



Coldfish aims and objectives

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Determine the large-scale ecosystem structure response to climate induced borealisation of the Arctic region

Focus on fish populations

By considering how:

- Habitat requirements, behavioural specialisation and species interactions influence **trophic and metabolic responses** to sea ice decline
- Emphasis on the **individual level** response
- **Barents Sea** as the main study area

Coldfish is primarily a stable isotope based project

- Measures **flux of nutrients** within and between food webs, functional groups or food web modules
 - Quantify benthic pelagic coupling
 - Relative trophic level
 - Predator-prey mass ratios
 - Test ecosystem scale model predictions
- Can quantify niches due to **individual level data**
- However poor taxonomic resolution of diet
- Builds on isotopic work conducted under the TIBIA and SI_Arctic programs

3 Work Packages – Main Aims

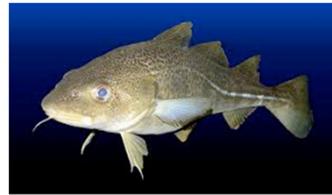
WP1: Determine **spatial controls** on the extent of **benthic-pelagic coupling** and stable isotope compositions of key fish species

WP2: Define the **isotopic niche traits** of key fish species and potential **drivers of change** in these

WP3: Compare **metabolic, behavioural and growth traits** of resident Arctic and northward-moving boreal fishes

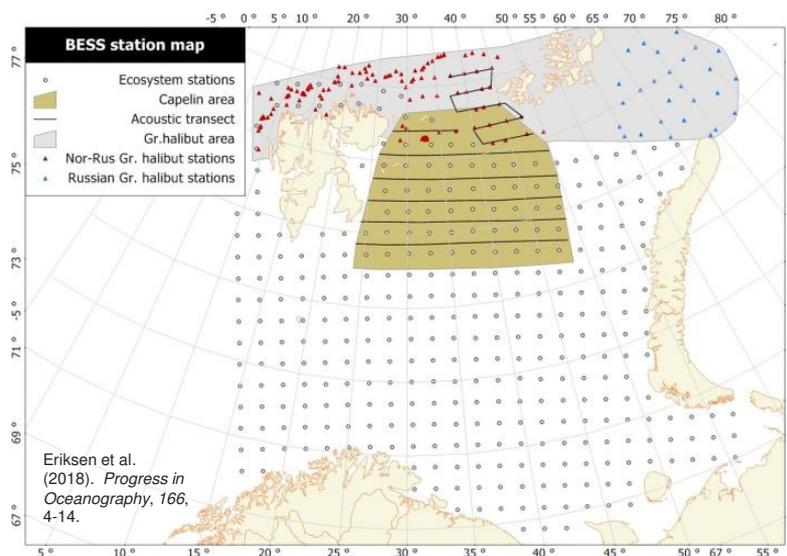
Key Focus Fish Taxa

- polar cod (*Boreogadus saida*)
- Atlantic cod (*Gadus morhua*)
- redfish (*Sebastes mentella*)
- herring (*Clupea harengus*)
- capelin (*Mallotus villosus*)
- Greenland halibut (*Reinhardtius hippoglossoides*)



Sample areas (WP 1+2)

Joint IMR and PINRO Barents Sea Ecosystem Survey

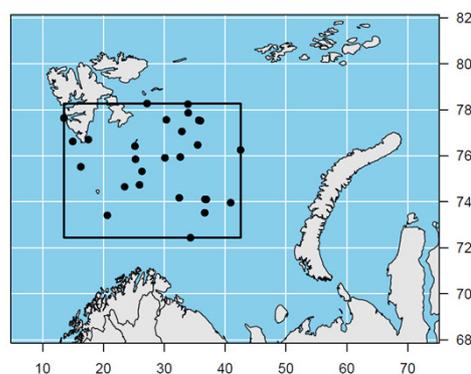


WP1 - spatial variation in benthic-pelagic coupling and stable isotope compositions of key fish species

- Construct benthic and pelagic **isoscapes** for the Barents Sea
- Identify potential **biogeochemical mechanisms** driving spatial variability in isotopic composition
- Determine spatial variability in **benthic-pelagic coupling** and their ecological/physiological drivers
- Quantify **ice algae dependence** in fish from the Marginal Ice Zone
- Compare empirical isoscapes with **predictions from isotope-enabled ecosystem models** – link to mobile predators

