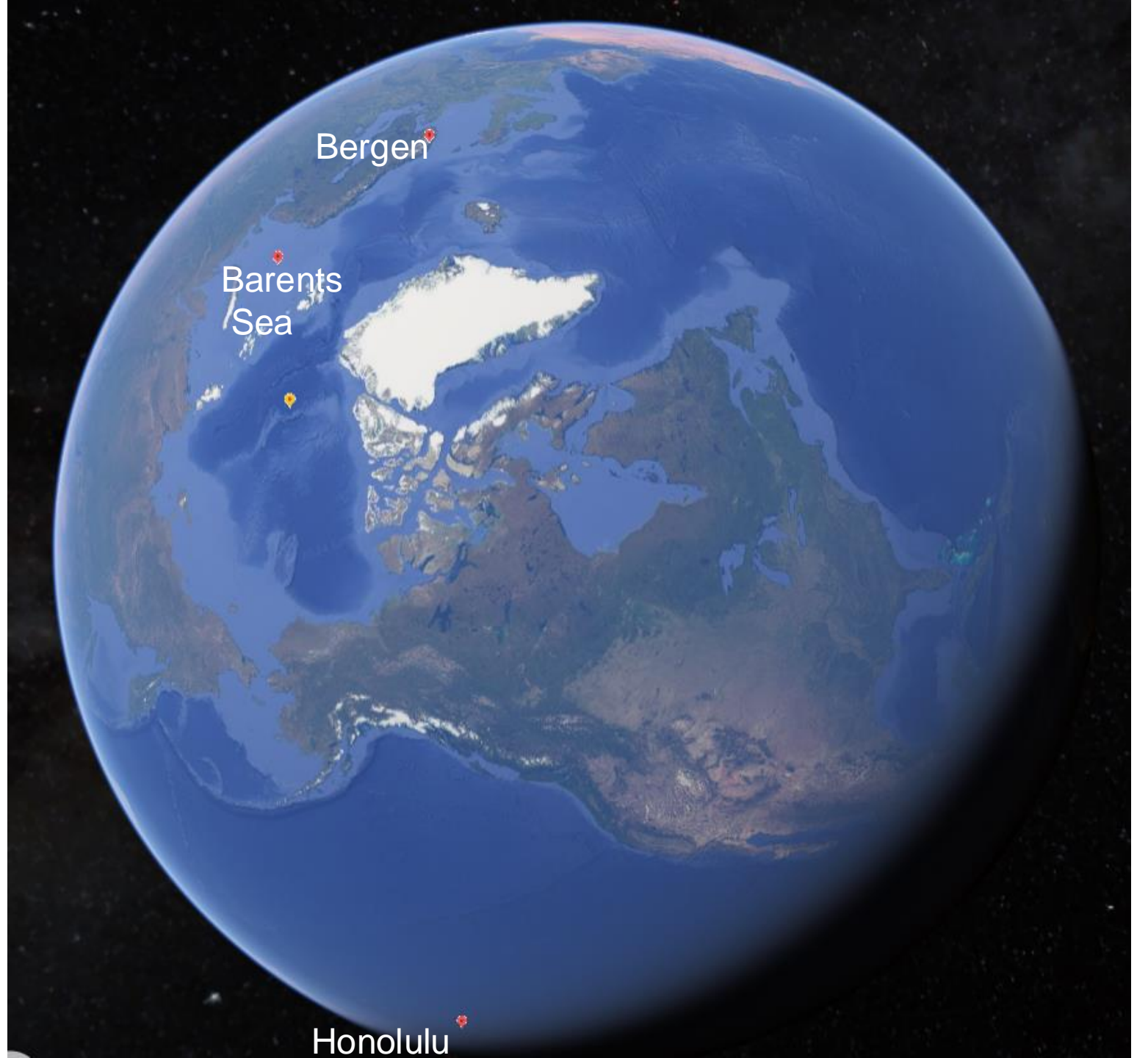


Environmental impact on growth in Barents Sea capelin, cod and haddock

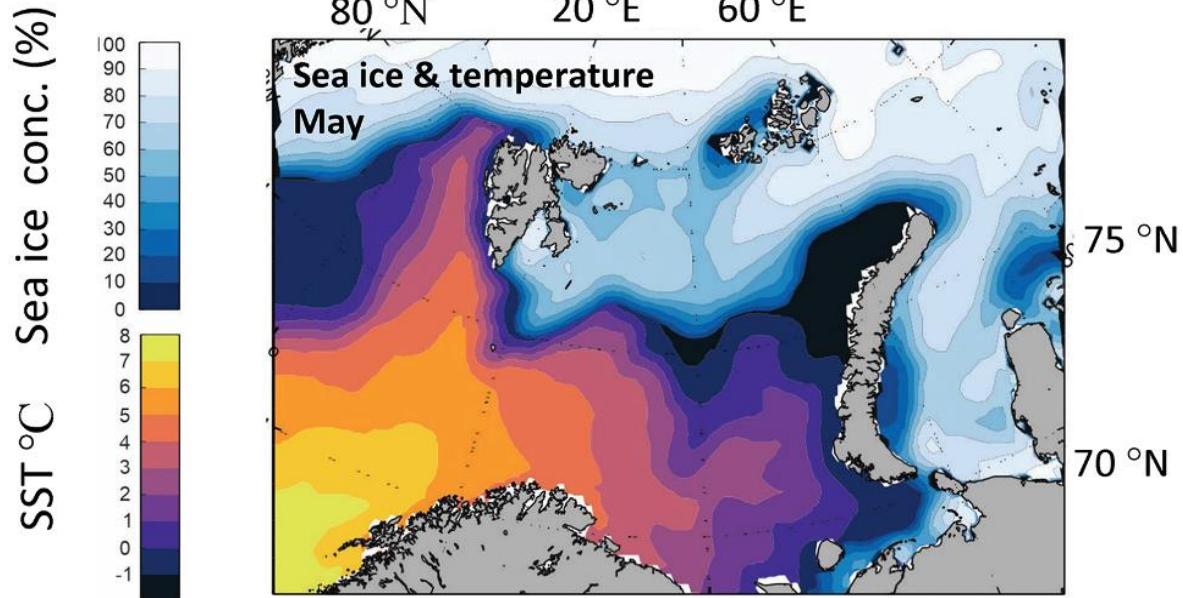
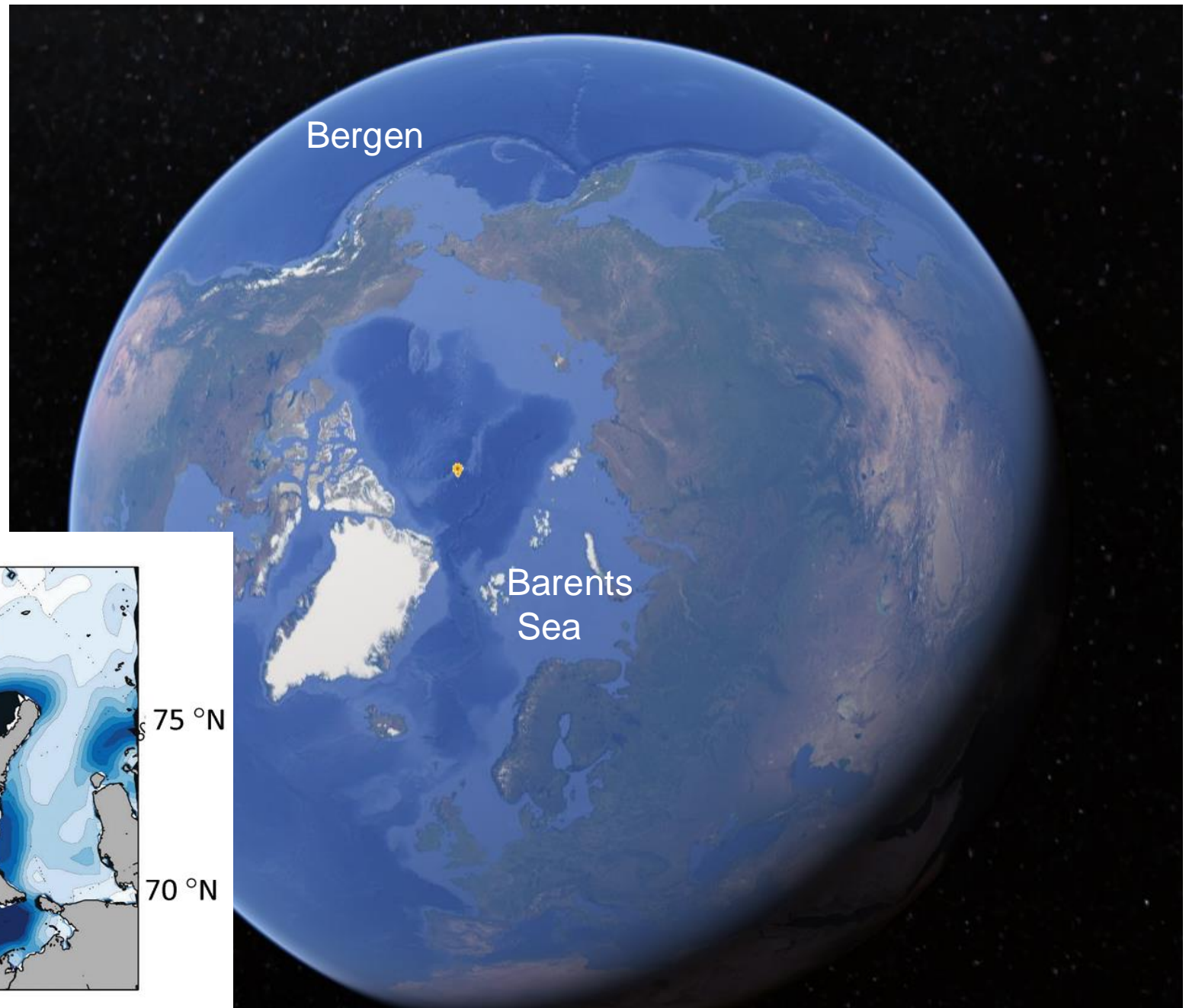
Edda Johannesen, Johanna
Fall and Georg Skaret

