HAFRANNSÓKNASTOFNUNIN

The Iceland Sea: Ecosystem structures and capelin distribution patterns

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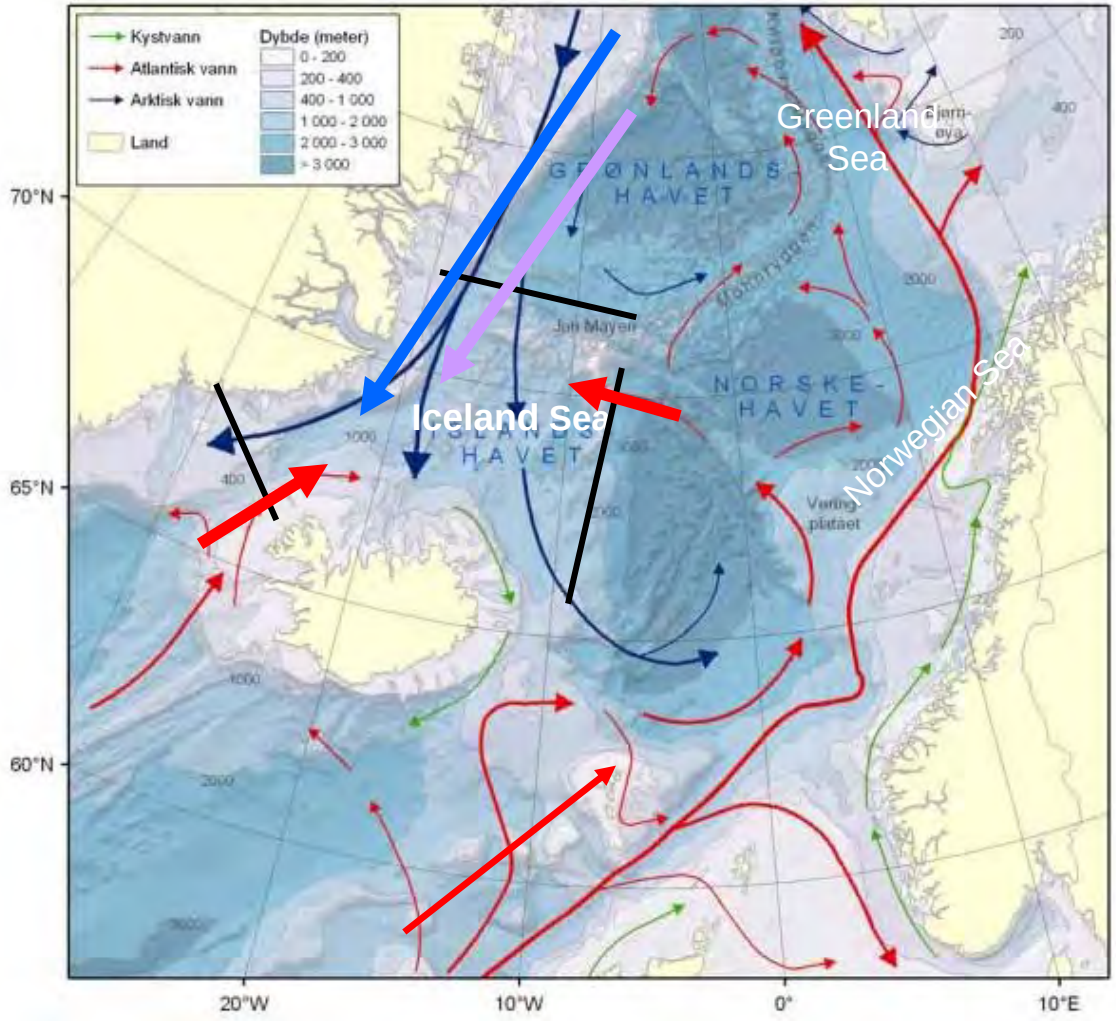
Hafrannsóknastofnunin, Marine Research Institute

The Iceland Sea and adjacent waters



The Iceland Sea is small and shallow in comparison to adjacent waters.

Main currents:
East Greenland Current, Arctic

Warm inflow from south west and east

Return Atlantic water from north, at 100-300m

K.Mork etal ‘07

Outline

- Data
- Ecosystem structures
- Capelin life history patterns
- Conclusions

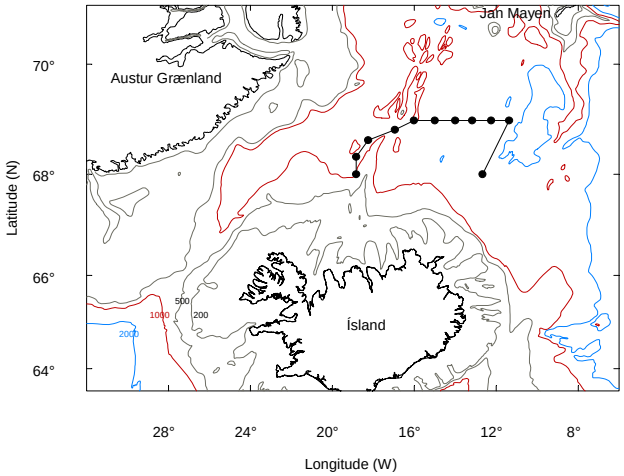
Main ecosystem data

- The Iceland Sea Ecosystem Project 2006-2008.

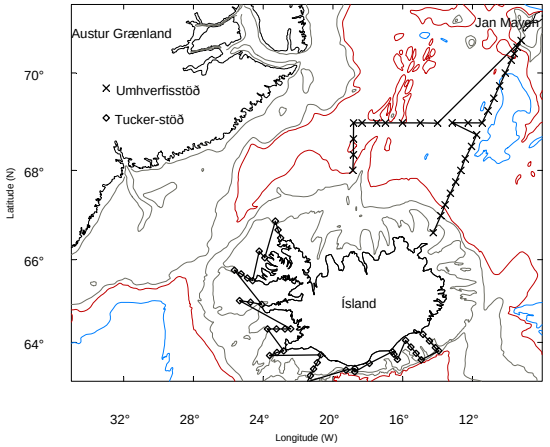
- 10 surveys
- 845 stations
- 558 CTD stations
- 1680 nutrient samples
- 745 carbon samples
- 4705 phytoplankton samples
- 1580 zooplankton samples
- 855 trophic samples (stable isotops, fatty acids)
- 318 capelin larval samples
- 96 pelagic trawl stations for pelagic fish
- ~10 000 nautical miles of echo abundance transects for capelin

Surveys and stations 2007

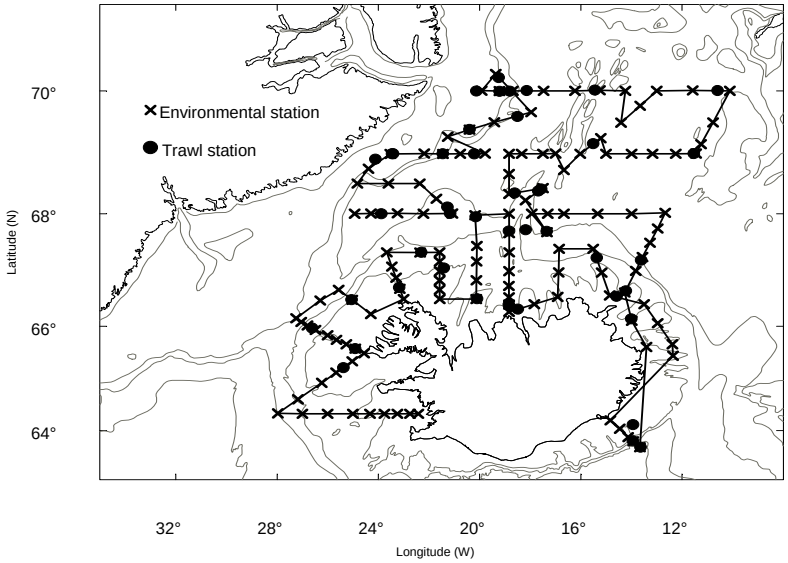
February - 11 stations



April - 68 stations



August - 176 stations



Ecosystem structures

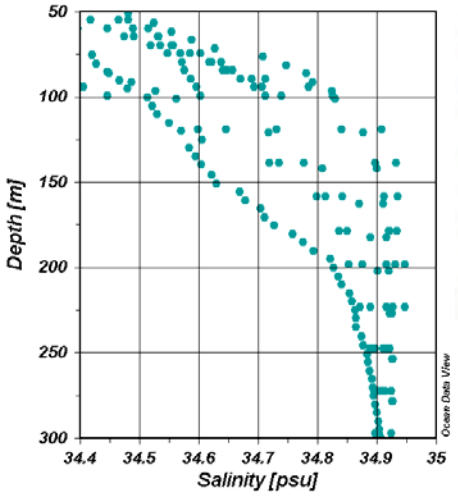
- Hydrographic trends
- Biological structure
- Spatial structure
- Seasonality
- Trophic structure
- Biomass

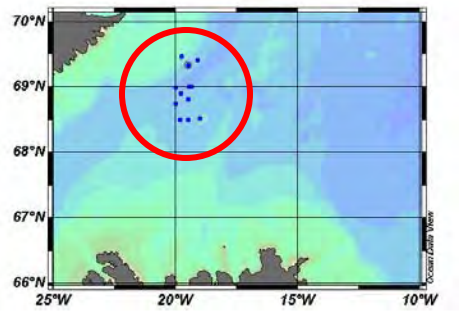
Salinity profiles in the western Iceland Sea

Showing Return Atlantic Water (RAW)

1985-1995
July/ August

NISE data

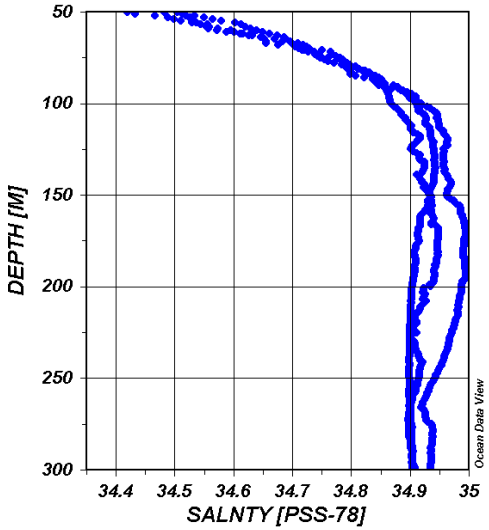


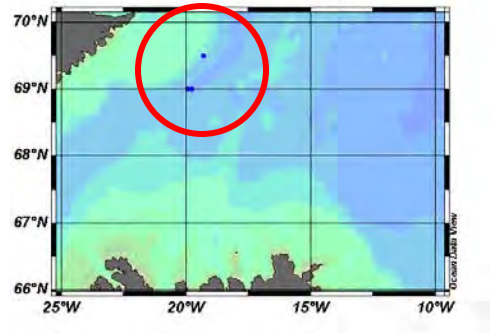


Higher salinity in recent years, associated with warmer water masses at depths of 100-300m.

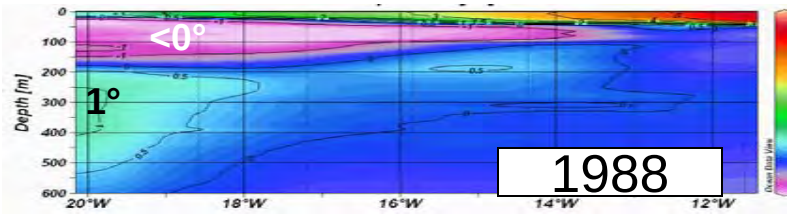
Those depths are capelin habitat.

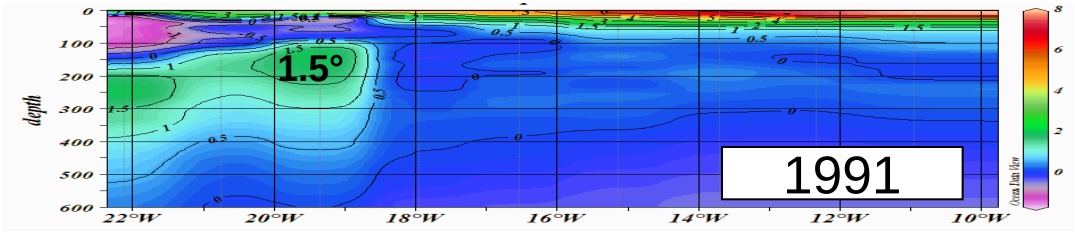
2006-2008
July/ August

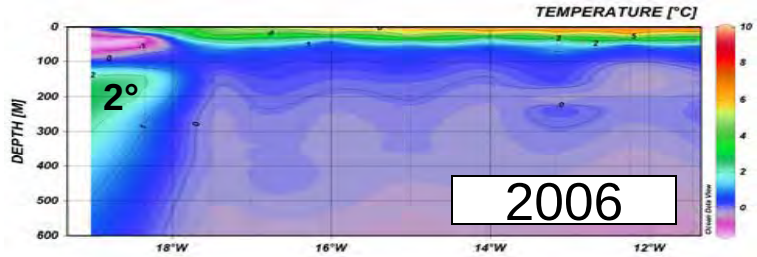


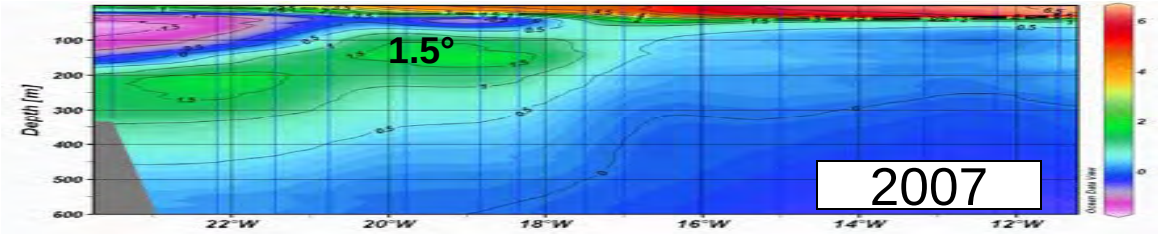


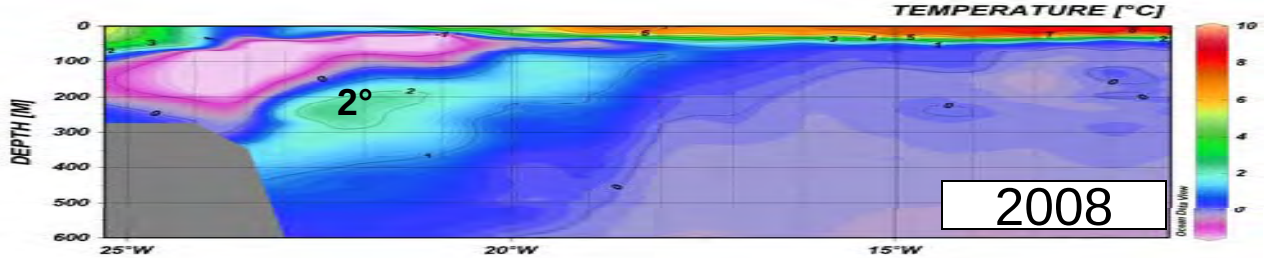
Vertical (0-600m) section at 69°N, August [°C]







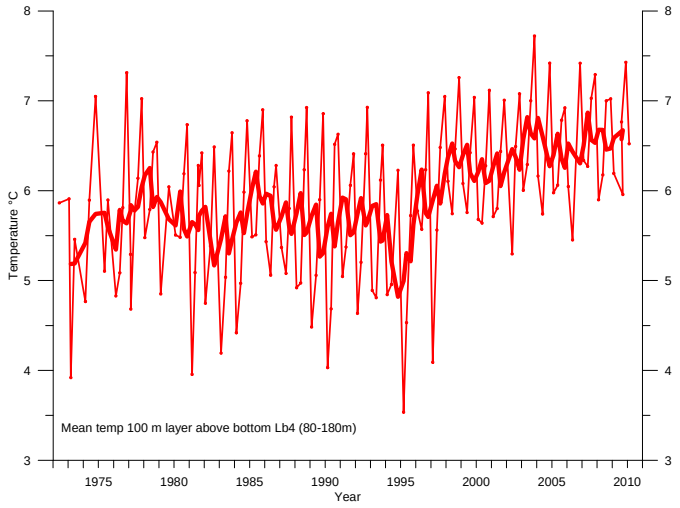




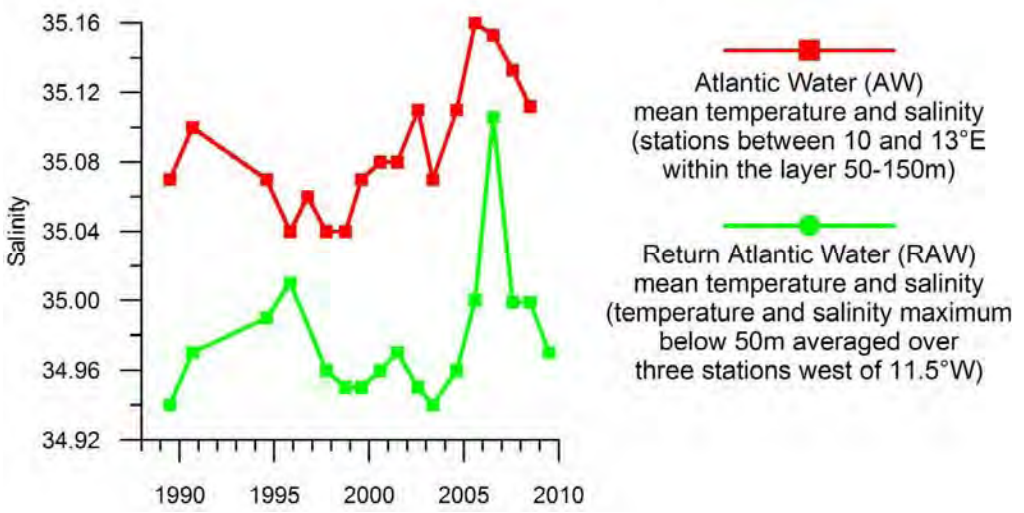
Hydrographic trends in adjacent waters

Látrabjarg 1973-2010.

