granskingarráðið
RESEARCH COUNCIL FAROE ISLANDS

The final report must be sent to Research Council Faroe Islands no later than 3 months after the project conclusion.

Please also attach a transcript of the expenses from Gjaldstovan or from the institutional financial department.

The document must be signed and submitted **by e-mail** to gransking@gransking.fo

Final Statement and Report

1. Project Number and Title	8013/109238 BlueOcean – Blue whiting recruitment, distribution and ocean-climate processes in the north Atlantic Ridge area
2. Host Institution/Company Director/Head of Department	DTU Aqua, Technical University of Denmark Institute director, Prof. Anna Rindorf
3. Project Manager	Brian R. MacKenzie
4. Time schedule for entire project:	Planned: 01-02-2022 – 31-01-2026 Actual: 01-02-2022 – 30-04-2026

5. Statement of account for <u>the entire project in DKK</u>

			From FRC	From others
Funds allocated for the project (1)		3.998.000	3.248.000	750.000
Expenditure specified:	**Original budget (a)**	**Actually spent total (b) (=c+d)**	**Actually spent (c)**	**Actually spent (d)**
VIP-salary	2.600.000	2.695.948,56	2.110.948,56	585.000,00
TAP-salary	0	0	0	0
Operational expenses	748.000	628.062,28	614.062,68	13.999,60
Overhead	650.000	673.987,14	527.737,14	146.250,00
Total (2)	3.998.000	3.997.997,99	2.252.748,39	745.249,60
Difference: 1 minus 2		**2,01**	*-4.748,39*	4.750,40

Invoiced Amonut from GRANSKINGARRÁDID 19-05-2026 Dkr 3.750.000.
Final invoicing to DTU from GRANSKINGARRÁDID is Dkr 247.997,99, when the final reporting is approved.

6. Cooperation

An overview of cooperation with institutions, companies and other projects:

BlueOcean project was a cooperation between the Faroe Marine Reseach Institute (FAMRI) and the National Institute for Aquatic Resources (DTU Aqua), Technical University of Denmark. FAMRI is a governmental research institute based in Tórshavn, Faroe Islands, and DTU Aqua is on the main campus of DTU in Lyngby, Denmark. Both organisations regularly provide fishery and marine ecosystem management advice to Faroes, Danish and other authorities, including the EU. This advice, when addressing international issues (e. g., fishery regulations), is developed via FAMRI and DTU Aqua participation and engagement in expert working groups of the International Council for the Exploration of the Sea (ICES).

The implementation and execution of BlueOcean by FAMRI and DTU Aqua has been productive, successful and highly collaborative. The collaborative nature of the project has included joint co-supervision of a Ph.D. student (Constanza Cappelli; thesis defended Jan. 31, 2026). The supervisory committee included two scientists from FAMRI and two from DTU Aqua where the student was based. The supervision has included frequent email contact and online meetings, a 3-month research stay at FAMRI, participation on one of FAMRI's fishery monitoring and research cruises and joint participation in other meetings (e. g., ICES working groups).

The project has produced new scientific results regarding oceanographic and climatic influences on one of the major fish stocks (blue whiting) for the Faroese and EU fishing industries. This has been done via a combination of statistical analyses and oceanographic particle-tracking modelling methods. These influences include improvements in forecast skill of population dynamics and the forecast horizon (leadtime) when such forecasts can become available. Analyses within the project have shown that the new links between oceanographic processes and reproductive success for this stock are sufficient strong to potentially inform the fishery advice provided by ICES.

Results of the project have been presented at the relevant blue whiting fishery and integrated ecosystem expert working groups of ICES (i.e., WGWIDE), where they have been received with much interest. In addition, the Ph.d. student has been invited to give presentations of her work at the ICES Science Committee (i.e., SCICOM, 11 March 2026) and at two major pelagic fishery industry meetings (i. e., Pelagic Avisory Council (PelAC) meeting, Paris, 26-29 February, 2024; fish meal and oil producers (i.e., Marine Nutrients Europe (EFFOP) meeting, Bremerhaven,, 9-12 June 2026), demonstrating interest and relevance of BlueOcean work to the fishing industry.