Institute of Marine Research
Bergen, Norway

PICES Annual Meeting 2024
Honolulu, Hawai'i

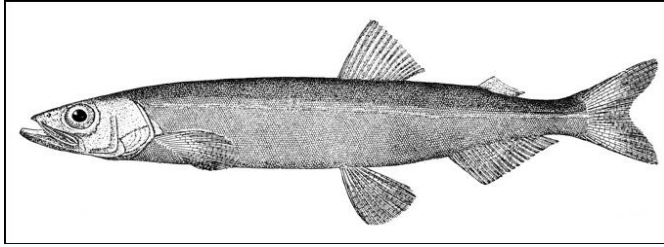


Barents Sea: Shelf Sea north of the Arctic circle

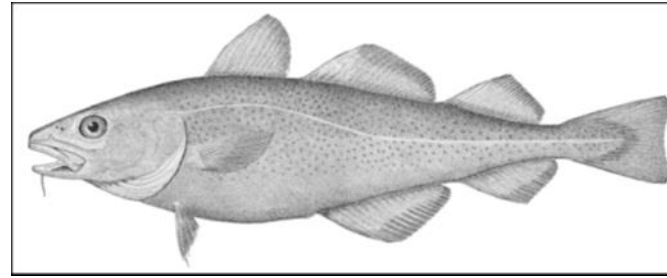


Dalpadado et al 2024

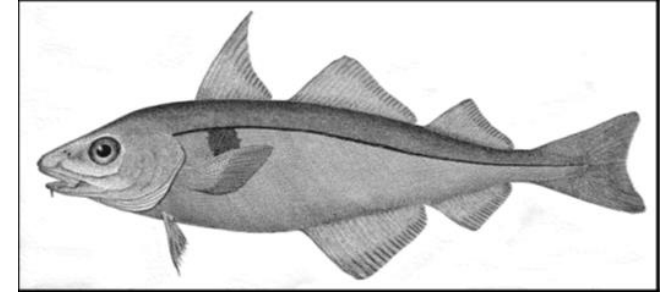
Barents Sea main commercial stocks



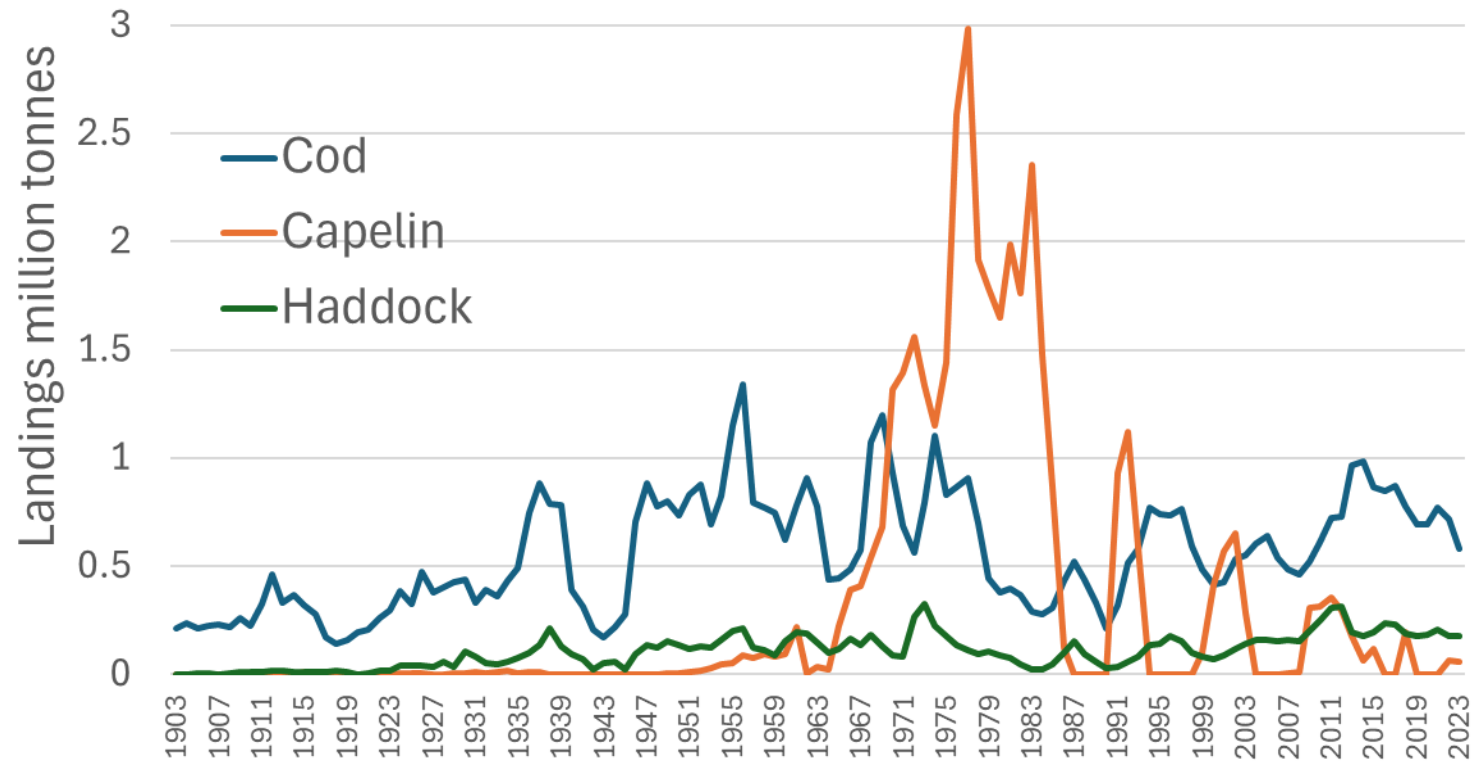
Capelin *Mallotus villosus*

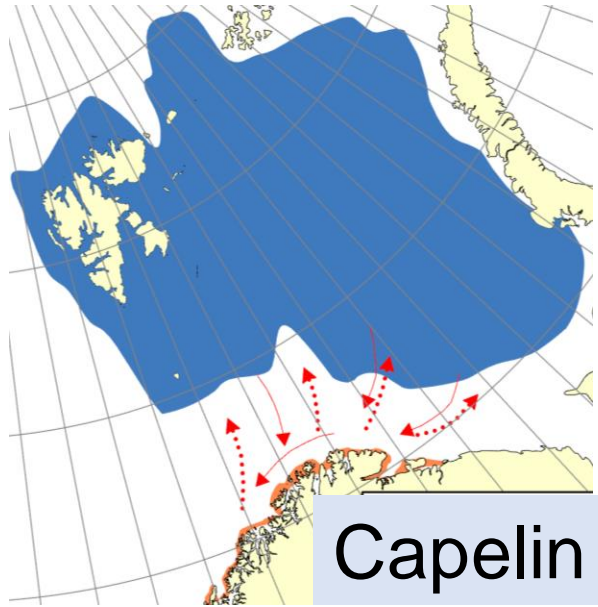
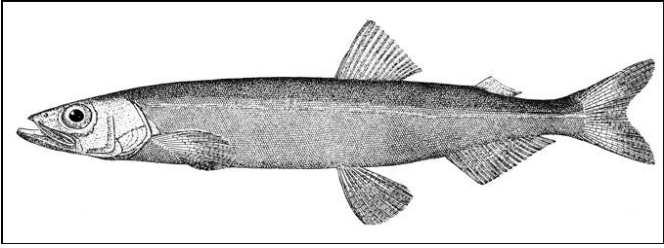


Atlantic cod *Gadus morhua*



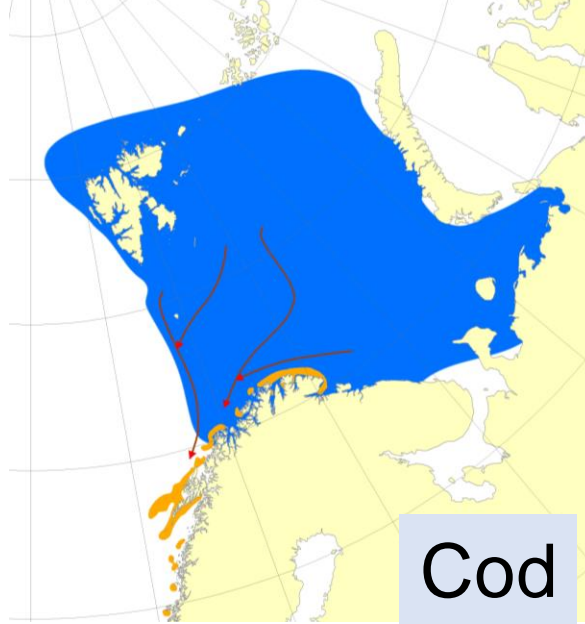
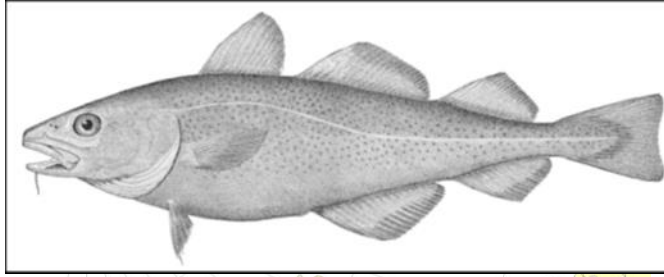
Haddock *Melanogrammus aeglefinus*





