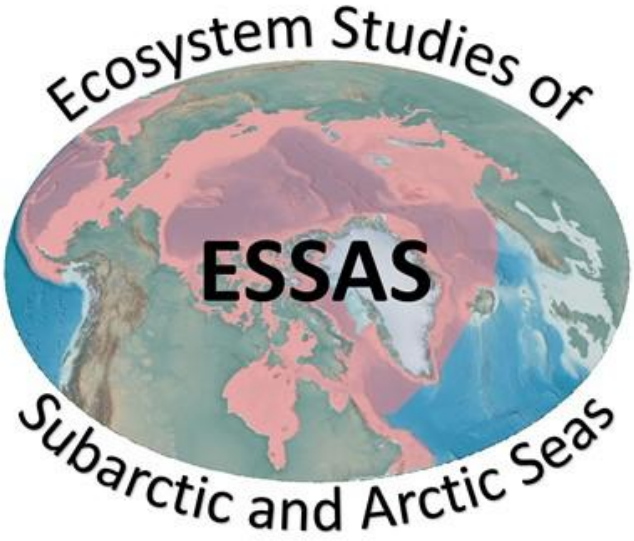

Borealization: Subarctic and Arctic Marine Systems in Transition

ABSTRACT BOOKLET

ESSAS Annual Science Meeting
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Contents

Session 1: Marine Heatwaves: Impacts on High-Latitude Ecosystems from Physics to Biology and Human Communities

KEYNOTE SPEAKER

Authors: **Beatriz S. Dias**; Bridget Ferriss, Andy Whitehouse, Kerim Aydin

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Title: Exploring the impacts of marine heatwaves in the Gulf of Alaska through an ecosystemic perspective.

Abstract

In the past decade, the northern Gulf of Alaska has seen an increase in frequency and intensity of marine heatwaves, therefore making it timely to understand ecosystem responses as a means to create management strategies for commercially important groundfish species. As a result of the past environmental dynamics, these groundfish have experienced changes in mortality, growth, and recruitment. Here, we aim to understand the ecosystem's structure during and post-marine heatwave periods, using a set of network analysis tools. We have developed an Ecopath model of the Western Gulf of Alaska with the base model year set in 1990-1993. The model has a total of 83 living functional groups, three detritus groups, and 11 fishery fleets. Among the living groups, 22 are federally managed groundfish, and nine groups are divided into age groups (multistanzas). We fit the model to biomass and catch time series using the Rpath package and the ROMS hindcast of sea surface temperature and bottom temperature. Temperature-dependent groundfish bioenergetics for consumption and respiration improved the fit of our model. We saw that among the groundfish groups, sablefish presented the highest Omnivory Index, demonstrating their high plasticity during marine heatwave events. Pacific ocean perch and walleye pollock presented high prey and predator overlap, meaning a redundancy in their niche. We also saw a substantial niche overlap for Pacific cod and Pacific halibut, which can potentially lead to intraguild competition. With these results, we can draft plans for the future development of harvest control rules (HCRs) that will account for niche overlap among these species in the face of a changing climate.

ORAL PRESENTATIONS

Authors: **Angel Ruiz-Angulo**; Simon Van Gennip, Kevin Dubois, Rakel Óttarsdóttir

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Title: Assessment of Marine Heat Wave Detection and Prediction in Icelandic Waters

Abstract

Anthropogenic climate change has led to significant increases in atmospheric and ocean temperatures, with the ocean absorbing the majority of the excess heat. In recent decades, Sea Surface Temperature (SST) has exhibited a marked upward trend, particularly in the North Atlantic region. Prolonged periods during which SST exceeds the climatological average for more than five consecutive days are defined as Marine Heat Waves (MHWs). In this study, we use Copernicus hybrid products to assess the capability of an operational application to monitor and forecast MHW events around Iceland. The results demonstrate the potential of this approach for improving regional MHW detection and prediction.

Authors: **Hreiðar Þór Valtýsson**; Stefán B. Gunnlaugsson, Daði Már Kristófersson

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Title: Are subarctic nations' fisheries benefiting from climate change?

Abstract

Assessing performance of fisheries through value of catch arguably offers deeper insight than traditional volume-based measures, which overlook large price differences among species. This study applies a novel cod equivalents (codeqs) metric to evaluate changes in the relative value of northern fisheries over since 1950 and to explore whether these shifts correspond with ocean warming trends observed. The results show that while total catch volumes have declined since the 1970s, the aggregated relative value of catches has remained stable at around five million codeqs per year. At the national level, Greenland, Norway, Russia, United States, and the Faroe Islands have experienced increased catch values, largely due to expanded groundfish and shellfish fisheries, while Denmark, Iceland, and Sweden have seen declines. Changes were insignificant for Canada and Finland. Despite localized gains, particularly in the Barents Sea and around Greenland, the analysis provides little consistent evidence that warming oceans have produced overall economic benefits for northern fisheries. Instead, factors such as improved management, changing species composition, and market dynamics appear more influential than temperature trends in shaping the long-term value of Arctic and subarctic fisheries.

Authors: **Marianne Williams-Kerslake**; Helene R Langehaug, Ragnheid Skogseth, Frank Nilsen, Annette Samuelsen, Silvana Gonzalez, Noel Keenlyside

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Title: Lower-Trophic-Level Responses to Marine Heatwaves in the Nordic Seas

Abstract

Under the current climate change trajectory, marine heatwaves (MHWs) are becoming a regular feature of ocean conditions. While previous studies have determined the timing, drivers and characteristics of MHWs in high-latitude regions, their biological impacts—particularly in the Nordic Seas—remain poorly understood. In this study, we utilise a coupled ocean, sea ice and biogeochemistry model (HYCOM-CICE-ECOSMO TOPAZ-BGC-17km) to assess the potential impacts of MHWs on primary productivity in the Nordic Seas. Specifically, we focus on patterns in chlorophyll, net primary production and phytoplankton biomass during MHW events within selected ecosystem regions, defined according to the date of peak chlorophyll-a. We focus on MHWs with onset occurring between spring and late summer. Lastly, we discuss the potential of developing a biology-based MHW definition. If attainable, developing such a definition will provide a useful criterion to distinguish events that have a high biological impact from those with limited ecological consequences.

Authors: **Russell R Hopcroft**; Jennifer M. Questel , Ana M. Aguilar-Islas, Daniel A. Cushing, Seth L Danielson, Gwenn M. Hennon, Suzanne L. Strom

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Title: Twenty-five years of heatwaves in the northern Gulf of Alaska

Abstract

The Seward Line in the northern Gulf of Alaska (NGA) has been monitoring ecosystem status for over 25 years. It continues to reveal climate-related shifts in ocean temperature and salinity with associated changes in the abundance, biomass and diversity of species, from plankton to upper trophic level such as seabirds and marine mammals. Over the past decade, we have observed 3 marine heat waves, during 2014-2016, 2019 and 2025, all with different manifestations upon ecosystem dynamics. Here we describe the specifics of those impacts at all trophic levels and suggest the mechanisms that have led to the wide range of impacts from simple shifts in phenology to massive mortality events. Heatwaves in the NGA are likely to become longer, more frequent, and more intense in the future, underscoring the critical importance of sustaining long-term ecosystem observations to understand and predict the effects of heatwaves on commercial and culturally significant species in this region.

Authors: **Szymon Surma**; Georg Skaret, Mimi E. Lam

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Title: Projecting marine heatwave impacts on Norwegian spring-spawning herring with an ecosystem model

Abstract

Norwegian spring-spawning (NSS) herring is the largest stock of Atlantic herring (Clupea harengus) in the world and a key node in the Norwegian and Barents Seas (NorBar) food web. It is also the target of a large, multi-jurisdictional commercial fishery providing food, income, and employment to numerous communities in Norway, Iceland, and beyond. Norwegian fisheries suffered the strongest impacts of marine heatwaves (MHWs) in the world from 1985 to 2022. Atlantic herring is particularly vulnerable to MHWs and accounted for much of their impacts on Northeast Atlantic fisheries. Thus, there is a clear need to evaluate the impacts of future MHWs on NSS herring. This paper tackles this problem using a NorBar food web model constructed in Ecopath with Ecosim (EwE). The model was fitted to historical biomass, catch, and temperature (50-200 m) time series (1950–2018). Foraging efficiencies of NSS herring and other consumers were scaled to Gaussian thermal niches defined by species-specific thermal optima and tolerance limits and linked to historical temperature time series. The model was then employed to project NSS herring biomass responses to several future scenarios with varying frequency, duration, and intensity of MHWs up to 2050 and 2100. Projected biomasses were compared to reference points (i.e. Blim and Bpa) used in NSS herring fisheries management. This paper is intended to provide a first step towards more climate-sensitive NSS herring fisheries management. This will be further investigated using management strategy evaluation with the NorBar ecosystem operating model.

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Title: The North Atlantic Heat Engine: Quantifying Half a Century of Ocean Warming, Seasonal Transformation, and Climatic Regime Shift (1982-2024)

Abstract

The North Atlantic Ocean functions as a critical thermal regulator of the global climate system. This investigation utilized the NOAA's Optimum Interpolation Sea Surface Temperature (OISST) data, to analyzes North Atlantic Sea Surface Temperature (SST) dynamics from 1982 to 2024. Our analysis reveals a dramatic and accelerating warming trajectory, with mean annual SST increasing from approximately 15.3°C in 1982 to 17.3°C by 2024—representing a total warming of 2°C over the 44-year study period. This translates to a remarkable average warming rate of approximately 0.045°C per year, with the post-2000 period exhibiting particularly accelerated thermal amplification. The scatter plot of annual values demonstrates a consistent, nearly monotonic increase, transitioning from decadal averages of 15.8°C in the 1980s to 17.3°C in the 2020s, confirming a persistent and intensifying warming regime. Seasonal decomposition analysis reveals critical structural changes in the North Atlantic's thermal architecture. Monthly boxplot distributions demonstrate progressive expansion of SST ranges, indicating not only mean warming but fundamentally altered variability patterns. Seasonal trend analysis exposes differential warming rates across the annual cycle, with summer months (peaking at 19°C) and fall seasons exhibiting the most pronounced temperature elevations, suggesting a fundamental reshaping of the basin's seasonal thermal cycle. The combined analysis yields exceptional statistical confidence (R^2 = 0.864-0.998, $p < 2e\text{-}16$ across multiple metrics), confirming the robustness of observed trends. Time-series decomposition isolates a powerful secular warming trend superimposed on consistent seasonal oscillations, with normalized trend components showing monotonic acceleration beginning in the mid-1990s and intensifying through 2024. This pattern indicates that recent North Atlantic warming represents not merely cyclic variability but a fundamental regime shifts in the basin's thermal equilibrium state. The North Atlantic's transformation documented here provides essential constraints for climate model validation and offers critical insights for predicting future trajectories of the Earth system under continued anthropogenic forcing.

Session 2: Tracking Borealization: Environmental Change, Biological Responses, Community Impacts

KEYNOTE SPEAKER

Authors: **Kaitlyn O'Brien**; Mike Litzow, Franz Mueter, Jens Nielsen, Trond Kristiansen, David Kimmel, Emily Ryznar, Erin Fedewa

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Title: Spatiotemporal Quantification of Bering Sea Borealization: Advancing Fisheries Management through Spatial Dynamic Factor Analysis

Abstract

Borealization—the transition from an Arctic to a subarctic (boreal) physical state—is one of the most consequential impacts of climate change for Arctic marine ecosystems and is considered a primary driver of ecosystem restructuring in the Bering Sea. Quantifying this transition is challenging because it requires integrating disparate environmental time series, such as sea ice, bottom temperature, and primary productivity. While previous research utilized Dynamic Factor Analysis (DFA) to produce a basin-wide borealization index, these non-spatial methods may mask sub-regional trends and "hot spots" critical for localized fisheries management. In this study, we developed a Spatial Dynamic Factor Analysis (SDFA) using the tinyVAST R package to produce a spatially resolved quantification of borealization across the southeast Bering Sea (SEBS) and northeast Bering Sea (NEBS). This method allows for the identification of a specific borealization "footprint" and the detection of localized hotspots where the pace of Arctic-to-boreal transition is most rapid. Preliminary results indicate that the intensity of borealization is spatially heterogeneous, with significant shifts identified in the NEBS and along the transition zone between the largely boreal SEBS and more Arctic NEBS. Additionally, to evaluate the management utility of a spatially explicit index, we will apply the SDFA results to a spatiotemporal model of Bering Sea snow crab (Chionoecetes opilio) abundance, a high-value fishery that recently experienced a catastrophic collapse and was previously analyzed using a DFA. We hypothesize that a spatially resolved borealization index will provide a more nuanced understanding of the collapse compared to non-spatial DFA indices. By comparing the SDFA framework to previous methodologies, this work aims to demonstrate how a spatially explicit borealization index could inform management and aid in adaptive decision-making for high-value or ecologically important stocks anticipated to be impacted by climate restructuring.