Project Consortium (Participants' name, degree, profession, and place of work):

Hjálmar Hátún, Ph. D., senior research scientist (physical oceanography), Havstovan, Faroe Islands

Jan Arge Jacobsen, Dr.Scient., senior scientist (fishery biology), Havstovan, Faroe Islands

Costanza Cappelli, Ph. D., Ph.D. student, National Institute for Aquatic Resources (DTU Aqua), Technical University of Denmark, 2800 Lyngby, Denmark

Andre Visser, D. Techn., Professor (physical oceanography), National Institute for Aquatic Resources (DTU Aqua), Technical University of Denmark, 2800 Lyngby, Denmark

Brian MacKenzie, Ph.D., Professor (fisheries oceanography), National Institute for Aquatic Resources (DTU Aqua), Technical University of Denmark, 2800 Lyngby, Denmark

7. Final report to the Research Council

Report of development of project, conclusions and possible application of results:

Development and conclusions of the project:

The project has been a successful and productive collaboration between FAMRI and DTU Aqua. It has resulted in new scientific findings relevant to our understanding of the dynamics of one of the most important fish stocks (blue whiting) for the Faroese (and EU) commercial fishing industry, and the training of a new early career research scientist (Ph. D. student Costanza Cappelli; thesis defended Jan. 30, 2026). This student was jointly supervised by FAMRI and DTU Aqua scientists, and was based at DTU Aqua with visits and stays at FAMRI (see section 6).

The ***main scientific result*** is the demonstration that climate-oceanographic conditions during the first few months of life affect the annual survival rate of newly produced young blue whiting, and that these variations are large enough that they affect population biomass and potentially also the fishery management advice several years into the future. The climate-oceanographic conditions include the regional wind stress and how it affects the spatial distribution, magnitude and properties of oceanographic water masses and currents (including the North Atlantic sub-polar gyre) in the northeast Atlantic and in particular in the main spawning area for the stock (west of Ireland and the UK; Porcupine Bank-Rockall Trough area of the northeast Atlantic Ocean). Analyses done in the project have shown that the wind and ocean currents affects the transport destinations and temperature that blue whiting eggs and larvae experience and that inter-annual differences in these conditions affect their survival rate and thus the total annual recruitment to the stock.

These effects on blue whiting are the consequence of climatic-oceanographic processes at large space-time scales. The oceanographic and biological response to these variations are not instantaneous due to the huge energy input and inertia required to alter ocean properties and currents are regional scales. Analyses in the project have shown that the blue whiting survival response trails (lags) the wind-oceanographic variations by one year. This means that wind conditions in a given year have significant oceanographic and ecological effects one year later.

Possible application of results:

We see three major applications of BlueOcean results.

First, BlueOcean findings can potentially be relevant for fishery management and for helping to increase sustainability and profitability of blue whiting fisheries. Until BlueOcean project, there were no quantitative, skilful models available for forecasting or predicting the survival rate of young blue whiting. However, given BlueOcean project results, such models now exist. Moreover, given the natural lagged responses within the climate-oceanographic-ecological cascade (see above), the new results and models provide longer warning of major changes in blue whiting survival rates than is currently possible. We have shown in the project that these models and results can impact the perception of fish stock development and the fishery advice (e. g., quota sizes) for the stock. These results could therefore, if implemented by ICES, have direct application to the management of the blue whiting fishery, and increase both its sustainability and profitability.

Second, the project could contribute to ongoing discussions and analyses within ICES of the stock structure, and the possible need to revise fishery stock management units. The BlueOcean project has shown that the dispersal probability and distance of transport of blue whiting eggs and larvae from distinct spawning areas (e. g., Hebrides area, Porcupine Bank, Rockall Plateau) depends on the local ocean currents, driven partly by wind stress and the sub-polar gyre dynamics, and differs between the spawning areas. Differences in dispersal potential among spawning areas could be a mechanism supporting a higher level of local population differentiation than is currently recognized in the literature. New studies of dispersal/retention processes are therefore needed to understand population structure and the definition of the stock management unit(s).

Third, BlueOcean findings provide a new scientific basis for advancing an Ecosystem Based approach to Fishery Management (EBFM) for this population. The detection of a climate-oceanographic influence on survival rate of new young blue whiting demonstrates that ***ecosystem processes and phenomena*** (e. g., ocean currents and temperatures) can influence the biology of the species with sufficient magnitude to affect population demographics and productivity. Given that advancing EBFM is a priority within ICES, FAO and many fishery management

organisations but has been difficult to achieve operationally, the new findings from BlueOcean could assist ICES towards EBFM for this stock.

Application (i. e., operational implementation) of the project results is the responsibility of other organisations and stakeholders, including the fishing industry. Project results have been presented to relevant expert working groups of the international organisation responsible for developing blue whiting fishery advice (ICES; see sections 6 and 8) and to key fishing industry groups, which have shown interest in the results. Our next step post-project is to continue our ongoing dialogue with these organisations to increase awareness, literacy, and potential uptake and application of the findings within the fishery advice process of ICES.

8. Information to be published in the Grants database on gransking.fo

Please report in English or Faroese

A brief summary of the project – work progress, main results:

The BlueOcean project has shown that climate-oceanographic conditions (winds, currents, temperature) during the first few months of life affect the annual survival rate of the young stages of blue whiting. This fish species is very important ecologically (i. e., as a prey for larger animals and as a predator of smaller animals) in the northeast Atlantic Ocean, and it supports one of the largest commercial fisheries in the Faroe Islands and even in the entire Atlantic Ocean. The effects of climate-oceanographic conditions on survival rate are large enough that they affect population biomass and potentially also the fishery management advice (e. g., quota size recommendations) several years into the future.

