance to the assessment and management of the stock make an ideal candidate for the development of a targeted climate service forecast product.

It was therefore agreed to attempt to develop a forecast product for the recruitment of North Sea herring. The initial timeframe for doing this was to have it ready to present in time for the second phase of the benchmark workshop in February 2018.

ICES WGIPS

In addition to the generation of scientific advice, ICES expert groups also have the responsibility for designing scientific surveys used in the monitoring of key fish stocks. These surveys are planned in detail prior to their commencement, so as to use the resources (vessel and personnel time) available as efficiently as possible to achieve the most reliable and useful estimate of the abundance of the stock(s) under study. As part of the planning exercise, prior knowledge about the expected distribution of the stock is particularly useful: most commonly this consists of assuming persistence from the previous year's distribution, although this can be problematic in cases where the distribution of the stock varies greatly between years.

The ICES Working Group of International Pelagic Surveys (WGIPS) coordinates the design and performance of acoustic and larval surveys for pelagic fish in the North Atlantic. WGIPS covers three larval surveys covering North Sea, Irish Sea, and Western Baltic for herring. For acoustic surveys, the group covers four international coordinated surveys, as well as five individual national surveys covering

the North Sea, West of Scotland, Malin Shelf, Western Baltic, Northeastern Atlantic, Norwegian Sea and Barents Sea: target species include herring, sprat, blue whiting, mackerel and boarfish.

Summary of the Meeting, 17 January 2018, IMARES, Den Helder, The Netherlands

Blue-Action recognised the potential early-on for a forecast product relating to the spatial distribution of blue whiting spawning, and therefore of relevance to the International Blue Whiting Spawning Stock Survey (IBWSSS) coordinated by WGIPS. This stock has been shown to vary appreciably in its spatial distribution from year to year, creating potential problems for designing and implementing a survey that robustly covers the full distribution of the stock. Previous work has linked this variability to the dynamics of the North Atlantic subpolar gyre (Hátún *et al.*, 2009a, 2009b), forming a basis for potential prediction. Recent work performed within Blue-Action has taken this a step further, and linked the spawning distribution to salinity in the spawning region (Miesner and Payne, 2018). Based on these results, a draft outline of a forecast product was prepared and presented to the 2018 WGIPS meeting, to form the basis for discussion.

The outline of the proposed climate service was presented to the approximately 20 scientific members of the WGIPS expert group in plenary. The presentation was well received, although there was initial confusion about how it could be used. However, it was emphasised that the main purpose of such a forecast was to ensure that the survey fully contained the stock, and therefore provided an unbiased estimate of abundance. At this point it became clear to the members of WGIPS how this could be used and interest in the product grew. Although it was viewed as being too early in the development of such a forecast to make decisions exclusively based on it, it was viewed as being a useful complement to existing practices. It was therefore agreed that the forecast would be updated in time for the start of the survey, on 1st March 2018, and distributed to the individual vessels performing the survey. Blue-Action was also invited to the post-survey meeting, in April, to follow up on the performance of its forecast, and to discuss future plans for how this could be used for the 2019 survey.

NordTun Atlantic Bluefin Tuna Workshop

Atlantic Bluefin Tuna (ABFT) is a highly sought after and endangered species that is widespread throughout the North Atlantic. The species is highly migratory and in recent years, a number of surprising observations have been reported around Iceland, East Greenland and the Irminger Sea. Work performed by researchers at DTU-Aqua, including those involved in Blue-Action, have linked these changes to the changes in sea surface temperature in this region (MacKenzie *et al.*, 2014).

In order to improve the understanding of these dynamics, a workshop ("Nordtun") was funded by Nordforsk to collate all of the available observations relating to these distribution changes and bring them into a standardised format that can be used for further scientific research. The workshop was held at DTU-Aqua in Lyngby, Denmark from the 29th January to 2nd February 2018 and was attended by 12 scientific experts from around the North Atlantic: particularly notable attendees included

- the chair of the working group within the International Commission for the Conservation of Atlantic Tunas (ICCAT), Ana Gordo, which is responsible for assessing the current state of this stock and making recommendations for the sustainable exploitation of this species
- researchers from Iceland, Greenland and Norway with direct links to their respective fishing industries

Summary of the Meeting, 29 January- 2 February 2018, Lyngby, Denmark

This meeting was viewed as being potentially very valuable for the work of Blue-Action in developing marine ecological climate services. Previous work performed within the EU FP7 project "NACLIM" has suggested that the habitat of this species can potentially be predicted on a decadal timescale: there is therefore a good scientific basis for developing a marine ecological climate service around ABFT. However, there is currently no clear end-user for such a product. The goal of participating in this workshop was therefore to identify end-users who could aid in the development of such a climate service and ultimately use it.