ORAL PRESENTATIONS

Authors: **Franz Mueter**; Mike Litzow, Kaitlyn O'Brien, Sam Kaiser, Pavel Emelin

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Title: Borealization hot spots of the Bering Sea groundfish community

Abstract

Borealization of marine ecosystems has been documented at both Atlantic and Pacific Arctic gateways, with boreal fish species increasingly expanding into regions formerly dominated by Arctic assemblages. However, the spatial structure of these shifts and their effects on benthic ecosystems remain poorly resolved. Here, we quantify the spatial footprint of borealization in the demersal fish community of the northern Bering Sea and evaluate associated changes in epibenthic organisms, with emphasis on the 2014–2021 marine heatwave. We estimated the median temperature of occurrence (T50) for 56 dominant fish and large invertebrate species using pre-heatwave observations. For each sampling location and year, we then calculated an abundance-weighted community mean T50 (CWMT50) and estimated location-specific linear trends from 1990–2025 to derive a spatially explicit borealization index. Preliminary results indicate that borealization has been most pronounced across the northern middle shelf (58-60 degrees North) and throughout much of the northern Bering Sea, corresponding to areas of cold-pool retreat during warm years. We further assess how epibenthic invertebrates changed within identified borealization hot spots and discuss potential consequences of this borealization for commercial and subsistence resources.

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Title: Borealization triggers reorganization of Arctic coastal and shelf ecosystems.

Abstract

Rapid borealization triggers functional and trophic reorganization of Arctic coastal and shelf ecosystems. Here, we review how climate-driven redistributions of boreal species establish novel functional traits and feeding links along the Norwegian coast and within the Barents Sea. Utilizing extensive survey data from the Norwegian Institute of Marine Research (Barents Sea: 2004–present; coastal: 1995–present), we integrated comprehensive functional trait and food-web datasets developed with UiT – The Arctic University of Norway. We analyzed spatio-temporal shifts using trait-based approaches, co-occurrence, and network analyses, focusing primarily on fish redistributions. While poleward shifts are evident across both regions, the Norwegian coast exhibits a significantly greater magnitude of change in diversity and community composition. The northward expansion of boreal species introduces novel functional traits and creates new feeding links, as confirmed by contemporary diet studies. Our findings demonstrate that this extensive reorganization alters ecosystem functioning and vulnerability. Shifting ecological roles of key species and changing control regimes necessitate novel management considerations to address High North ecosystems in rapid transition.

Authors: **Emma Schena**; Matteo Zucchetta, Raul Primicerio, Lis L. Jørgensen, Fabio Pranovi

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Title: Trophodynamic indicators to map changes in a Subarctic ecosystem: the Barents Sea case

Abstract

The Barents Sea is one of the fastest-warming places on earth, representing a hotspot even within the Arctic context. Increasing temperatures are causing a redistribution of species and the borealization of Arctic communities, primarily driven by incoming large generalist fish species. Moreover, the poleward shift of commercial fisheries, favored by sea ice loss, is expected to impact both pelagic and benthic assemblages. While comprehensive ecosystem models exist for the region, the fast rate of change calls for rapid and efficient metrics to assess ecosystem status. To address this gap, we evaluated the performance of the cumulative biomass over trophic level (CumB-TL) method, a system-level indicator derived from emergent ecosystem properties, as a tool for detecting early warning signals of community shifts. Curves were fitted for different areas across the Barents Sea considering different periods, to represent the gradient from Arctic to boreal conditions and its change through time. We compared curve shape and their parameters across space and time, utilizing both scientific survey and fisheries catches data as inputs. This approach allowed us to test outputs from different data sources and evaluate how they reflect community shifts in terms of emergent properties. The curves show differences between Arctic and boreal communities regarding energy transfer and biomass accumulation, as well as the northward shift of generalist fish species. These species seemed to drive the curve shape dynamics, suggesting a significant influence on the community structure. Moreover, spatial comparison highlighted patterns potentially linked to fishing pressure. These results indicate that the CumB-TL curves could represent a powerful and efficient tool for ecosystem-based management.

Authors: **Francesco Golin**; Georg Engelhard, Marcel Rozenmeijer, Martin Lindegren, Haseeb Randhawa, Julian Burgos, Ingibjörg G. Jónsdóttir

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Title: Sensitivity of Icelandic groundfish communities to climate change and fishing revealed through a trait-based approach.

Abstract

The marine fauna of Iceland is situated in a transition zone and includes species with Arctic, Boreal, and Atlantic biogeographical affinities. With climate change, its composition is expected to shift towards species adapted to higher temperatures. At the same time, fishing effort has recently decreased in Icelandic waters, expected to lead to increased abundance of large, slow-growing species vulnerable to exploitation. Here we assess the sensitivity of Icelandic groundfish communities to both climate change and fishing using a trait-based approach, informed by available data on species abundances and composition, environmental conditions and fishing intensity over the period 1996-2024. The results show that the sensitivity of fish communities to climate change (SCC) has been increasing, while sensitivity to fishing pressure (SFP) has been decreasing. Since the expansion of Atlantic species in the area confirmed the effect of climate change on community composition, we proceeded to analyse trends in abundance of species characterized by higher-than-average SCC and SFP scores. We found that SCC increased in the southwest, primarily due to a marked abundance and biomass rise of Boreal and Atlantic species. These species migrate with temperature rise and import their suiting higher SCC sensitivity. The Artic species sensitive to the higher temperature decreased at the same time. In the northeast, we observed a mere substitution of fishing-sensitive species by climate-sensitive species. This is in line with interactive effects of climate change and fishing pressure on Icelandic fish communities. Our trait-based approach provides improved process understanding of the underlying sensitivity of marine fish communities to climate change and fishing, while serving to inform broader risk and vulnerability assessments. This approach can inform dedicated management measures that can be defined and prioritized in time and space, such as the protection of Arctic species hotspots.

Authors: **Kate Stafford**

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Title: Shifting northwards: changing phenologies of subarctic and Arctic marine mammals in the Pacific Arctic

Abstract

Global climate change has already had significant observable effects on the environment. Nowhere are the consequences of the Anthropocene epoch more apparent than in the Arctic, where rapid, extreme reductions in Arctic sea ice extent, age, and thickness are driving cascading effects in Arctic ecosystems from physical oceanography to marine predators. The impacts from these changes are reflected in the life histories, migratory timing, and biogeographic distribution of marine animals. Borealization may in turn affect communities that rely on Arctic species for nutritional, cultural and spiritual subsistence. Both visual and acoustic data are documenting changes in the phenologies of Arctic endemic species as well as borealization of the Pacific Arctic. Passive acoustic data have identified changes in the timing and distribution of bowhead and beluga whale migrations; both species are delaying their southbound fall migrations and bowhead whales appear to have shifted their wintering grounds north of Bering Strait. At the same time, subarctic whales, among them killer, fin and humpback whales, are arriving in the Pacific Arctic earlier, staying later, and moving consistently farther north and east, as evidenced by shipboard and aerial surveys, local observations, and acoustic detections. Both humpback and killer whales are now regularly seen in the Beaufort Sea where humpbacks may compete for food with endemic bowhead whales and killer whales prey upon endemic species including bowhead and beluga whales as well as walrus and ice seals. Increasing ice-free habitat, along with changes in primary and secondary productivity in the Arctic, are drawing upper trophic level cetacean species northward by expanding their spatial and temporal habitat. This suggests a large-scale shuffling of subarctic and Arctic communities is underway that may be reorganizing high-latitude marine ecosystems.

Authors: **Shannon E. Moore**; Marcel Montanyès, Federico Maioli, Paul Primicerio, Laurene Pecuchet

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Title: Predicting shifts in demersal fish distributions and functional diversity across the Barents Sea

Abstract

The Barents Sea hosts the world's northernmost large-scale commercial fisheries, yielding 1.1 million tonnes of fish and megabenthos annually, valued at 1.3–1.7 billion USD. However, it is also one of the regions most affected by global warming, with the northern Barents Sea warming 2 to 2.5 times faster than the Arctic average. This rapid warming is known to have altered the distribution and composition of fish communities, with many stocks shifting northward or northeastward to follow prey, retreating cooler Arctic waters, or expanding warmer Atlantic waters. Despite these past changes, little is known about how demersal fish distributions and key biodiversity and functional diversity indices will respond to future climate change in the Barents Sea. Understanding these dynamics could identify species or regions most vulnerable to climate change and highlight diversity hotspots and species groups ideal for conservation prioritization. To address this, we used bottom-trawl fish community data from the Barents Sea from 2004 – 2022 to fit a joint species distribution model (JSDM), specifically, a hierarchical model of species communities (HMSC). Fish community data was combined with trait data and climate predictions from the NEMO-MEDUSA model to quantify spatially patterned community responses to future environmental conditions through 2040. We analyzed temporal trends in community-weighted mean (CWM) trait values and compared shifts in the center of gravity for Arctic, boreal, and arcto-boreal groups. Additionally, we mapped rates of change in biodiversity and functional diversity indices across the Barents Sea, including CWM trait values, Shannon's diversity, Bray-Curtis dissimilarity, and functional richness, evenness, and redundancy. Preliminary results show CWM maximum body size, fecundity, and trophic level increase north of the Polar Front and decrease south of the Polar Front. Furthermore, while most demersal fish are shifting northward, with Arctic species experiencing the longest northward shifts, some boreal species are also moving south.

Authors: **Matthew Robertson**; Noel Cadigan, Tyler Eddy, Erika Eliason

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Title: Hungry like the fish: Evidence and implications of starvation mortality on marine animal population dynamics

Abstract

Stock assessment models are simplifications of a stock's population dynamics. One commonly simplified component of population dynamics is natural mortality, which refers to all components of mortality that are not attributed to harvest, including predation, starvation, disease, and senescence. In sub-Arctic and Arctic ecosystems, rapid environmental change and borealization are altering food webs, seasonal energy availability, and predator–prey interactions, potentially increasing the importance of starvation as a source of mortality. Despite this, most assessment research has focused on estimating aggregate natural mortality or predation mortality rates, while continuing to simplify or ignore other mechanisms. We contend that starvation-induced mortality, particularly for mature marine animals, represents an overlooked component of natural mortality and should be more frequently considered when developing scientific advice for ecosystem-based fisheries management. To defend this contention, we 1) describe marine animal energy maintenance and when starvation may be important, 2) highlight three case studies (Eastern gray whales, Bering sea snow crabs, Newfoundland Atlantic cod) where starvation-induced mortality of mature animals may have affected population dynamics, 3) describe methods for measuring and estimating starvation to improve ecosystem-based fisheries management, and 4) describe how starvation risks may increase with climate change. Starvation-induced mortality is likely to be a growing concern in sub-Arctic and Arctic ecosystems characterized by strong seasonality in energy availability, particularly as climate-driven ecosystem reorganization progresses. Improving scientific advice for the fisheries management requires continual reassessment of whether existing assumptions adequately represent reality.

Authors: **Martin W. Miles**; Astrid E.J. Ogilvie

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T**itle**: The Early 20th Century Warming of the 1920s–1930s around Greenland - A Context for the Present Borealization

Abstract

Abrupt ocean-climate shifts, whether warming or cooling, are exceptionally pronounced in the Atlantic Arctic and Subarctic. The recent shift toward borealization and its effects on marine ecosystems are increasingly well-documented. A striking earlier example of an abrupt warming is the Early 20th Century Warming of the 1920s-1930s, an "astonishing" event that impacted regional marine ecosystems including a generally northward movement of fish. The underlying causes of the Early 20th Century Warming remain under debate, although both ocean and atmospheric circulation anomalies clearly have a large role. Comparison between the Early 20th Century Warming and the present, ongoing warming will be made for the broad region around Greenland, with subsequent focus on southwest and west Greenland waters extending northward to Disko Bay (Qeqertarsuup Tunua). This presentation draws upon modern oceanographic data, century-scale instrumental and historical records, as well as ocean proxy records from sclerochronology (e.g., the marine bivalve Arctica islandica and the coralline alga Clathromorphum compactum). These are being analysed by Miles and Ogilvie for a newly funded project on the effects of warming Greenland waters on marine and human life.

