Avoiding pitfalls in interdisciplinary education

As the world's social-environmental problems increasingly extend across boundaries, both disciplinary and political, there is a growing need for interdisciplinarity, not only in research per se, but also in doctoral education. We present the common pitfalls of interdisciplinary research in doctoral education, illustrating approaches towards solutions using the Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change (NorMER) research network as a case study. We provide insights and detailed examples of how to overcome some of the challenges of conducting interdisciplinary research within doctoral studies that can be applied within any doctoral/postdoctoral education programme, and beyond. Results from a selfevaluation survey indicate that early-career workshops, annual meetings and research visits to other institutions were the most effective learning mechanisms, whereas single discipline-focused courses and coursework were among the least effective learning mechanisms. By identifying the strengths and weaknesses of components of NorMER, this case study can inform the design of future programmes to enhance interdisciplinarity in doctoral education, as well as be applied to science collaboration and academic research in general.
Research involving the processes governing early life of fishes is important for understanding recruitment to the adult population. The forcing factors, like oceanographic processes and the associated plankton communities, impact the distribution and transport of fish larvae and determine their growth conditions, survival and recruitment to the adult stock. The temporal and spatial overlap of fish larvae and their prey is essential for their feeding, growth and survival. Investigations of the prey size spectra in fish larvae made possible to observe inter-specific prey competition and gain knowledge on the role in the food web. The changes in environmental factors between subarctic and Arctic areas along the west coast of Greenland provide a unique study frame. Here, the period of high primary productivity is short and limited by seasonal changes in light, consequently prey availability for the fish larvae during the summer. The duration of the productive season is of great importance for the early life of fish.

The present thesis investigates the diets of capelin and cod in the subarctic Kapisigdlit, as well as the feeding of non-commercial larval fish in the entire Godthåbsfjord system. Furthermore, growth and feeding of capelin were compared between the two distant localities, Kapisigdlit Fjord and Disko Bay. In Kapisigdlit Fjord, the zooplankton community structure was dominated by rotifers and harpacticoid copepod. These organisms appeared too small as prey for cod larvae, where they were feeding on prey sizes of about 5% of their own size (Paper I) and consequently the prey preference spectra covered calanoid nauplii, cladocerans and calanoid copepoidites with increasing larval size. 

Early life of key fish species, capelin Mallotus villosus and Atlantic cod Gadus morhua, in West Greenland

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The present thesis investigates the diets of capelin and cod in the subarctic Kapisigdlit, as well as the feeding of non-commercial larval fish in the entire Godthåbsfjord system. Furthermore, growth and feeding of capelin were compared between the two distant localities, Kapisigdlit Fjord and Disko Bay. In Kapisigdlit Fjord, the zooplankton community structure was dominated by rotifers and harpacticoid copepod. These organisms appeared too small as prey for cod larvae, where they were feeding on prey sizes of about 5% of their own size (Paper I) and consequently the prey preference spectra covered calanoid nauplii, cladocerans and calanoid copepodites with increasing larval size.
In the Godthåbsfjord system and Fyllas Bank area, 4 hydrographic zones were defined; in each zone distinct zooplankton and ichthyoplankton assemblages were observed (Paper II). Calanus spp are mainly found off Godthåbsfjord, while the smaller copepods are found in the inner fjord. Cladocerans and rotifers were mainly found in Kapisigdlit Fjord, where the key fish species capelin and cod spawn. Sixteen larval fish species were found in the area, and 3 main assemblages were identified according to their similarities, which are related to the hydrographic zones. Fish larvae may benefit from the estuarine circulation to distribute themselves from the spawning areas through the Godthåbsfjord. The diet of the larval fish species varied markedly along the fjord. Prey size preferences of fish larvae were positively correlated to their mouth sizes. American plaice and sandeel were probably do not compete for food with other fish species since these, contrary to other species, had higher preference for microplankton. Capelin larvae from Kapisigdlit Fjord and Disko Bay emerged from the spawning sites when the sea surface temperature reached 6°C, this temperature was reached 1 month later in the northern locality though (Paper III). Their highest pelagic abundances were found when the sea surface temperature reached 8°C. Larval growth rate differed between the two localities, larvae growing faster in the northern Disko Bay than in Kapisigdlit Fjord.