The work performed previously within the NACLIM project was presented to the workshop, and the results were well received. There was a clear interest from several parties in working to develop this further, and potentially incorporate it into their decision-making processes. It was therefore agreed to continue the dialogue between Blue-Action and the members of the Nordtun workshop, with a view to implementing and developing a climate service around the distribution of Atlantic Bluefin Tuna.

Non-Governmental Organisations and the General Public

Recreational Fishers

In collaboration with "*Fangstjournal*", Blue-Action has explored the possibility of developing climate services for use by recreational fishers and the general public. *Fangstjournal* is a citizen science project developed and coordinated by Christian Skov from DTU-Aqua in Denmark. The project is centered around an app that is used by recreational fishers to log information about their fishing trips e.g. target species, weather conditions, time spent fishing, location, and catches. The project has been running for several years and has a stable user-base with a good retention rate. Data gathered is by default private but can be shared with other users. The data collected is also available to researchers at DTU-Aqua, who are able to use it for both research and potentially for monitoring of fish populations. This data set, together with the physical forecast models developed in Blue-Action, could also be used to develop fishing opportunity forecasts that could aid in both the success and enjoyment of recreational fishers across Denmark.

Development of collaboration between Blue-Action and *Fangstjournal*

During the course of the first year of Blue-Action, several meetings were held within DTU Aqua between Christian Skov, as leader of the *Fangstjournal* project, and Mark Payne and Brian MacKenzie who were both interested in scientific applications of the data collected by the app. Whilst the initial focus was not on Blue-Action-related topics, it rapidly became clear that developing a climate service / forecast product for use by end-users of the app could be beneficial for all partners involved as well as end users. The decision was therefore made to pursue this avenue of collaboration.

Several starting points were considered. Migratory fish species, such as Garfish (*Belone belone*) and Mackerel (*Scomber scombrus*) were viewed as being particularly relevant to users, as they migrate into and out of Danish waters: the likelihood of a successful fishing trip therefore varies throughout the year, throughout space, and between years, opening a niche for improved knowledge about the current and future state of these speices. Two different types of products that could be useful were also identified in discussions between Blue-Action and *Fangstjournal*. The simpler of these is a "nowcast" product, where information is extracted from the *Fangstjournal* database on a regular (e.g. weekly) and visualised (possibly with the aid of geostatistical models): maps from both the current season and previous seasons could be presented to users to gain an overview of the current state of the migration. While the are technical hurdles (e.g. access to the database, anonymisation of data), there are few scientific

hurdles. The second type of product would build on this idea, but start to actively forecast the migration timing, based on data from within the app and from other sources.

The idea of holding a workshop with recreational anglers that could be used to define products that could be of relevance was initially discussed. However, it was quickly agreed that it may be too early to hold a large event, given both that the main fishing season (spring / summer) is a long-way off and that there are not, as yet, test products that could serve as a potential point of discussion. Instead, it was agreed to develop an "expert panel" of 5-10 active users of the app recruited from the *Dansk Sportfiskerforbund* (Danish Recreational Fishers Association - DSF) that could serve as a starting point to define what could potentially be of interest. Invitations were sent out to a small set of active users of the app identified in collaboration with DSF and six accepted. The meeting was hosted at the new offices of DSF in Vingsted, Jutland, with the end-users travelling primarily from the Jutland and Funen regions of Denmark.

Summary of End-User Workshop, 22 January 2018, Vingsted, Denmark

The workshop started with a plenary presentation by Mark Payne describing the work of Blue-Action and *Fangstjournal*, and the ideas for how these two unique projects could be brought together for the benefit of all parties. This presentation was given in Danish, which proved to be a challenge, although there were clearly no problems with communication at any point in the workshop. The presentation was well received and a number of insightful questions were asked along the way.