Authors: **Astrid E.J. Ogilvie**; Martin W. Miles

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Title: Warm Times, Cold Times: Variations in the Past Climate of Iceland - A Context for the Present Borealization

Abstract

Warm Times, Cold Times: Variations in the Past Climate of Greenland - A Context for the Present Borealization Astrid E. J. Ogilvie1,2 and Martin W. Miles1,3 1 Institute of Arctic and Alpine Research, University of Colorado, Boulder, USA 2 Stefansson Arctic Institute, Akureyri, Iceland 3 NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research, Bergen, Norway Borealization is a relatively new phenomenon that is evident in most regions of the Arctic. Greenland and its adjoining waters are no exception. Drawing on a variety of data sources, this presentation will consider whether the past several hundred years represent a period of unmitigated cold, or whether there were in fact, periods with warmer temperatures, thus providing a climatic context for the present developments. The specific evidence discussed will include published palaeoclimatic and historical analyses of sea ice and temperature variations. Examples are a sea-ice record based on historical observations of multiyear ice (storis) in the southwest Greenland waters for the period 1820–2000, obtained from ship's logbooks and ice charts and other similar but separate reconstructions. A further North Atlantic context will be provided by a historical sea-ice reconstruction for Labrador/Newfoundland, the sea-ice record for Iceland, and a record based on sclerochronology from the region of the Faroe Islands. A discussion of hitherto unpublished material will include meteorological data sets for Greenland, as well as manuscript accounts of climatic and sea-ice conditions and variations in marine-mammal stocks. These latter are to be found in records of the Royal Greenland Trading Company dating from 1774 to 1916. The unpublished records are currently being analysed by Ogilvie and Miles for a newly-funded project regarding the effects on marine and human life of warming Greenland waters.

Session 3: Gadids under Borealization: Ecology, Fisheries, and Management

KEYNOTE SPEAKER

Authors: **Steven Campana**; George Hambrecht, Nicole Misarti, Habiba Moshfeka, Mary Efird, Sara M. Schaal, Guðbjörg Ásta Ólafsdóttir, Ragnar Edvardsson, Árni Daníel Júlíusson, Einar Hjörleifsson, Frank J. Feeley, Grace Cesario, Lilja Björk Palsdóttir

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Title: Cod dynamics and the changing roles of humans and the environment over 1100 years of fishing

Abstract

Every generation of environmental scientists considers the conditions present early in their lives to be "normal", which means that apparent baseline conditions shift through time. Yet true baseline conditions in an ecosystem are often difficult to uncover, since they require minimal human impact and little in the way of recorded data. Using archaeological excavations of fish otoliths dating from the first appearance of Viking settlers in Iceland, combined with historical records and geochemical proxies, we have been able to reconstruct the population dynamics of the Icelandic cod population from the time of first fishing through 1100 years of increasingly intensive effort. Both the environment and fishing activity are known modifiers of fish population dynamics, but which is more important? Let’s find out, shall we?

ORAL PRESENTATIONS

Authors: **Anders Frugård Opdal**; Christian Jørgensen, Øystein Langangen, Maud Alix, Ørjan Karlsen, Olav Sigurd Kjesbu, , Kate McQueen, Daniel Nyqvist, Esben Moland Olsen, Anders Thorsen, Jon Egil Skjæraasen

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Title: Phenotypic plasticity in Atlantic cod spawning phenology can mitigate trophic mismatch under ocean warming

Abstract

At high latitudes, early life stage survival of fish is often associated with how spawning time relates to the timing of the spring bloom. With ocean warming, basic physiological rates of ectotherms, like fish, will speed up. This includes gonadal development rates which dictate spawning time. Since warmer water is thought to influence the spring bloom timing differently than that of fish spawning time, the two may fall out of sync in the future. The precise mechanisms between temperature and gonadal development and spawning time have, however, been difficult to disentangle. Here, we take advantage of a series of independent laboratory experiments measuring individual oocyte development up to or near spawning for 153 Atlantic cod kept between 3 and 12 °C. From these data we derive a predictive and mechanistic equation for daily oocyte growth rate as a function of temperature and oocyte developmental status (diameter). The vitellogenic oocyte growth follows an accelerating pattern, and the model predicts that spawning can advance by up to 7 days per 1 °C increase. Within-treatment variation is, however, of comparable magnitude to between-treatment temperature effects. The model was also tested in the field by backcalculating oocyte development of 82 fish (2018-2021) sampled at 2 locations along the Norwegian coast using daily ambient temperatures from telemetry tags during vitellogenesis as model input. Model predictions generally fit well with the observed oocyte sizes. Finally, we use published projections (2000-2050) of sea surface temperature to estimate change in spawning time for Atlantic cod across their distribution area in the North Atlantic and compare this with corresponding projections of phytoplankton phenology. We find that the predicted change in bloom timing is always within the 95% CI of the predicted mean cod spawning time, i.e. within model uncertainty and likely within their range of behavioural and physiological plasticity

Authors: **William Butler**; Pamela Woods, Ingibjörg G. Jónsdóttir

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Title: A haul-level Bayesian state-space model for estimating juvenile cod abundance and mortality from survey data

Abstract

Juvenile fish typically experience high mortality rates that decline with age, and even small changes in early-life survival can strongly influence recruitment variability. However, estimating juvenile mortality is challenging, as traditional approaches such as catch-curve analysis rely on assumptions of a closed population and stable catchability that are rarely met in early life stage data. In this study, we developed a hierarchical Bayesian state-space model to estimate age-specific abundance and mortality of juvenile cod from haul-level survey data collected from two northwestern Icelandic fjords. The model incorporates several key features: (1) a mixture distribution for recruitment to accommodate occasional strong year classes, (2) age-declining mortality within a flexible survival framework, (3) length-based gear selectivity, (4) time-varying catchability modeled as a random walk with haul-level random effects, and (5) a nonlinear haul-level correction for shrimp-induced gear clogging affecting age-0 catchability. By integrating biological structure with fine-scale survey variability and gear effects, the framework provides robust estimates of juvenile mortality while explicitly quantifying multiple sources of uncertainty. This approach offers a flexible tool for understanding early-life population dynamics and improving our understanding of mortality and recruitment from survey data.

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Title: Juvenile gadid dynamics in northwest Icelandic fjords (1994-2025)

Abstract

High co-occurrence in nursery grounds can intensify interspecific competition among juvenile gadids due to shared habitat use. Following a substantial increase in cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) biomass in Icelandic waters since the early 2000s, we investigate the long-term spatial dynamics of juvenile gadid species within two nursery fjords in Northwest Iceland. Analysis of Center of Gravity (COG) reveals a significant shift towards inner fjord regions for all four gadid species over the 31-year study period. Specifically, 0-group juveniles have become concentrated in the innermost regions, while individuals age-1 and older have shifted toward the middle and outer fjords. Spatial overlap was highest between cod and haddock, as well as between haddock and whiting, while saithe consistently exhibited the lowest overlap. Our findings indicate that temporal variance was a more significant driver of distribution than measured environmental factors. These results suggest that the spatial dynamics of juvenile gadid species are shaped by a suite of complex ecological processes, likely involving a combination of ontogenetic preferences, competitive interactions, and fjord-specific environmental influences.

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Title: Thermal niche partitioning in juvenile gadoid nurseries - an acoustic telemetry study in a sub-Arctic fjord

Abstract

Nearshore nursery habitats are critical for juvenile gadoids, providing favourable thermal conditions and enhanced prey availability that promote growth and survival during early life. In Iceland, juvenile gadoids may spend their first two to four years in shallow coastal habitats, particularly during summer and autumn, when temperature is an expected key driver of growth rates and habitat use. Here, we investigate thermal niche partitioning between juvenile Atlantic cod (Gadus morhua) and saithe (Pollachius virens) in a sub-Arctic fjord, focusing on how horizontal distribution and seasonal residency reflect species-specific thermal preferences and tolerances. We used acoustic telemetry to track 65 juvenile gadoids (43 cod and 22 saithe) tagged during summer and early autumn between 2021 and 2024 in Dýrafjörður, northwest Iceland. Acoustic tags with a battery life of up to 246 days enabled individual tracking across multiple seasons. Fish detections were coupled with temperature records to quantify experienced thermal ranges and habitat use. Juvenile saithe consistently occupied shallow, warm nearshore habitats during summer and autumn but vacated the study area as temperatures declined, indicating a relatively narrower thermal tolerance and a preference for warmer waters. In contrast, Atlantic cod exhibited greater between-individual variation in residency and habitat use, with some individuals remaining in the fjord year-round and experiencing temperatures ranging from −0.5 to 12 °C. Vertical thermal gradients were weak due to strong water-column mixing, indicating that differences in depth distribution could not substantially alter experienced temperatures. These results demonstrate pronounced thermal niche partitioning between juvenile gadoids, with potential implications for growth, survival, and species responses to changing thermal regimes in sub-Arctic coastal nurseries.

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Title: Divergent thermal modulation of juvenile cod and saithe in subarctic nearshore nurseries

Abstract

Shallow coastal habitats function as key nurseries for many marine fishes, yet species differ markedly in how they occupy and persist in these environments and in their sensitivity to coastal temperatures. We examined seasonal and interannual patterns in the presence, size, and condition of young-of-the-year Atlantic cod (Gadus morhua) and saithe (Pollachius virens) in northwest Iceland using beach-seine surveys conducted across multiple fjords and years (2015–2021). Generalized additive mixed models were used to relate juvenile catch numbers, length, and Fulton's K to anomalies in coastal temperature, local density, and seasonal progression. The results showed species-specific differences in phenology and temperature modulation of coastal nursery use. Cod size was determined by temperature, and their facultative residency was shaped by an interaction of season and temperature anomalies later in the season, a pattern that aligns well with the high intraspecific diversity and behavioral flexibility of cod. Saithe, by contrast, were dominant in those habitats during summer, followed by declining, and intermittent use later in the season. Saithe showed weak temperature dependence, whether at annual, regional, or seasonal scales, perhaps as their high mobility reduces coupling to the coastal thermal environment. The results reinforce the ecological importance of fucoid adjacent nurseries for both cod and saithe in Icelandic coastal ecosystems and suggest that coastal warming may influence the two species differently, with potential implications for their coexistence, growth trajectories, and recruitment processes.

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Title: Cod Chronicles: Unravelling environmental effects on growth and condition of western Baltic cod based on otolith microchemistry

Abstract

The western Baltic cod (WBC) stock has recently collapsed most likely due to overfishing, changes in the environment and resulting low recruitment. In order to assess recovery potential, knowledge about the mechanisms influencing growth and condition is required. Recurrent hypoxia and increasing temperature in the western Baltic Sea are intensifying the habitat of WBC. However, links between the environmental change and the physical state of WBC are currently lacking. We analysed growth histories of individual WBC with the same size at capture (40 cm TL) and their exposure to variable environmental conditions over 20 years (2004 – 2024) using archived otoliths. We measured seasonal growth increments and analysed otolith microchemical profiles, using laser ablation – inductively coupled plasma – mass spectrometry. Modelling of 'von Bertalanffy' growth curves and derived parameters showed a decline in growth performance (ϕ') by - 1.5% and condition factor by - 20% in the study period. Our analysis of Mn/Ca otolith profiles, a proxy for ambient oxygen availability, demonstrated a reduction in Mn/Ca level and profile peaks. We interpret the shift in element ratios as a behavioural relocation, avoiding exposure to hypoxic water layers, as oceanographic models indicate no directional trend in overall hypoxic water volume in the western Baltic Sea during the study. Avoidance behaviour may reduce foraging opportunities, leading to changes in growth and condition. Further, chronically high Mn/Ca and Ba/Ca were interpreted as energetically costly exposure to hypoxic and eutrophicated systems. This study highlights possible links between low oxygen conditions in the western Baltic Sea and declines in condition and growth of WBC and opens further research questions on WBC movement patterns in compressed suitable habitat.

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Title: Newly discovered Pacific cod ecotypes with distinctive life histories provide a portfolio effect for a commercially important Alaska groundfish

Abstract

Pacific cod (*Gadus macrocephalus)* research over the past several decades has repeatedly revealed increasing levels of genetic complexity. Tagging studies have shown that some cod from the western GOA migrate into the eastern Bering Sea after the winter spawning season. We examined temperature, depth, movement, and genetics in adult Pacific cod from the western Gulf of Alaska region to test for a genetic component to migratory behavior, which has been described in Atlantic cod. Results did not provide strong evidence for migration linked to genetics; rather, we found two distinct genetic groups in western Gulf of Alaska Pacific cod with differences in size, habitat preference, and migratory behavior. The two distinct groups were encountered on the same spawning areas from the western Gulf of Alaska as far west as Unimak Pass, but adults appear to occupy different depth profiles. A significant difference in depth preference was found among 5,899 daily temperature and depth records from 64 satellite tagged adult cod. The group found in shallower depths had a significantly smaller weight/length ratio, and tags from those that were migratory were recovered in a specific location south of St. Lawrence Island in the eastern Bering Sea. The other genetic type migrated in a less specific pattern, and tags were recovered more randomly throughout the Bering Sea, with one recovered in the Chukchi Sea. No significant difference in temperature was identified, although differences were observed that were associated with depth and location. We identified 19 genomic regions showing evidence for selection, each on a different chromosome, that ranged in size from 0.01 to 23 Megabases. Divergent selection between these ecotypes is strong enough to maintain adaptive differentiation and bimodal genotype distribution upon secondary contact, possibly through depth preferences on spawning grounds. More work is needed to understand these two ecotypes.