Mean T in upper layers



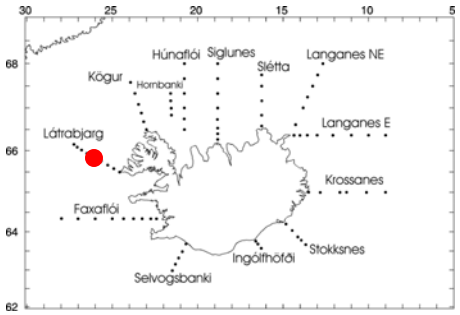
Greenland Sea (75°N) salinity



Increasing T since mid 1990s …

(A.Beszczynska-Möller, AWI Bremerhafen)

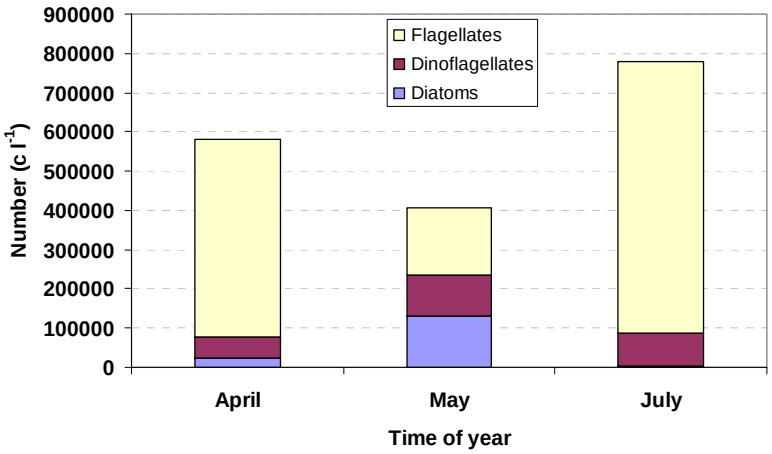
… affecting hydrographic conditions north and north west of Iceland



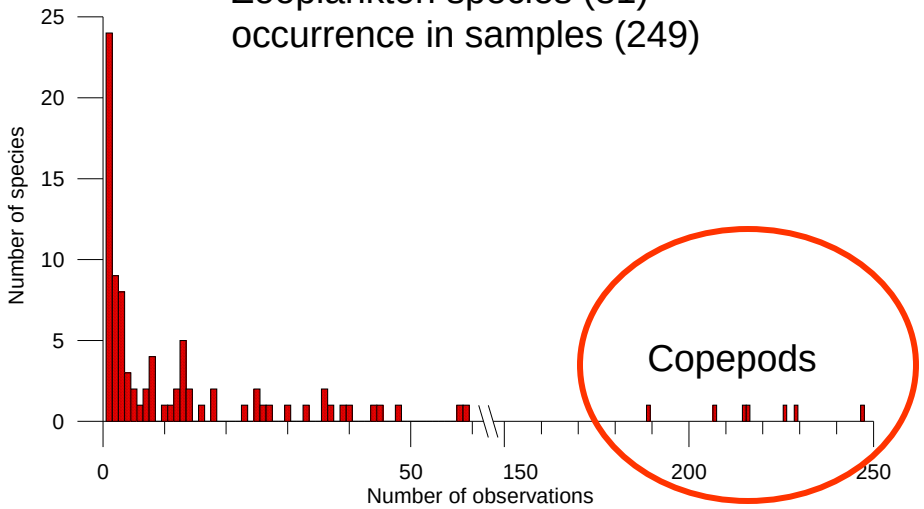
Biological structure

Species and biodiversity

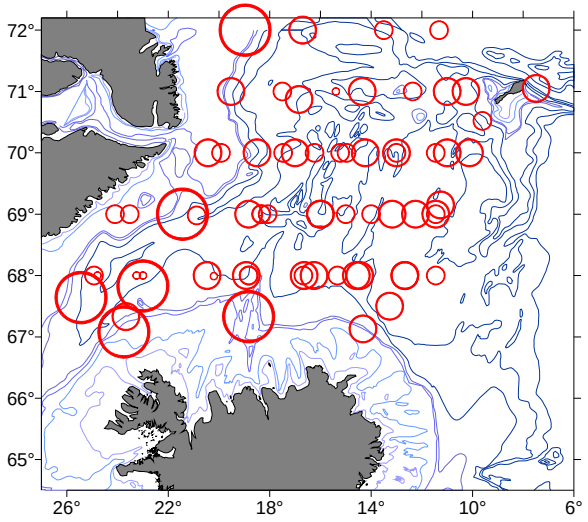
Phytoplankton 69°N, cells/liter at 10m



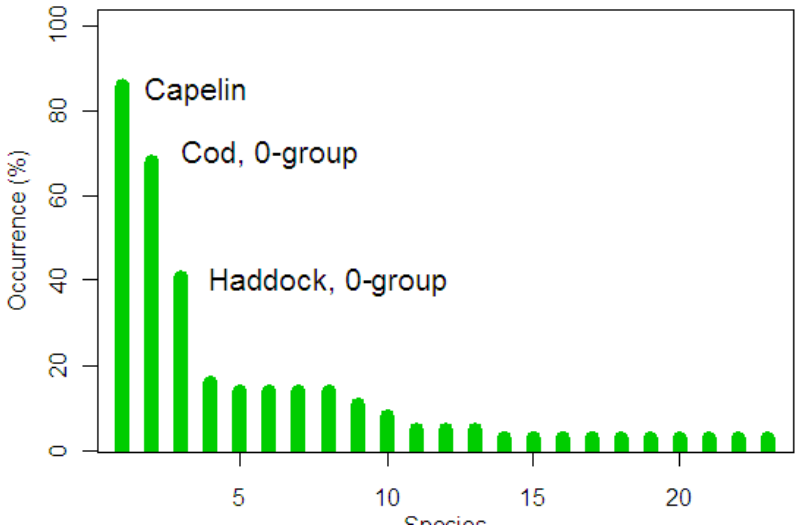
Zooplankton species (81)
occurrence in samples (249)



Zooplankton diversity (Shannon-Wiener)

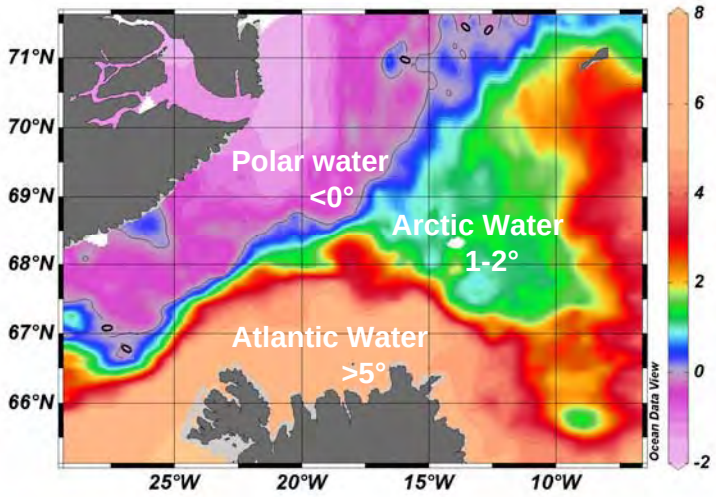


Fish species occurrence (%) in tows

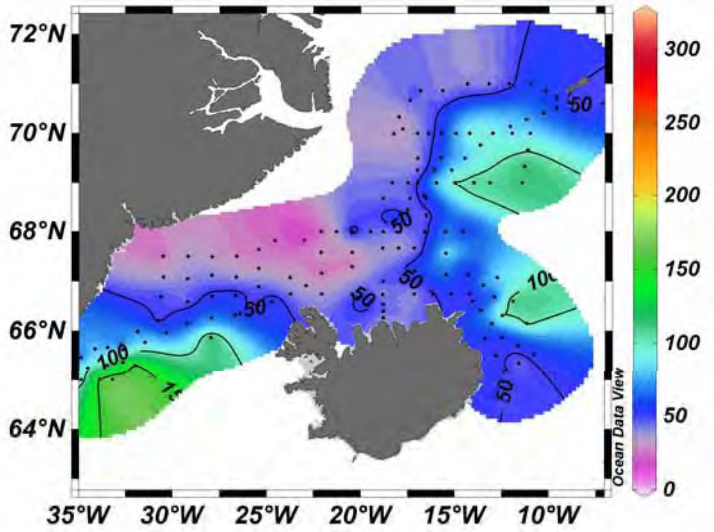


Spatial structure (summer)