Next, the participants split into two groups and guided by Skov, Payne and MacKenzie through a series of prepared questions about the type of forecast information that could be of interest to recreational fishers, how it could be presented, and for which target species. Finally, the two groups came back together and compared their answers to the questions.

Based on their experience and some previous work on the topic, the researchers felt that there was scientific potential for forecasting the timing of migration of two key recreational species into Danish waters: garfish (Scientific name: *Belone belone.* Danish name: *hornfisk*) and mackerel. The anglers were generally very positive about these ideas, particularly with respect to garfish forecasts, and highlighted the potential use of such forecasts for the general public: fishing for garfish is a popular family activity in Denmark during the season when they migrate into Danish waters, and the species is renowned for both the fight that it puts up while on the line, for its excellent taste, and for the numerous green bones. For many, this is their first experience of fishing, and some of the anglers could still relate the experience of catching their first garfish (one related how he was afraid that it would pull him out into the fjord!), and DSF specifically targets the peak of garfish season for their outreach activities.

However, the anglers also surprised the researchers in the way that they personally would use such a forecast: as a way to avoid garfish. When garfish arrive in Danish waters they are extremely plentiful and make it difficult to catch other more prized species, such as sea trout: one fisher described garfish as being “fun the first couple of times, but after that its gets too easy and you nearly want to stop finishing”. Another noted that they would plan fishing trips after such a forecast, while a third remarked that the start of the garfish season marked the point where it was time to switch from the ocean to rivers and lakes.

With respect to the delivery format, it was viewed that a form of barometer would be a sufficient way to communicate the likelihood of catching garfish. A forecast lead-time of 1 month was viewed as sufficient (anything more was excessive) but now-cast / near-real time observations could also be useful. Weekly

updates would also be sufficient. Spatial resolution was not viewed as being particularly important, although it would be useful to be able to differentiate between different parts of Denmark.

The fishers also discussed a number of other target species that could be used for developing either forecasts or nowcasts, including sea trout, sea bass, turbot, mullet, salmon, herring and mackerel. However, there was general agreement that garfish was a good place to start the development of forecasting applications, and one that would have wide appear to both serious fishers and the general public.

The decision was therefore made between Blue-Action and *Fangstjournal* to pursue forecasts of garfish into Danish waters as a first codeveloped climate-service, with the aim of having preliminary analyses ready in time for the start of the garfish season in April 2018.

Main results achieved

The primary result obtained by this work has been the successful identification of potential climate service products that are of potential use to end-users. Many ideas were generated during this user-engagement process, but in each case the users were asked to prioritise the products by their perceived usefulness and importance. While it remains to be seen whether the development of these services is technically feasible, these results provide a guide for the work done towards developing climate services for marine fisheries over the next two years within the Blue-Action project.

Details of the proposed individual services are provided in the above sections. However, a brief overview of the main priority product for each end-user contacted is provided in the table below.

End-user	Highest Priority Potential Climate Service(s)
Pelagic Freezer Trawler Association (PFA)	Timing of spawning in Downs herring
Danish Pelagic Producers Organisation (DPPO)	1) Recruitment and 2) Phenology (timing) of Sandeel in the North Sea
Marine Ingredients	Recruitment of the portfolio of small pelagic fish stocks in the North Sea
WKPELA2018	Recruitment of herring in the North Sea
WGIPS	Spatial distribution of Blue whiting spawning
ICCAT / Iceland, Greenlandic Fishing Industry	Distribution of Atlantic Bluefin tuna in the North Atlantic
Recreational Fishers / *Fangstjournal*	Timing and distribution of garfish migration

In the event that one or more of these climate services are completed, or prove to be scientifically infeasible, further proposals for climate services may be examined based on the conversations documented above, as resources and time allow. Furthermore, the conversation with the end-users listed here, and with other potential end-users, is seen as an ongoing one and new ideas and needs may also be incorporated in the future, again subject to resource constraints. However, the climate services listed above will form the first priority for development in the Blue-Action project.