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Title: Distribution, movement, and behavior of inshore and offshore juvenile Atlantic cod (*Gadus morhua*) in nearshore waters

Abstract

In a changing world, accounting for intraspecific phenotypic variation is essential for effective conservation, as variation within species may facilitate adaptation and persistence. Atlantic cod (*Gadus morhua*) exhibits substantial variation in migration and movement among populations and individuals, and maintaining migratory diversity is particularly important for management and conservation. Atlantic cod differ in many ecologically important genes and inhabit distinct environments, occupying contrasting temperature and depth regimes. In Iceland, cod comprises distinct ecotypes—offshore (frontal) and inshore (coastal). However, the development of these ecotypes and migratory strategies during early life remains poorly understood. In partially migratory species, migration decisions arise from interactions between intrinsic (within-individual) and extrinsic (external) factors, highlighting the importance of examining juvenile ecotypes in the context of their origin site. We examined differences in juvenile cod (1-3-year-olds) in their distribution, seasonal migration, timing of departure from nursery grounds, and behavior. Specifically, using acoustic telemetry, we test whether ecotype, body size, or origin of catch influence fjord residency, horizontal and vertical movements, and activity patterns, and whether temperature interacts with ecotype and origin to influence these behaviors. Implications for the conservation of juvenile cod are discussed.

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Title: Embryonic Bottlenecks: Linking Antioxidative Defense and Oxidative Damage to Temperature-Driven Mortality in Polar Cod (Boreogadus saida)

Abstract

The embryonic phase represents a critical bottleneck in the life cycle of animals, with mortality rates that can shape population dynamics and long-term species resilience. While early development is particularly sensitive to environmental stress, the fundamental mechanisms underlying mortality peaks during embryogenesis remain poorly understood. Oxidative stress – caused by an imbalance between reactive oxygen species production and antioxidant defenses – may be a key driver of developmental mortality. In cold-adapted species such as Polar cod (Boreogadus saida), these developmental challenges are compounded by narrow thermal tolerance and slow developmental rates, making them especially vulnerable to climate-driven warming. This study aims to disentangle developmental and temperature-driven embryonic mortality in this arctic keystone species. Embryos from multiple females were reared at ambient (0 °C) and elevated (4 °C) temperatures, with stage-specific measurements of mortality, total antioxidative capacity (TAC), and malondialdehyde (MDA) as an indicator of lipid damage. At 4 °C, TAC declines during cleavage, coinciding with elevated MDA levels and a subsequent mortality peak. Surviving embryos later showed TAC and MDA values comparable to 0 °C controls, suggesting natural selection of embryos with higher antioxidative capacity at 4 °C. At 0 °C, decreasing TAC coupled with increasing MDA levels occurred before hatching, followed by mortality, suggesting oxygen limitation during late embryonic stages. Additional transcriptomic and metabolomic analyses are underway to test these hypotheses. These stage-specific mortality patterns have important implications for early-life survival and recruitment dynamics, potentially constraining population resilience under Arctic warming. Understanding how cellular stress responses translate into mortality schedules during critical developmental windows will improve predictions of species responses to ongoing climate change.

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Title: Ocean warming affects gonadal maturation of female polar cod

Abstract

Rapid ocean warming of the Arctic ocean is expected to have serious impact on cold-acclimated Arctic species. Polar cod (Boreogadus saida) is a key species in the Arctic food web, with a high biomass and an important prey item for larger fish, seabirds and marine mammals. Although the effect of warming on reproduction is crucial in assessing the vulnerability of a species to climate change, little is known about the impact of warming on the gonadal maturation of polar cod. In this study the effect of projected ocean warming on gonadal growth was investigated. We combined non-invasive magnetic resonance imaging (MRI) with classical methods such as histological sectioning. Therefore, B. saida were incubated for six months at a control temperature of 0°C and at elevated temperatures of 3°C and 6°C from August 2022 to February 2023. Histological samples of female gonads were taken to determine maturation stages at three sampling points (December, January and February) covering the late maturation before spawning. MR imaging to follow the gonad development was applied on a subsample of female individuals. Gonadal volume and oocyte diameter were determined from MR images. Elevated temperature leads to a delay in gonad maturation. Fish at control temperatures reached maximum gonadal volume and most mature gonads in December, whereas females at 3°C showed continued development and females at 6°C showed only small gonads and did not reach the spawning capable stage during their natural spawning season. Our results indicate a trade-off between reproductive investment and maintenance costs at warmer temperatures.

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Title: Arctic cod (Boreogadus saida) morphometrics as an energy and health indicator along a 3400km latitudinal gradient in the Canadian Arctic.

Abstract

Arctic cod (Boreogadus saida) is the main forage fish species in the Arctic. Alterations to the Arctic marine ecosystem impacting Arctic cod have the potential to cascade upwards through the food web. A shift from arctic copepods to potentially less nutritious Calanus finmarchius from the north Atlantic, combined with increasing temperature, could alter the distribution, abundance and physical condition of Arctic cod, and thus impact energy transfer to higher order predators through the food web. While the importance of Arctic cod for their ecosystem has been well established, knowledge gaps persist. Few estimates of energy and carbon transfer through Arctic cod exist, with most studies centered on bioenergetic modelling of larvae and juveniles, or energetic value estimates from stomach contents of predators. Using a 10-year dataset of fish caught in the Canadian Arctic, the main objective of this study is to measure simple morphometric traits as proximate indicators of condition and energy content of Arctic cod. Arctic cod are sampled along a 3400-kilometer latitudinal gradient in the eastern Canadian Arctic, from Nares Strait to the Labrador Sea, to investigate key morphometric and life history traits. Length-weight relationships, size-at-age, size-at-maturity, hepatosomatic index, gonadosomatic index and le Cren's condition factor will be analyzed to identify changes in the physical status of Arctic cod over time, and across regions with varying environmental conditions. We will analyze the effects of past temperature, sea ice cover and secondary production on the life history traits of Arctic cod, to investigate the effects of short-term climate variability in key areas. These results will be complemented by carbon content analysis, which will be converted into energy content and body composition, to be used in bioenergetics modelling. Ultimately, we aim to develop a bioenergetics model describing the flow of energy from zooplankton to higher order predators, through Arctic cod.

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Title: Spatial variation in Icelandic cod growth and condition

Abstract

A common goal of fisheries policy is to maximize profit from the fishing industry as a whole while providing future opportunities for fishing sustainably in the long-term and conserving marine resources. Stock assessment models that model population dynamics are used to inform advice regarding fishing populations. However, population dynamics can also have dependencies on biological properties that vary temporally or spatially, such as growth and condition, which can affect stock profitability and impact the effectiveness of stock harvest strategies into. In this study, we link spatial variation in cod growth around Iceland to environmental trends, and compare patterns to product traits known to provide a price premium, including size and gut ratio. Potential implications for fisheries management and maximising optimal yield are discussed.

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Title: Seasonal and size-dependent energy shifts in polar cod and capelin: asymmetric implications of borealization for predators

Abstract

Changing prey-community composition can impact the energy landscape available to predators. More so, such impacts are likely not consistent among predators but may be asymmetric due to differences in how prey quality scales with size or season across species. Arctic marine systems are rapidly changing, such as the borealization of Barents Sea fish communities affecting polar cod (Boreogadus saida) and capelin (Mallotus villosus), both important prey items. This study quantified the energy content of polar cod and capelin across different seasons and sizes (total lengths) and examined the results through the lens of two contrasting predators; black-legged kittiwakes (Rissa tridactyla) and beluga whales (Delphinapterus leucas). We found season and size significantly affected energy density (kJ-1 g) and energy per individual (kJ-1 ind) of polar cod and capelin. However, effect sizes varied considerably between the two fish species, likely as a result of differences in diet and life histories. This resulted in a changepoint between the species, in which small capelin switched from being energy poorer to more energy dense than polar cod at larger sizes. For kittiwakes, a switch from polar cod to capelin within their prey size range was mostly suboptimal, with small capelin being low energy prey, but was relatively neutral at the upper prey size range. Whilst for belugas, a change to capelin would provide substantial energy benefits, with larger capelin offering more energy per individual compared to polar cod. However, the magnitude of the energetic effects of changing prey also varied seasonally. We highlight how single changes at lower trophic levels, such as shifting polar cod to capelin dominance, may have varied and asymmetric effects to higher trophic levels. We emphasize the importance of holistic approaches when assessing the impacts of borealization, to understand how energetic landscapes are uniquely changing for different predators.

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Title: Does maternal size structure affect larval viability in Atlantic cod (Gadus morhua)?

Abstract

Long-term fishing pressure and changing marine food webs are altering size structure and productivity of gadid populations, with many now dominated by smaller, younger individuals. In Atlantic cod (Gadus morhua), size truncation coincides with persistent recruitment failure, raising concerns about population resilience in rapidly changing northern ecosystems. These patterns are central to the Big Old Fat Fecund Female (BOFFF) hypothesis, which states that large, old females contribute disproportionately to recruitment through increased fecundity and improved offspring quality. While size-dependent fecundity is well documented, testing whether offspring from larger females experience enhanced early-life viability remains challenging due to the difficulty of assigning wild-caught larvae to maternal size. Here, we present the framework and progress of an ongoing project focused on North Atlantic cod populations, stocks that have experienced recruitment failures and collapses in recent decades. We use natural biochemical tracers (stable isotopes) to link maternal size to larval viability. Maternal isotopic signatures are transferred from female gonads to eggs and larvae through nutrient provisioning, providing a size-specific biochemical signal. Preliminary results show a significant increase in female $\delta^{15}N$ values with increasing size, while no relationship is observed between female $\delta^{13}C$ and size within the Faroe Plateau population. In contrast, larval $\delta^{15}N$ and $\delta^{13}C$ values decrease significantly and non-linearly with increasing larval size. Ongoing work aims to assess size-dependent isotope transfer in controlled laboratory experiments, assign wild-caught larvae to maternal size classes using stable isotope profiles, and explore how population size truncation alters the relative contribution of different female size classes to larval viability using a simple modeling framework. By integrating maternal effects, trophic pathways, and size structure, this work provides a mechanistic perspective on how shifts in energy flow and demographic composition influence recruitment potential in gadids, with implications for adaptive management in northern marine ecosystems.

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Title: Menu changes - Are barnacle nauplii a suitable prey for cod larvae (Gadus morhua)?

Abstract

Atlantic cod (Gadus morhua) is one of Norway's most economically important fish species and a key species of the sub-Arctic, but both total and spawning stock have been in decline since 2014. This decline could be due to low recruitment rates of past several years, which indicate poor survival rates of early life stages. The larval stage is a particularly vulnerable life stage due to high predation and starvation risk. Atlantic cod larvae are pelagic, gape-limited planktivores that rely on a wide range of prey during their early life stage, especially different stages of the copepod Calanus finmarchicus. Successful recruitment therefore depends on a close temporal match between larval feeding requirements and prey availability, as suggested by the Match-Mismatch Hypothesis. A rapidly warming Arctic could disrupt this delicate temporal balance by altering the timing and duration of the spring phytoplankton bloom and copepod abundance, potentially leading to a trophic mismatch between cod larvae and their main prey. In such a scenario, barnacle nauplii, which are extremely abundant in spring, could represent an alternative prey source. To investigate their suitability as prey for cod larvae, we conducted a feeding experiment where we reared cod larvae under three different diets: 1) Copepod nauplii only (Acartia tonsa), 2) barnacle nauplii only (Balanus crenatus), and 3) a mix of both preys. We assessed survival, growth, condition, and feeding incidence. Additionally, we exposed a subset of larvae to a mix of both preys (regardless of diet treatment), to see if cod larvae develop a preference for the prey they were reared with. Our results revealed clear differences in survival, growth, and condition between the diets, as well as a preference towards barnacle nauplii, supporting the hypothesis that barnacle nauplii could indeed represent an alternative prey to copepods in mismatch scenarios

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Title: Habitat Segregation of key gadid fishes in the Pacific Arctic region revealed by environmental DNA

Abstract

Gadid fishes are widely distributed throughout the Arctic Ocean and its surrounding seas, and constitute one of the most abundant fish groups in this region. They serve as key prey for a wide range of predators, including polar bears, cetaceans, seabirds, and predatory fishes, thereby linking lower and higher trophic levels in Arctic marine ecosystems. However, ongoing global warming is expected to reduce suitable habitats for gadids, potentially leading to declines in their biomass. To assess the impacts of warming on Arctic ecosystems and to predict future ecological changes, it is essential to clarify the current distribution and abundance of these species. In this study, the distributions of Arctic cod (Boreogadus saida), saffron cod (Eleginus gracilis), and walleye pollock (Gadus chalcogrammus) were investigated in the Pacific Arctic and Bering Sea using environmental DNA (eDNA) analysis. Seawater samples were collected from the Bering Sea to the southern Arctic Ocean aboard the R/V Mirai during cruises conducted between August and October from 2020 to 2023. eDNA was concentrated on the filter onboard the vessel, and was subsequently extracted in the laboratory. eDNA concentrations of the target taxa were quantified using species-specific quantitative PCR assays. Arctic cod eDNA was detected most frequently on the continental shelf and slope of the Chukchi Sea and in the marginal sea ice zone, but was rarely detected in the Bering Sea. In contrast, saffron cod eDNA showed similar detection frequencies in both regions and was primarily confined to continental shelf areas. Walleye pollock eDNA was detected at nearly all Bering Sea shelf stations and exhibited the lowest-latitude distribution among the three species, although its northern extent varied markedly among years. These contrasting distribution patterns highlight species-specific responses to environmental conditions and provide insight into how Arctic gadid fishes may respond differently to ongoing ocean warming.