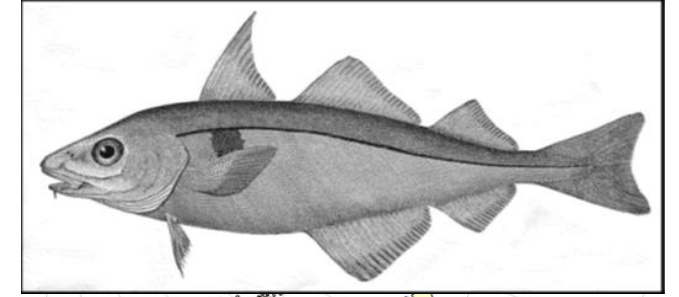
Capelin

- Arcto-Boreal, migratory
- Entire life cycle in BS



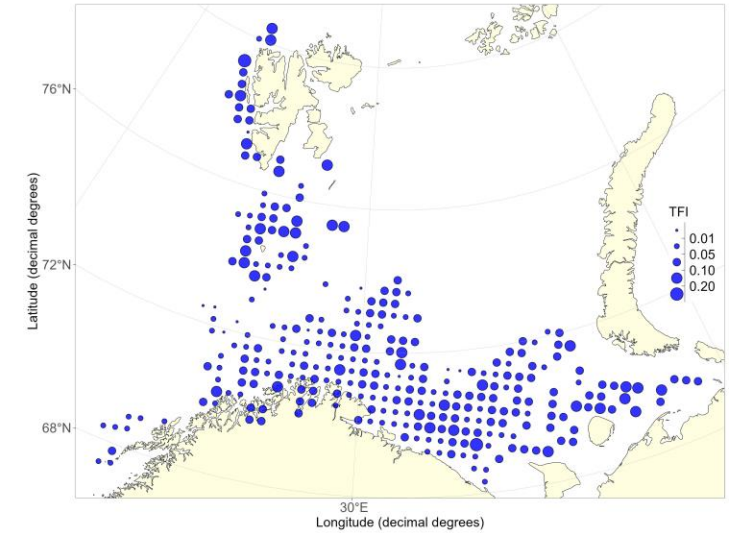
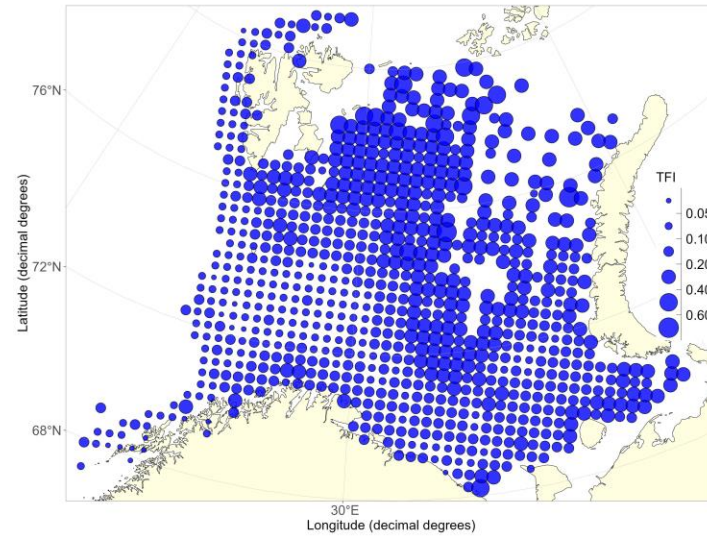
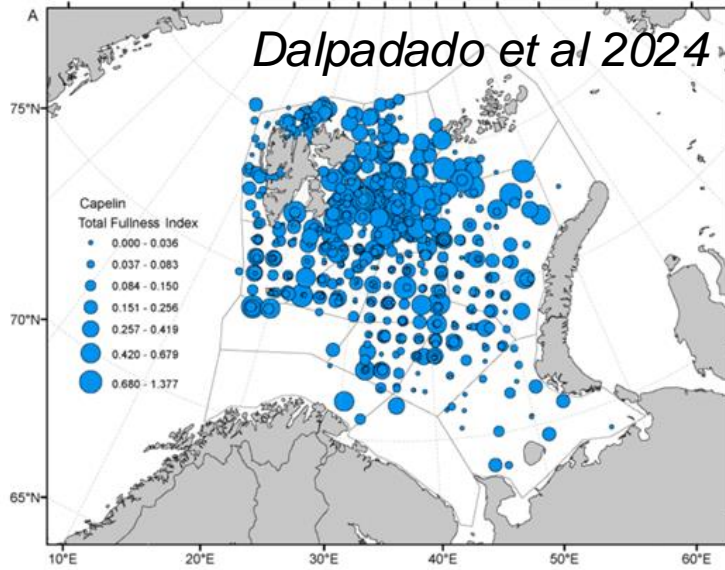
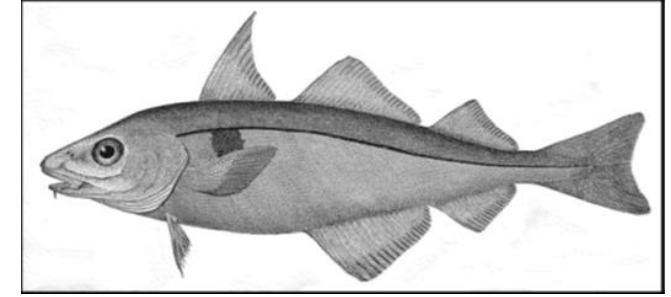
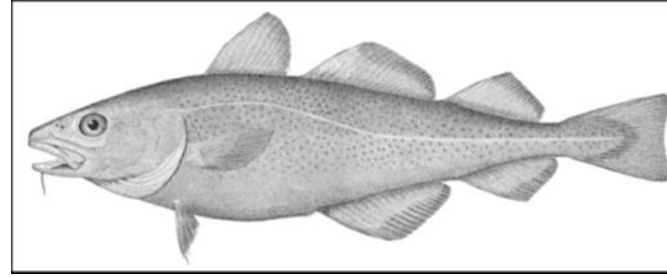
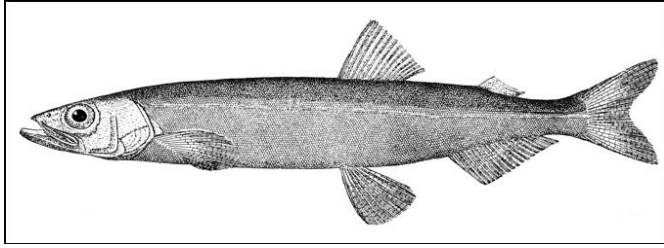
Cod

- Boreal, migratory
- Spawns coast of Norway



Haddock

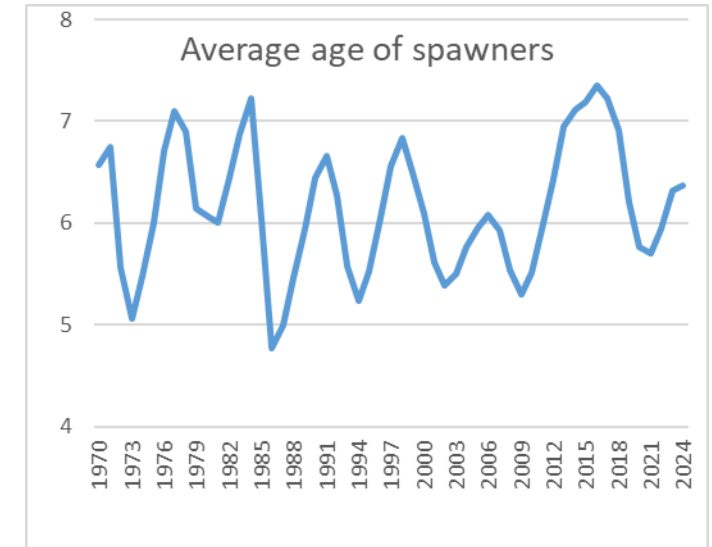
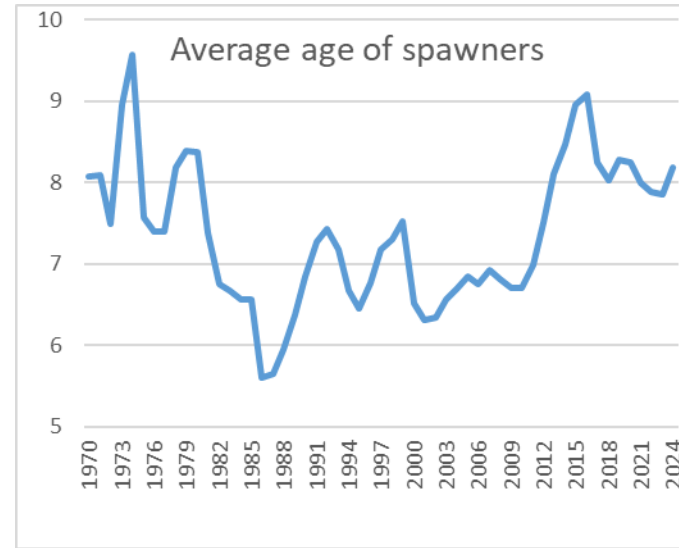
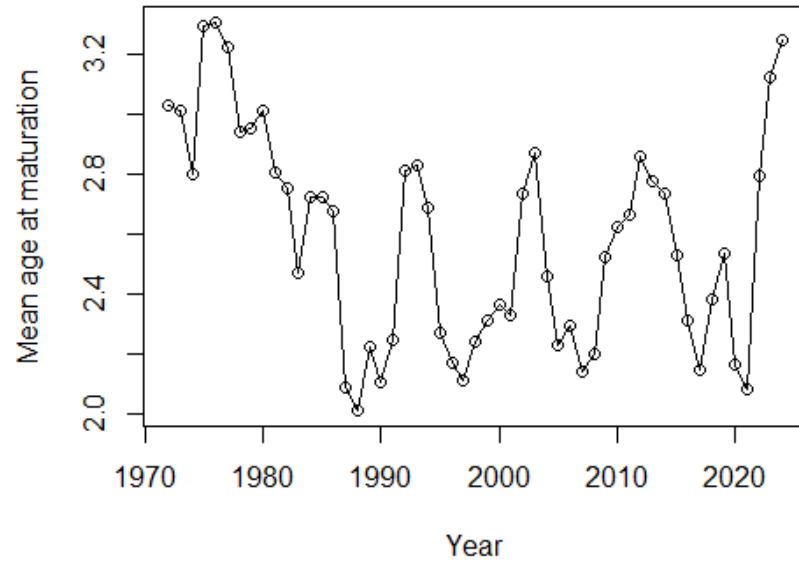
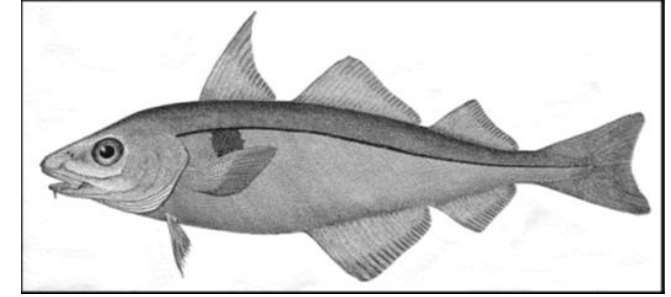
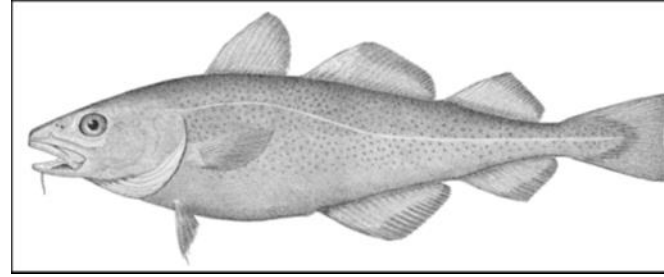
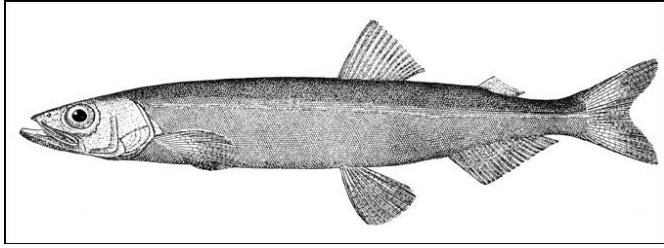
- Boreal, migratory
- Spawns shelf break



- Arcto-Boreal, migratory
- Entire life cycle in BS
- **Planktivorous**
- **Main feeding period Northern BS in summer**

- Boreal, migratory
- Spawns coast of Norway
- **Piscivorous**
- **Feeding migrations Northwards in summer**