Progress beyond the state of the art

The work performed here has advanced our understanding of end-user needs for marine ecological climate services in Europe. As our review showed (Payne *et al.*, 2017), there are currently no marine ecological climate services or forecast products in Europe that we are aware of, and there has been no effort undertaken to map these requirements. The work performed here has therefore moved our understanding of these requirements before the (rather poor) state of the art, and thereby paved the way for the development of these services in the rest of the Blue-Action project and in the future.

Furthermore, Blue-Action has been ambitious and creative in the breadth of the end-users contacted here. The case study has learnt from the user consultations that it has performed, and adapted its strategies along the way. Whilst the process has been, of necessity, limited by the available resources, it has nevertheless covered a broad span of potential end-users beyond the "traditional" commercial fishing industry applications originally envisaged in the project Description of Work. It is therefore hoped that the climate services that result will be able to reflect a broad set of applications for climate data and information across multiple sectors.

Impact

How has this work contributed to the expected impacts of Blue-Action?

The work performed here has contributed to the expected impacts of the Blue-Action project as follows:

- *Improve the capacity to respond to the impact of climatic change on the environment and human activities in the Arctic, both in the short and longer term*
  By identifying where climate service information could be useful, Blue-Action has paved the way to improve the capacity of end-users and stakeholders to respond to climate change and climate variability. Future work in Blue-Action will then develop the climate services, based on these priority areas, that can allow active decision making.
- *Improve the uptake of measurements from satellites by making use of new Earth observation assets*
  The work performed here has identified key climate services that need to be developed to aid end-users in their day-to-day decisions. Many of these climate services will rely on existing and new Earth observation assets and technologies to drive the forecast models. Identification of these services is therefore the first step to improving the uptake of these products.
- *Improve stakeholders' capacity to adapt to climate change*
  The identification of end-user needs for climate services in this case study is very much motivated by their needs to responds to changes in the marine living resources that they are dependent. This organisms are in turn strongly influenced by the vagaries of a variable and changing marine climate. Identification of potential climate services therefore paves the way for adapting to this variability in the future.
- *Contribute to better servicing the economic sectors that rely on improved forecasting capacity (e.g. shipping, mining)*
  The identification of potential climate services that could be utilised by end-users is the first step towards their development and thereby improving the servicing of these sectors by developing new forecasting capacity.
- *Improving innovation capacity and the integration of new knowledge*
  As our review of the current state-of-the-art in marine ecological forecasting has shown, there is relatively little uptake of the new-found forecast skill developed in the climate sciences. This work contributes to integrating this new knowledge into the management and utilisation of marine living resources by first identifying where it could be of use. Future work will then build on top of these aspects.

- *Strengthening the competitiveness and growth of companies by developing innovations meeting the needs of European and global markets; and, where relevant, by delivering such innovations to the markets*
  The work performed this far, and the potential climate services that we have aimed to develop based upon it, will strengthen the competitiveness and growth of the companies using them by reducing key uncertainties associated with their businesses.

Impact on the business sector
As detailed above, the work performed here paves the way for having a positive impact on the business sector and for fuelling Blue Growth. By identifying where there is a need for marine ecological climate service information, it becomes possible to focus our research efforts in the areas where they will have the most important. Future research effects then aim to fill these gaps and thereby have a positive impact on the business sector.

Lessons learned and Links built

The initial review of existing forecast systems highlighted some key points about the successful development of climate services for use in applications to marine living resources. Foremost amongst these was the need for co-development of these products, and for end-users to be closely involved in the specification and development of these outputs: a philosophy that we have attempted to carry through the work as much as possible.

The review also identified a number of criteria for what makes a feasible forecast product. “Low-hanging fruit” can be identified by looking for situations where 1) there is mechanistic understanding of the relationship between the physical variable and the biological response 2) the physical variables themselves in question can be forecast and 3) there is high proximity between the driver and response. However, it is also critical to remember that a good forecast is also useful to an end-user (Murphy, 1993), and it is only at the intersection between what is feasible with what is useful that we can truly develop climate services of value to society.

Notably, while our review process highlighted the value of engaging with stakeholders in other peoples’ forecast products, it wasn’t until we started doing it ourselves that we truly appreciated how important and valuable it was. Most commonly, this came in the form of challenging our preconceptions about the needs of the end-user. Notable examples include e.g.