Session 4: Connections across the Subarctic Atlantic: Physics to Biology, Fjords to Gyres, Surface to Seafloor

ORAL PRESENTATIONs

Authors: **Björn Birnir**; Alethea Barbaro, Daniel Balagué Guardia

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Title: The Mean Depth Difference and Ocean Currents in the Subarctic Seas

Abstract

A quantitative measure of the difference of simulations and direct measurements, called the Mean Depth Difference (MDD) was developed in: Birnir, B. et al. (2025). Data Analysis Predicting Accelerated Melting of the Greenland Ice Sheet. In: Azevedo, L., Narciso, J., Soares, A., Pereira, M.J., Vargas-Guzmán, J.A. (eds) International Geostatistics Congress 2024. GEOSTATS 2024. Quantitative Geology and Geostatistics, vol 20. Springer, Cham. https://doi.org/10.1007/978-3-031-92870-3_37. We use the Mean Depth Difference to investigate the ocean currents in the subarctic seas; in particular, the Returning Atlantic Water (RAW) current, flowing from the Fram Straight towards the Denmark Straight along the coast of East Greenland. This current is believed to move away from the coast of Greenland with increased flow of cold and fresh water from the polar regions, through the Fram Straight and move back towards the coast as the flow of freshwater decreases. We examine if this is the case and the extent of the movement of the current. The MDD is also used to examine the reliability of different simulation products in Copernicus.

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Title: Drivers of Biodiversity Patterns in Deep-Sea Benthic Communities and Vulnerable Marine Ecosystem Indicators Around Iceland

Abstract

Growing societal demand for seafood sourced from responsible fisheries has intensified the need to document and mitigate fishing impacts on Vulnerable Marine Ecosystems (VMEs). VMEs like deep-sea coral gardens and sponge aggregation are characterized by species that are fragile, slow-growing, and long-lived, making them particularly sensitive to bottom-contact fishing gears. International commitments, including those under the Food and Agriculture Organization (FAO), emphasize the need to identify and protect VMEs to avoid potential adverse impacts. Around Iceland, increasing attention has therefore been directed toward understanding how fishing activities interact with deep-sea benthic communities that may qualify as VMEs. Deep-sea benthic species are adapted to cold, dark, and stable environments, but these same traits often entail slow growth and limited recovery capacity. Consequently, repeated trawling in areas where VME indicator species occur can lead to long-term habitat degradation. Since 1996, the Marine and Freshwater Research Institute (MFRI) has conducted annual autumn deep-sea groundfish surveys (144–1340 m) with standardized trawl methods around Iceland, primarily to support stock assessments. However, during 2016–2018, benthic bycatch data from these surveys was collected and recorded including diversity, biomass, and spatial distribution of benthic taxa. The benthic bycatch dataset was used to: 1. Quantify the diversity and community composition of deep-sea benthos. 2. Identify the spatial distribution and examine relationships between benthic communities and environmental drivers such as depth, bottom temperature, and seafloor geomorphology. By linking standardized survey data with environmental variables, the study aims to improve and support evidence-based conservation measures. The results contribute directly to strengthening ecosystem-based fisheries management in Icelandic waters, identifying areas potentially at risk from bottom-contact fisheries, and informing spatial protection and mitigation strategies for vulnerable deep-sea habitats.

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Title: Physical Boundaries, Connectivity, and Functional Group Resilience Across Subarctic–Arctic Marine Ecosystems

Abstract

Rapid environmental change is reshaping ecological boundaries and connectivity across the Subarctic–Arctic region. Using coordinated observations from zooplankton surveys, fisheries acoustics, biological sampling, animal tracking, and deep sea video systems, we examine how physical structures—such as ocean fronts, thermal transitions, bathymetric sills, and depth gradients—govern the distribution and resilience of marine communities. Across multiple datasets, water mass boundaries emerge as major drivers of zooplankton, mesopelagic organisms, and pelagic fish composition, while deep sea assemblages follow distinct diversity and abundance patterns along environmental gradients. Large scale movements of apex predators demonstrate that certain species can traverse these boundaries, highlighting selective permeability across trophic levels. Functional group comparisons further show that zooplankton, pelagic fishes, benthic fishes, juvenile stages, and macrozooplankton exhibit different biogeographic transitions and sensitivities to environmental change. These contrasts indicate that no single boundary or habitat type captures ecosystem level structure. Collectively, this synthesis underscores the need for conservation and management approaches that integrate multiple taxa and physical drivers, anticipate climate driven shifts, and support policy development and Indigenous stewardship in an increasingly dynamic Arctic.

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Title: The study of observation technique of suspended and settling particles with an Event-based Vision Sensor for understanding biological pump in waters

Abstract

In recent years, satellite and other observational data have revealed that rapid ice sheet melting associated with climate change is progressing in a part of the East Antarctica such as Totten glacier. In the Totten glacier, the relatively warm sea water mass would accelerate to melt at the bottom of the ice shelf. The progress of ice shelf melting release fresh water surrounding water and would give an impact on the biogeochemical cycles and biological production through a dilution effect of nutrients. However, observations remain insufficient and comprehensive studies are lacking regarding the responses of physical and biogeochemical cycles to oceanic environmental changes induced by such rapid melting of ice shelf, as well as the amount of carbon fixed through biological production (the biological pump). In general, the biological pump has been estimated by in situ observation to catch settling particles such as sediment trap etc. The trap system is also known as an insufficient method to estimate all amount of carbon brought by particles of various sizes because the system can only catch the giant settling particles. The problem of underestimation of the biological pump using the trap system has been an open question and new observation systems are required to find the solution that estimate the carbon content of other size particles such as suspended particles. In this context, the present study aims to employ a novel observational approach using an Event-based Vision Sensor (EVS) to capture all particles of various sizes including fine suspended particles that could not be measured using conventional methods. Observations and experiments which are necessary to estimate the carbon content of biogenic particles with various sizes in water mass, will be conducted at the Otsuchi Coastal Research Center operated by the University of Tokyo to establish and validate EVS-based observational methodologies.

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Title: Shifting interactions between marine mammals: the case of killer whales and pilot whales off Iceland

Abstract

Killer whales (Orcinus orca) and long-finned pilot whales (Globicephala melas) display interactions in several locations in the North Atlantic, where their range overlaps. In Iceland, interactions were not described until 2014, when pilot whale occurrence appeared to increase in coastal waters. During these interactions, that appear to be agonistic, pilot whales approach killer whales at speed. Observations of these interactions in Iceland showed that in 68% of recorded interactions killer whales avoided the pilot whales by moving away. High-speed avoidance, defined as porpoising behaviour, was recorded in 28% of interactions, suggesting killer whale responses to approaching pilot whales are not uniform. Killer whales often interrupted functionally significant behaviours, such as feeding, to avoid approaching pilot whales, raising questions as to the long-term energetic consequences of these interactions. The interactions may be driven by competition for resources or as a mobbing anti-predator strategy, but the exact causes remain unknown. To address the hypothesis of potential competition for prey, we compared the overlap in trophic niche between the two species. We used published and unpublished measurements of stable isotope ratios of carbon and nitrogen. Samples were collected from individuals that stranded along the coast of Iceland or from biopsies of free-ranging individuals. We found little evidence of trophic niche overlap between both species, suggesting competition for prey is unlikely to drive these interactions. This study contributes to a growing body of evidence showing that interactions between highly social top marine predators, such as marine mammals, can be complex and driven by multiple factors. As climate change impacts intensify and marine mammal geographical ranges shift, such interactions are likely to occur more often. A better understanding of marine mammal interspecific interactions will contribute to predict how distribution shifts may affect community dynamics under future climate scenarios.

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Title: The importance of the Nordic Seas to a deep-diving cetacean, the northern bottlenose whale

Abstract

The northern bottlenose whale (Hyperoodon ampullatus) is a deep-diving oceanic odontocete that primarily inhabits the arctic and subarctic waters of the North Atlantic but is occasionally found in temperate waters. The species has historically been suggested to undergo seasonal north–south migrations, however, previous whaling data and more recent sighting surveys insufficiently covered the winter months. The species appears to be highly sensitive to underwater noise, but information on movements and diving is limited due to its inconspicuous behaviour at the surface and preference for deep, offshore waters. Here, we analysed depth-and-position transmitting satellite tag deployments and deep-ocean hydrophone deployments in the Nordic Seas between 2014 and 2023. Passive acoustic monitoring revealed a near year-round presence of northern bottlenose whales with a gradual northward shift in spring between Iceland and Jan Mayen. The lowest numbers of acoustic detections occurred from July into September, contradicting the hypothesis of north–south migrations to enable overwintering at lower latitudes. The observed seasonal occurrence patterns were stable across years and associated with covariates indicative of a distribution driven by their squid prey, Gonatus fabricii. Tagged individuals were observed to have extraordinary capabilities to dive, and presumably feed, throughout the water column including at the sea floor. High rates of deep dives highlighted the importance of the Nordic Seas to this population of deep-sea predators. Further, while being tagged in the arctic, individuals were found to periodically visit the Azores archipelago for brief periods in summer during fast roundtrips. This adds to a growing body of work suggesting feeding-moulting, as opposed to feeding-breeding, as a function for migration in odontocetes. Our studies provide important benchmarks to evaluate effects of changes in climate and anthropogenic activities and can inform planning of noisy activities such as deep-sea mining, sonar exercises and seismic surveys, in the region.

Authors: **Hildur Pétursdóttir**; Teunis Jansen, Teresa Silva, Sigurður Þ. Jónsson, Warsha Sing

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Title: Diet composition and feeding behavior of capelin (Mallotus villosus)$ in the changing Iceland–East Greenland–Jan Mayen ecosystem

Abstract

Capelin (Mallotus villosus) is a key forage fish in the Iceland–East Greenland–Jan Mayen (IEGJM) ecosystem and an important conduit of energy from zooplankton to higher trophic levels. In recent decades, capelin have shown pronounced shifts in distribution and feeding areas within the IEGJM region, raising questions about how feeding ecology responds when fish occupy new habitats and prey fields. We investigated capelin diet composition and feeding behaviour in the newly occupied East Greenland autumn feeding area during September–October 2018–2021. Stomach content analysis was used to characterise short-term diet, and stable nitrogen isotope analysis ($\delta^{15}N$) to provide a longer-term indicator of trophic position. Feeding activity was high, with 77–98% of stomachs containing prey. Diets were dominated by euphausiids (mainly Thysanoessa inermis) and copepods (mainly Calanus hyperboreus and C. finmarchicus), reflecting the local zooplankton community. This indicates a shift from a previously copepod-dominated diet in earlier feeding areas to a mixed euphausiid–copepod diet in the new feeding habitat. The relative importance of dominant prey groups varied spatially and among years, suggesting flexible foraging in response to local prey availability. Stable nitrogen isotope results showed higher $\delta^{15}N$ values in larger capelin, consistent with size-dependent feeding at higher trophic levels and consumption of larger prey over longer timescales. Overall, our results show that capelin diets in the East Greenland feeding area track local prey fields and vary across space and years, highlighting flexible feeding in a changing IEGJM ecosystem.