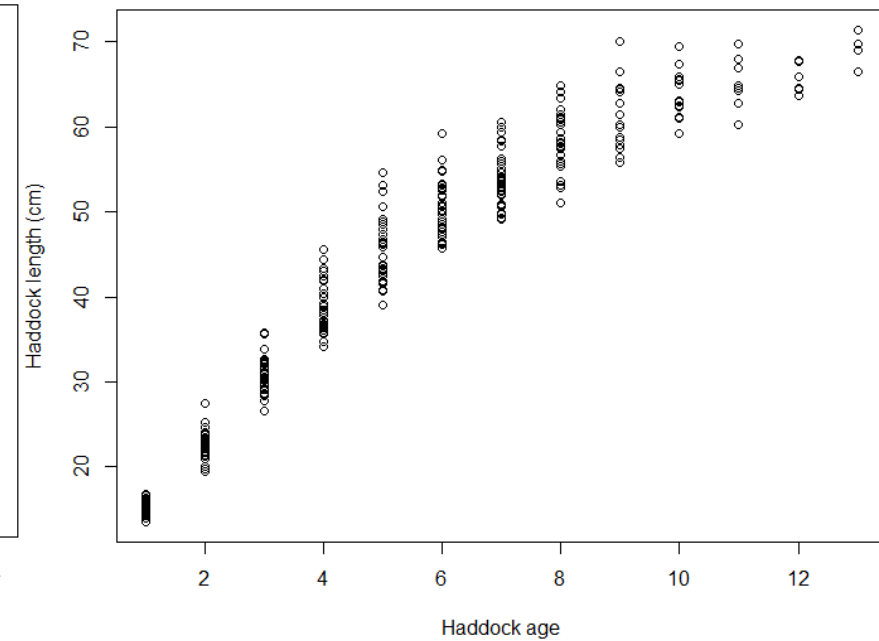
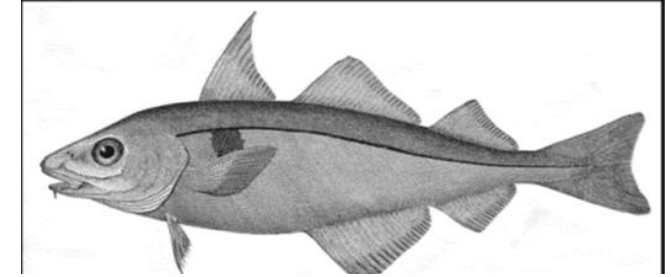
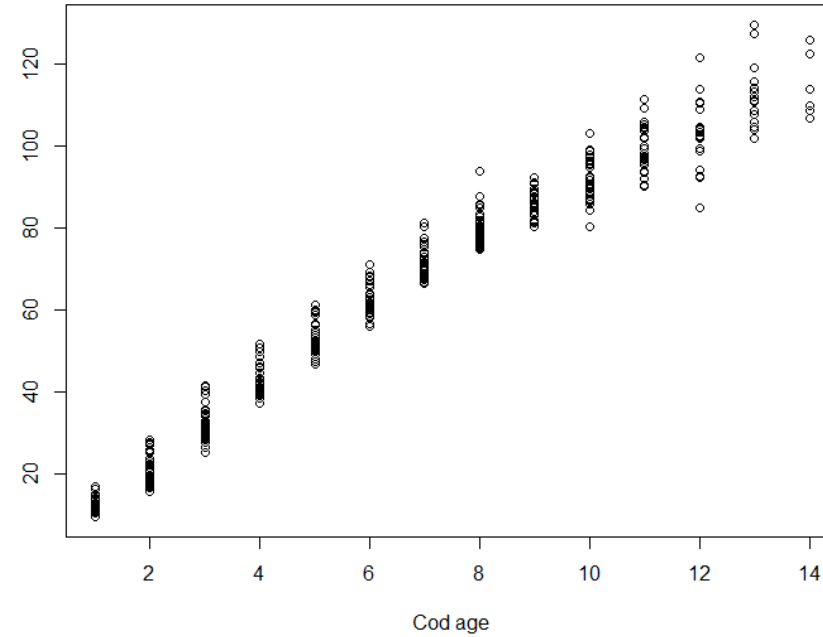
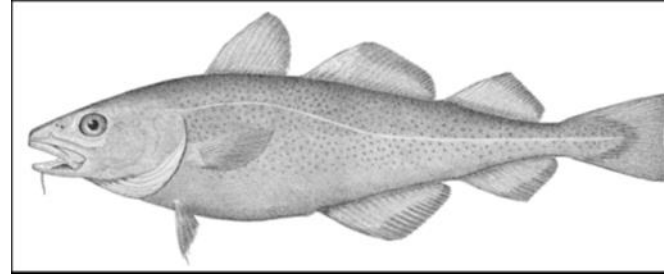
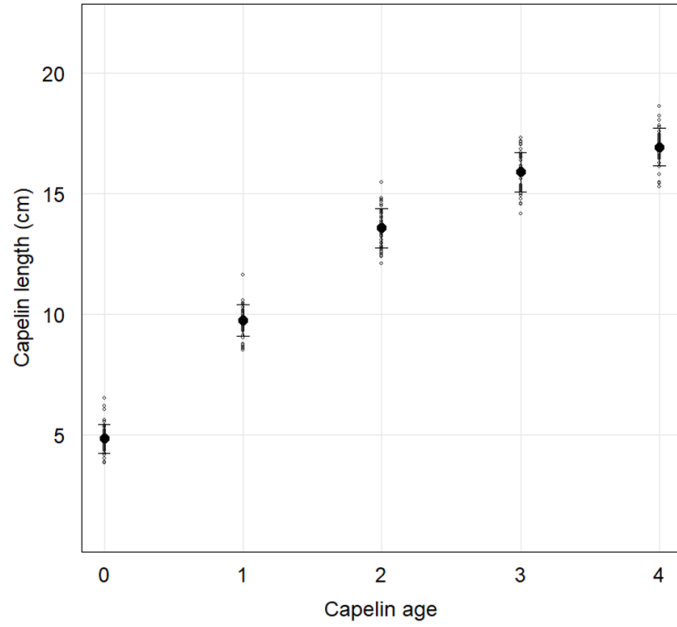
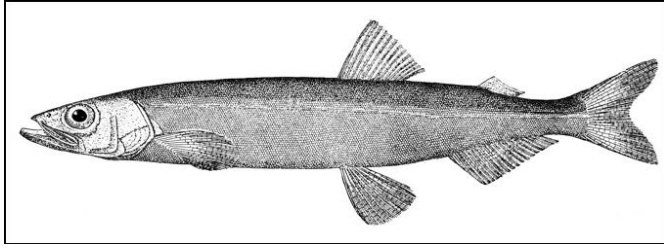
- Boreal, migratory
- Spawns shelf break
- **Bentivorous**
- **Seasonal feeding migrations**



- Arcto-Boreal, migratory
- Entire life cycle in BS
- Main feeding period
Northern BS in summer
- Planktivorous
- **Semelparous**
- **Age of maturity 2-4 years**
- **Max age (our data): 5 years**

- Boreal, migratory
- Spawns coast of Norway
- Feeding migrations
Northwards in summer
- Mainly piscivorous
- **Iteroparous**
- **Mean age of maturity 7-8 years**
- **Max age (our data): 20**

- Boreal, migratory
- Spawns shelf break
- Seasonal feeding migrations
- Mainly benthivorous
- **Iteroparous**
- **Mean age of maturity 6-7 years**
- **Max age (our data): 18**

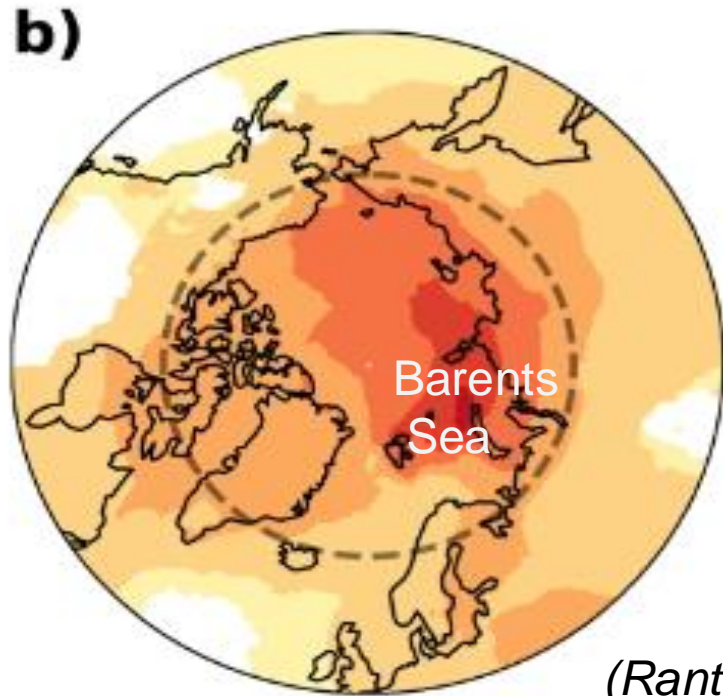
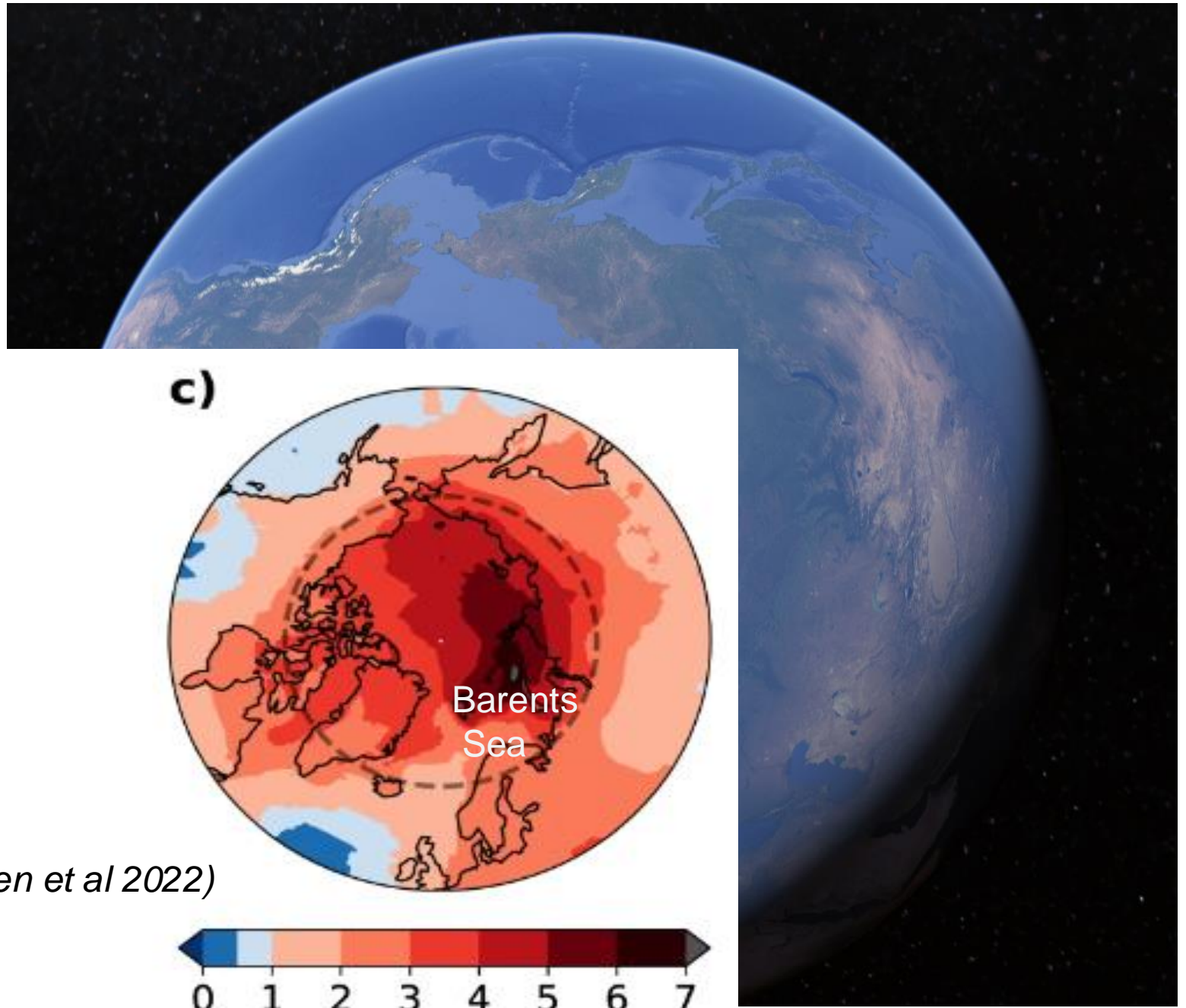