- Representatives of the fishing industry who saw the development of climate services to improve fisheries management and thereby generate more quota as being more useful than developing products to be used directly by them.
- Recreational fishers who wanted to know where the fish were, so that they could avoid them, rather than catch them

Finally, this process facilitated the development of a number of important links between Blue-Action and outside organisations. In addition to the sectors and end-users contacted, important links were also formed to

- The INTAROS project, whose WP6 has close similarities with the work performed in this Case Study
- The CLIMATEUROPE project, whose expertise and experience in developing climate services has already proved to be both inspirational and invaluable.

It is expected that these links will strengthen as the process of developing climate services progresses.

Some additional links have been built to a parallel project run by the WP5 and case study leader, Mark Payne at DTU AQUA, together with the Yellow-Eyed Penguin (YEP). Mark's work on the Yellow-Eyed penguins is not funded by Blue-Action, but shows interesting correlations with the work Mark Payne is implementing in the Blue-Action case study on fishery. Here below we have provided a short overview on this activity.

Yellow-Eyed Penguin Trust

The Yellow-Eyed Penguin (YEP) Trust is a non-governmental organisation based in Dunedin, New Zealand. The trust is focused on efforts to conserve the Yellow-Eyed Penguin, a charismatic species that is native to the south island of New Zealand and its out-lying islands. The species drives a large eco-tourism industry in the area around Dunedin that is estimated to be worth around $NZ 100 million (€60 million) to the local economy. The species is however, endangered and current estimates put the population at around 4000 individuals. The YEP trust works to protect this species by controlling predators and restoring coastal forest along the south-east coast of New Zealand. The species has been hard-hit by the introduction of ground-based predators (e.g. rats, cats, dogs) by humans to this areas, together with habitat loss and occasional (and poorly understood) mass mortality events.
Meetings with YEP so far: 11 April 2017, University of Otago, Dunedin, New Zealand, 21 April 2017, YEP Trust Offices, Dunedin, New Zealand, Subsequent follow up discussions electronically.

Summary of meetings and discussions:

Recent work (Mattern *et al.*, 2017) has also linked the decline in this species and poor survival of the juveniles to sea-surface temperatures in the region: projections from climate models project the populations around Dunedin to be extirpated before 2050. **Given the link with sea temperatures, and the potential predictability of sea surface temperatures in this region, it is possible to envisage a climate service that could potentially predict adverse conditions for the population and the survival of the young.**

It was therefore agreed to explore the potential for forecasting juvenile survival rates of this species based on observations and forecasts of sea-surface temperature together with estimates of oceanic productivity. Such climate services could be used to help inform the deployment of measures to increase survival rates of juveniles: similar approaches have been seen with fairy penguins in Australia.

Initial work will focus on examining the robustness of the published work, and the predictability of SST in this region, to check that there is both a useable relationship between the physical environment and survival, and that this environment can be reliably forecast. Once these analyses were completed, it was agreed to examine the potential for developing a targeted climate service for Yellow-Eyed Penguins in more detail.

Contribution to the top level objectives of Blue-Action

This deliverable contributes to the achievement of the following objectives and specific goals indicated in the Description of the Action, part B, Section 1.1: http://blue-action.eu/index.php?id=4019

- **Objective 7 Fostering the capacity of key stakeholders to adapt and respond to climate change and boosting their economic growth** by identifying their needs for marine ecological climate services that can be used to both forsee and thereby adapt to changes in the marine living resources that they are dependent upon.
- **Objective 8 Transferring knowledge to a wide range of interested key stakeholders** by

identifying how climate predictions generated in climatology and oceanography can be used to develop forecasts of marine living resources that are relevant to end-users in their everyday decision making.