Apparently, the later emergence of larvae in the northern locality was compensated by a higher growth rate, so the capelin larvae could reach the appropriate larval stage and size for overwintering. With respect to diet of capelin larvae, the feeding incidence was found to be greater than 50% and we found a broader spectra of prey taxa than seen in other investigations (Paper IV). The dominating prey items in both localities are: numerically, the rotifers and cyclopoid copepophiles, and harpacticoid nauplii in Kapisigdlit only; while in terms of biomass, calanoid nauplii and cyclopoid copepophiles dominated in both localities. The prey size spectra calculations show some feeding on microplankton, invertebrate eggs and rotifers for the smaller larvae, but the main organisms of preference – and of importance as biomass consumed – were calanoid nauplii and cyclopoid copepophiles.

The findings indicate that capelin and cod larvae were not competing for food as their prey size spectra do not overlap. While cod is preying on larger organisms as they develop, the increase in maximally preferred prey size showed a slower increase during growth of the capelin larvae. Cyclopoid copepophiles are food source for both capelin and cod, and there might be some competition for this item, however this plankton group is very abundant in the west coast of Greenland. However, the competition for food seems to be greater between cod and other fish larvae. With capelin, competition with other fish larvae seems to be minor. The increase in water temperatures in west of Greenland may impact the capelin stocks. When larval emergence is linked to temperature, and the initiation of productive cycles is linked to the break-up of ice cover and the subsequent irradiance increase in the water column, climatic changes in Arctic regions could lead to a mismatch between larval emergence and optimal conditions for their feeding and growth. Thus it would be feasible to investigate the capelin stock genetic characteristics in these areas, to evaluate the potential impact generated by the global warming because of the importance of the capelin for the food web in the west coast of Greenland.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Authors: Malanski, E. (Intern), Nielsen, T. G. (Intern), Munk, P. (Intern)
Publication date: 2016

Publication information
Publisher: DTU Aqua. Institut for Akvatiske Ressourcer
Original language: English
Main Research Area: Technical/natural sciences

Structuring of zooplankton and fish larvae assemblages in a freshwater-influenced Greelandic fjord- Influence from hydrography and prey availability
The recent increase in temperature and freshwater runoff in the Arctic will influence the functioning of the plankton ecosystem and hence the life of the fish larvae residing in these areas. Here, we studied the strength of physical–biological linkages and the adaptability of individual larval fish species to changing hydrographical and feeding environments in a sub-Arctic area in Greenland. The study was carried out along a transect covering a wide range of physical conditions from the deep ocean to the iccap in the Godtha’bsfjord on the south-western Greenland coast. Along the transect, we identified a series of distinct zooplankton and larval fish assemblages which showed linkage to water mass characteristics, to the presence of frontal structures and to availability of preferred prey. Spawning site location and water circulation was also likely to influence distributional patterns of the individual larval fish species. Larvae were feeding on a variety of prey taxa and sizes; some larval species were generalists, while others were more specialized or fed on alternative prey taxa. Differences in feeding strategies might have the consequence that the species will be differently affected by changes in the plankton community. Accordingly, fish larvae that have a greater feeding flexibility and that are more adaptable to environmental variability may cope better with climate related changes.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
What are the major global threats and impacts in marine environments? Investigating the contours of a shared perception among marine scientists from the bottom-up

Marine scientists broadly agree on which major processes influence the sustainability of marine environments worldwide. Recent studies argue that such shared perceptions crucially shape scientific agendas and are subject to a confirmation bias. Based on these findings a more explicit engagement with scientists' (shared) perceptions of global change in marine environments is called for. This paper takes stock of the shared understanding in marine science this article explores if a shared research agenda in relation to global change in marine environments exists. The analysis demonstrates that marine scientists across disciplines are largely in agreement on some common features of global marine change. Nevertheless, the analysis also highlights where natural and social scientists diverge in their assessment. The article ends discussing what these findings imply for further improvement of interdisciplinary marine science.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Ecosystem based Marine Management, Section for Marine Ecology and Oceanography, Section for Marine Living Resources, Centre for Ocean Life, University of the Faroe Islands, Wageningen IMARES, University of Oslo, University of Iceland, University of Helsinki, Åbo Academy University, Stockholm Business School, University of Bergen
Pages: 197-201
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Policy
Volume: 60
ISSN (Print): 0308-597X
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.7 SJR 1.335 SNIP 1.182
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.591 SNIP 1.397 CiteScore 3.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.438 SNIP 1.56 CiteScore 3.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.472 SNIP 1.635 CiteScore 2.71
Distribution and abundance of ichthyoplankton in the Pecém harbor region, Ceará State