- Arcto-Boreal, migratory
- Entire life cycle in BS
- Main feeding period
Northern BS in summer
- Planktivorous
- Semelparous
- Age of maturity 3-4 years
- Max age (our data): 5 years

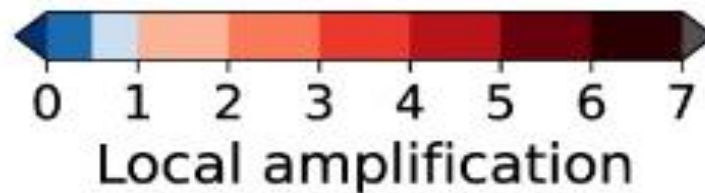
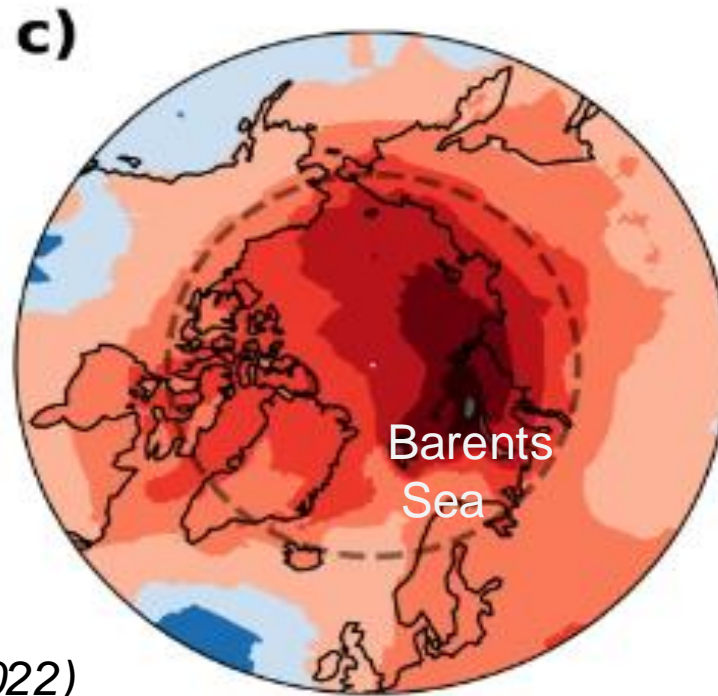
- Boreal, migratory
- Spawns coast of Norway
- Feeding migrations
Northwards in summer
- Mainly piscivorous
- Iteroparous
- Mean age of maturity 7-8 years
- Max age (our data): 20 years

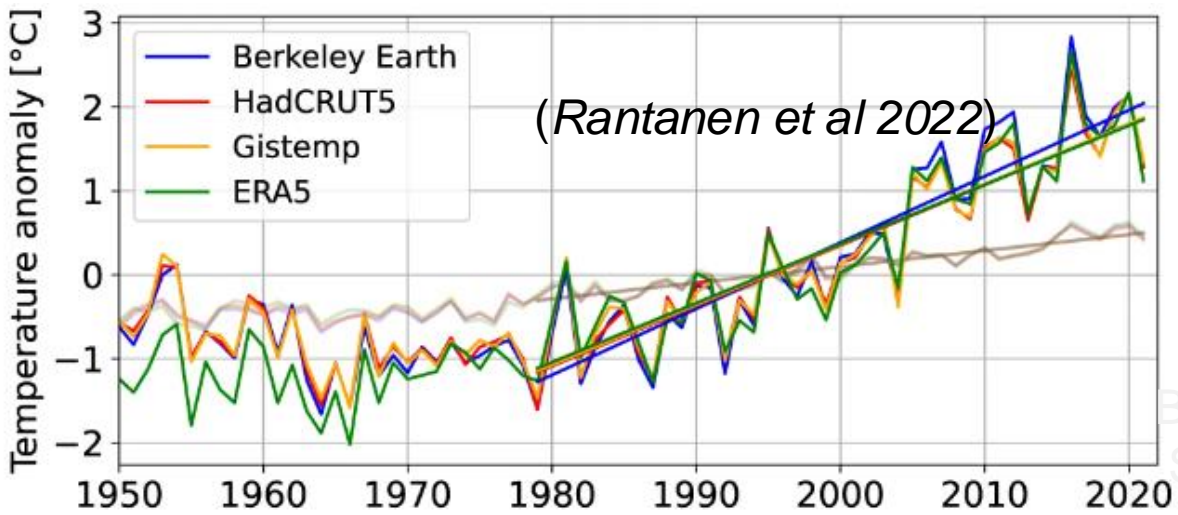
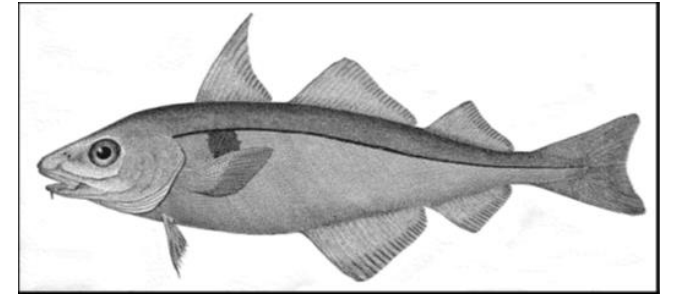
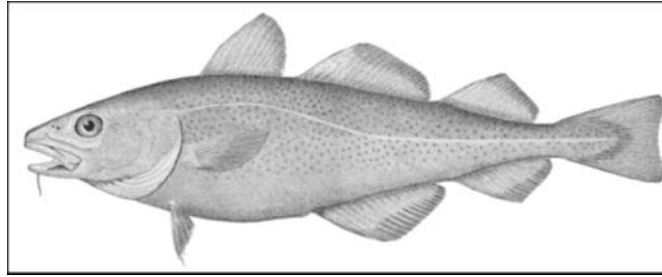
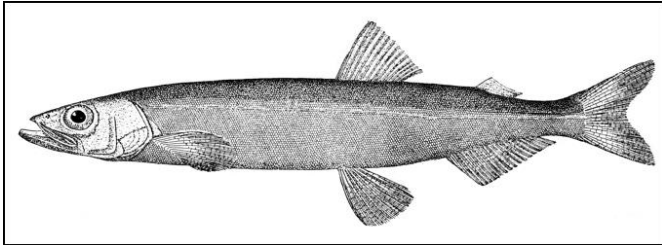
- Boreal, migratory
- Spawns shelf break
- Seasonal feeding migrations
- Mainly benthivorous
- Iteroparous
- Mean age of maturity 6-7 years
- Max age (our data): 18 years

Barents Sea: Shelf Sea north of the Arctic circle



(Rantanen et al 2022)



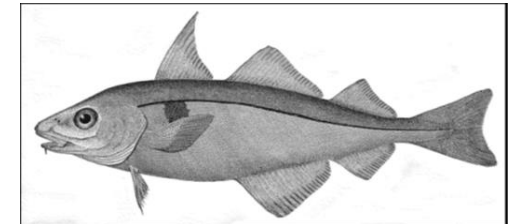
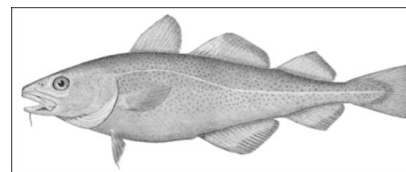
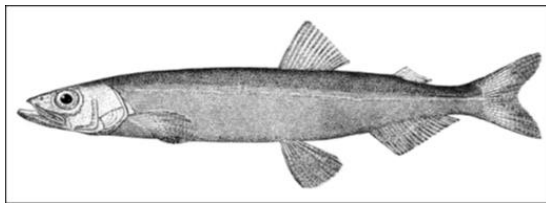


Temperature Size Rule:

Warmer waters =>

- faster juvenile growth,
- earlier maturation,
- smaller adults

Has there been a decline in adult size of the Barents Sea main commercial stocks?

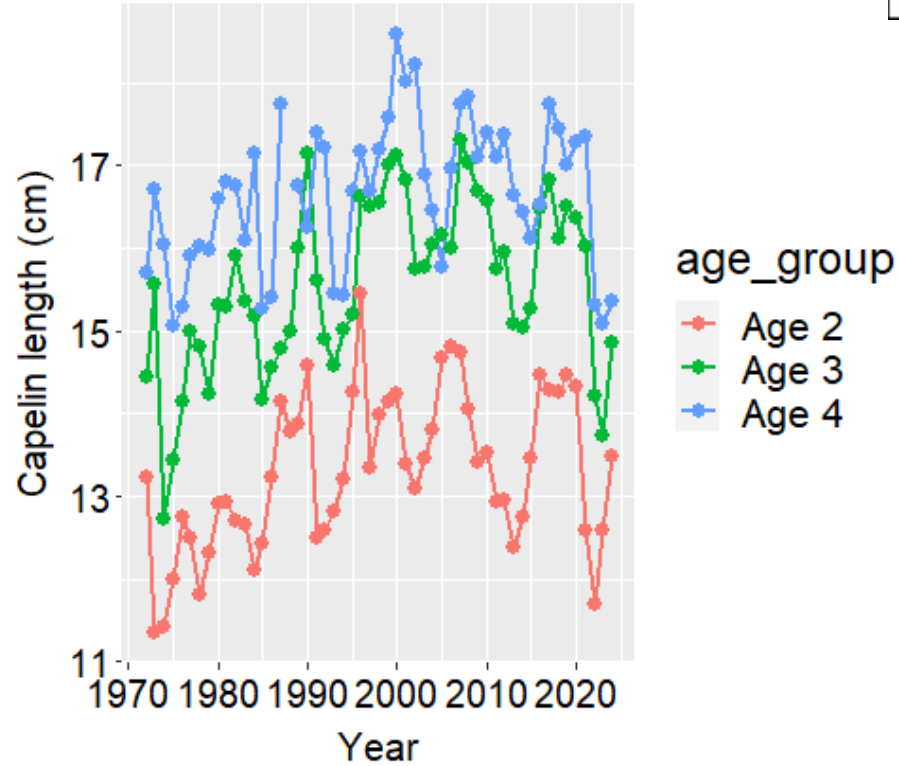
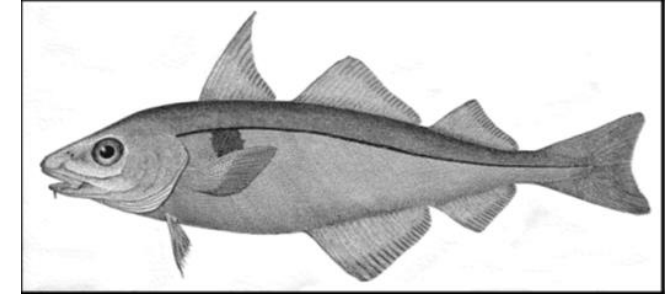
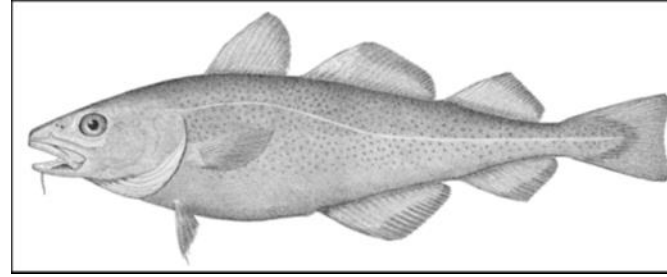
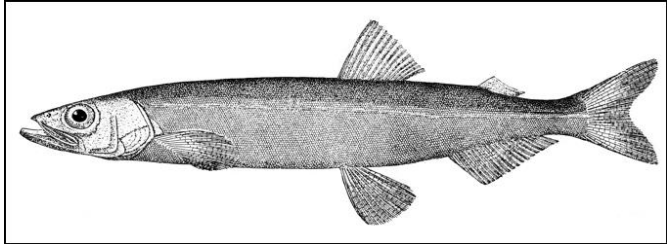