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Dissemination and exploitation of Blue-Action results

Dissemination activities

Type of dissemination activity	Title	Date and Place	Estimated buget	Type of Audience	Estimated number of persons reached
Participation in a Workshop	WKPELA2018 data preparation workshop	6 December 2018, Copenhagen, Denmark	See the form C of the relevant partners.	Scientific community	20
Participation in a workshop	WGIPS	17 January 2018, Den Helder, The Netherlands	See the form C of the relevant partners	Scientific community	20
Organisation of a workshop	*Fangstjournal* users workshop	22 January 2018, Vingsted, Denmark	See the form C of the relevant partners	General Public	6
Participation in a conference	Arctic Circle	13-15 October, Reykavik, Iceland	See the form C of the relevant partners	General public	Conference participation ~2000
Organisation of a workshop	ICES WGS2D	12-16 June 2017, Copenhagen, Denmark	See the form C of the relevant partners	Scientific community	~10
Participation in a workshop	ICES WGCHAIRS	23-25 January 2018, Copenhagen, Denmark	See the form C of the relevant partners	Scientific community	50
Organisation of a workshop	Blue-Action – GERICS collaboration workshop	10-12 July 2017, Hamburg, Germany	See the form C of the relevant partners	Scientific community	50
Participation in a conference	Dansk havforskermøde (The Danish Marine researchers meeting)	25 January 2017, Helsingør, Denmark	See the form C of the relevant partners	Scientific community, general public	~500
Participation in a workshop	Nordtun workshop on Atlantic Bluefin Tuna	31 January 2018	See the form C of the relevant partners	Scientific community	12
Participation	University of Otago seminar series	11 April 2017, Dunedin, New	See the form C of	Scientific	~50

to an event other than a conference or workshop		Zealand	the relevant partners	Community	
Poster	Payne, Mark, Keil, Kathrin, Kolstad, Erik, Ballester, Joan, Mettiainen, Ilona, Vangsbo, Peter, … Olsen, Steffen. (2017). Translating advances in Arctic climate science to climate services across the Northern Hemisphere (Version November 2017). Zenodo. http://doi.org/10.5281/zenodo.1065467 Presented at the EASME workshop „Climate services at work, Projects exchange and networking lab, Brussels (BE)" Presenter: Steffen Olsen (DMI)	29-30 Nov. 2017, Brussels (BE)	See form C of partner involved.	General public, policy makers	200
Poster	Miller, Raeanne, Payne, Mark, Keil, Kathrin, Kosltad, Erik W., Ballester, Joan, Lesser, Pamela, & Vangsbo, Peter. (2017). Translating advances in Arctic climate science to climate services across the Northern Hemisphere. Zenodo. http://doi.org/10.5281/zenodo.827081 5-9 June 2017, 3rd European Climate Change Adaptation Conference, Glasgow (UK) Presenter: Raeanne Miller	5-9 June 2017, Glasgow (UK)	See form C of partners involved.	Scientific community and policy-makers	200
Publication	Dale, Thomas, Miller, Raeanne, Vangsbo, Peter, Mettiäinen, Ilona, Ballester, Joan, Kolstad, Erik, … Nikitina, Elena. (2018, January 18). Climate Service Case Studies Booklet. Zenodo. http://doi.org/10.5281/zenodo.1154792	18 Jan 2018	See form C of partners involved.	General public, policy makers	200

Peer reviewed articles

Title	Authors	Publication	DOI (if available)	Publication Status (in preparation, under review, accepted)	Open Access
Lessons from the First Generation of Marine Ecological Forecast Products	Payne, M.R. *et. al*	Frontiers in Marine Science	10.3389/fmars.2017.00289	Published	Golden OA

Uptake by the targeted audiences

As indicated in the Description of the Action, the audience for this deliverable is the general public (PU) is and is made available to the world via CORDIS.

This is how we are going to ensure the uptake of the deliverables by the targeted audiences:
As indicated in the Description of the Action, the audience for this deliverable is the general public.

This is how we are going to ensure the uptake of the deliverables by the targeted audiences:
Despite of the PU nature of the deliverable, priority in dissemination will be given to the end-users indicated in this document.
Additionally:

- This deliverable will be shared with the consortium in the project intranet.
- We plan to share it with the Arctic Cluster project teams and EU-PolarNet CSA.
- We also plan to share this document the RIAG and SEG advisors of Blue-Action.

For reaching out to the general public, the contents of this deliverable will be taken up by WP8 and disseminated broadly using the social media of the project.

Additionally, the deliverable will be archived in Zenodo for granting open access to larger audiences.

Intellectual property rights resulting from this deliverable

At present, we are monitoring the development of the work performed in this case study and the interactions with the Blue-Action WP1-4: we will check if the IP emerging from the research need to be protected, and how, with the legal advisors of the organisations involved.