The new results have the potential to increase the sustainability of the population and its fishery, and have attracted interest from relevant international fishery management authorities (e. g., ICES) and the commercial fishing industry. By demonstrating that ecosystem conditions have significant impacts on population dynamics, the study also makes a scientific contribution towards international efforts to develop ecosystem-based approaches to fisheries management. Many of the project findings have been discovered as part of a dedicated, completed Ph.D. project jointly supervised by scientists from the BlueOcean partner institutes (Faroe Marine Research Institute and the National Institute for Aquatic Resources, Technical University of Denmark; DTU Aqua, coordinator).

Storage and access rights to collected data:
Data on blue whiting recruitment is available at ICES.dk and is published every year in the ICES WGWIDE report and stored in the ICES library (https://ices-library.figshare.com/)

The data underlying the published articles are available in the following open-access GitHub repositories:
1) ICES JMS: https://github.com/costanzacappelli/BlueWhiting_WSC
2) Frontiers: https://github.com/costanzacappelli/BlueWhiting_Transport

Communication:
If the project is registered on Pure.fo please provide link here:

BlueOcean is presented as a collaborative project on the FAMRI homepage:
https://www.hav.fo/verkaetlan/blue-ocean-blue-whiting-recruitment-distribution-and-ocean-climate-processes-in-the-north-atlantic-ridge-area/

OR provide information here:

1. Scientific articles, books, thesis etc.

Cappelli, C., Hátún, H., Jacobsen, J. A., Visser, A. W., Nielsen, A., Berg, C. W., Ferreira, A. S. A., and MacKenzie, B. R. (2025). Ocean-climate conditions one year prior to spawning drive recruitment success of blue whiting. *ICES J. Mar. Sci.* 82, fsaf102. doi: 10.1093/icesjms/fsaf102

Cappelli, C., Hátún, H., Jacobsen, J. A., Visser, A. W., Hansen, F. T., Mortensen, J. B., Accornero, S., Rodrigues, F., and MacKenzie, B. R. (2026). Circulation-driven dispersal and retention affect blue whiting recruitment dynamics in the Northeast Atlantic Ocean. *Front. Mar. Sci.* 13, 1764145. doi: 10.3389/fmars.2026.1764145

Cappelli, C. (2025). Physical processes affecting stock dynamics of blue whiting in the Northeast Atlantic Ocean. *PhD thesis*, Technical University of Denmark (DTU), National Institute of Aquatic Resources (DTU Aqua), Section for Oceans and Arctic, Kongens Lyngby, Denmark.

2. Other results, such as unpublished articles, patents, computer systems, original models and new procedures

Cappelli, C., Hátún, H., Jacobsen, J. A., Visser, A. W., Hansen, F. T., and MacKenzie, B. R. Understanding early-life thermal environment and recruitment variability of blue whiting in the Northeast Atlantic Ocean. Thesis chapter now in preparation for submission to a peer-reviewed international journal.

3. Publications outside the scientific community, i.e. lectures, periodicals, articles in newspapers, television and radio
DTU Aqua news: https://lnkd.in/dcU-c7VK

4. Presentations at meetings, workshops and conferences
   1) ICES Annual Science Conference, Bilbao, 7-11 September 2023
   2) MARiNAO annual meeting, Nuuk, 27-29 May 2023
   3) ICES WGINOR, Tórshavn, 18-21 November 2023
   4) 22 Danske Havforskermøde, Lyngby, 21-23 January 2024
   5) Pelagic Advisory Council meeting, Paris, 26-29 February 2024
   6) ICES-SEAwise WKEcoMSE, Copenhagen, 21-24 May 2024
   7) ICES WGWIDE, Copenhagen, 28 August - 3 September 2024
   8) ICES Annual Science Conference, Gateshead, 9-12 September 2024
   9) MARiNAO annual meeting, Helsingør, 30 September - 2 October 2024
   10) Blue whiting benchmark preparatory meeting, Copenhagen, 26 August 2025
   11) ICES WGWIDE, Copenhagen, 27 August - 2 September 2025
   12) 23 Danske Havforskermøde, Helsingør, 20-22 January 2026
   13) ICES Science Committee (SCICOM) meeting, Copenhagen, 11 March 2026
   14) Marine Nutrients Europe (EFFOP) meeting, Bremerhaven, 9-12 June 2026

Benificiary, Manager/Head of department Project Manager

29/5 2026 | May 29/26 Brian R. MacKenzie

Date Signature Date Signature