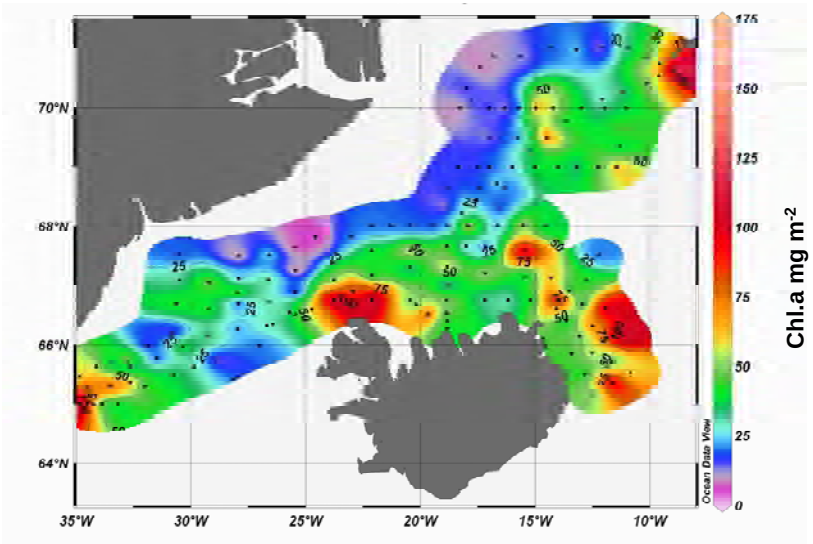
Water masses, T °C, 50m



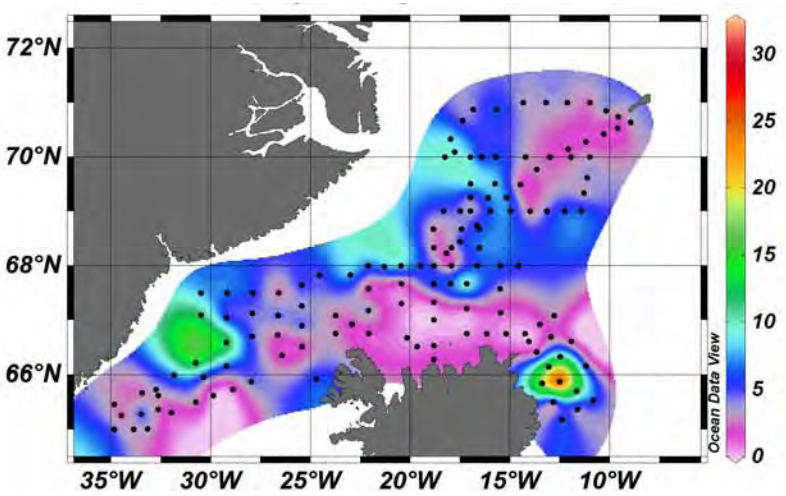
Nitrate 0-30m, 2006



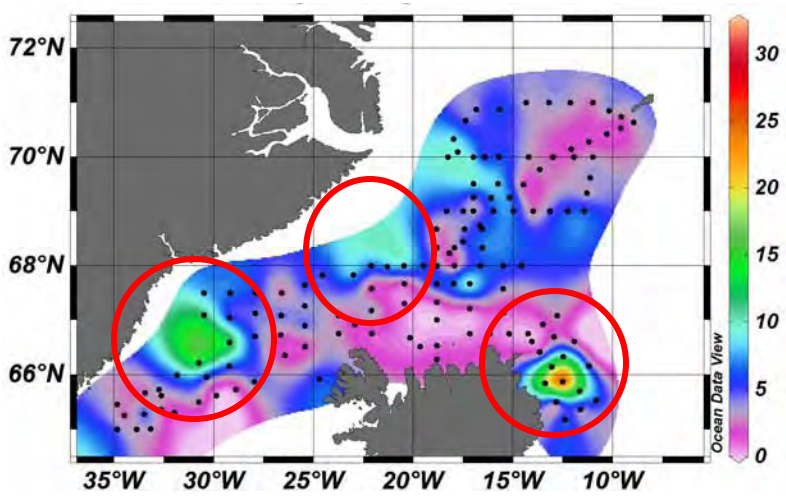
Chlorophyll a 0-30m, 2006



Mesozooplankton 0-50m, 2006

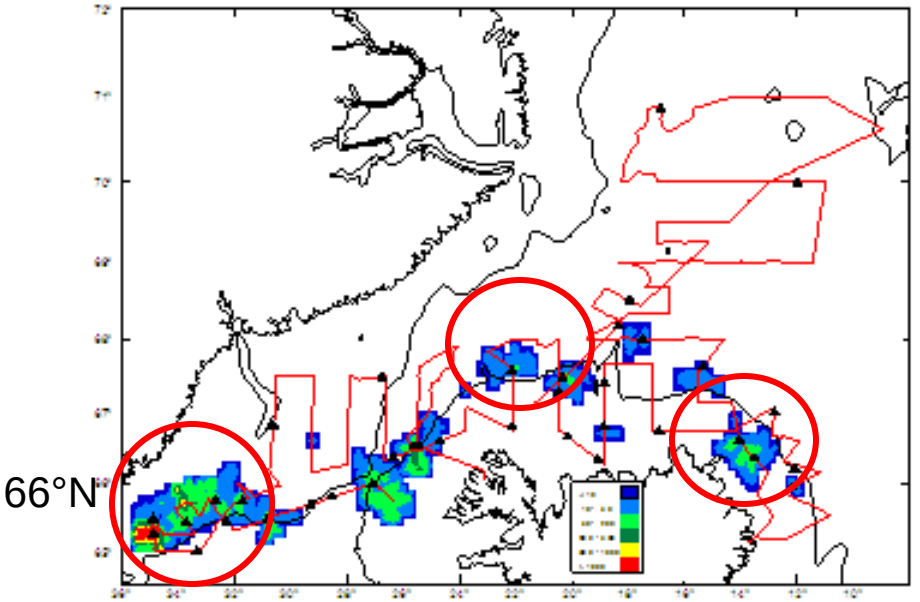


Zooplankton and capelin distributions 2006

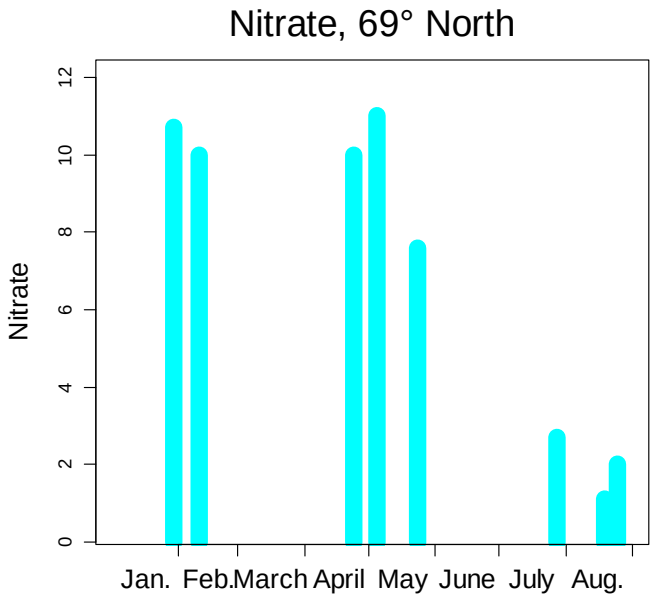


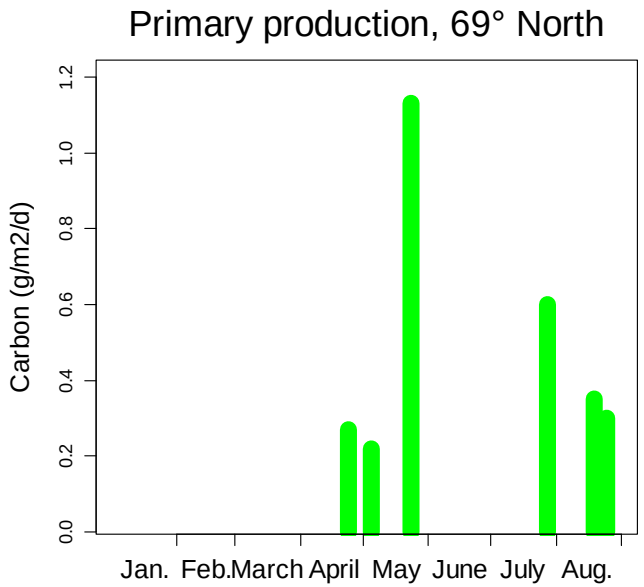
Mesozooplankton 0-50m, 2006

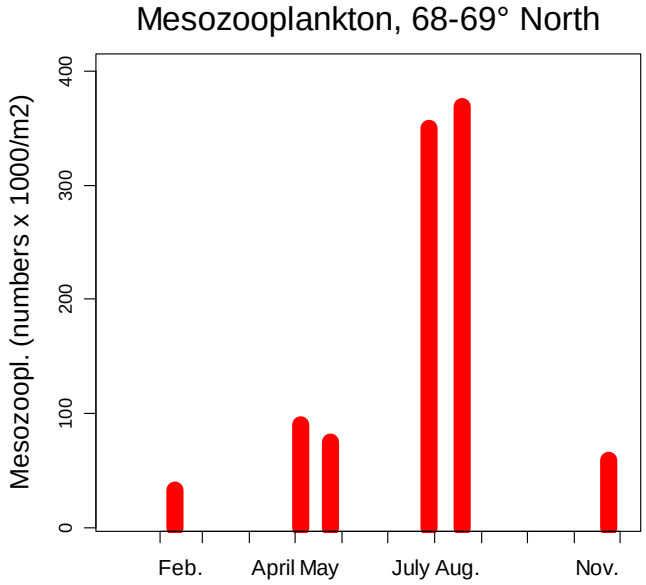
Capelin age 1+, acoustic abundance



Seasonal structure







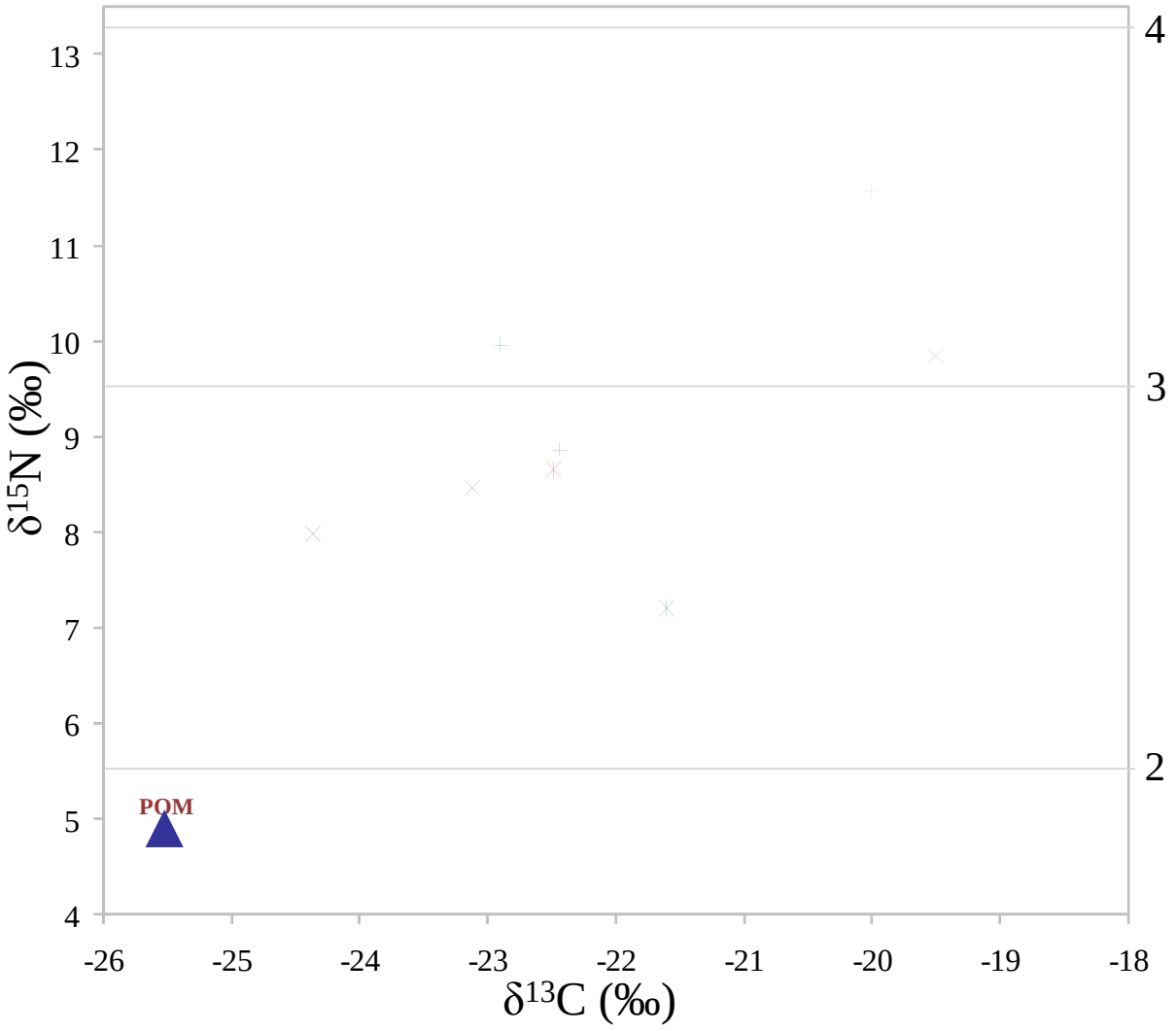
Spring bloom in late May

Zooplankton high in July – August

Increase already in June, most likely

Trophic levels

Nitrate source



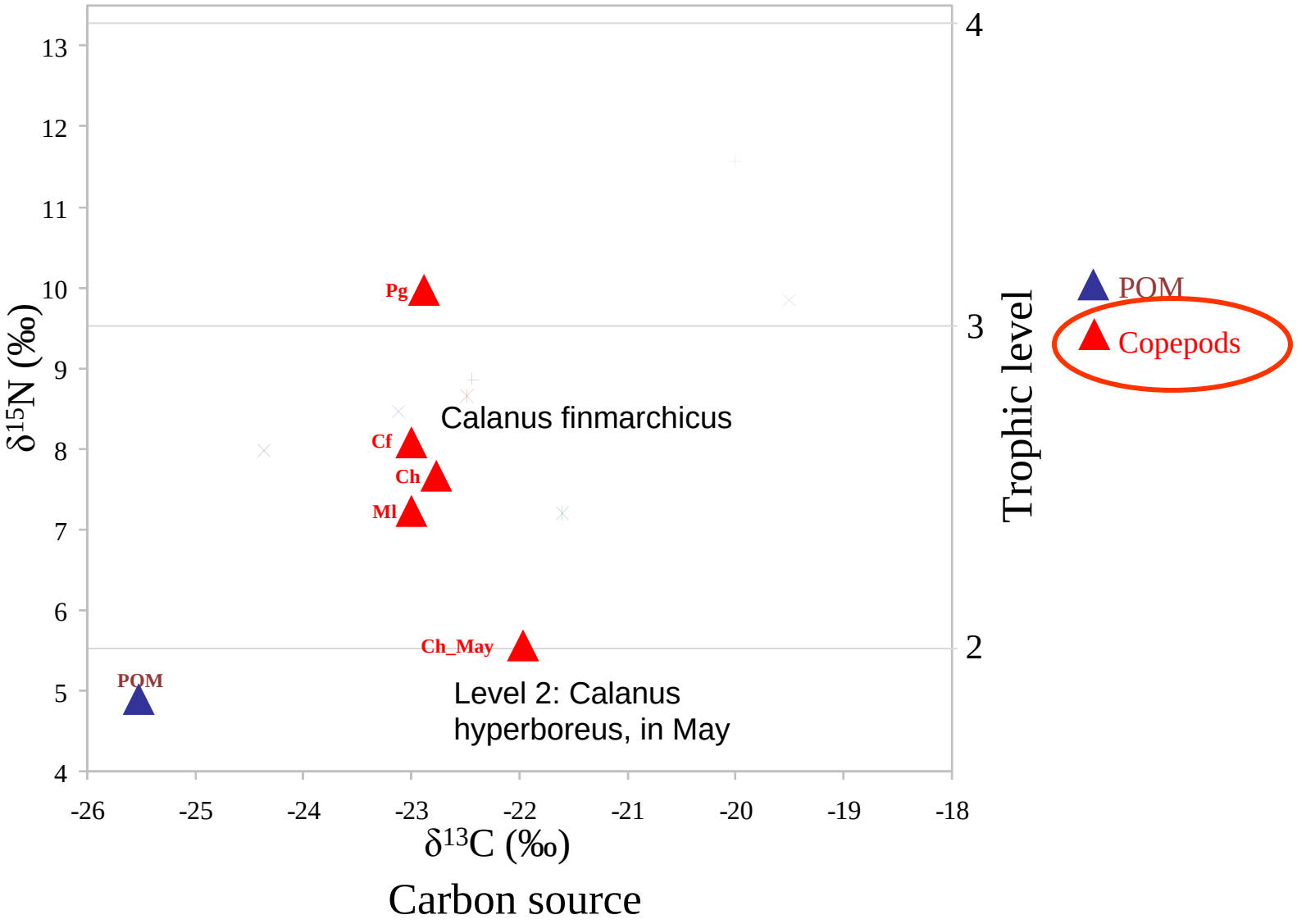
Carbon source

Nitrate stable isotops used to calculate tropic level

POM

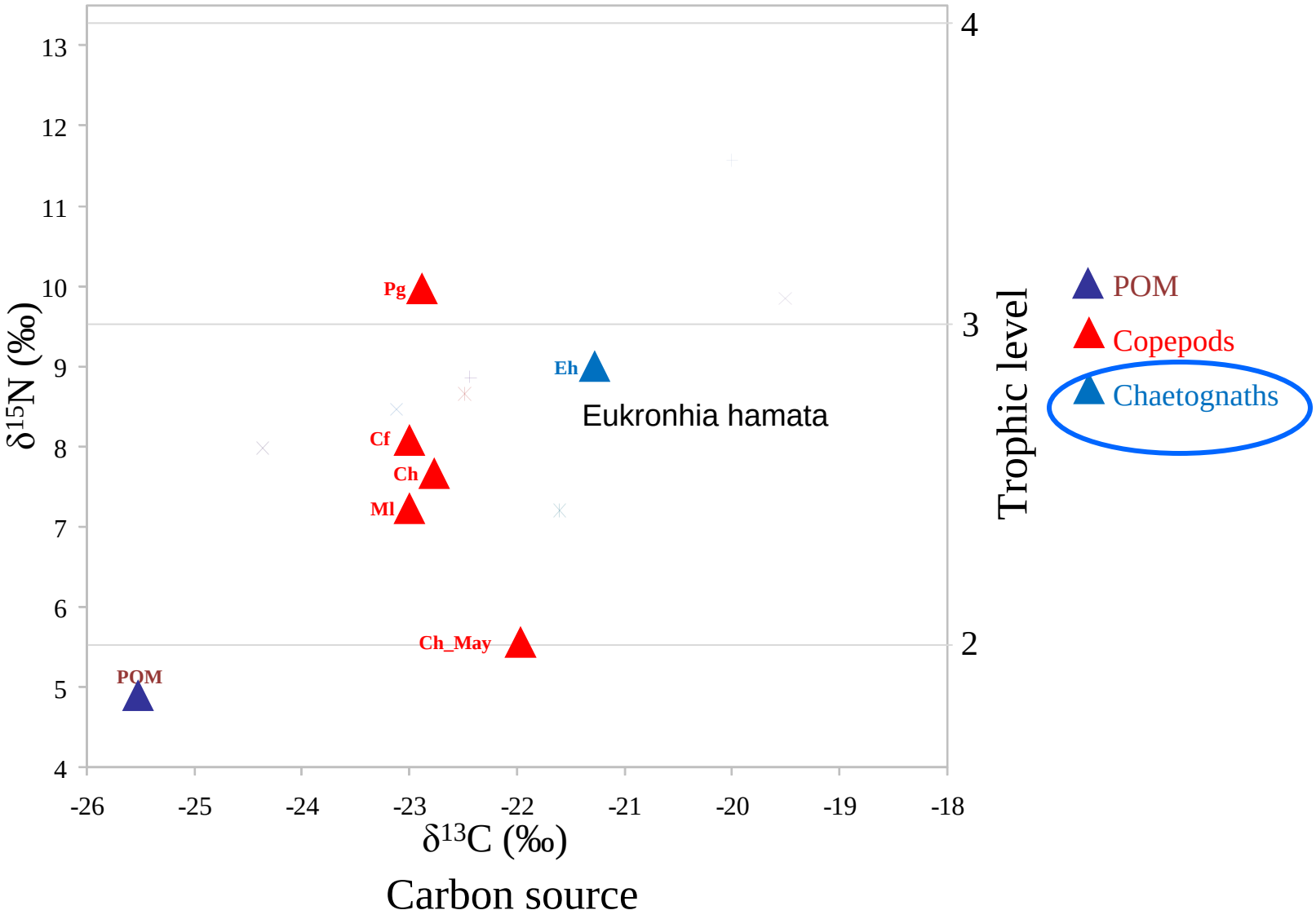
Lowest level:
Particulate **O**rganic **M**atter