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, Universidade Federal do Rio Grande
Authors: Mota, E. M. T. (Ekstern), Totufo, T. M. D. C. (Ekstern), Garcia, T. M. (Ekstern), Malanski, E. (Intern), Campos, C. C. (Ekstern)
Pages: 38-44
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Arquivos de Ciencias do Mar
Volume: 47
Issue number: 1
ISSN (Print): 0374-5686
Ratings:
Web of Science (2018): Indexed yes
Web of Science (2014): Indexed yes
Original language: English
Publication: Research - peer-review › Journal article – Annual report year: 2015
Feeding opportunities and growth of larval cod (Gadus morhua) in a Greenlandic fjord

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Authors: Swalethorp, R. (Intern), Munk, P. (Intern), Kjellerup, S. (Intern), Malanski, E. (Intern), Nielsen, T. G. (Intern)
Publication date: 2014
Event: Poster session presented at Ocean Science Meeting 2014, Honolulu, United States.
Main Research Area: Technical/natural sciences
Publication: Research › Poster – Annual report year: 2015

Feeding opportunities and growth of larval cod (Gadus morhua) in a Greenlandic fjord: temporal and spatial linkages between cod and their preferred prey

Feeding of fish depends on a spatial and temporal match with prey, and since larval and juvenile feeding can be highly selective, their preferences for given prey sizes and taxa should be considered when quantifying the actual availability of potential prey. We investigated the diet and prey preferences of the early-life stages of Atlantic cod (Gadus morhua) to quantify the availability of prey during a spring-summer season in a West Greenlandic fjord. We hypothesized that abundances of larval and juvenile cod at size were synchronized to optimal availability of preferred prey in space and time. The present analysis is based on nine cruises each covering 5 stations visited between 24 May and 5 August 2010 comparing zooplankton abundance, cod gut content and distribution patterns. Cod 4–25 mm in length preferred prey of about 5% of their own length. During ontogeny, their preferences changed from calanoid nauplii towards Pseudocalanus spp. and Calanus spp. copepodes. The larvae/juvenile had an exceptionally high dietary contribution from cladocerans, which were highly preferred by cod larger than 9 mm, while the abundant Metridia longa and the non-calanoid copepods contributed less. These findings stress the importance of focusing on abundance of preferred prey when assessing the actual prey availability to young fish. We found a spatio-temporal overlap between cod and their preferred prey, and observations suggest that advection of both zooplankton and cod contributed to this overlap. Hence, the larval feeding opportunities might be sensitive to climate-related changes affecting the circulation patterns in this fjord.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Authors: Swalethorp, R. (Intern), Kjellerup, S. (Intern), Malanski, E. (Intern), Munk, P. (Intern), Nielsen, T. G. (Intern)
Pages: 2831-2846
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Marine Biology
Volume: 161
Issue number: 2
ISSN (Print): 0025-3162
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 1.198 SNIP 0.993
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.315 SNIP 0.932 CiteScore 2.21
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.204 SNIP 1.041 CiteScore 2.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.272 SNIP 1.064 CiteScore 2.4
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Fish larvae community structuring by prey and environmental conditions within a glacial impacted Greenlandic fjord system

**General information**
State: Published
Organisations: National Institute of Aquatic Resources, Centre for Ocean Life
Authors: Swalethorp, R. (Intern), Malanski, E. (Intern), Agersted, M. D. (Intern), Nielsen, T. G. (Intern), Munk, P. (Intern)
Publication date: 2013
Event: Paper presented at 37th Annual Larval Fish Conference, Miami, United States.
Main Research Area: Technical/natural sciences
Publication: Research - peer-review › Journal article – Annual report year: 2014

Food preferences in Atlantic cod larvae, Gadus morhua, in Godthåbsfjord, Greenlandic waters

**General information**
State: Published
Organisations: National Institute of Aquatic Resources, Centre for Ocean Life
Authors: Malanski, E. (Intern), Swalethorp, R. (Intern), Munk, P. (Intern), Nielsen, T. G. (Intern)
Measuring small organisms under microscope: the case for fish larvae

**General information**

State: Published  
Organisations: National Institute of Aquatic Resources, Centre for Ocean Life  
Authors: Malanski, E. (Intern), Muelbert, J. H. (Ekstern)  
Publication date: 2013  
Event: Abstract from 37th Annual Larval Fish Conference, Miami, United States.  
Main Research Area: Technical/natural sciences  
Publication: Research › Conference abstract for conference – Annual report year: 2013

Preferential feeding in West Greenlandic inshore cod larvae (Gadus morhua) – relationship between prey availability and larval distribution