Preliminary (capelin) Isoscapes

(with Dr Kirsteen
MacKenzie, data
omitted) here



WP1 – Sampling

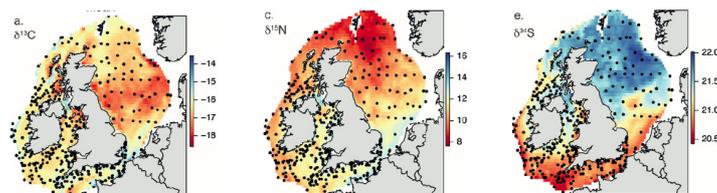
Empirical Isoscapes PELAGIC and BENTHIC

- Extension of work from TIBIA and SI_Arctic (INLA modeling)
- Focus on copepods, capelin and amphipod species
- Key benthic species to be determined
- Sampling in a regular grid pattern
- Wide east-west range (especially in Russian sector)
- 5-10 individuals of reference taxa sampled per site

Combined with WP2 samples to explore spatial variation in ecosystem scale metrics and their drivers

WP1 Practical Deliverables

- Expanded pelagic and benthic isoscapes covering whole Barents Sea
- Link between biogeochemical models and food web parameters (and test of models)
- Spatio-temporal context for any subsequent isotope work in the Barents Sea region
- Quantification of benthic pelagic coupling strength as a function of ecological (community composition) and environmental parameters



St John Glew et al 2019, Methods Ecol Evol

WP2 - Isotopic niches of key fish species and potential drivers of change

Testing key predictions of ecosystem and species responses to change

1. Spatial and ecological **conservation of** species trophic **traits**
2. Spatial **differences** in food web structure are driven by **ecological and environmental variables**
 - taxonomic or functional trait compositions
 - sea ice cover and SST

And with **increasing borealisation**:

1. **Reduced modularity** of food webs
2. Increasing **functional redundancy** in benthic food web compartments
3. Increasing importance of **general foraging** across food webs

WP2 – Sampling (coupled with IMR food web data)

- Focus on **key fish taxa**
- Sample **≥ 30 individuals** (ideally more) per area and date.
- Focus on boreal dominated, mixed and arctic dominated food webs
- Sampling across a **range of body sizes**
- Up to **6000 samples** over the duration of the project
- Key stations to conduct wider scale sampling:
 - Community-level PPMR
 - Biomass size spectra
 - Trophic transfer efficiency

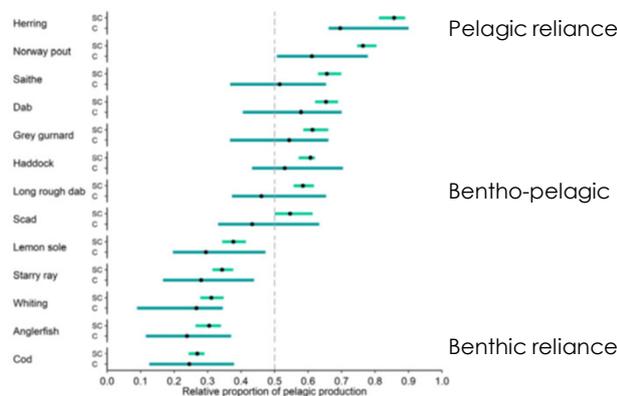
WP 2 Practical Deliverables

- Detailed view of isotopic **niche variability** in key fish taxa across **ecological and environmental gradients**
- Direct test of predictions from food web theory models
- Assessment of the **sensitivity** of large scale **food web structure and function** (PPMR, TE) to ecological and environmental drivers

WP 2 Deliverables

e.g. benthic and pelagic pathways, and **food-web resilience**

e.g. benthic-pelagic spectrum in North Sea

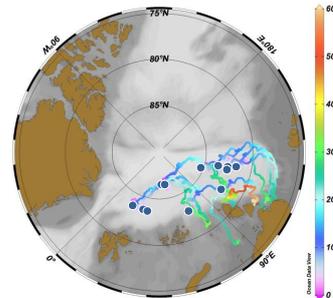


Duffill Telsnig et al. (2018) *Journal of Animal Ecology* [DOI: 10.1111/1365-2656.12929]

WP 3 - Metabolic and behavioural traits of resident polar cod and range-shifting Atlantic cod

Focus on ecological and physiological impacts of climate change on cod life history, performance and long term potential.