Adult size:

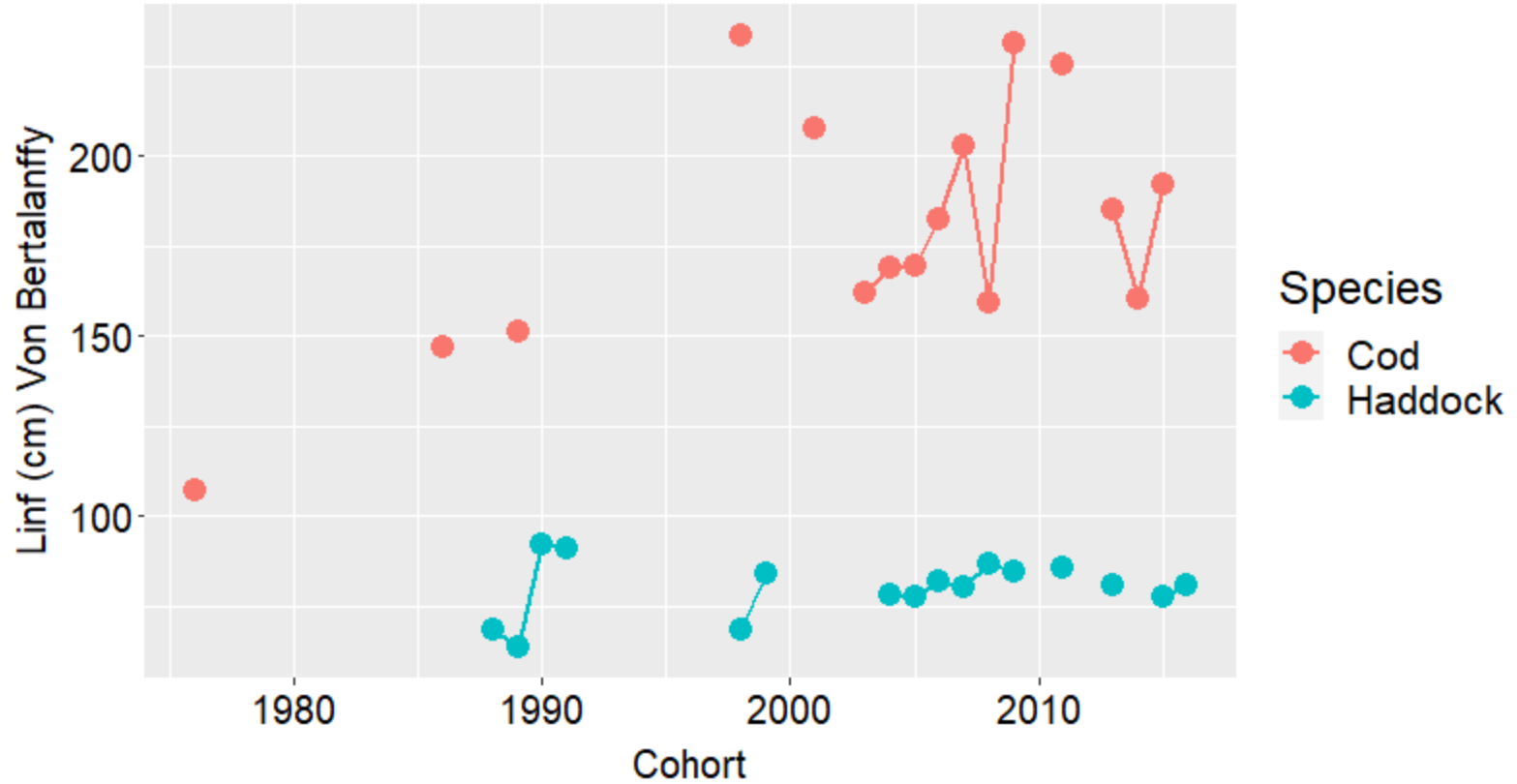
- Size at maturation?
 - indeterminate growth
- Max size in population?
- Asymptotic size?
 - implies metabolic constraints

Audzijonyte et al 2024





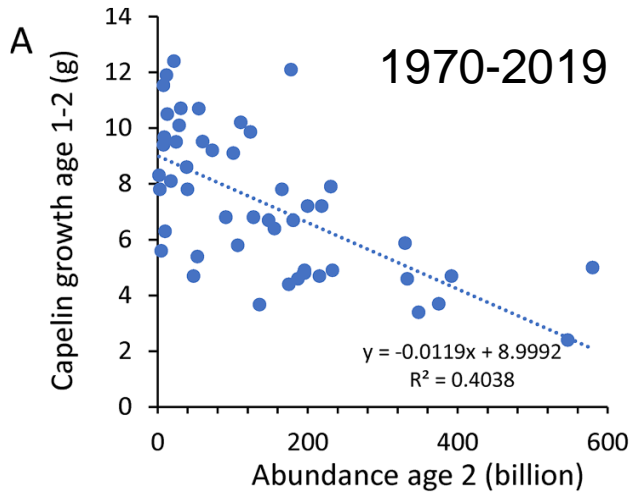
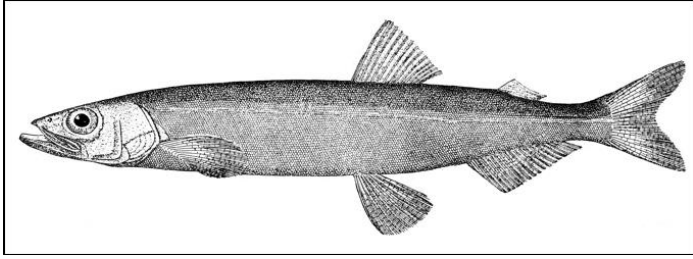
Adult size==size when
mature and die



Von Bertalanffy asymptotic size (*Baudron et al 2014*)

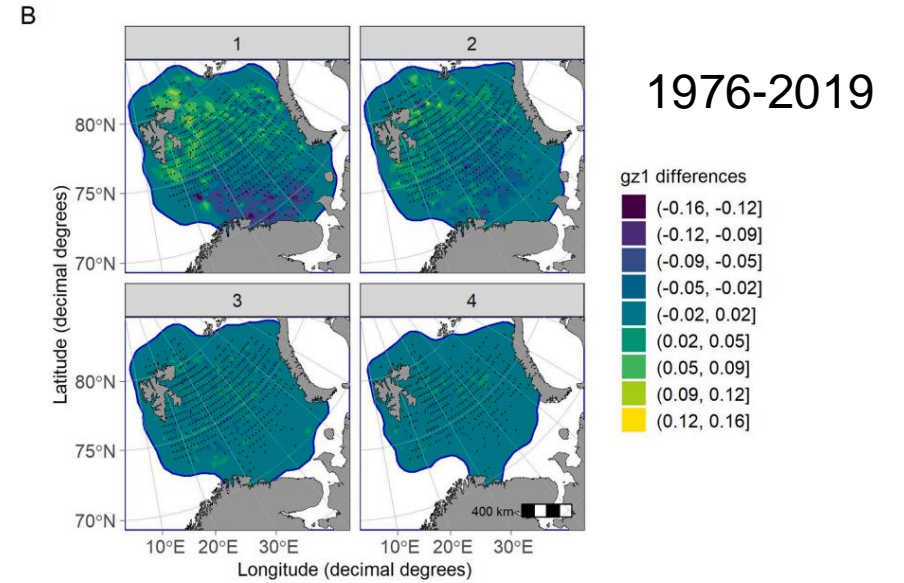
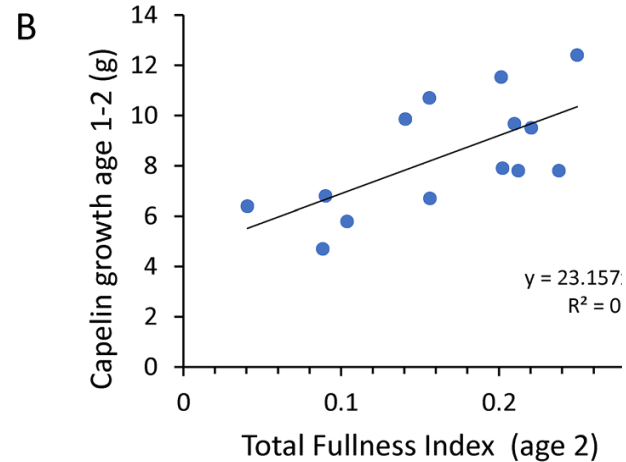
No clear trends

Capelin published work:



Dalpadado et al 2024

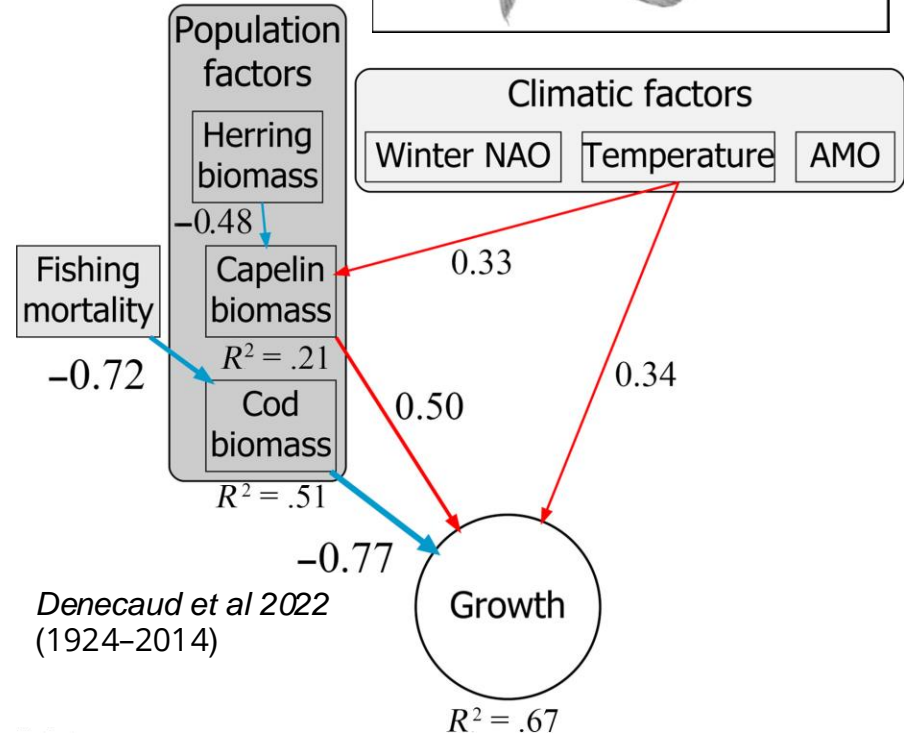
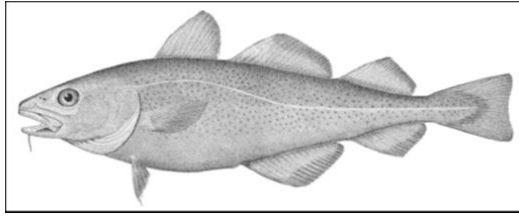
Density dependent growth
⇒ Food availability
⇒ Inflow of zooplankton
from Norwegian Sea



Berg et al. 2021

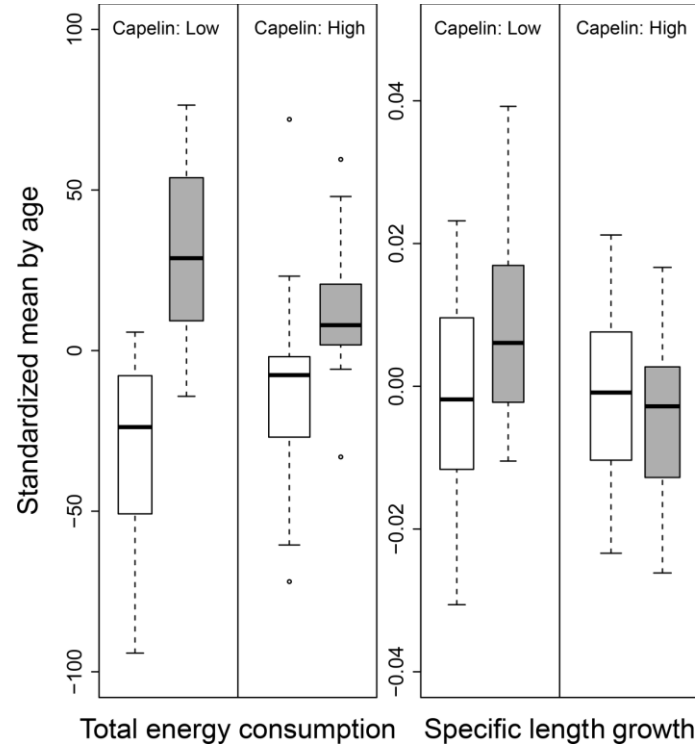
Capelin first year growth higher in the North
⇒ spatial pattern in size at age 1 and age 2
⇒ Mixing, predation and maturation
⇒ erase the pattern for older capelin

Cod published work:



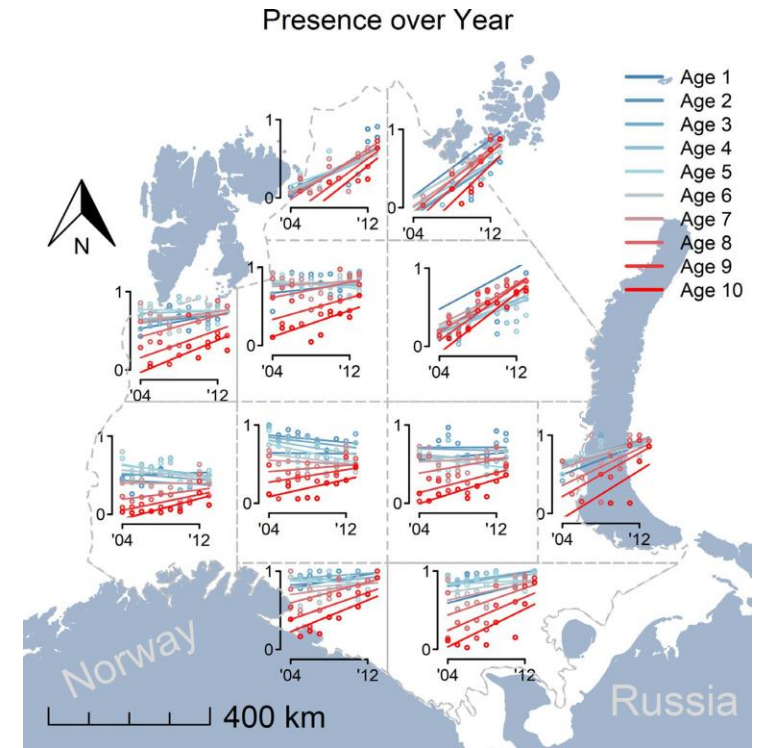
Denecaud et al 2022
(1924–2014)

- Strong density dependence in growth
- Positive effect of temperature
- Positive effect of capelin,
- Positive temperature effect on capelin
- Negative effect of fishing



Johannesen et al 2016
(2004–2013)

- Feeding on capelin mainly in winter,
- Cod compensate in summer with other prey
- Affects seasonal growth rates



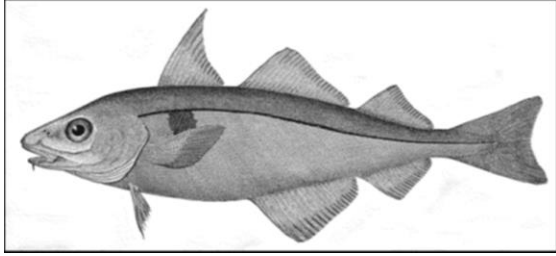
Johannesen et al 2020
(2004–2013)

- Range expansion during record high population levels driven by food competition

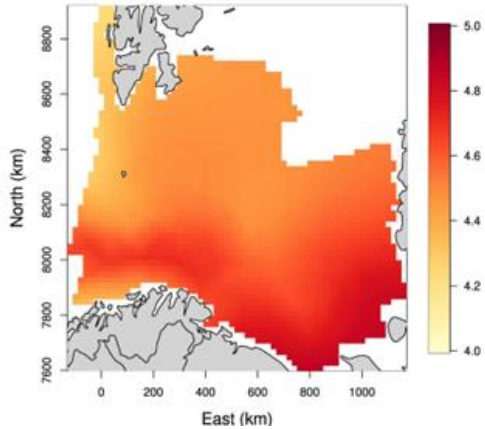
Van Leesen et al 2022:

- BS cod moved into colder waters with increasing abundance

Haddock published work:

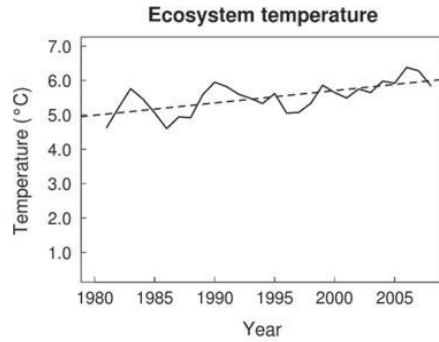


Mean age at 40cm in years 1994–2020



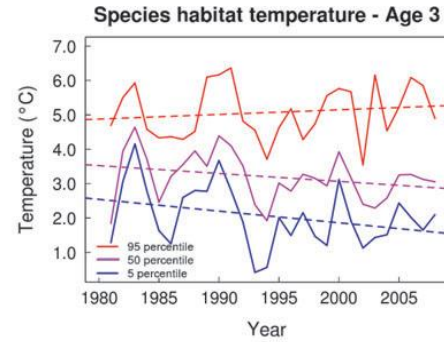
Breivik et al 2024

Spatial pattern
Smaller size at age east
=> Colder area, higher density

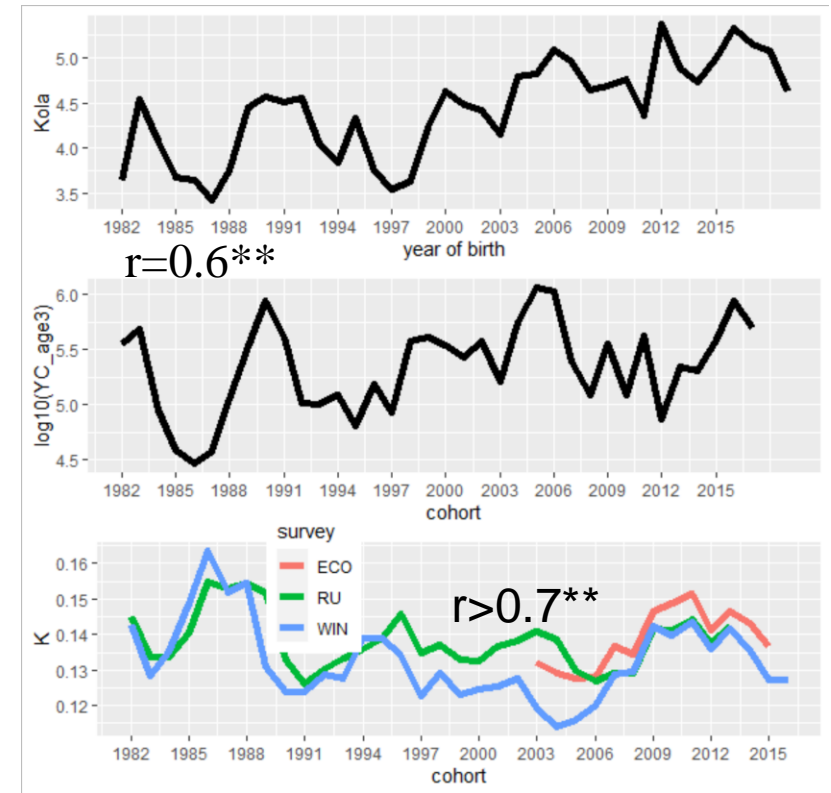


Landa et al 2014

Warm years:
abundance increase
haddock expands into colder water



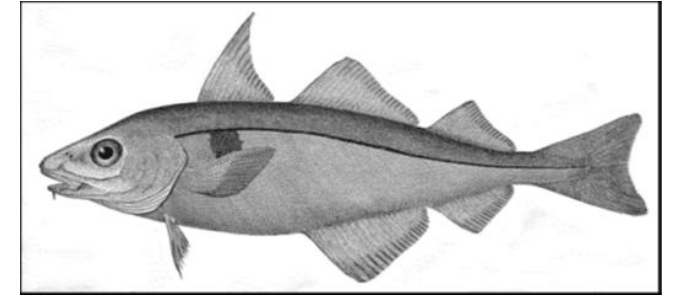
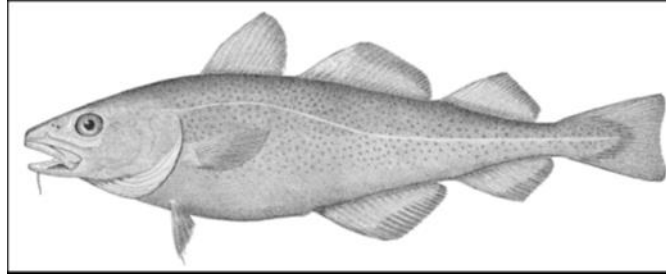
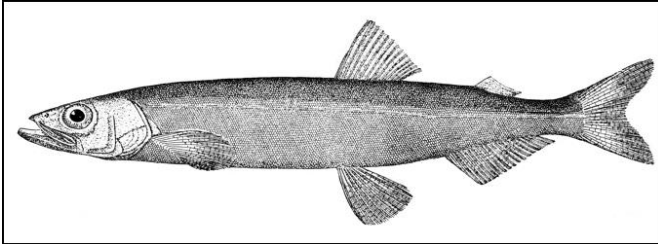
Survey	Winter	Russian	Ecosystem
Temperature	-0.01 ns	-0.3 *	-0.02 ns
YC strength	-0.02 **	-0.005 ns	-0.01 ns
Adj-R2	0.40	0.25	0.07