Authors: **Warsha Singh**; Collective output from a WG, many **Authors** are involved

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Title: Integrated Ecosystem Assessment to support sustainable management of the Icelandic Waters ecoregion in a changing environment

Abstract

The Icelandic Waters ecoregion is characterized by a complex ocean circulation system, where waters of Atlantic, Arctic and Polar origin mix, creating areas of high productivity that have sustained commercial fisheries and community well-being for decades. Fisheries and associated processing contribute approximately 8-10% to the national GDP and remain an important part of Iceland's cultural heritage. However, climate change is increasingly posing risks to the stability of these interconnected ecological and economic systems in the region. Range shifts have been observed in key fish species, along with changes in biomass of lower and higher trophic level organisms such as zooplankton, benthic organisms, seabirds and marine mammals. To address these challenges, an Integrated Ecosystem Assessment (IEA) has recently been initiated for the region, providing a framework to compile the ecosystem status and inform integrated management measures. This presentation will highlight the selection of indicators across the various ecosystem components including oceanography, plankton, fish, seabirds, marine mammals and socioeconomics to track the long-term changes in the ecosystem. It will also outline the role of the Working Group on the Integrated Ecosystem Assessment of Icelandic Waters (WGICE) and its goals for advancing IEA to support adaptive and sustainable management in a changing environment.

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Title: Investigating the coexistence of Sebastes mentella and Sebastes norvegicus caught in a mixed slope fishery off Southeast Greenland by combining timeseries from three scientific surveys in a sdmTMB framework.

Abstract

Two species of redfish, beaked redfish (Sebastes mentella) and golden redfish (Sebastes norvegicus), co-exist in a mixed fishery along the south-east Greenland slope. The highly heterogeneous bathymetry of the shelf and slope gives rise to varied habitats. The species typically have overlapping depth preferences: S. mentella occurs deeper while S. norvegicus occurs in shallower regions. Further interactions between these species and other biotic or abiotic factors that influence their abundance have not been previously established for this ecosystem. We used fisheries-independent timeseries from demersal trawls carried out by Thünen institute of Sea Fisheries and the Greenlandic nature institute to compare spatial and temporal distribution of the species. The data covers year 1981-2024, in area 59.4-68.6°N and 24.1-44.3°W, with depths 200-1500 meters. We used the sdmTMB framework to model the response of each species density, to in situ measurements of depth, temperature, and cod density. This study thus aimed to 1) identify the main drivers behind spatial and temporal distribution changes of the two species and 2) Determine where the fishery should locate to preserve its populations. Depth and abundance of cod (Gadus morhua) were found most important for S. mentella, while depth and temperature were most important driver for S. norvegicus. Species distribution was predicted over the full survey area using bathymetry and temperature from GEBCO and E.U. Copernicus Marine Service Information.

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Title: Deep-sea fish communities at the eastern slope of the Norwegian Sea – spatial and temporal gradients and vulnerability to climate change.

Abstract

Deep-sea fish species inhabiting the continental slope in the eastern Norwegian Sea show great variability in distribution and abundance. Some of the species are commercially exploited in trawl, longline and gillnet fisheries. Bearing in mind anticipated habitat alterations driven by environmental change, the aim here is to detect patterns in deep fish communities structure along environmental gradients, and map their vulnerability to climate warming and harvesting based on temperature affinities and life history characteristics. Based on bottom trawl surveys along the continental slope from approximately 62°N - 80°N the study relates major fish communities, or species assemblages, to temporal and spatial gradients using multivariate analyses. Spatial and temporal variation in deep-sea fish communities is partly related to climatic variation, which may be differently expressed at greater depths compared to what is observed in more shallow, demersal fish communities.

Authors: **Hildur Magnúsdóttir**; Rakel Guðmundsdóttir, Stefán Áki Ragnarsson, Laure de Montety, Andreas Macrander, Niall McGinty, Magnús Freyr Ólafsson, Hjalti Karlsson

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Title: Open net-pen aquaculture of Atlantic salmon (Salmo salar) in an Icelandic threshold fjord – Carrying capacity and far-field impacts

Abstract

Open net-pen salmon farming can result in a range of localised impacts on the seafloor under pens and in their nearest vicinity. Far-field impacts, however, are more subtle and harder to detect but may over time cause an overall degradation of ecosystem health. Fjord ecosystems are particularly sensitive as they have limited water exchange compared to open coastal waters, strong stratification, and organic matter and pollutants can accumulate over time. These ecosystems play essential roles in ecosystem services, e.g. nursery and feeding areas for fish and invertebrates, migration corridors for salmonids, aside from their role in tourism and cultural heritage. Thus, monitoring of fjord ecosystems is of utmost importance. In Iceland the growth of net-pen salmon farming has been rapid. From 2014-2024, annual production of farmed salmon has increased from 2,847 t to 45,684 t. The carrying capacity for salmon biomass of each fjord is assessed based on projected accumulation of organic material within the fjord and the sensitivity of its environment to such accumulation. After aquaculture has started, monitoring of the far-field impact of net-pens includes oceanographic parameters, benthic invertebrate diversity, sediment grain size and organic content, as well as detailed microsensor measurements of sediment cores (O2, H2S, pH, Eh). Here we present a case study from Arnarfjörður in NW-Iceland, which is of specific interest, due to a threshold limiting oxygen exchange, isolation of the bottom layer due to seasonal stratification, and a rapid increase in aquaculture during the last decade. The carrying capacity of Arnarfjörður has been estimated as a maximum of 20,000 tons biomass of farmed fish, of which 14,500 t are currently being utilized, but plans are in progress to utilize the full capacity. Results of baseline studies and annual monitoring since 2018 will be discussed.

Session 5: The effects of multiple drivers on Arctic and Sub-arctic coastal/fjord environments: bridging marine chemistry and biology

ORAL PRESENTATIONS

Authors: **Øystein Varpe**; Trond Kristiansen, Tom Langbehn

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Title: Ecological consequences of less sea ice and more light

Abstract

A new light environment is emerging as sea ice declines, allowing light to enter the water column instead of being reflected by snow-covered ice. Subarctic and Arctic seas are highly impacted by this ongoing change. More light impacts numerous biological processes, from photosynthesis to predators that require light to see their prey. We estimate light changes and use mechanistic modelling and data analyses to point at ecological consequences. We focus on fish, vision-based foraging, and top-down impacts. Fish responses, such as potential range shifts, will differ along trait axes, including the extent that fish migrate. Light-driven impacts, altered prey phenology and abundance, and physiological effects of ocean warming all shape the net response and the resulting extent of borealization. With more light for fish, zooplankton face greater predation risk, favouring smaller body-sizes and stronger diel vertical migrations. We conclude that Arctic sea-ice loss triggers a massive light experiment with complex ecological consequences and implications for Subarctic and Arctic Marine Systems.

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Title: Adapting to a changing Arctic: Investigating eco-physiological responses of the diatom, Pseudo-nitzschia delicatissima, to climate-driven shifts in temperature and pH

Abstract

Anthropogenic increases in atmospheric CO_2 are altering ocean conditions, causing rising temperatures and acidification. This affects phytoplankton growth and distribution, which can increase the risk for harmful algal blooms. This study analyses the composition of the spring phytoplankton bloom in Krossanes, East Iceland in 2024 at three depths (0 m, 10 m, 30 m) and two stations: coastal Krossanes 2 and offshore Krossanes 6. Species identification and enumeration revealed dominant taxa within the bloom and highlighted presence of several harmful algal species. Chaetoceros convolutus and Corethron pennatum, were dominant at Krossanes 2, both harmful species capable of damaging fish gills. Pseudo-nitzschia delicatissima was present at both stations, although more abundant at Krossanes 6. Some Pseudo-nitzschia species produce domoic acid, a dangerous biotoxin. While P. delicatissima is generally considered low or non-toxin producing, some strains may become toxic under changing environmental conditions, highlighting a need for focused scientific research on this species and their potential toxicity. Multi-stressor experiments were conducted using strains of P. delicatissima, isolated from Krossanes. The ecophysiological responses across a range of temperatures and two pCO_2 scenarios were assessed, specifically the growth rate, productivity and domoic acid production P. delicatissima exhibited highly enhanced growth under elevated temperature, slight inhibition under higher pCO_2, and no interaction between stressors. No domoic acid production was detected, but if future strains become toxic and warmer conditions promote blooms, it could have consequences for the ecosystem and human health.

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Title: Acidification trends and biological consequences in coastal Arctic

Abstract

More than a decade of ocean acidification (OA) monitoring in the coastal Arctic Ocean now shows trends of declining pH, increasing pCO2 levels, and lowering CaCO3 saturation state. Decreased CaCO3 saturation increases the dissolution potential of CaCO3 minerals resulting in a higher energy demand of organisms to build shells and skeletons. This has potentially detrimental consequences for all organisms that use CaCO3 including calcifying organisms such as foraminifera, sea urchins, bivalves, molluscs, and corals. The rates show that acidification in parts of the region occurs between two to four times the global ocean mean surface pH decline. The observed acidification rates and the associated shifts in key carbonate system variables are evaluated alongside reported biological thresholds and tipping points to better understand the potential biological impacts of ocean acidification.

Authors: Hrönn Egilsdóttir; **Emily Donham**, Sam Dupont

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Title: Ocean acidification as a collective action problem – the case of Iceland

Abstract

Ocean acidification (OA) is an alteration of the ocean carbonate chemistry as a direct consequence of anthropogenic carbon dioxide emissions. A growing body of evidence is documenting its impact on marine species, ecosystems, and associated services. While being recognized as a major threat in high level science and policy frameworks, significant actions are still lacking. OA can be considered within the framework of collective action. A collective action problem is a situation in which the short-term self-interest of individual actors conflicts with longer-term collective interests, generating a substantial risk that the collective benefit is not produced. Solutions to OA differ in scales, from global (mitigation) to local (adaptation). Current framework predicts that collective action becomes more improbable as it becomes larger. This is a consequence of the increased number of actors, spatial and temporal distances to impacts, and complexity. This can be improved through intervention toward each actor (promoting fairness, concerns of all needs), relationship between them (building trust, reciprocity, communication) and at the societal level (improving social norms, developing capacity and technology in local institutions). In this presentation, we will discuss how stakeholder engagement can help designing a realistic and timely strategic plan based on collective action theory to optimize the chance to address OA. Iceland will be used as a case study. Its egalitarian culture valuing independence, science, strong family ties, nature, and creativity, as well as progressive values, gender equality, and emphasis on self-sufficiency and community make it an ideal environment for such implementation.

Authors: **Samuel P.S. Rastrick**; Helen Rastrick, Lars Asplin, Michael Bank, James Brown, Weiwei Jiang, Zengjie Jiang, Tanja Kögel, Terje van der Meeren.

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Title: Ocean acidification may increase the biological impact of legacy metal pollution, a case study from mine waste deposits in Arctic Norway.

Abstract

Historically Norway has used fjords for the disposal of waste including mine-tailings, fine grained waste produced during mining which is often contaminated with toxic metals. At present advice to regulators regarding the possible legacy effects of proposed, present, and historic mine-tailing deposits in Norwegian fjords is based on current environmental conditions. However, little is known about how metals associated with these mine tailings will interact with climate change and ocean acidification and the subsequent effects on costal fisheries and aquaculture. Recent studies of commercial bivalve species (Arctica islandica, Venerupis corrugate) show that elevated pCO2 leads to adjustments in coelomic acid-base balance, with increased bicarbonate concentrations buffering pH in response to elevated pCO2. However, this bicarbonate compensation is not observed in bivalve's exposed to mine tailings resulting in significant acidosis and mortality. To investigate the mechanisms and breakpoints behind these physiological responses, bivalves were exposed to sediments collected from historic mine-tailing deposits (Repparfjorden, Norway) in combination with 5 different pH/pCO2 treatments (pH 7.4 to 8.2). Mine-tailings reduced the activity of gill enzymes (Na^+/K^+-ATPase) involved in ion-regulation and critical for bicarbonate up-take. The effect of individual metals associated with mine tailings (Cu2+) on these critical enzymes was also investigated. Combined with effects on energetics and electron transport chain activity, and the possible increased bioavailability of metals under more acidic conditions, metal contamination may further exacerbate the negative effects of climate change. Furthermore, climate change may affect temporal and spatial fluctuations in hydrodynamics, modulating the resuspension and distribution of mine-tailing particles and so the concentration of mine-tailings organisms and ecosystems are exposed to at different depths and distance from the source. The findings from our investigations highlight the regulatory importance of considering future environmental conditions when assessing the possible legacy effects of proposed, present, and historic mining activities.

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Title: Chemical gradients from fjord to shelf in Arctic fjords - impacts of glacial meltwater and biological CO2 drawdown on ocean acidification and calcifying marine organisms

Abstract

Arctic fjords are sensitive to impacts by climate change such as increased meltwater from glaciers, sea ice, and river runoff. Increased freshwater reduces the seawater alkalinity, carbonate ions and calcium carbonate saturation (aragonite saturation, ΩAr) state hence increasing ocean acidification (OA) resulting in decreased potential for calcium carbonate formation of shells by marine organisms. We focus on west-Spitsbergen shelf and Kongsfjorden and north-east Greenland and waters adjacent to the Nioghalvfjerdsbræ (79 North Glacier), which are influenced by glacial runoff and sea-ice meltwater. We investigate the role of freshening, primary production, and air-sea CO2 exchange; in both areas in summer, biological CO2 drawdown at primary production caused increased ΩAr in the surface, which compensated for most of the ΩAr decrease due to the freshwater dilution of carbonate ions reducing total alkalinity, hence preventing corrosive conditions. In future conditions where increased meltwater effects may overcome the alleviating effects of biological CO2 drawdown on OA with unfavorable conditions for calcifying organisms.