Nitrate source



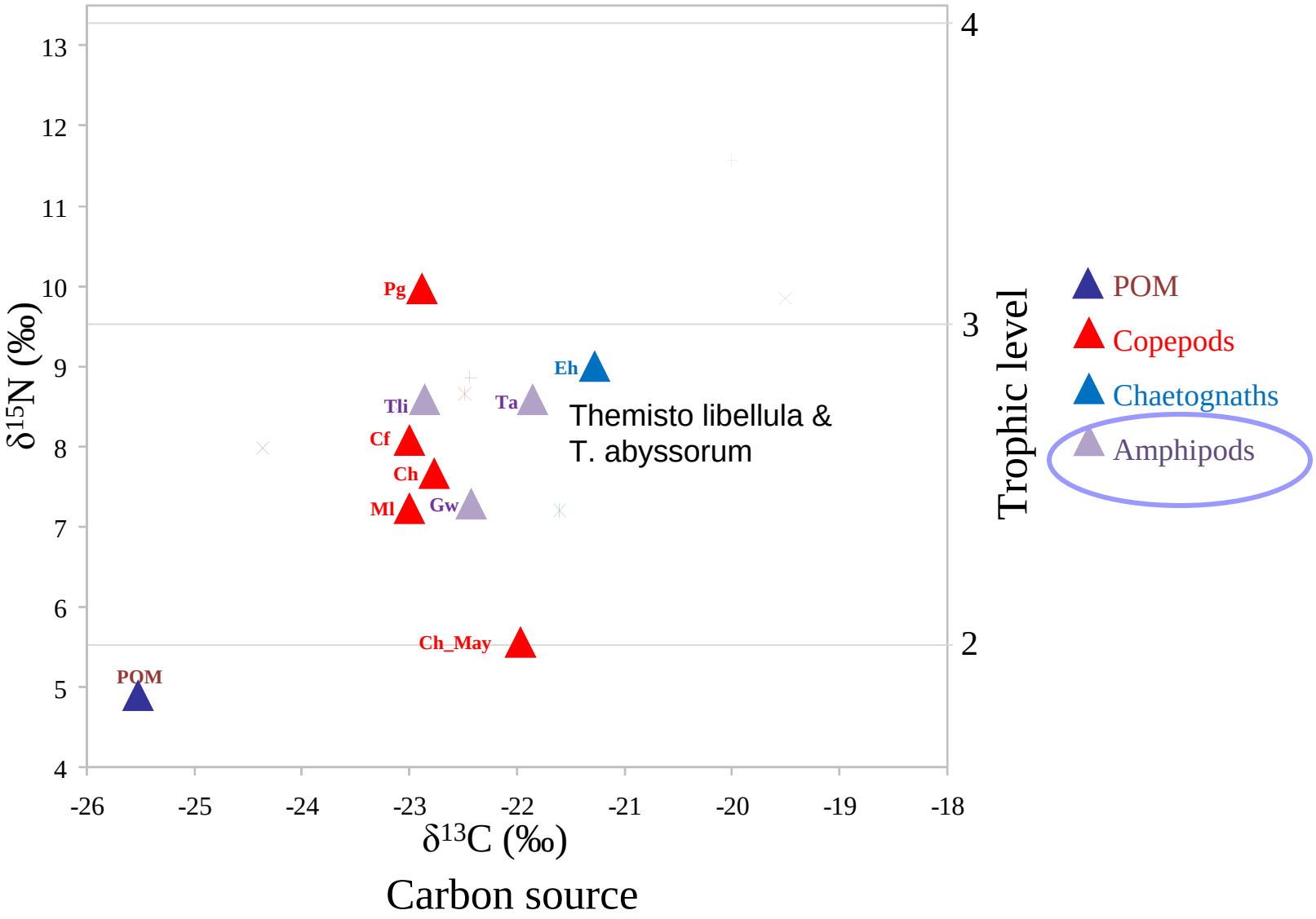
Carbon source

Nitrate source

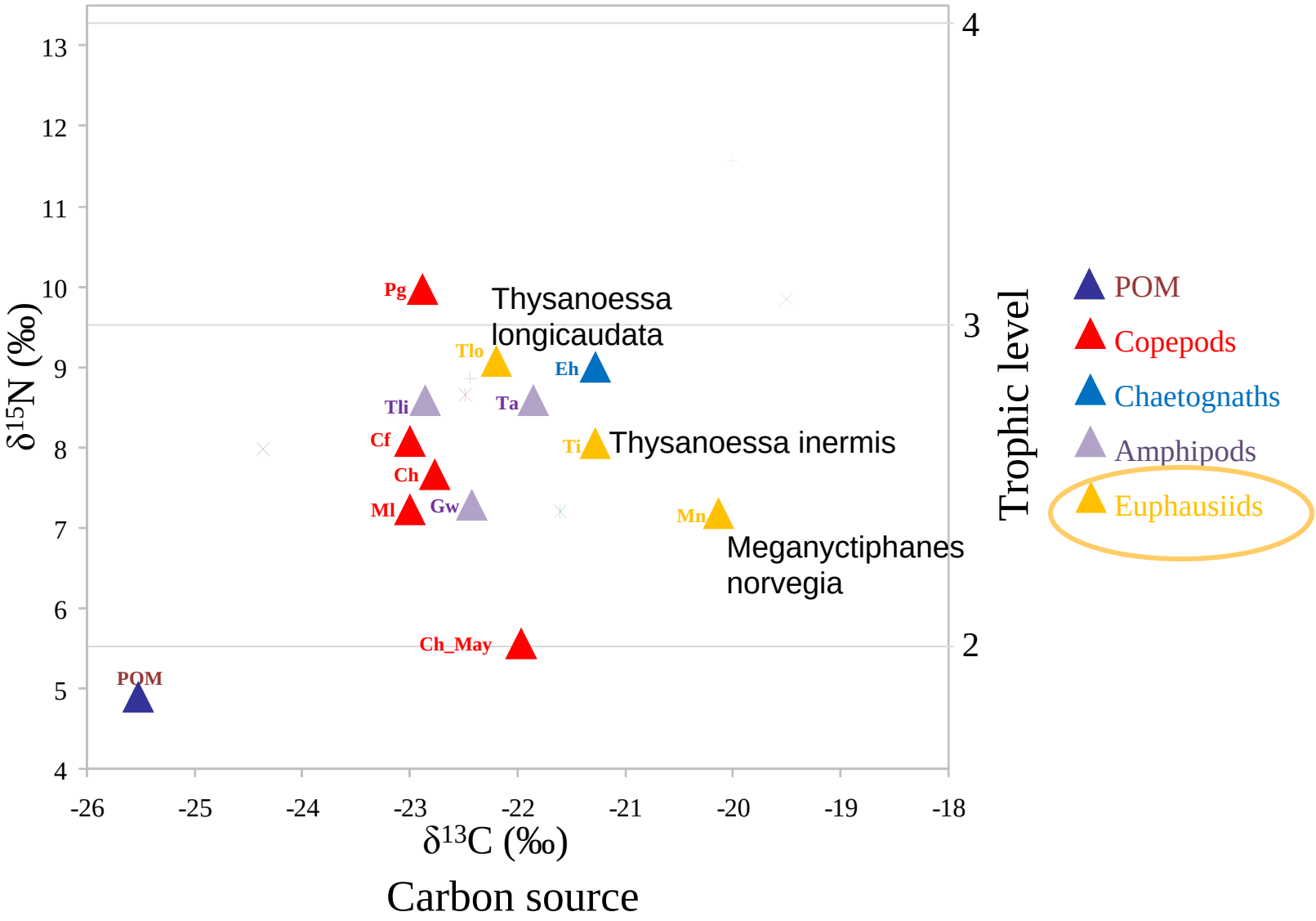


Carbon source

Nitrate source



Nitrate source



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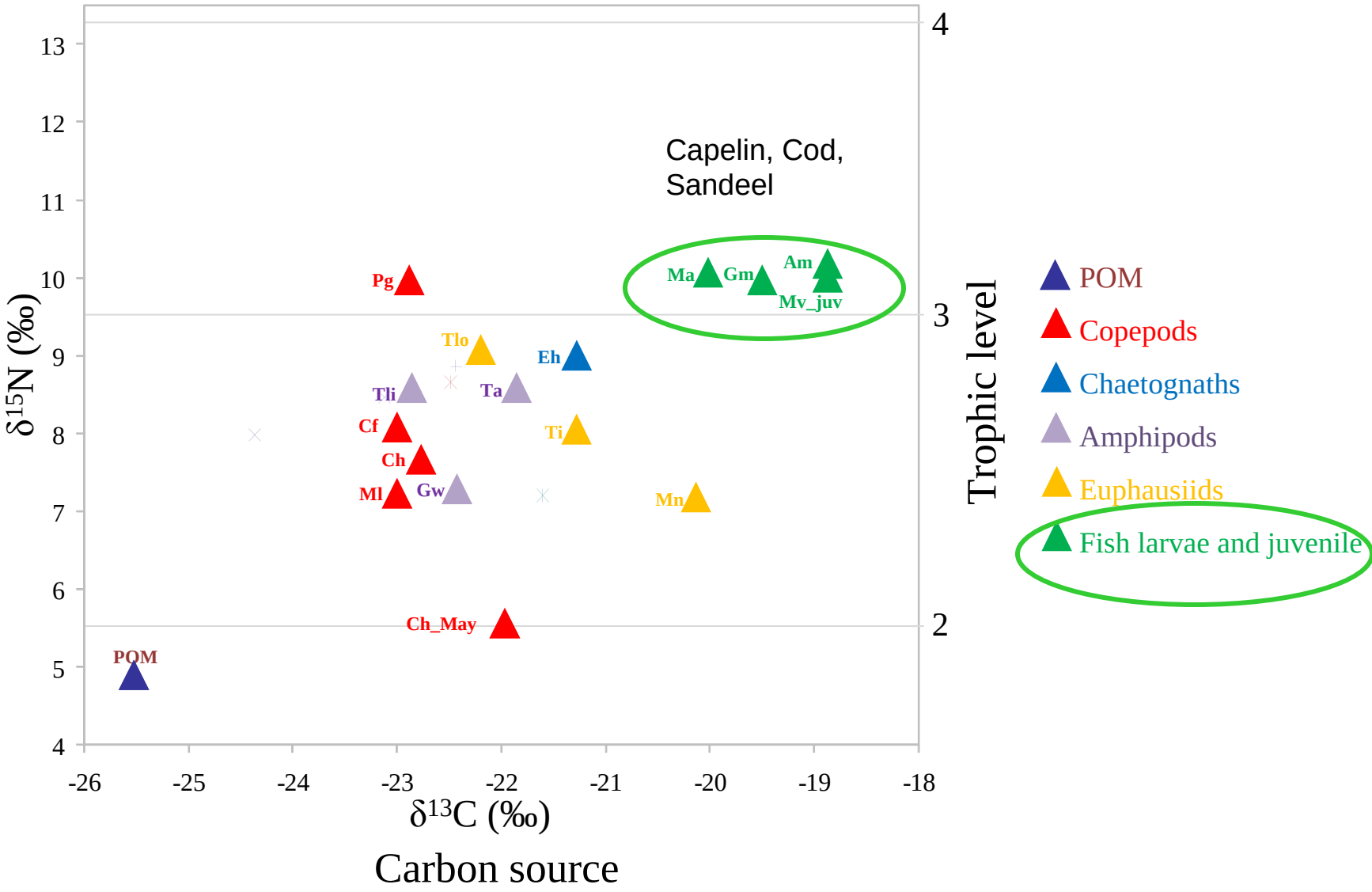
Nitrate source



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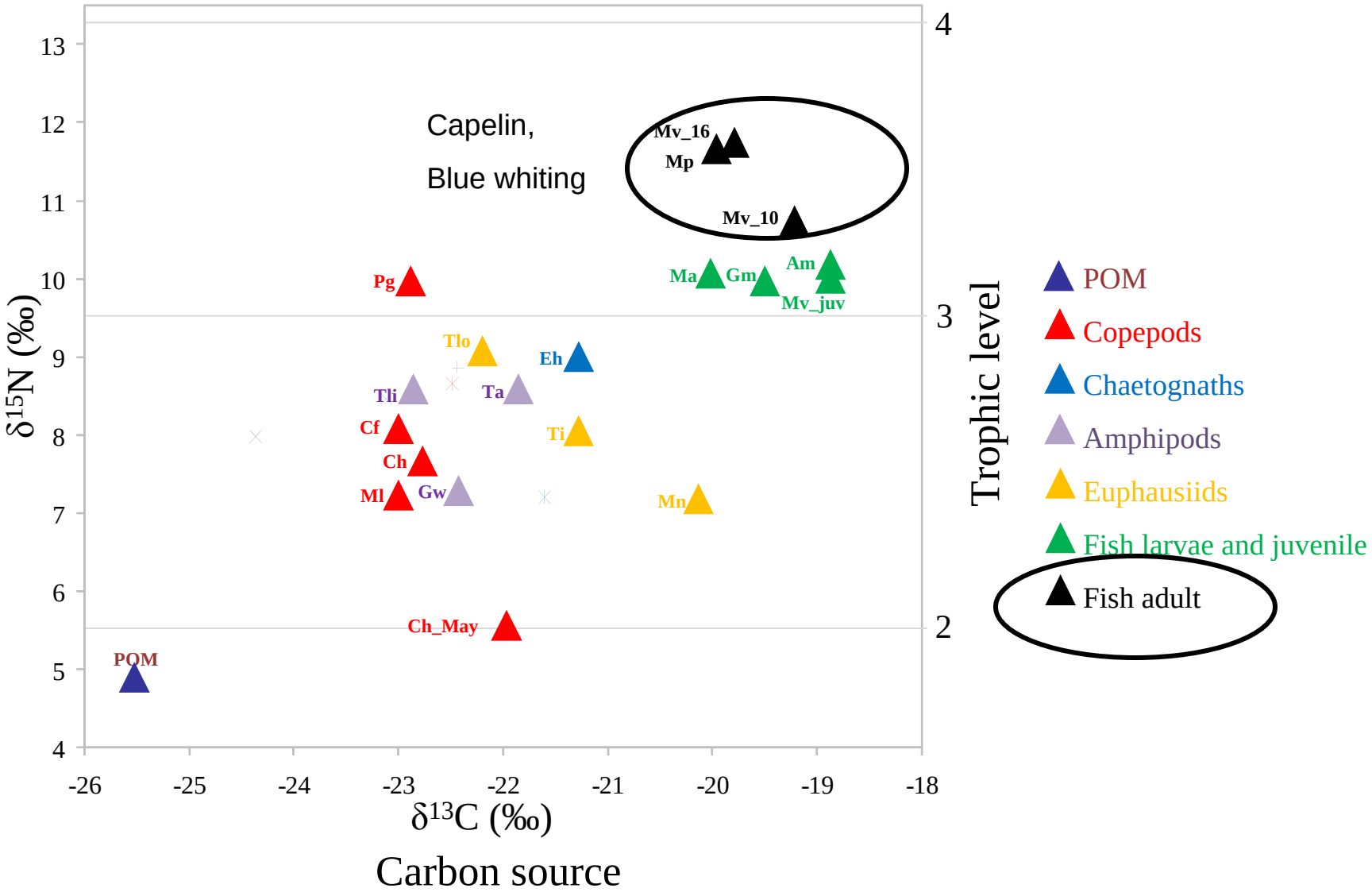
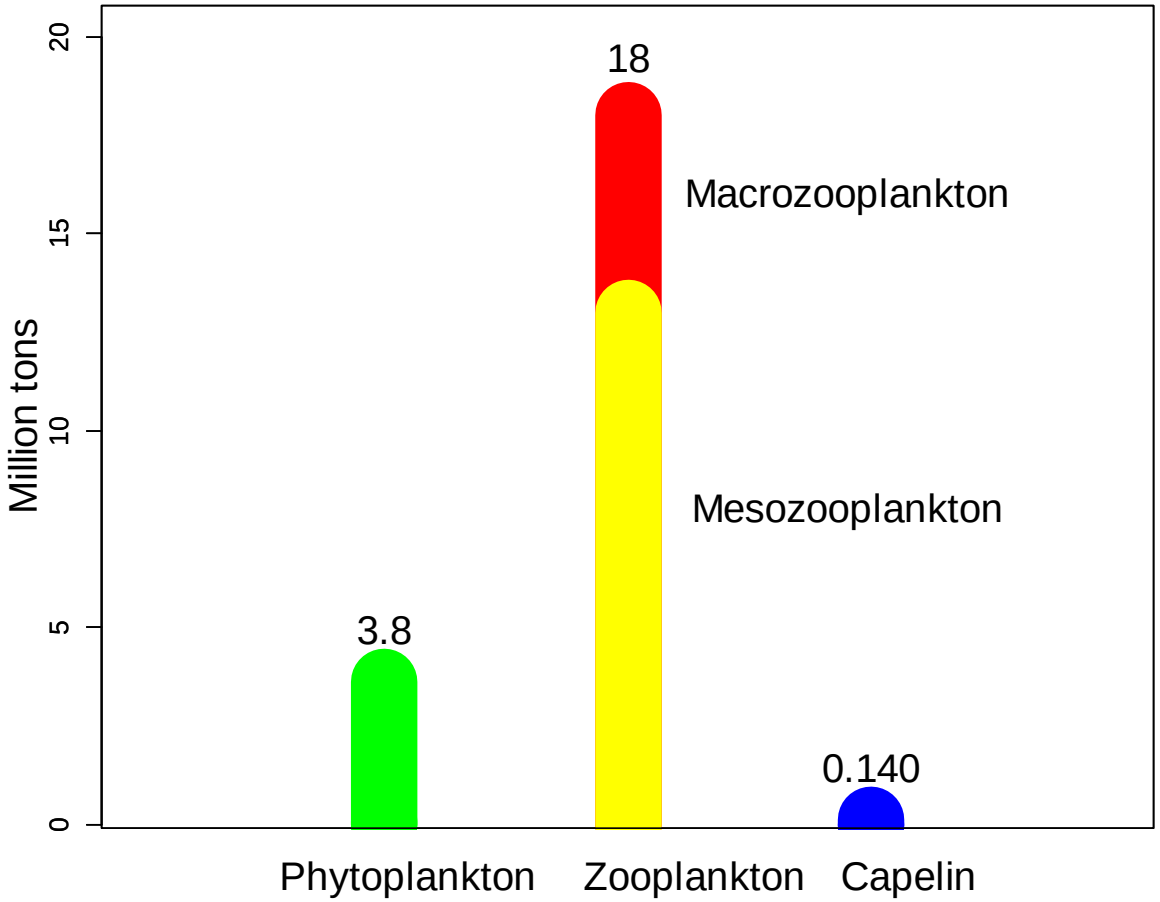


Mean annual biomass 2006-2008

Wet weight (million tons)



Relatively on par with results from the Norwegian Sea.

Capelin life history patterns

- Adult capelin feeding migration 1993
- Long-term changes in migration extent

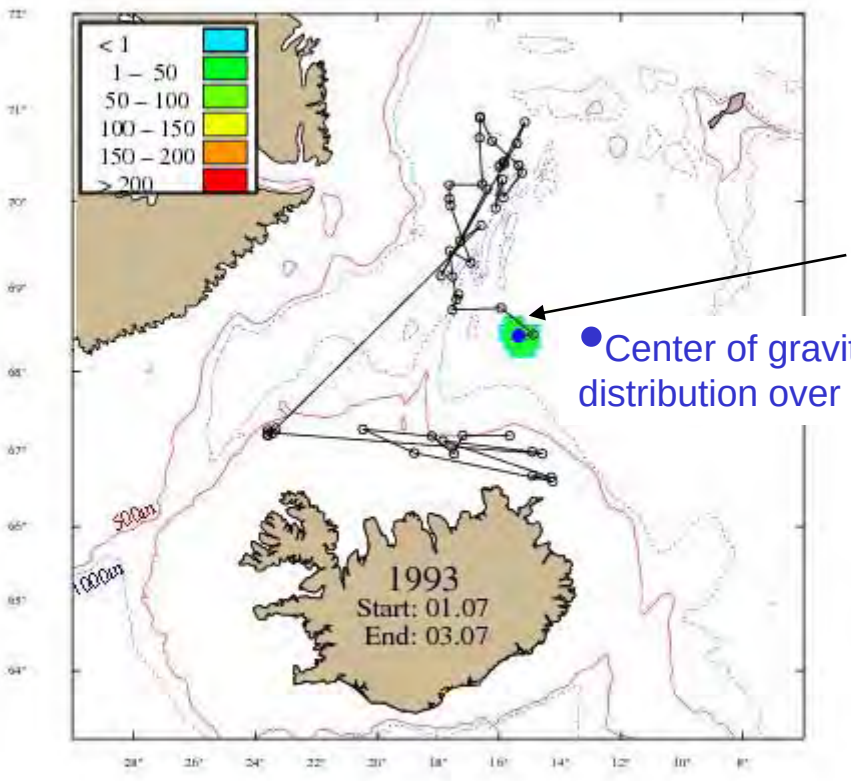
Using log-book data to track feeding migration of capelin in the Iceland Sea during summer and autumn of 1993

The summer - autumn fishery 1993

- Log-book data of purse seine fishing June – December.
- 420 thousand tons in 3600 shots. Average catch per shot = 115 tons (range 0-800)
- Spatial distribution of catches and center of gravity of the distribution are calculated for every three days of the fishing season.
- It can be assumed that the fishers aim to locate capelin shoals of highest density and at shortest possible distance from landing sites.
- Therefore, distribution of fishing can be assumed to indicate approximate timing and location of the center of the capelin feeding migration.