Johannesen et al 2024

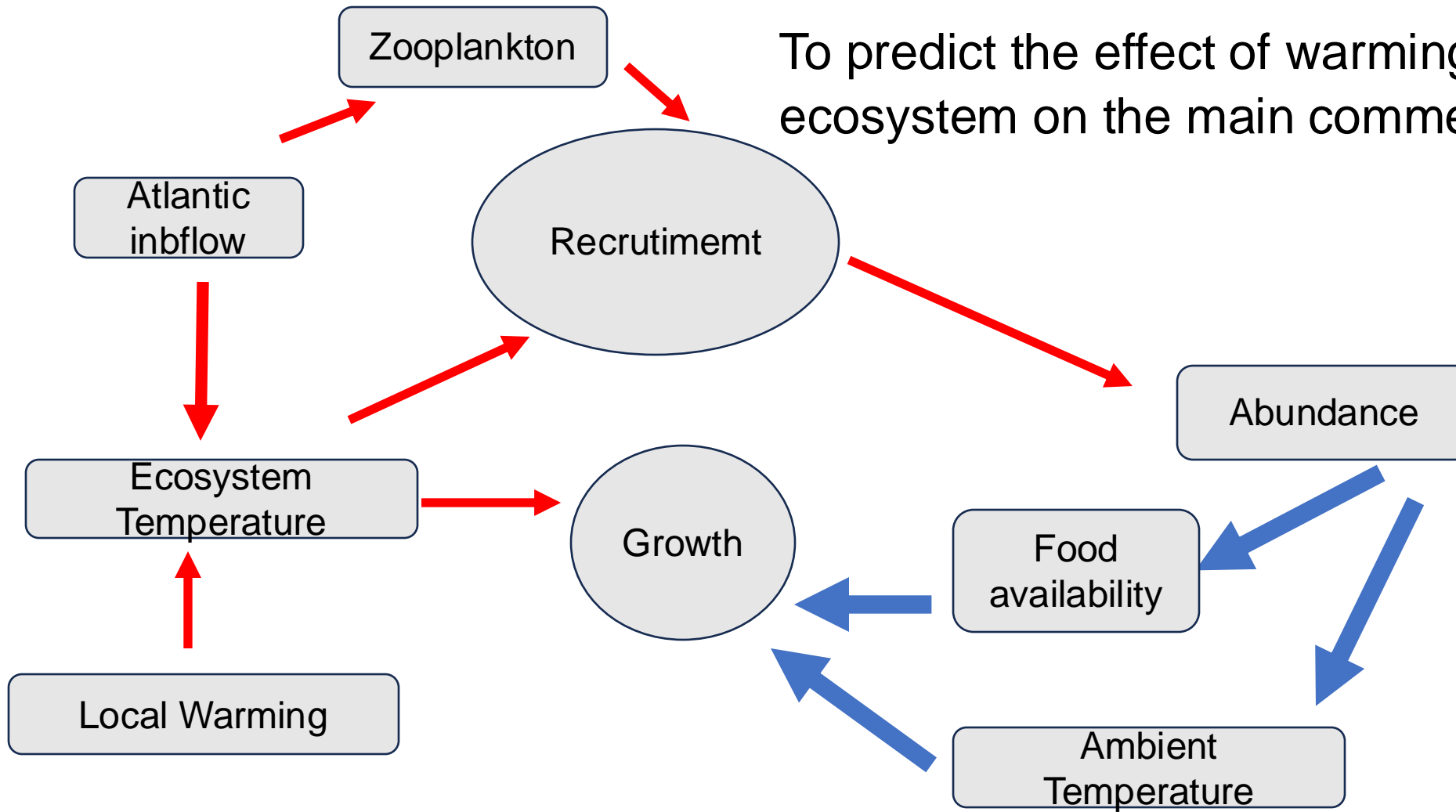
Negative impact of
cohort strength and temperature
=> Temperature effect indirect through density

Conclusions:



- No evidendence for uni-directional trend in adult size with warming
- Strong variation in density of Barents Sea stocks
 - => strong variation in recruitment
 - => density main determinant of growth
- Temperature have direct impact on growth
 - => indirect effects appear more important

To predict the effect of warming of the Barent Sea ecosystem on the main commercial stocks:

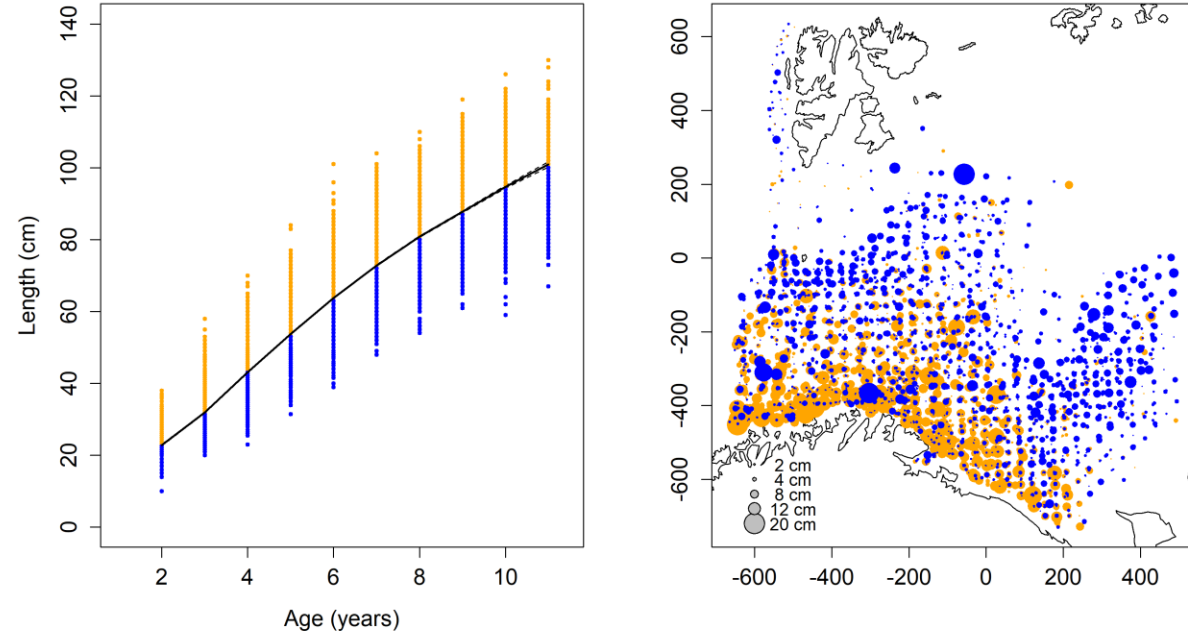


Both direct metabolic effects and indirect effects of temperature via basal resources must be accounted for
Lindmark et al 2022

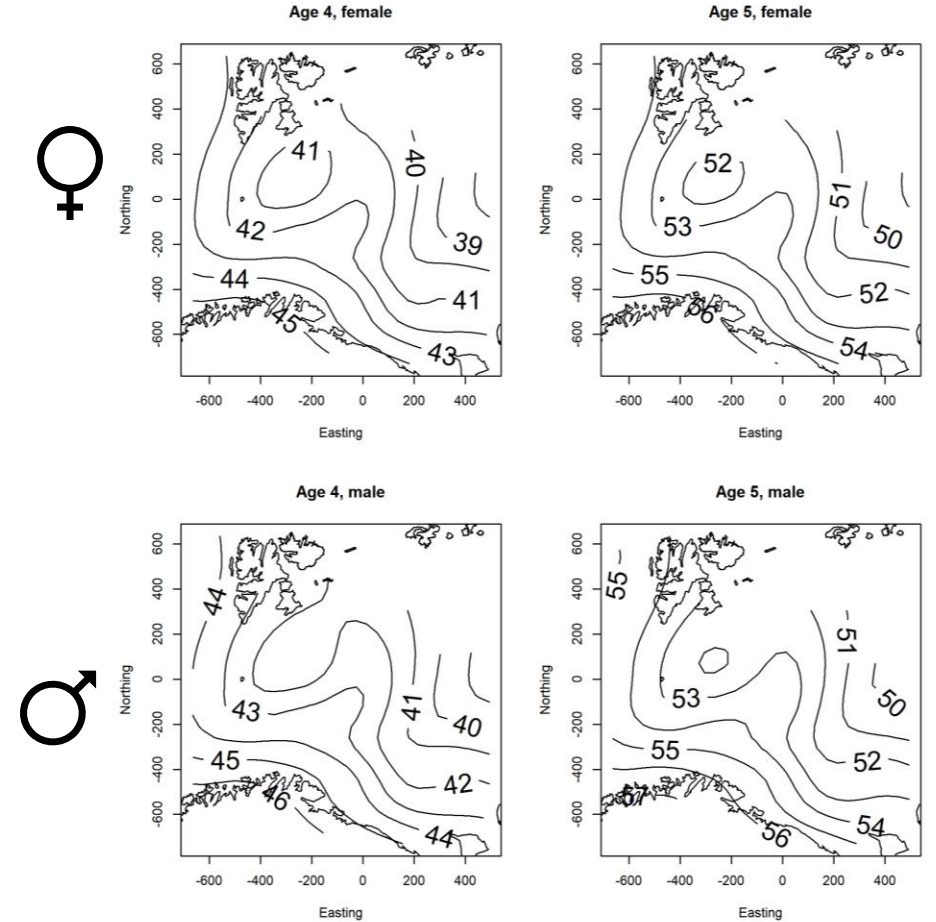


Work in progress:

Spatial survey data:



Average residuals at each station (across ages)



- What is the relative importance of temperature and density on growth and maturation?
- At what age and what factors determine growth trajectories of cohorts?

Thank you
for listening!



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