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Title: Observing the biogeochemistry of Alaska's subarctic fjords to detect ocean acidification

Abstract

Alaska's coastal waters are naturally more acidic than the global average, with additional pressure as the ocean continues to absorb anthropogenic carbon dioxide. The northeastern Gulf of Alaska receives a significant amount of freshwater input from rainfall and snow and glacial meltwater. Ongoing climate change processes, including increased snow and ice melting, are further expected to enhance corrosive conditions in these coastal ecosystems. Here, we present synthesized biogeochemical observations from 2011 to 2024 across Lingít Aaní, Alaska's southeast region. This data product includes repeated, full water column profile biogeochemical profiles, encompassing carbonate parameters, dissolved oxygen, and macronutrients, from multiple glacially influenced and deglaciated fjords. The dataset complements ongoing research on fjord ventilation physics, zooplankton community structures, and community-led observing programs. Previous studies have identified a contemporary ocean acidification signal in surface waters throughout Lingít Aaní, with indications of emerging biological impacts. By extending publicly available observations through the entire water column, this new product enables assessment of acidification and ecosystem vulnerability from surface to depth, supporting a broad range of applications. We demonstrate how these observations are used by Tribal, state, and federal decision-makers to inform fisheries and resource management, including the rapidly expanding mariculture industry in the region.

Authors: **Haley Geizer**; Francesco Bisiach, Alexandre Normandeau, Maria Armstrong, Stephan Hamisch, Silas Jones, Casey Hubert, Kumiko Azetsu-Scott, Paul Snelgrove, Christopher Algar

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Title: Biogeochemical differences in Arctic fjord sediments 3- and 5-years post submarine landslide

Abstract

Few studies have documented benthic geochemical and microbial community responses to a fjord-wall submarine landslide through time, despite the importance of fjord sediments as hotspots for carbon (C) storage and the potential impacts that redistribution processes, such as submarine landslides, may have on storage. Submarine landslides on fjord sidewalls are frequent and their recurrence is predicted to increase in response to Arctic warming through declining sea ice and increase in sediment delivery. A previous study pinpointed the timing of a submarine landslide in Southwind Fjord, Nunavut, to September 2018 through repeated high resolution multi-beam echo sounder (MBES) seabed surveys between 2013 and 2019 paired with satellite imagery. This event created a unique opportunity to monitor slide-related alterations in benthic biogeochemistry. Box-coring during research cruises in Southwind Fjord in 2021 and 2023 both inside and outside the slide scar enabled us to document shifts in biogeochemical properties using porewater chemistry, onboard flux incubations, oxygen profiling, and 16S ribosomal RNA fingerprinting. Despite similarity in benthic-pelagic dissolved inorganic carbon and oxygen fluxes, microbial communities clearly differed inside and outside the landslide with higher relative abundances of sulfate reducers inside the landslide and higher concentrations of reduced porewater solutes. Benthic-pelagic phosphate and silica cycling was also amplified inside the slide scar, but weakened over time. These findings suggest that rapid C degradation in older exposed sediment inside the slide scar may not occur, despite enhanced nutrient cycling closer to the slide event that re-equilibrates through time.

Authors: **Sonnich Meier**; Frantzen S., Wiech M., Ali A.M., Valdersnes S.,Nilsen, B.M., Varunjikar M.S., Boitsov S., Jensen H.K.B., Close H., Aguirre G.E., Bagøien E., Lindstrøm U., Sanden, M.

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Title: Persistent organic pollutants (POPs), emerging contaminants, metals, and energy in the Barents Sea food chain

Abstract

The Barents Sea is one of the most productive oceans in the world and serves as a nursery area for several commercially exploited fish stocks. Climate warming in the Arctic region has occurred at a rate at least two times higher than globally. The Arctic amplification of global warming is changing the biogeochemical and physical settings of the ocean, affecting contaminant fate and transport dynamics in ways that are not yet well understood. Through the project, CLIMESEAFOOD, we have made a comprehensive assessment of contaminants in the Barents Sea food web to evaluate, test, and validate mechanistic marine ecosystem and trophic transfer model capabilities. As part of this, we will establish baseline data on trophic magnification factors (TMFs) for the Barents Sea, including key organisms from both the boreal and arctic communities and covering both the benthic and pelagic food webs. In addition to analyses for contaminants, detailed lipid-, energy- and stable isotope analyses have been conducted. Samples of 6 zooplankton species, 4 benthic invertebrate species, 22 fish species, and minke whales have been collected from three different areas of the Barents Sea, Atlantic water, Mixed zone and Arctic water (Fig. 1). Persistent organic pollutants (POPs) such as lipophilic poly-chlorinated biphenyls (PCBs) and poly-brominated diphenyl ether (PBDE) and protein-associated per- and poly-fluoroalkyl substances (PFASs), as well as heavy metals (mercury, methyl-mercury, cadmium, lead, and arsenic) will be included as target contaminants for the modelling. Fig.1 The Barents Sea. The colored boxes show the three areas that are compared.

Authors: **Michael S. Bank**; Ingrid A. Johnsen, Samuel P.S. Rastrick

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Title: Using machine learning and isotope geochemistry to track pollution in Norwegian fjord ecosystems

Abstract

Pollution in Norway's fjords has become an issue of substantial concern, and these areas are often considered to be ecologically significant and complex, supporting a high degree of biodiversity. Sources of pollution to these ecosystems vary and include industrial, agricultural, maritime, and urban runoff, the effects of which may be exacerbated by global environmental change and climactic factors. Here we use machine learning models and isotope geochemistry to synthesize the major pollution issues that threaten these ecosystems in the context of land/sea exchange dynamics, ocean circulation, trophic transfer, and ecosystem complexity. The results from this synthesis show that pollution of fjords in Norway is highly context specific, and that sources and risks can vary substantially throughout the country. Using these models, we present mitigation and management strategies to preserve these ecologically important marine environments in the context of both food security and ecosystem health.

Authors: **Einar Pétur Jónsson**; Erin Kathleen Redmond, Hrönn Egilsdóttir, Kristján Þórhallsson, Sara Harðardóttir, Tómas Árnason

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Title: Insights from multi-driver experimental research conducted in Iceland

Abstract

Research on multiple drivers in Icelandic waters is relatively scarce, although the area is of course not exempt from pressures exerted by anthropogenic change, such as ocean warming and comparatively rapid ocean acidification. Substantial multi-driver research has been done elsewhere and can to some extent be applied to the Icelandic context, but studies specifically on locally adapted organisms are needed to gain better insight into local responses to pressures from multiple drivers. The Marine and Freshwater Research Institute (MFRI) began an initiative to carry out experimental research on multi-driver effects relevant to Icelandic waters to eventually strengthen predictions about the ramifications of ocean changes. The initiative has focused on capacity building and experimental infrastructure, with a buildup of a fish tank laboratory within the MFRI's experimental aquaculture facility, as well as small mobile setups. Research projects have so far taken on different aspects of multi-driver research: i) the effects of extreme events, such as marine heatwaves and acidic waves, ii) mechanistic study of temperature, mixed with a scenario approach for its interaction with pCO2 and iii) a comprehensive single driver mechanistic study of temperature, a strong driver of fish growth and migration. These approaches have different constraints regarding feasible experimental setups, scales, and organisms used, so that a flexible setup has been advantageous. The talk will provide an overview of the buildup of the experimental infrastructure and capacity needed to carry out multi-driver research in Iceland, as well as providing some insight from experiments on the effect of extreme events on larva of the green sea urchin (Strongylocentrotus droebachiensis), temperature and pCO2 effects on the diatom (Pseudonitzchia delicatissima), and temperature effects on life history traits of the pelagic fish capelin (Mallotus villosus).

POSTER PRESENTATIONS

Authors: **Silvana Gonzalez;** Heather Cannaby, Solfrid Hjøllo, Helene Langehau, Nadine Goris

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Title: The cascading impacts of marine heatwaves on Norwegian coastal ecosystems

Abstract

Marine heatwaves (MHWs) are increasing in frequency, duration, and intensity due to global warming, yet their short-term impacts on ecosystem functioning remain poorly understood, especially in Norwegian waters. MHWs interact with ocean stratification through a two-way feedback: enhanced stratification can promote surface warming by limiting vertical mixing, while MHWs further strengthen stratification and density gradients. This feedback may reduce nutrient exchange, alter primary production, and shift plankton size spectra toward smaller, fast-growing species, with implications for energy transfer to higher trophic levels and food-web structure. We used the coastal, high-resolution (800 m) Norkyst-NORWECOM.E2E coupled physical–biogeochemical model to explore these processes using a 14-year hindcast (2012–2025) encompassing several recent MHW events in Norwegian waters. Outputs from this model provide early insights into how ecosystem responses in nutrient cycling, primary production, carbon export, and dissolved oxygen vary with MHW intensity, duration, and seasonal timing, and how these responses are shaped by stratification feedbacks. Our results advance mechanistic understanding of how short-term climatic extremes shape biogeochemical cycles and ecosystem functioning in warming high-latitude marine systems.

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Title: Linking ecosystem variability to individual energy use and growth in Faroe Shelf cod

Abstract

A population's biomass changes over time as a result of several interacting processes, including mortality, recruitment, and individual growth. Individual growth is constrained by the amount of energy gained by feeding subtracted the experienced metabolic loss. Field metabolic rate (FMR) describes how much energy an individual uses under natural conditions and therefore reflects the total energetic costs of basic maintenance, movement, and food intake. Therefore, variation in FMR determine how much energy remains available for somatic growth and reproduction, providing a direct link between individual energy use and population-level biomass dynamics. Using stable isotope records preserved in otoliths, we reconstruct individual-based estimates of FMR and experienced temperature of adult Atlantic cod (Gadus morhua) from the Faroe Shelf, spanning a period of more than 60 years. Carbon isotopes of otolith carbonate ($\delta^{13}C$) are used to estimate field metabolic rate, while oxygen isotopes ($\delta^{18}O$) provide information on the temperature experienced by individual fish. These estimates provide insight into metabolic rate and experienced temperature during the months prior to capture. Individual-level reconstruction of FMR and temperature are combined with environmental information of local and large-scale oceanographic conditions. We explore whether strong environmental variation are associated with variation in metabolic rate, leading to changes in energy available for somatic growth and reproduction. Linking energetics to environmental conditions may help identify the environmental regimes associated with biomass increase and decrease.

Authors: **Clarke A. Blair**; Einar Pétur Jónsson, Tómas Árnason, Haseeb Randhawa, Kristján Þórhallsson, Thassya dos Santos Schmidt

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Title: The effect of temperature on gonad development and reproductive investment in capelin (Mallotus villosus)

Abstract

Capelin (Mallotus villosus) is an Arctic and sub-Arctic forage species that occupies a keystone mid-trophic role in Icelandic waters. Since the early 2000s, capelin have demonstrated a climate-driven range shift in their nursery and autumn feeding grounds, which historically were in the North of Iceland and are now off the East coast of Greenland. Despite capelin's ecological and commercial importance, their reproductive biology in Icelandic waters remains poorly understood, particularly in relation to temperature. This project will examine the gonads of capelin reared in captivity under different experimental temperature treatments to investigate the following question: Does temperature influence gonad development and reproductive investment in capelin? The experimentally-reared capelin were kept at five constant temperatures (3°C, 7°C, 9°C, 12°C, and 15°C) from metamorphosis until sampling. Ovaries will be characterized via microscopic staging, and reproductive investment will be assessed via fecundity and egg quality measured across time and temperature treatments. Microscopic staging will be compared to the macroscopic staging of the whole ovaries at dissection to assess the bias of staging methods, and gonads from experimentally-reared capelin will be compared to age-matched wild-caught capelin as a quasi-control. As ocean temperatures warm and currents shift, the results of this study will supply temperature-dependent reproductive metrics for capelin that can be used in stock assessment and fisheries management.

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Title: Monitoring Fishes in Elson Lagoon, Utqiaġvik (Barrow), AK, for evidence of Borealization.