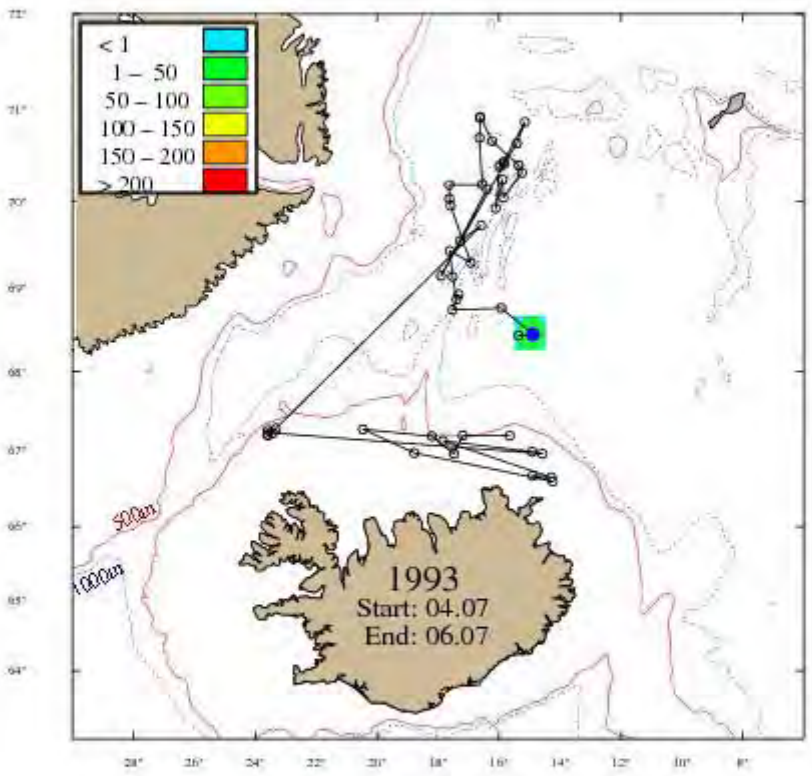
Begin of northward migration 1 July

Scale: Tons/shot in purse seine



Capelin distribution

Center of gravity of catch distribution over 3 days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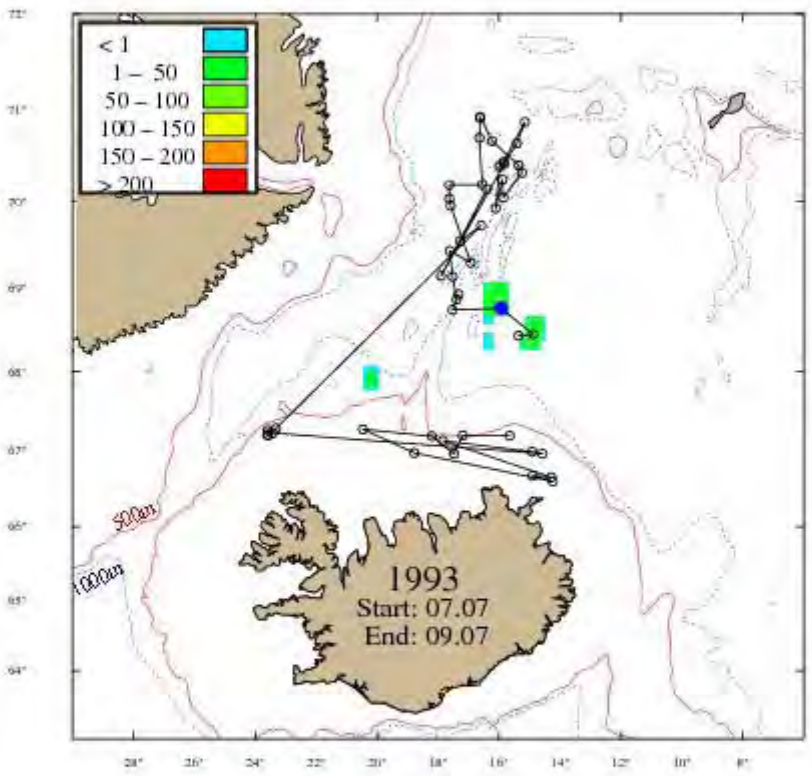
1 – 50
50 – 100
100 – 150
150 – 200
> 200
500m
1000m
1993
Start: 04.07
End: 06.07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1000m
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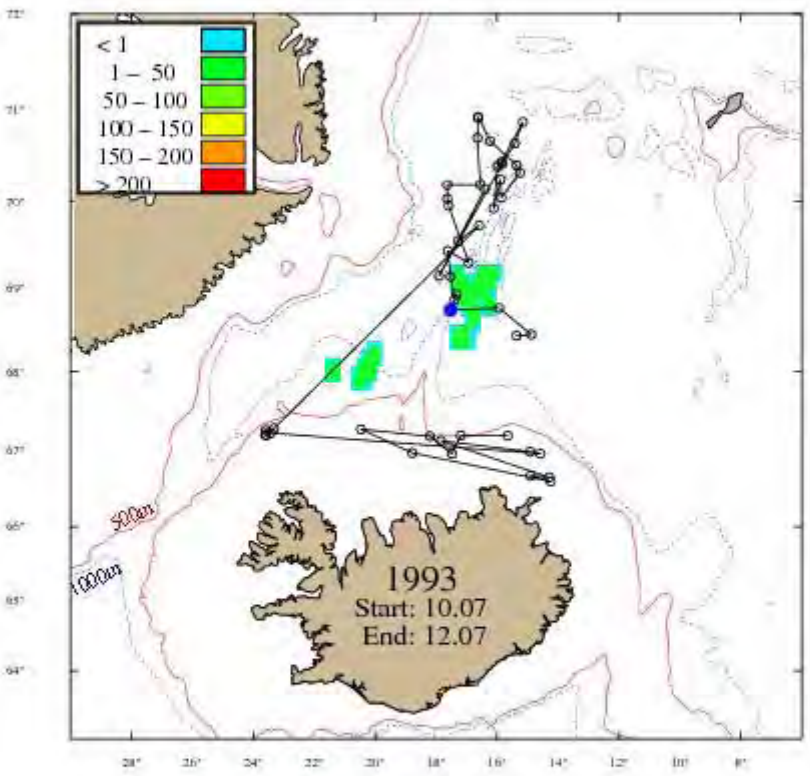
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500m
1000m
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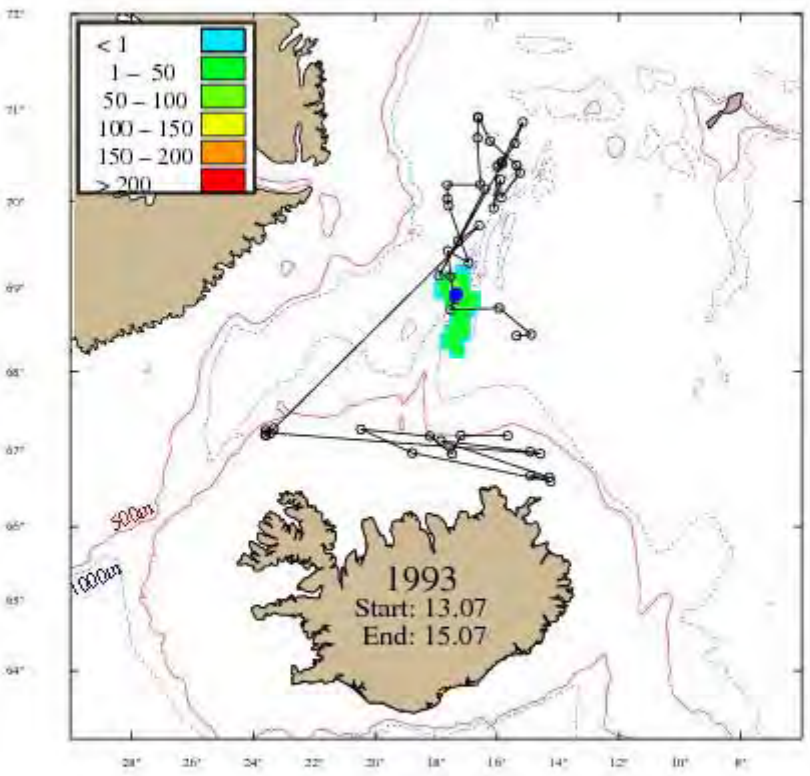
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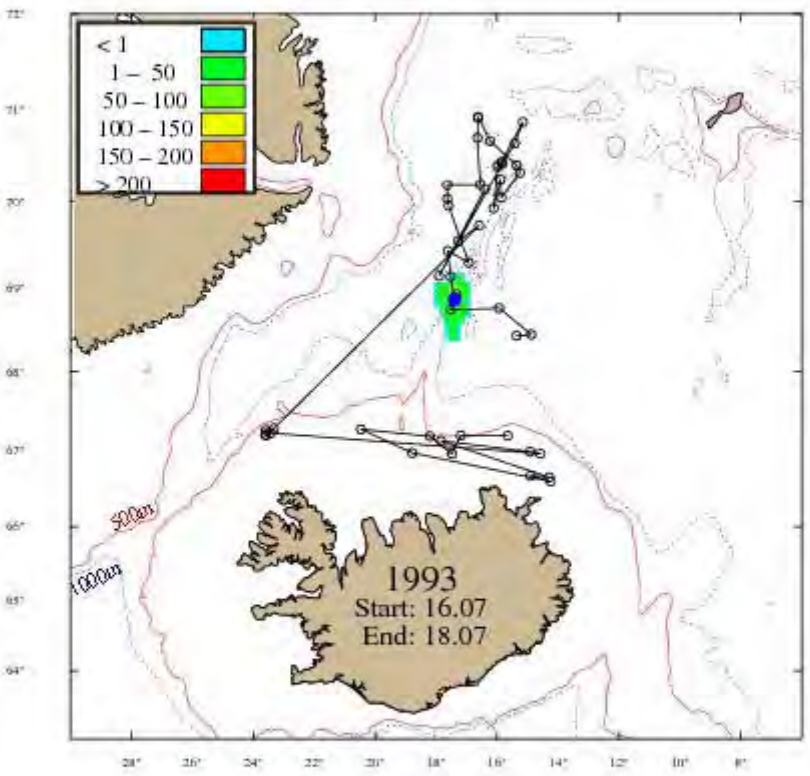
End: 15.07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100 – 150
150 – 200
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1000m
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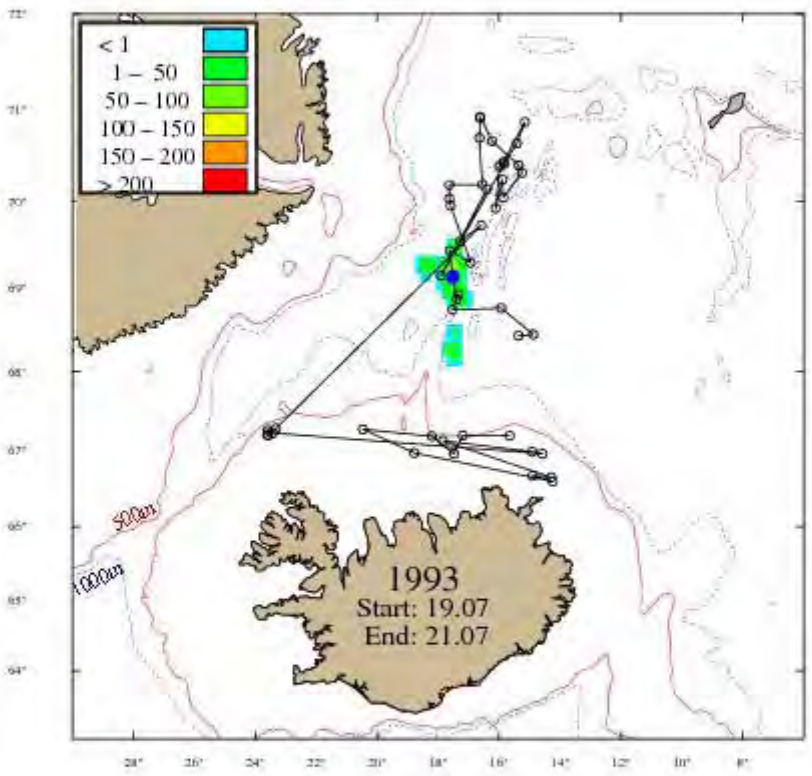
End: 18.07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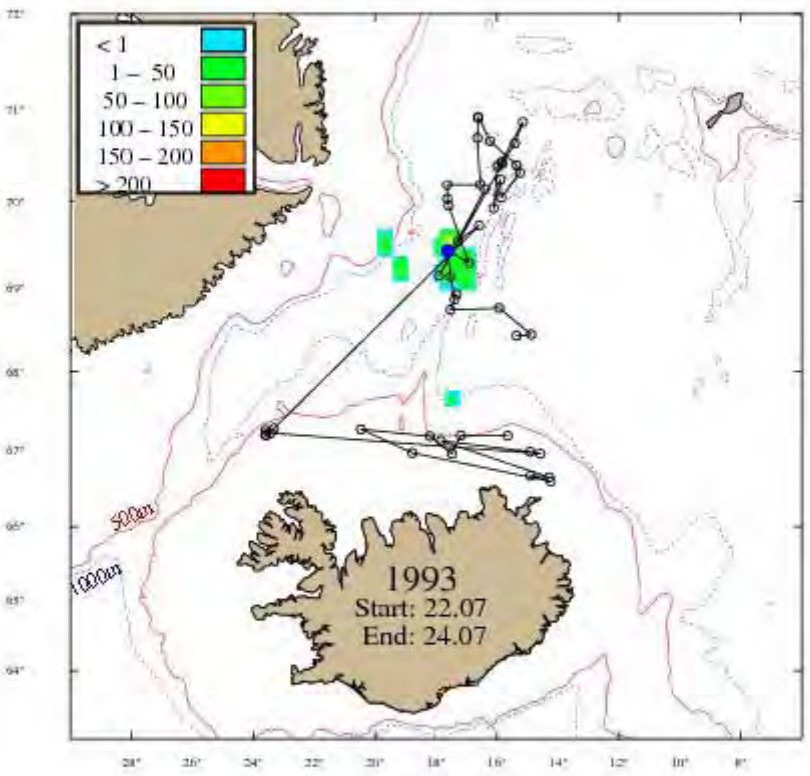
End: 21.07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150 – 200
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1000m
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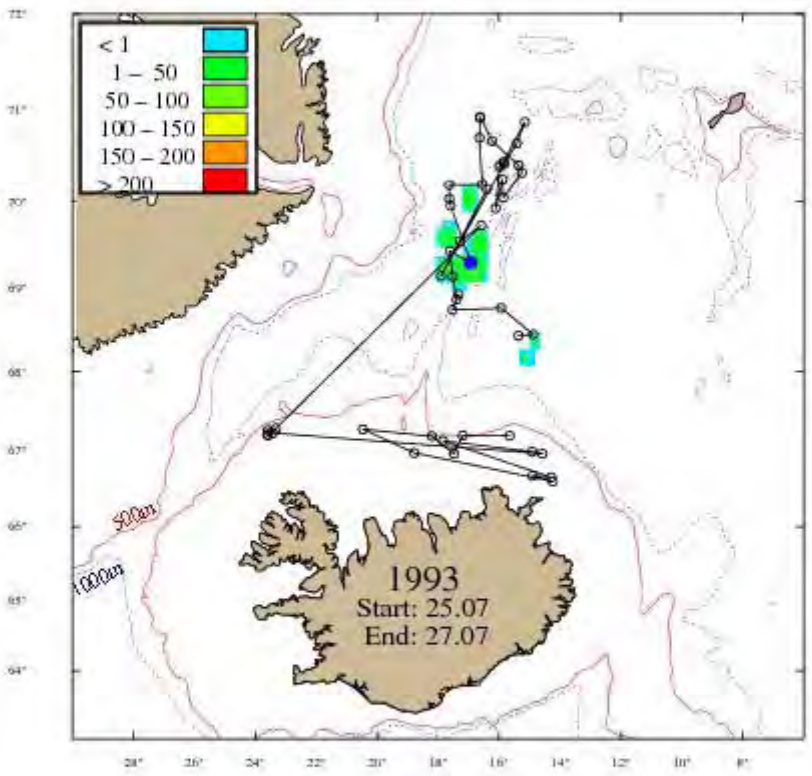
End: 24.07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150 – 200
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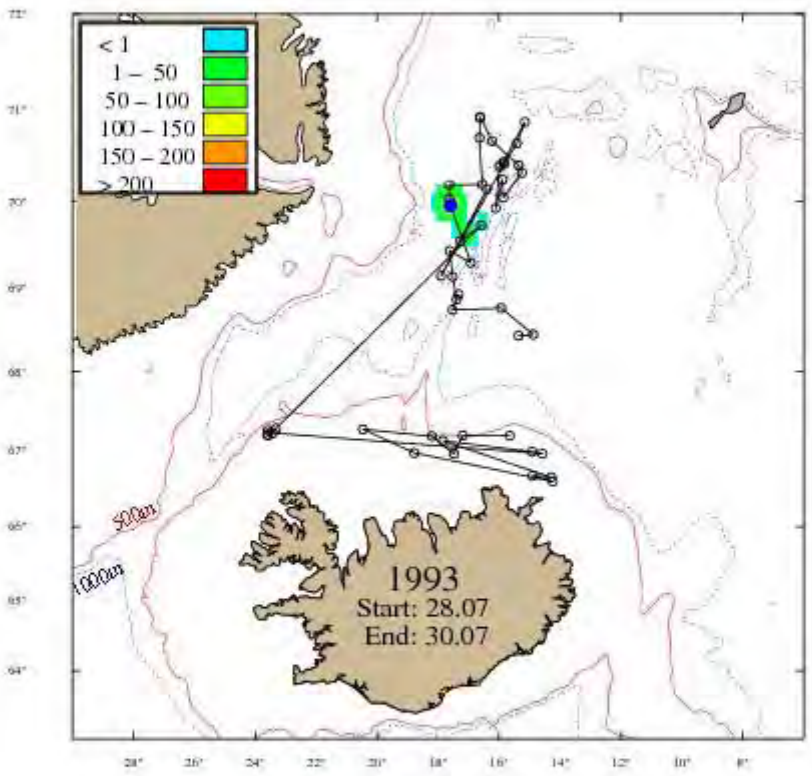
End: 27.07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100 – 150
150 – 200
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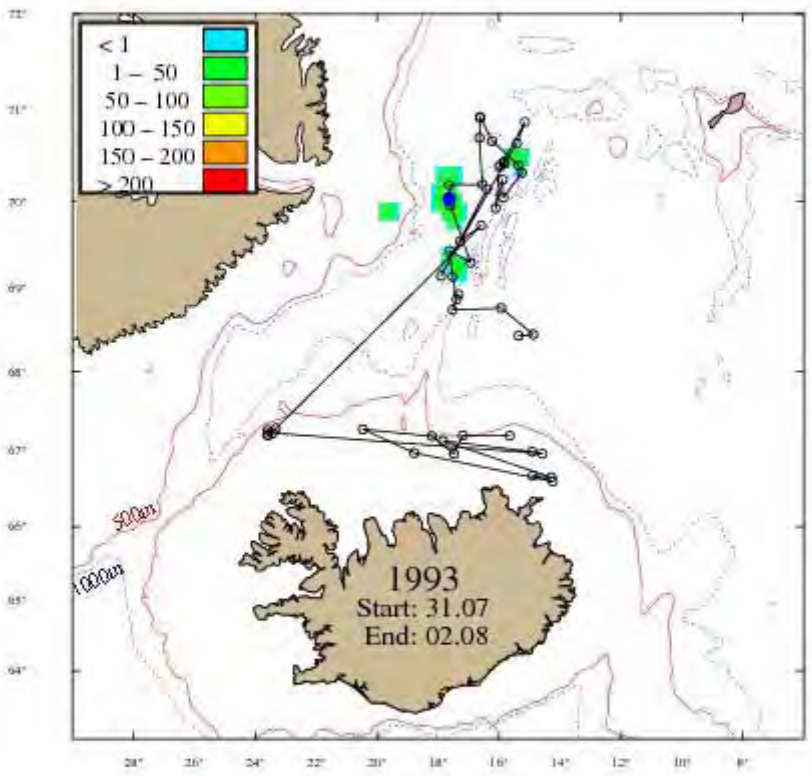
500m
1000m
1993
Start: 28.07
End: 30.07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150 – 200
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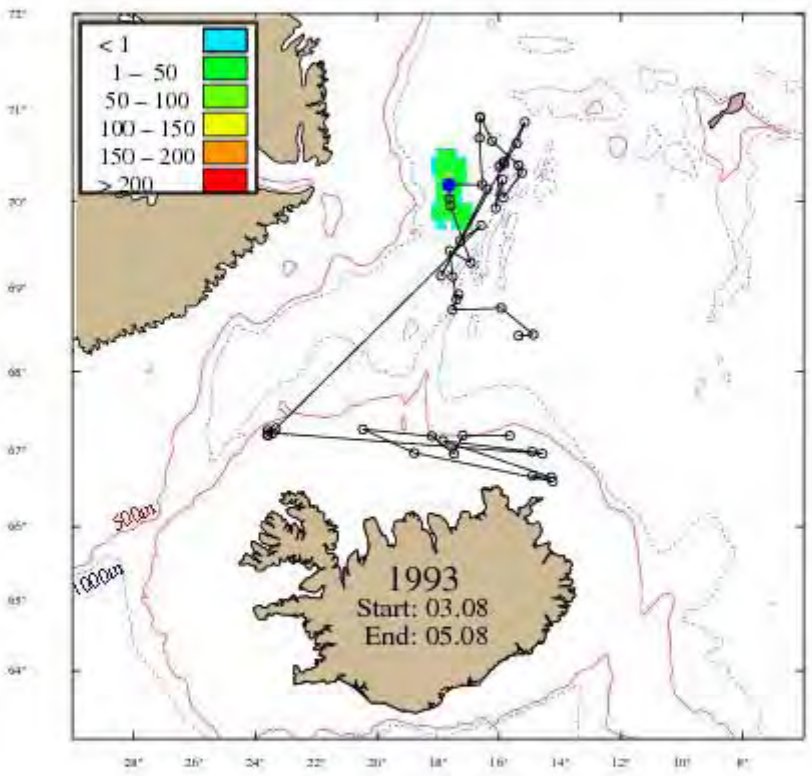
End: 02.08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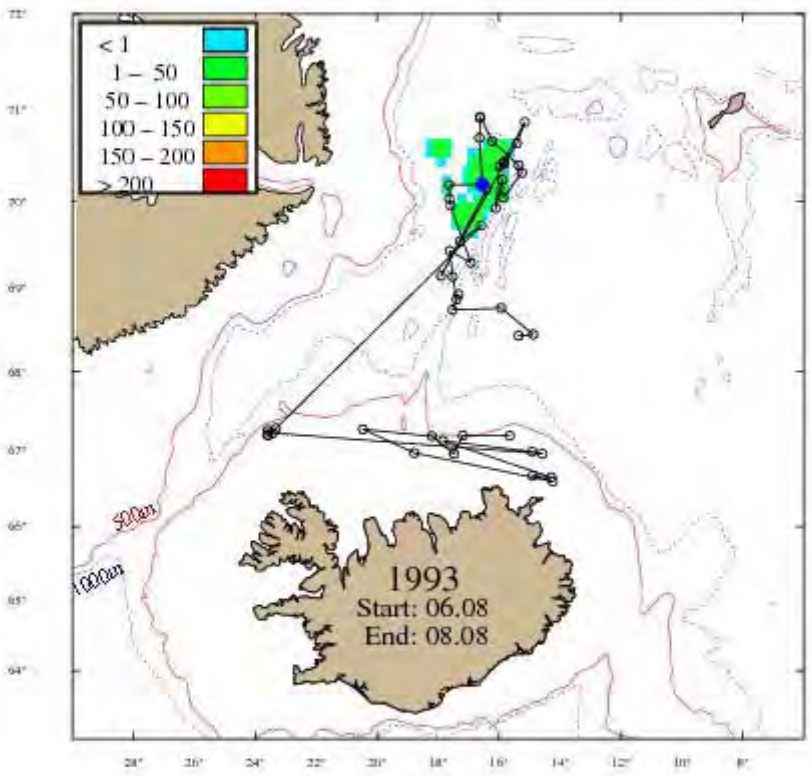
100 – 150
150 – 200
> 200
500m
1000m
1993
Start: 03.08
End: 05.08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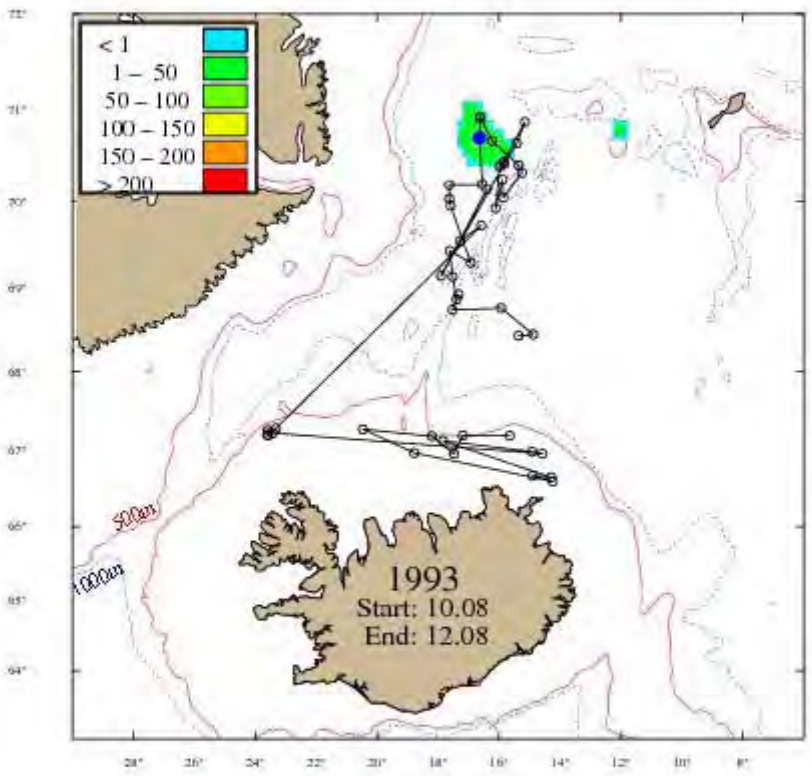
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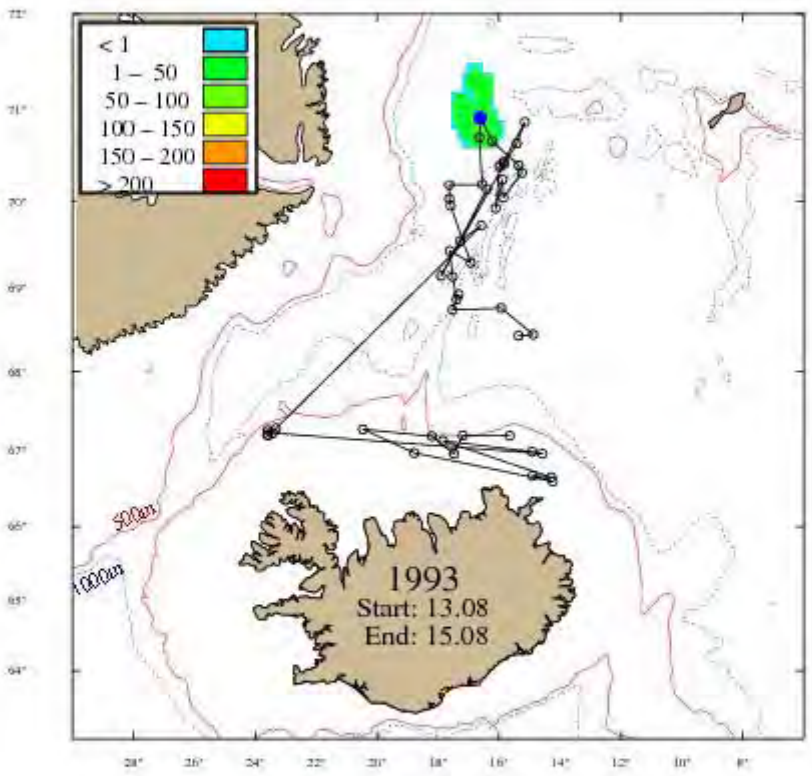
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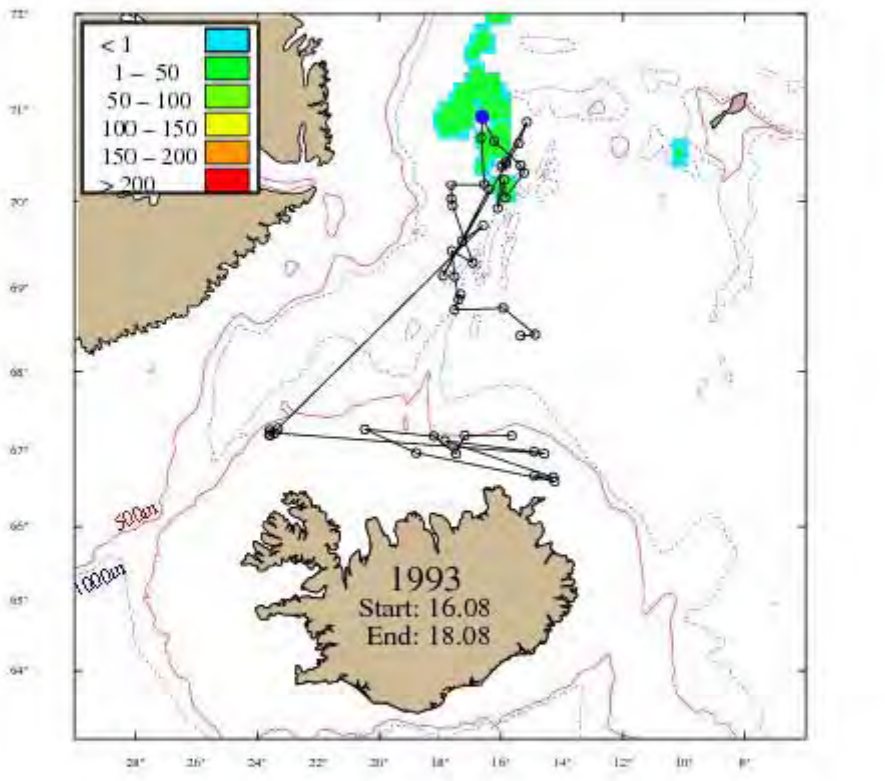
End: 15.08