1. measuring **relative field metabolic rates** and growth rates in Atlantic and Polar cod across boreal, mixed and polar waters
2. determining the **significance of ice algal dependency** in early life stage migration of polar cod
3. determining **thermal histories** of polar caught Atlantic cod



Sea-ice back-tracking of ice areas where polar cod were sampled (David et al. 2016)

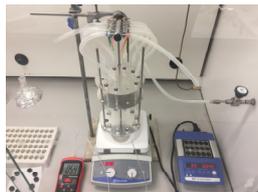
WP3 – Sampling

Metabolic rate work:

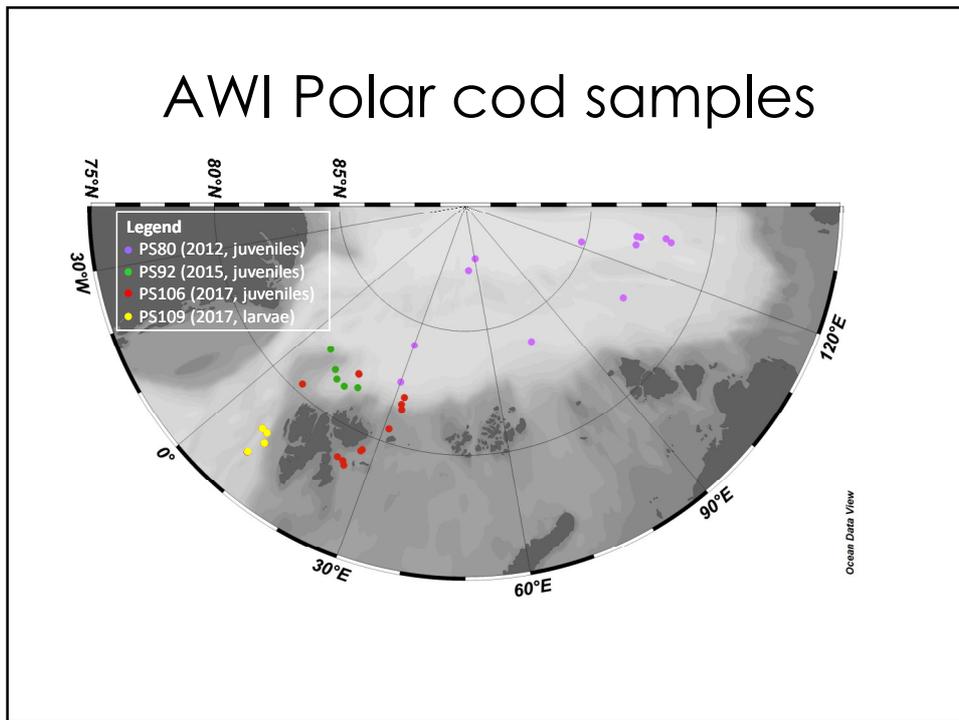
- Atlantic and polar cod **otoliths** (and muscle tissue)
- Boreal, mixed and Arctic waters

Migration and resource utilization work:

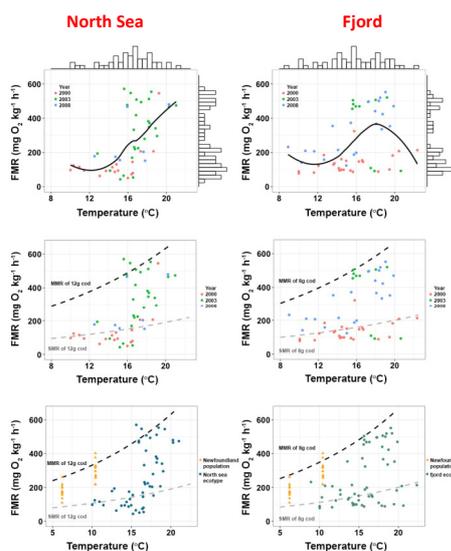
- **Adult** Atlantic and polar cod otoliths (all life stages \geq 2yrs)
- Individual muscle tissue
- Regions spanning Barents as well as **Laptev and Kara Seas**



AWI Polar cod samples



Differential metabolic response to temperature change in co-existing, genetically distinct cod populations



Otolith isotope-derived field metabolic rates show different responses to temperature between ecotypes

The rate and extent to which individual FMR approaches MMR as a function of temperature differs between ecotypes

Metabolic response to temperature differs markedly among ecotypes / stocks

Measure retrospectively - so track metabolic responses under different temp*ecology conditions

WP 3 Practical Deliverables

- **First *in-situ* field-based measurements** of comparative **field metabolic rates** of Atlantic and polar cod
- Identify the relative **sensitivity** of field metabolic rate and growth to **temperature and sea conditions** in polar and Atlantic cod.
- Identify **areas amenable to poleward expansion** of boreal fish and as refugia for polar fishes
- Quantify potential **risk of failing Transpolar Drift** advection for juvenile polar cod in polar refugia
- Provide **field-derived physiological data** to inform **climate-driven predictions** of stock abundance, fecundity and distribution