**General information**

State: Published  
Organisations: National Institute of Aquatic Resources, Centre for Ocean Life  
Authors: Swalethorp, R. (Intern), Kjellerup, S. (Intern), Malanski, E. (Intern), Munk, P. (Intern), Nielsen, T. G. (Intern)  
Publication date: 2013  
Event: Paper presented at 37th Annual Larval Fish Conference, Miami, United States.  
Main Research Area: Technical/natural sciences  
Publication: Research › Paper – Annual report year: 2014

Projects:

The early life of eel in the Sargasso Sea – Influence of oceanography and climate (SARGASSO-EEL) (39107)

The recruitment of the European eel has been in dramatic decline during the last 30 years, and is at a severe low of only 3-5% of earlier magnitude. This change and its influence on the eel fishery have led to an intensified research in the oceanic phase of the European eel.

In order to contribute to further understanding of the life cycle of eel the Danish eel expedition set out in 2014 for the eel spawning grounds in the Sargasso Sea. Here a consortium of Danish scientists and international collaborators focused on the linkages between oceanography, biological production, eel spawning and the growth and drift of eel larvae.

During the expedition, a wide range of organisms was collected: From the smallest plankton of less than a millimeter to very large fish. A number of research groups are now working on samples and data from the expedition and assembling information on key processes in the early life of eels. Preliminary findings indicate that biological and physical changes have taken place in the spawning areas that may affect the eel larvae’s chances of survival and their journey to Europe.

The project was coordinated by DTU Aqua.

The project is funded by the Carlsberg Foundation and Danish Centre of Marine Research (cruise).

National Institute of Aquatic Resources  
Section for Marine Ecology and Oceanography  
University of Copenhagen  
Aarhus University  
Pierre and Marie Curie University - University of Paris VI  
Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin  
Université de la Méditerranée  
University of Alaska Fairbanks  
University of Rhode Island
Sir Alister Hardy Foundation for Ocean Science (SAHFOS)

International Council for the Exploration of the Sea
Period: 01/08/2013 → 01/08/2016
Number of participants: 11
Research areas: Marine Populations and Ecosystem Dynamics & Fish Biology & Oceanography
Project participant:
Thomsen, Helge Abildhauge (Intern)
Serensen, Sune Riis (Intern)
Bekkevold, Dorte (Intern)
Malanski, Evandro (Intern)
Jaspers, Cornelia (Intern)
Koski, Marja (Intern)
Christoffersen, Mads (Intern)
Hansen, Susanne (Intern)
Phd Student:
Ayala, Daniel Jiro (Intern)
Project Manager, academic:
Nielsen, Torkel Gissel (Intern)
Project Coordinator:
Munk, Peter (Intern)

Early Life of Capelin (Mallotus villosus) in West Greenland Waters
National Institute of Aquatic Resources
Period: 01/12/2012 → 01/09/2016
Number of participants: 6
Phd Student:
Malanski, Evandro (Intern)
Supervisor:
Munk, Peter (Intern)
Main Supervisor:
Nielsen, Torkel Gissel (Intern)
Examiner:
Neuenfeldt, Stefan (Intern)
Grønkjær, Peter (Ekstern)
Pedersen, Torstein (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Science Without Borders, Brasi
Project: PhD

Activities:

37th Annual Larval Fish Conference
Period: 2 Jun 2013 → 6 Jun 2013
Evandro Malanski (Participant)

National Institute of Aquatic Resources
Centre for Ocean Life

Links:
http://www.rsmas.miami.edu/LFC2013/

Related event
37th Annual Larval Fish Conference
02/06/2013 → 06/06/2013
NorMER brings together the expertise of leading research groups from all Nordic countries, and several North American institutions, to implement a collective and multidisciplinary research strategy to explore the biological, economic, and management consequences of global climate change on fisheries resources. It will achieve this through a unique program of primary research, implemented by PhDs and Postdocs in a system of collaborative projects, with a focus on the Atlantic cod (Gadus morhua). Though our Nordic focus is on cod, this research is intended to be a platform to extend this knowledge to other marine systems.

Body type: NorMER
Degree of recognition: International

Related external organisation
Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change
Activity: Membership › Membership of research networks or expert groups

Prizes:
Science without Borders - Brazil
Evandro Malanski (Recipient)
National Institute of Aquatic Resources, Centre for Ocean Life
Description
PhD scholarship
Details
Awarded date: 1 Dec 2012
Granting Organisations: Technical University of Denmark
Prize: Prizes, scholarships, distinctions