End of northward migration 18 August



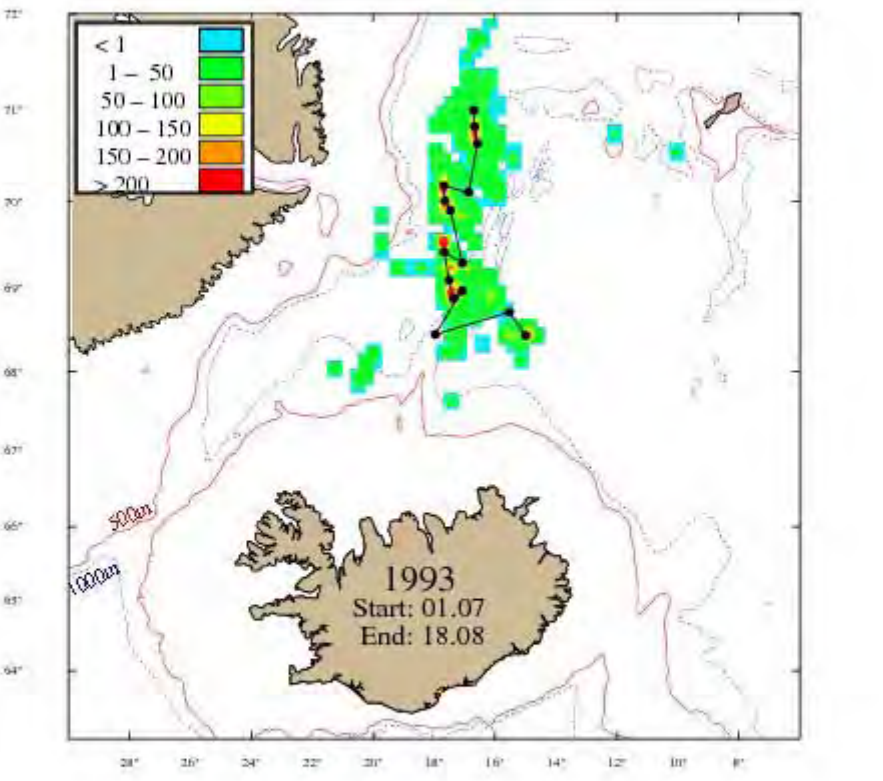
Northward migration

Path of the migration:

Start: over the Kolbeinsey ridge.

End: midway between the ridge and the East Greenland shelf.