Abstract

Two Alaska Beaufort Sea lagoons in Kaktovik, North Slope Borough, Alaska, indicate that borealization—a decline or replacement of Arctic specialist species with increased relative abundance of boreal species—is taking place on the North Slope (Von Biela et al. 2022). Fish in Elson Lagoon, also a Beaufort Sea lagoon near the city of Utqiaġvik (Barrow), have been monitored beginning in 1996 and from 2009-2017. Using fyke nets, we have recorded ~ 35,000 entries that serve as baseline to compare to data collected during the open-water periods in 2025 and 2026. Elson Lagoon is a shallow body of water formed by a series of non-continuous barrier islands that encloses a bay that seasonally varies in salinity (surface water ranging from 2 to 31 psu) and temperature (from ~ -1.8 to approximately +14°C) within three months. We propose to detect change or to show no change in catch rates (catch-per-unit-effort) of key fish species (least cisco, Arctic cisco, fourhorn sculpin, rainbow smelt, saffron cod, and Arctic flounder) as a preliminary step in assessing whether borealization is taking place in this Beaufort Sea lagoon. Fish data collected for this assessment include number and timing of species, relative abundance, length-weight, age structure, and age at maturity data for non-salmon species.

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Title: Borealization? The stability of demersal offshore fish assemblages in the Canadian Beaufort Sea and Amundsen Gulf

Abstract

Climate change is driving borealization of Arctic seas throughout the circumpolar north. In North America, borealization in biotic communities occurs via Pacific and Atlantic gateways through a combination of increasing inflow water temperatures and shifting local conditions that impact the extent and distribution of sea ice. A lack of biological data in the Canadian Archipelago and adjacent southern seas makes it difficult to detect and track borealization at the extreme outflow extents of both Pacific and Atlantic influence. The Canadian Beaufort Sea Marine Ecosystem Assessment established baselines for the diversity and community structure of demersal offshore fishes in the Canadian Beaufort Sea and Amundsen Gulf. Using trawl survey data and environmental DNA, we examined the stability of fish assemblages between 2012 and 2024 for evidence of environment-mediated shifts in community structure and to assess potential borealization of offshore fish communities. Our analysis indicates relative stability within demersal fish communities over the study period, however, environmental DNA suggests potential range expansion of species not previously recorded in the study area. This work provides a baseline from which to detect borealization in the western Canadian Arctic.

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Title: Toxigenic diatoms in Icelandic waters: insights from long-term monitoring and sedimentary ancient DNA

Abstract

Shifts in oceanographic conditions have led to significant changes in the composition of phytoplankton communities across the North Atlantic and Polar regions, with a northward expansion of temperate phytoplankton. Iceland is positioned at the intersection of two waterfronts with different ecosystems making it an ideal place to study occurrences and bloom dynamics of HABs in a changing world. The spring bloom is a key event in the Arctic and by long term monitoring of phytoplankton we have collected samples at several coastal and oceanic sites since the 1950s during the spring bloom event. In this study we investigate if there has been an increase in occurrences of the toxigenic diatom genus Pseudo-nitzschia in the North Atlantic water mass correlated to changes in water temperature and salinity. At several study sites Pseudo-nitzschia spp. was enumerated and when possible, compared with eDNA results. We show the occurrences of Pseudo-nitzschia spp. over 15 years in spring at Selvogsbanki and Faxaflói, south and southwest of Iceland, respectively. By sedimentary ancient DNA metabarcoding of a core retrieved from the Selvogsbanki area, we investigate multi-decadal occurrences of Pseudo-nitzschia.

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Title: Let the dead tell the story: Marine mammals strandings as evidence of changes in Icelandic Waters.

Abstract

As the climate shapes the environment, variations of the environmental components impact the balance of the marine ecosystem and reshape its biodiversity. Iceland is located on the front line between two powerful oceanic entities, the North Atlantic current, which carries warm and saline water to the south of the island, and the East Greenland current coming from the Arctic ocean, which brings cold and relatively fresher waters over the North Icelandic shelf. Any changes to these currents will disrupt the balance of the Icelandic marine ecosystem sitting right on the fence between the Arctic Ocean and the rest of the North Atlantic Ocean. Since the late 1980s the Marine and Freshwater Research Institute (MFRI) has kept record of all reported events of stranded marine mammals along its coast. To date the MFRI database holds records of more than 1,200 stranded animals, from about 700 stranding events. Our study demonstrates that the variations in cetacean stranding events and compositions tell a story of profound changes in the Icelandic marine biodiversity. Since 2005, we observed a steady increase of both the number of events and the number of individuals of boreal cetacean species stranded on the Icelandic coast. These increases suggest that changes in environmental conditions, may facilitate the arrival of southern species. It furthermore emphasis the value of long-term monitoring in a changing ocean.

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Title: Geneflow and genetic structure of a wide-spread Arctic fish, *Liparis fabricii*

Abstract

The spread of large migratory fish predators, such as Atlantic cod, into Arctic ecosystems through borealization has led to reduced Arctic species abundances and ranges. Snailfishes (Liparidae) are a common gadid prey item throughout Arctic-subarctic food webs and are important to many generalist fish species. Liparis fabricii, an Arctic snailfish with a circumpolar distribution extending into sub-Arctic areas, is perhaps the most abundant snailfish species in this region. While primarily demersal as adults, their pelagic larval stage integrates them into both demersal and pelagic food webs, and coupled with high energy content, underscores their significance as a prey species. However, warming waters and roving predators are constricting their distribution, with potential consequences for Arctic food webs. This study evaluates the population genetic structure of L. fabricii across the Arctic, analyzing populations from Alaska, Baffin Bay, East Greenland, and Svalbard using genome-wide nuclear SNPs and mitochondrial data. Our results reveal a largely mixed metapopulation, likely driven by larval dispersal through Arctic currents. These findings offer essential baseline knowledge on the population structure of a common prey item in marine Arctic food webs and will be beneficial to assessing the impacts of climate change on Arctic biodiversity. Additionally, as climate change alters Arctic currents, this study serves as a reference for future research on the climate-related genetic impacts on larval fish dispersal.

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Title: Diet of deep-sea fish on the Norwegian continental slope

Abstract

The deep sea is one of the largest ecosystems on Earth, yet remains among the least understood. Climate-driven changes in temperature, circulation, and productivity are expected to alter trophic interactions in deep-water systems, but baseline knowledge of food-web structure along environmental gradients is still limited. Diet studies are therefore essential for understanding predator–prey dynamics and anticipating ecosystem responses to future change. We investigated the diet of greenland halibut, roughhead grenadier, beaked redfish, thorny skate and arctic skate sampled along the Norwegian Sea continental slope (68–79°N, 400-1300 m depth). Stomach contents were grouped to functional groups then analysed using prey specific index of relative importance, frequency of occurrence, and percent average prey weight to quantify prey importance. Multivariate analyses, including PERMANOVA, NMDS, and cluster analysis, were applied to examine patterns in diet composition, while SIMPER identified prey groups contributing most to observed differences. Generalized linear models (GLMs) were used to assess the change towards piscivory with predator size. Canonical correspondence analysis was applied to evaluate how environmental gradients (depth, longitude, and temperature) and biological traits (sex, size, and species) structure dietary composition. Results indicate increased predation on cephalopods across all species compared to appearances in the Barents Sea. greenland halibut, thorny skate, and arctic skate exhibited similar feeding patterns, characterized by a mix of pelagic and benthic prey, with large demersal crustaceans (primarily Pasiphaea tarda) contributing substantially to the diet. In contrast, beaked redfish and roughhead grenadier displayed more distinct trophic strategies: beaked redfish showed higher reliance on hyperiid amphipods (mainly Themisto sp.), whereas roughhead grenadier fed predominantly on benthic invertebrates such as polychaetes and ophiurids. These findings provide new knowledge of trophic structuring along the Norwegian Sea continental slope and contribute to understanding how deep-sea fish communities may respond to environmental change.

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Title: The MOON infrastructure project - Marine Open Observation Network

Abstract

Healthy marine ecosystems are essential to Iceland's society and economy, yet ocean observation beyond fisheries surveys remains fragmented in Iceland and can be difficult to sustain. The Marine Open Observation Network (MOON) was established to strengthen Icelandic marine research infrastructure through three components: (1) autonomous ocean observatories, (2) autonomous and remotely operated vehicles, and (3) open data management and computational services. The initiative responds to emerging challenges including climate-driven ecosystem change, biodiversity monitoring, aquaculture expansion, and underwater noise. MOON combines cost-effective technologies with coordinated field observations, recognizing that many biological and ecological measurements still require local expertise and in situ sampling. The network builds on collaboration among University of Iceland research centres, the Marine and Freshwater Research Institute, and the Icelandic Research e-Infrastructure (IREI), ensuring secure data management and open access. By lowering barriers to equipment, data, and expertise, MOON aims to support interdisciplinary research, ECR training, and long-term marine monitoring in Iceland while contributing to broader European and Ocean Decade objectives.

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Title: Seasonality and water masses shape energetics of polar cod (Boreogadus saida): Quantifying energy density and condition indices

Abstract

Seasonal life history decisions and environmental factors, such as temperature and prey availability, shape energetics over annual cycles. We quantified seasonal energy density of polar cod (Boreogadus saida), a central predator and prey in the Arctic marine food web. We collected individuals from Atlantic and polar waters in the Barents Sea, to assess the impact of seasonality and water masses on energy density (kJ g-1 wet weight). Additionally, we compared energy density to four condition indices (Fulton's, residuals, hepatosomatic indices and percent dry weight) to test their accuracy as energetic proxies for polar cod. Energy density varied seasonally and was lower in Atlantic waters. In polar waters, energy density was lowest in April/May, whereas seasonal variation was weaker in Atlantic waters, being low from spring and summer. Energy density was highest in December in both water masses, although not much higher than March in polar water. Differences between water masses was seasonal, greatest in March and negligible in December. Percent dry weight best represented energy density, while Fulton's and residuals (derived from wet weight) indices were poor indicators. Our results show that seasonality and environmental factors shape energetics, and that energy proxies must be carefully selected to accurately represent the energetic status of an organism. Our seasonal resolution highlights potential "critical windows", when polar cod may be most vulnerable to stressors. This is important to consider in conjunction with the spatial differences in polar cod energy density, especially in light of ongoing borealization. Increasing temperatures and changing prey availabilities in a future Arctic, as well as potential added energetic costs (e.g. increased competition and anthropogenic activities), will almost certainly alter ecosystem energy fluxes. Understanding spatiotemporal energy dynamics of key organisms is an important step in predicting the ecosystem-wide effects of borealization in the Arctic.

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Title: Interannual variation in diet composition and dietary diversity of 0-group juvenile cod and saithe in nearshore nurseries

Abstract

Understanding trophic interactions during early life is important for evaluating ecological functioning and ecosystem interactions of juvenile fish. Atlantic cod and saithe co-exist in shallow coastal nursery habitats during their first summer and autumn and are generally considered opportunistic generalist foragers. We examined variation in stomach content composition and dietary diversity of juvenile gadids collected from Icelandic coastal nursery habitats using beach seine surveys. Preliminary analyses focused on temporal changes in prey composition and Shannon dietary diversity across the settlement season and into early winter. Diet composition shifted markedly through time, and differences were observed between species. Dietary diversity also varied seasonally. These preliminary analyses provide a basis for ongoing MSc research examining trophic niche dynamics in juvenile gadids.

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Title: ICE Fish Research: Science Communication from Iceland

Abstract

Science communication is often undervalued and underfunded, making public engagement challenging, especially for early-career researchers. Yet scientists have a responsibility to share their work and its relevance with society. To support this, we founded ICE Fish Research in May 2024 to make fish research in Iceland visible and accessible while providing researchers with an easy platform to share their science. Through social media, blogs, and our podcast “Fiskaspjall”, we showcase research, highlight the people behind science, promote diversity and representation, and inspire future generations to explore scientific careers and opportunities

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Title: Synergies between underwater cultural heritage and biodiversity conservation in Iceland: Insights for achieving 30× 30 targets

Abstract

Underwater cultural heritage (UCH), including shipwrecks, is increasingly recognized for its dual significance as both historical artifacts and ecologically valuable marine features. With the adoption of the Convention on Biological Diversity (CBD) 30 × 30 framework, there is growing interest in exploring synergies between heritage conservation and biodiversity protection. Integrating UCH into 30 × 30 conservation goals requires a multidisciplinary approach that considers heritage laws, sovereignty, governance, planning, and associated risks. The current study specifically evaluates the potential of Iceland's UCH sites for marine biodiversity conservation by analyzing heritage laws, public case records, and media reports. Additionally, vessel monitoring system (VMS) data reveal that Icelandic trawlers actively avoid well-documented wreck sites, suggesting an existing—though informal—form of protection. The findings underscore the need for improved site documentation, clearer policy communication, and stronger collaboration between cultural heritage and fisheries management authorities. Recognizing UCH sites as Other Effective Area-Based Conservation Measures (OECMs) could enhance both heritage preservation and marine biodiversity protection by leveraging existing management actions and *de facto* conservation measures, ultimately contributing to a more diverse and resilient marine protected area (MPA) network in Icelandic waters.