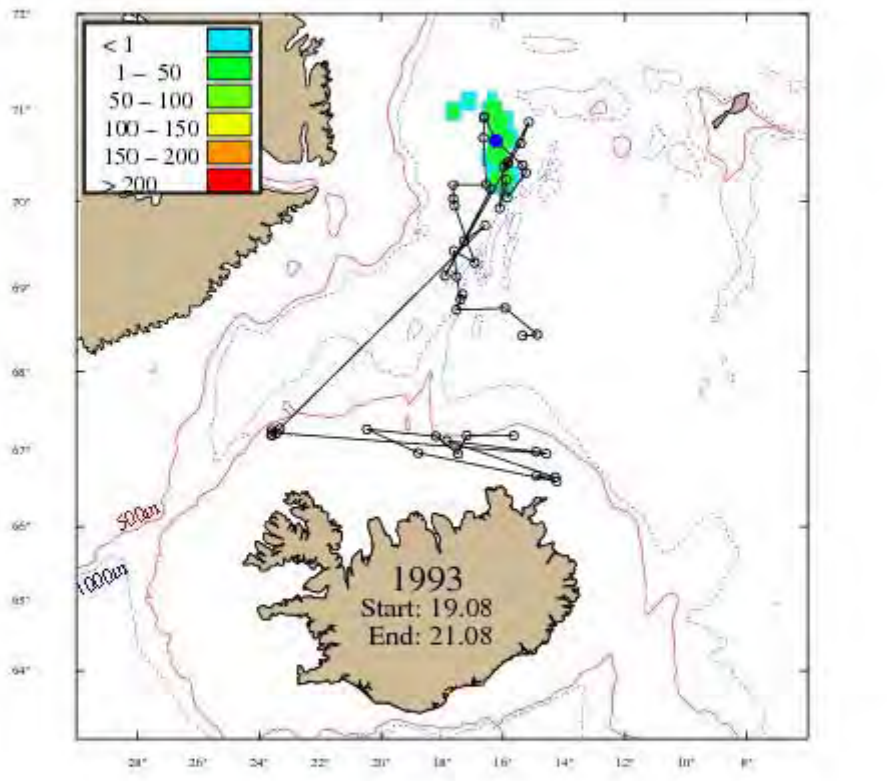
Direction: High north

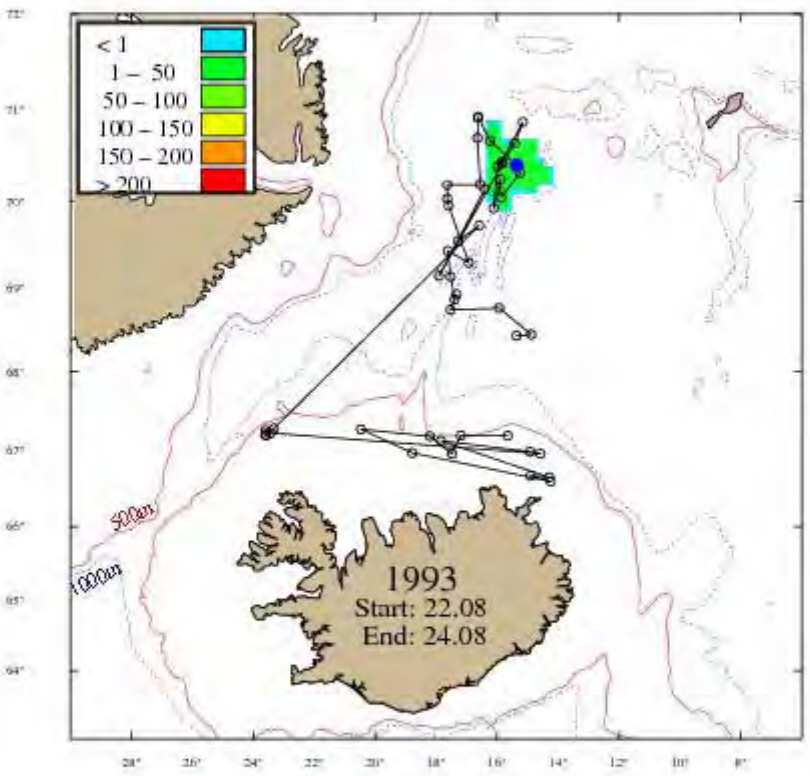


End: 18 August

Start: 1 July

Begin of intensive feeding 19 August

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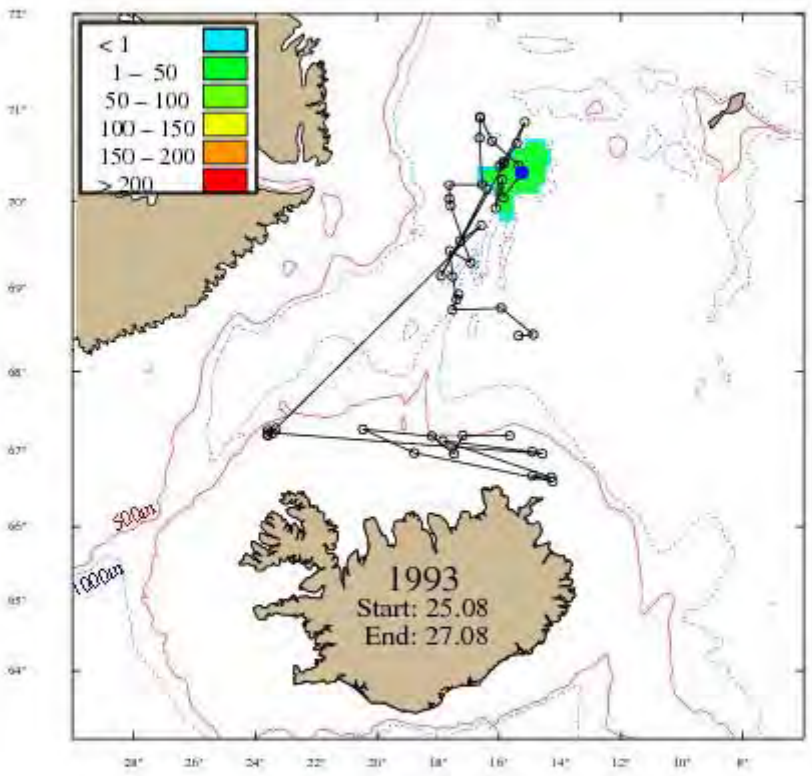
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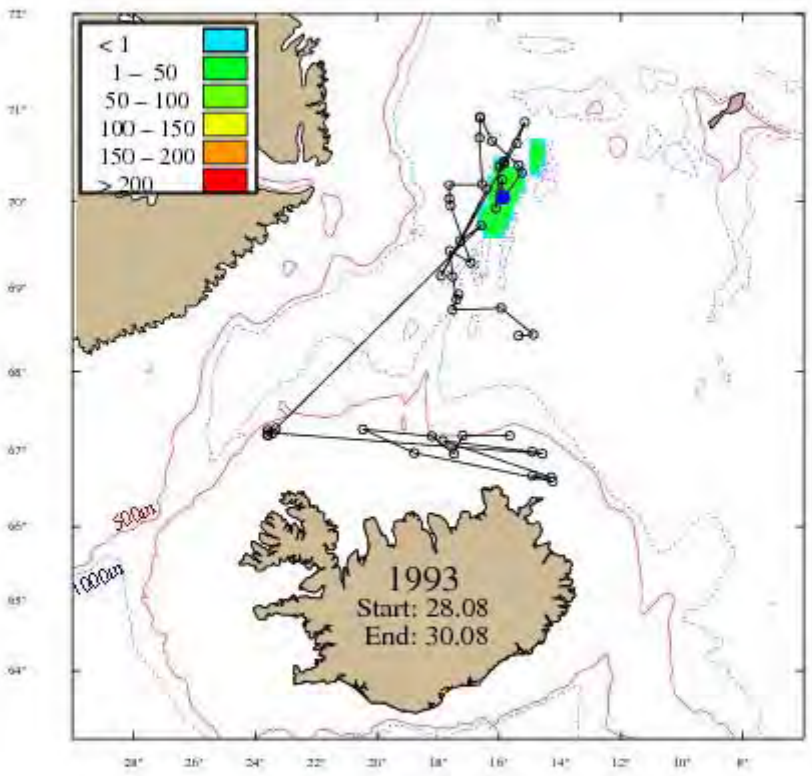
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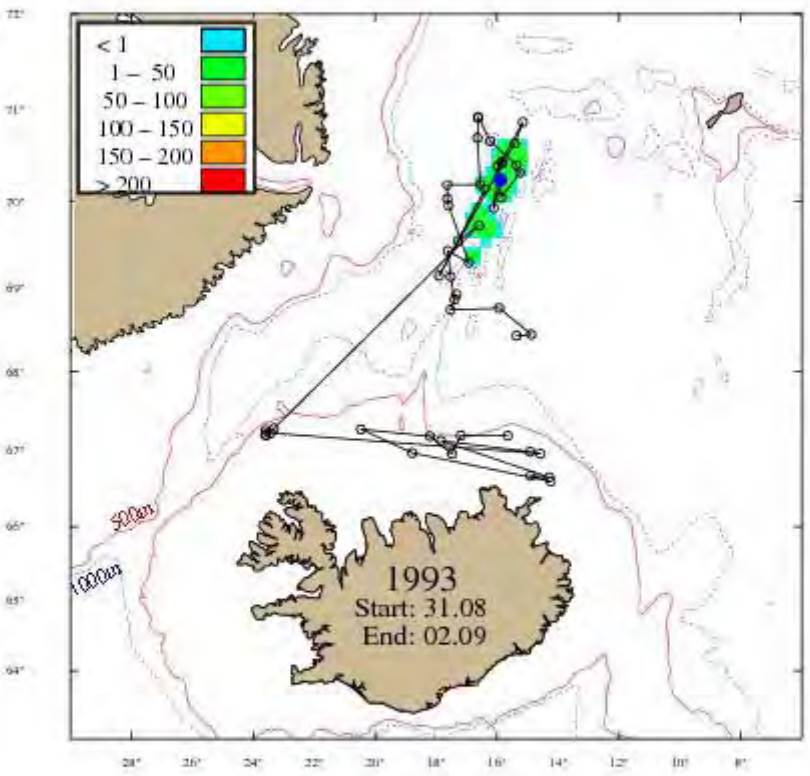
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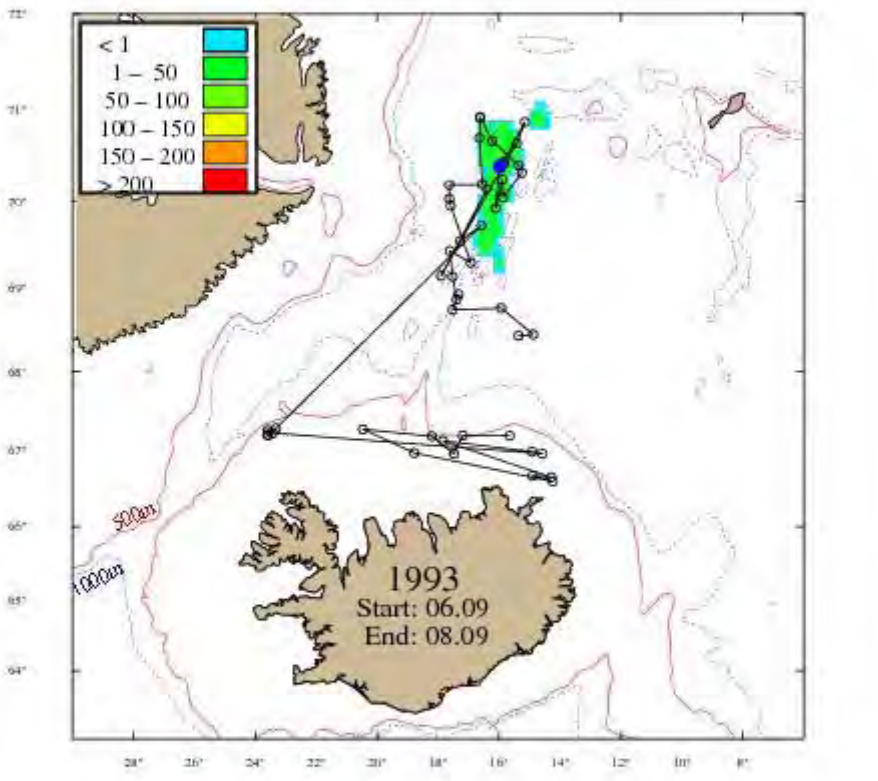
End: 02.09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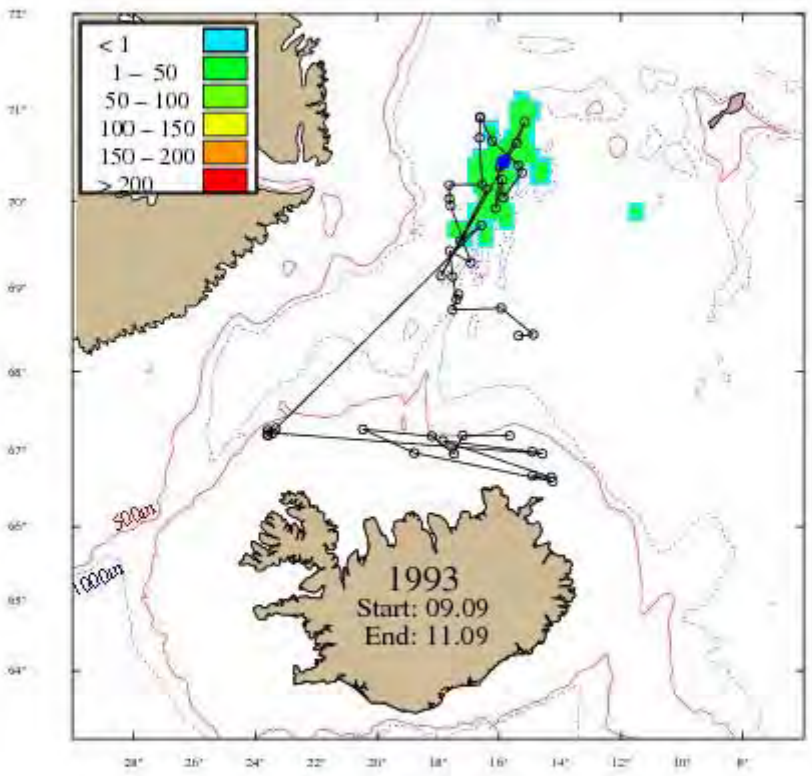
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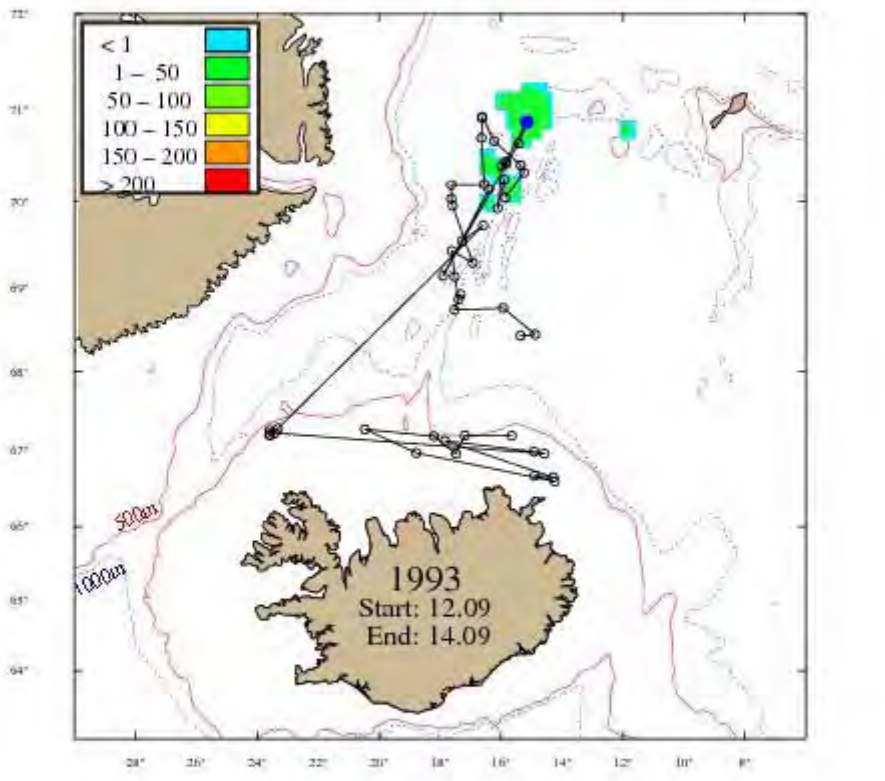
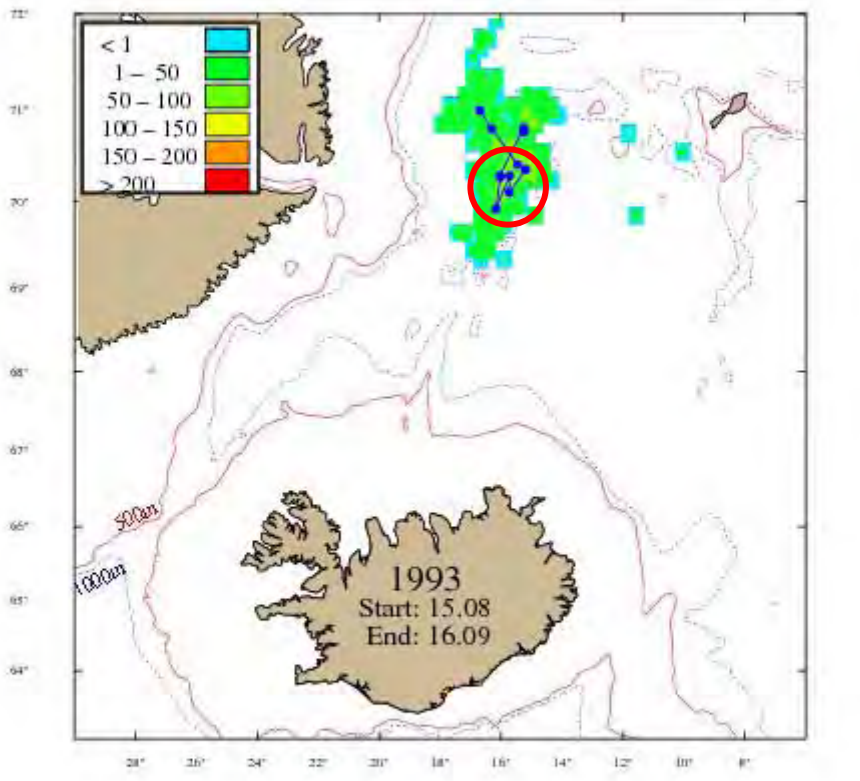
1993
Start: 09.09
End: 11.09

End of intensive feeding 14 Sep.



Intensive feeding phase



Start: ~19 August

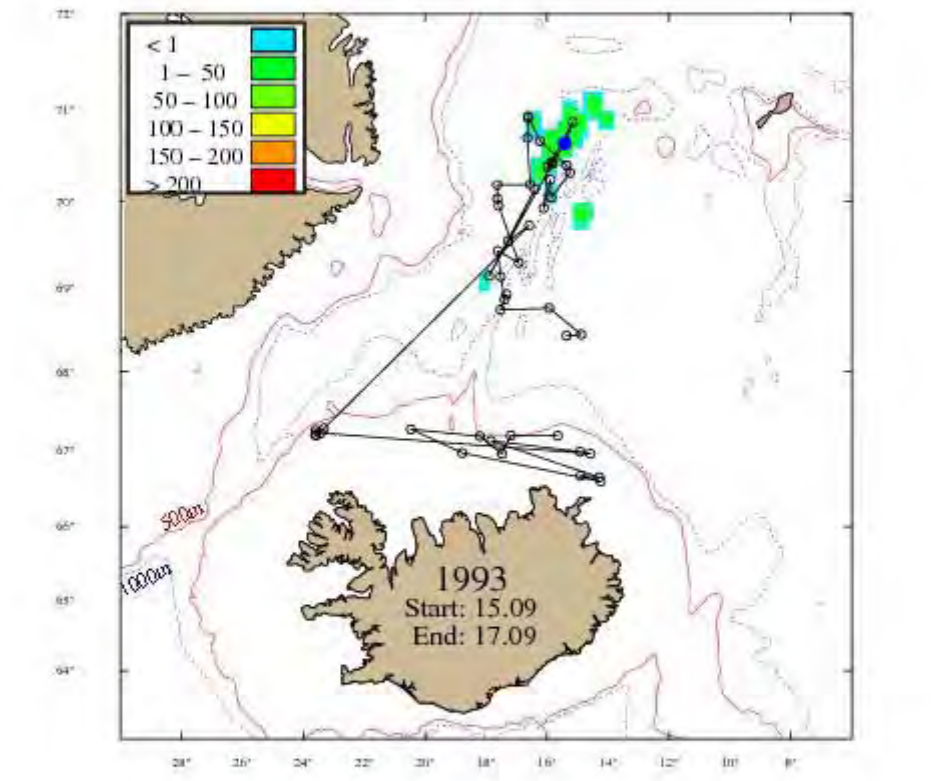
End: ~14 September

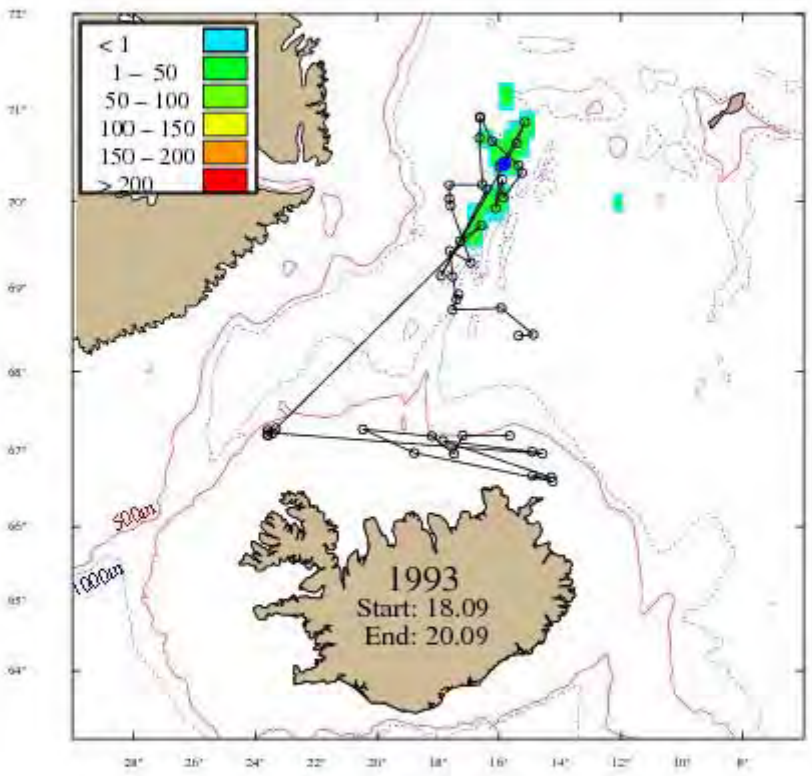
Location:

Between ~69,5-72°N

Moving east, closer to the Kolbeinsey ridge, than the northward migration

Begin of southward migration 15 Sept.

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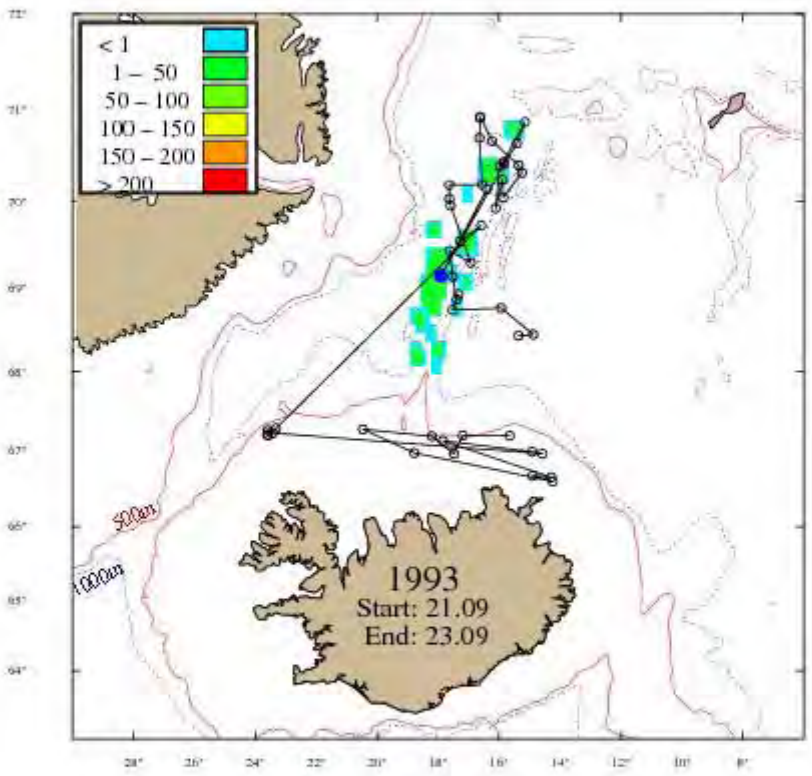
End: 20.09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1993
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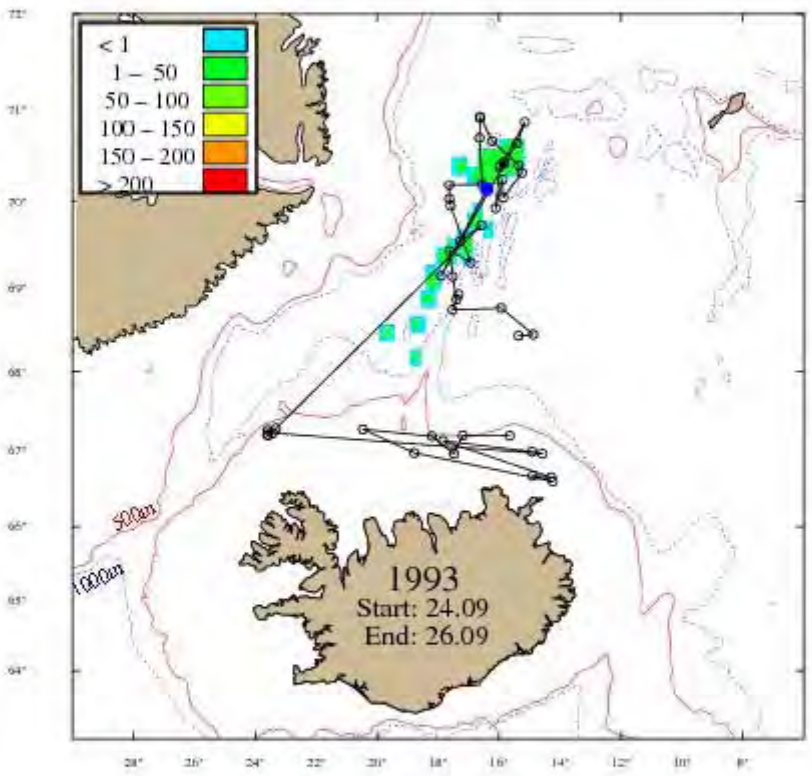
End: 23.09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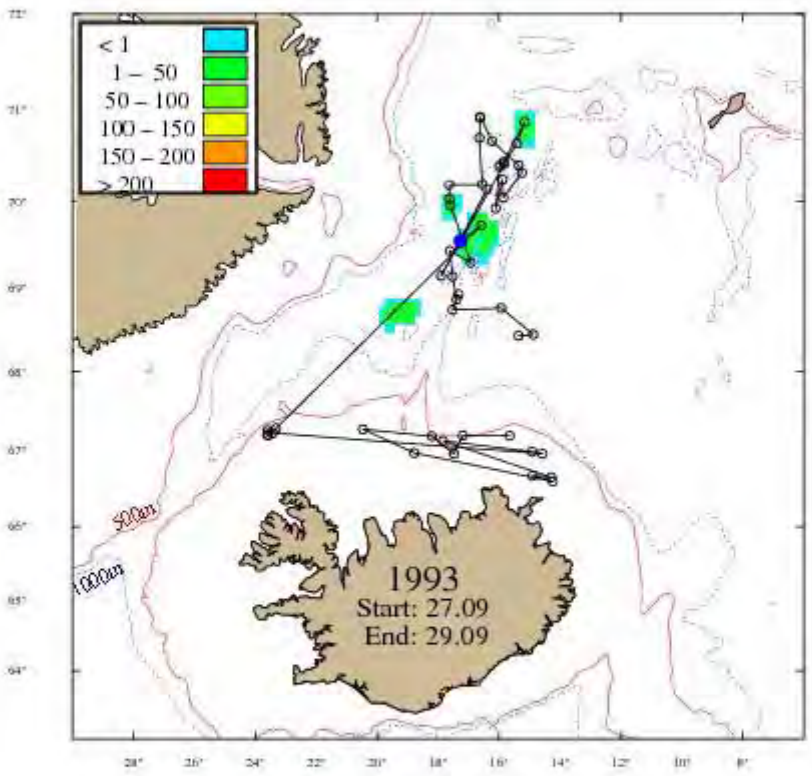
1993
Start: 24.09
End: 26.09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1993
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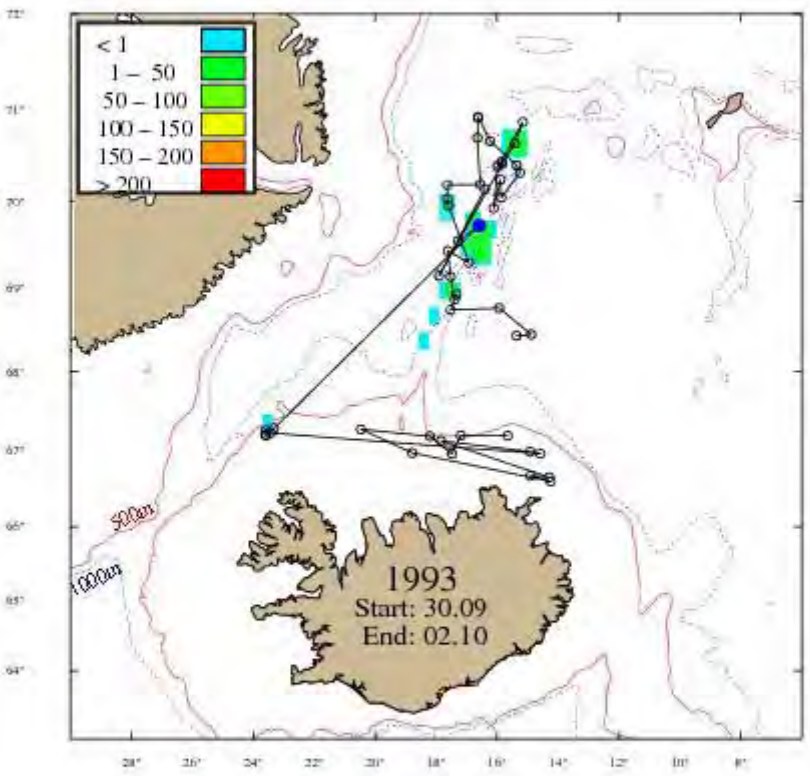
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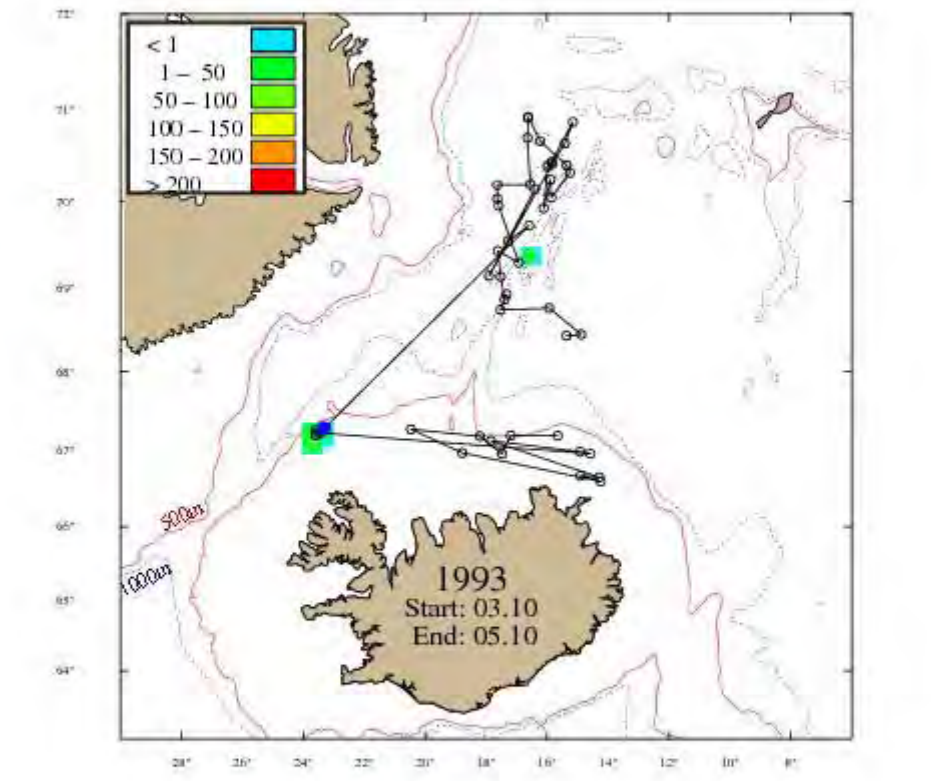
1000m
1993
Start: 30.09
End: 02.10

End of southward migration 5 Oct.

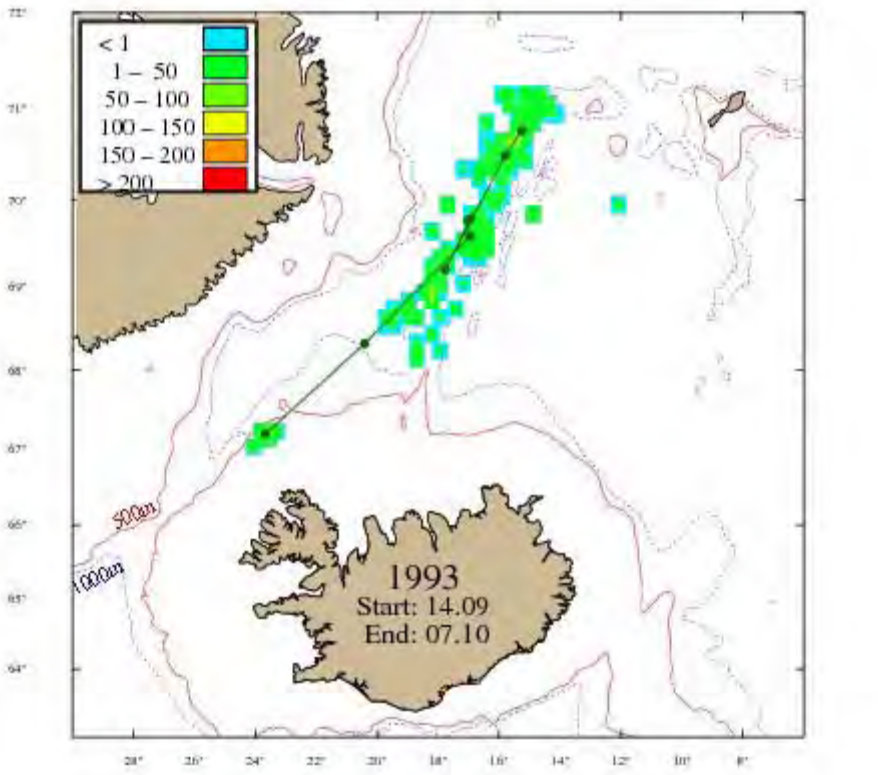


Southward migration

Path of the migration:

West of the Kolbeinsey ridge.

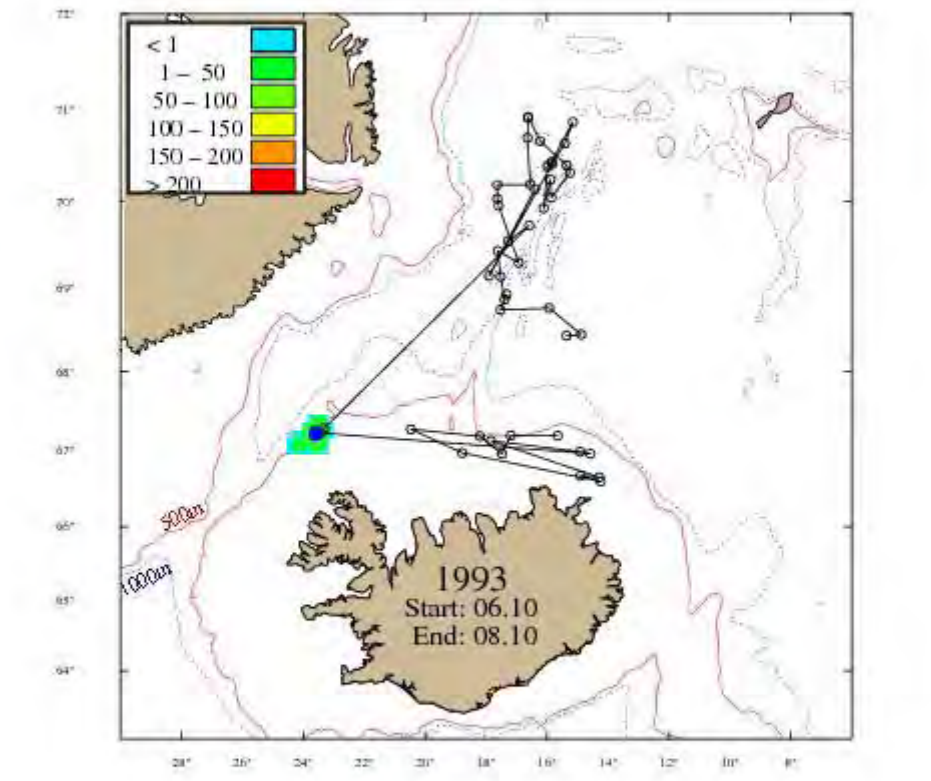
South west direction

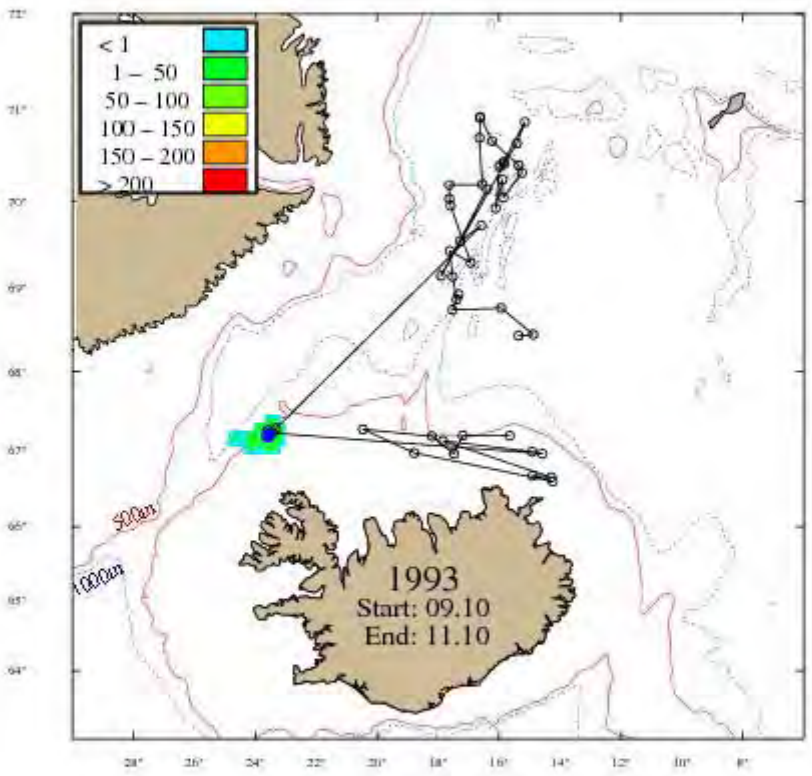


Start: ~15 September

End: ~5 October +

Begin of pre-spawning phasem 6 Oct.

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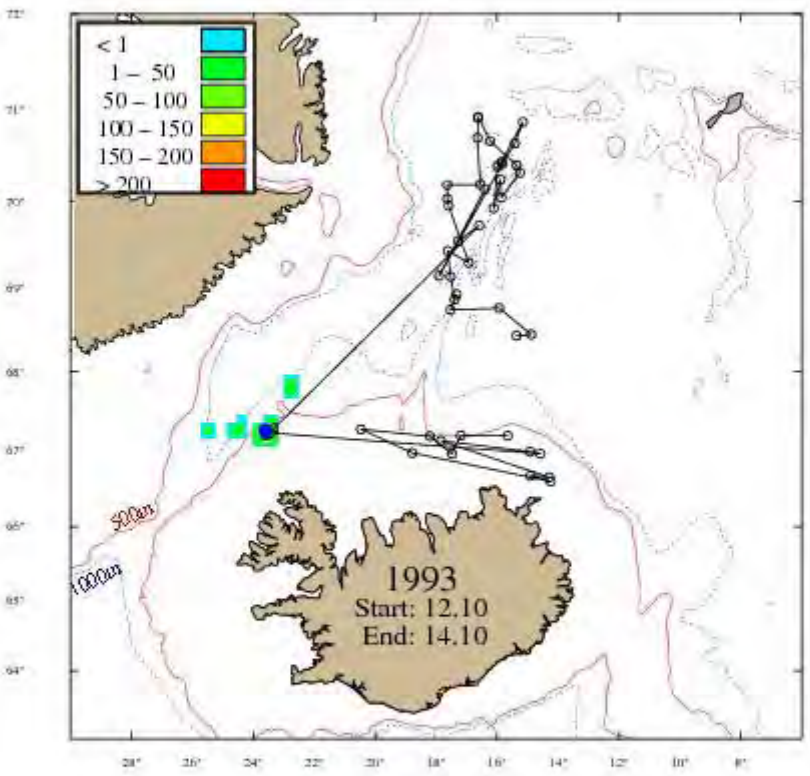
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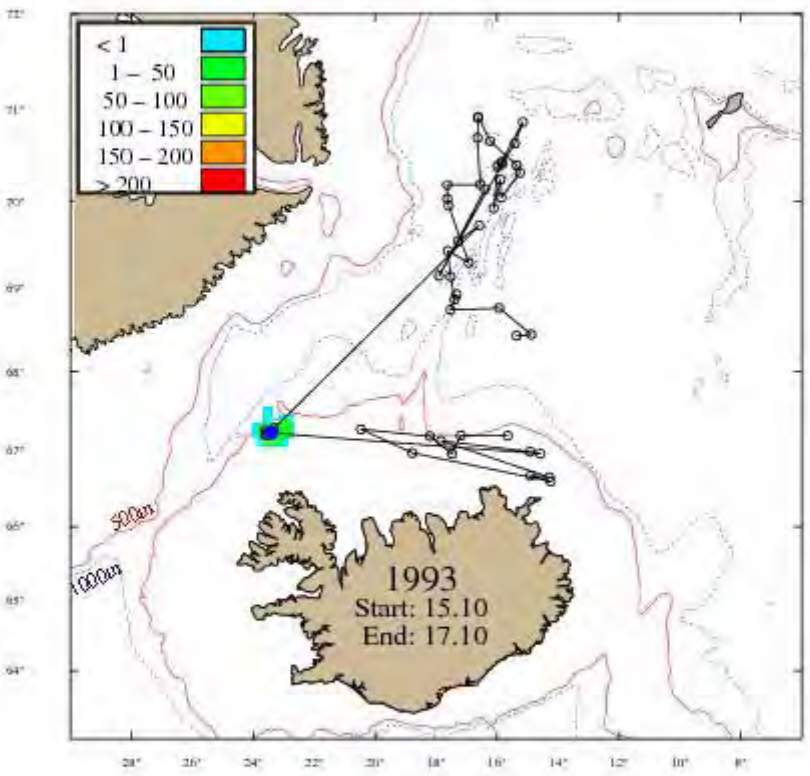
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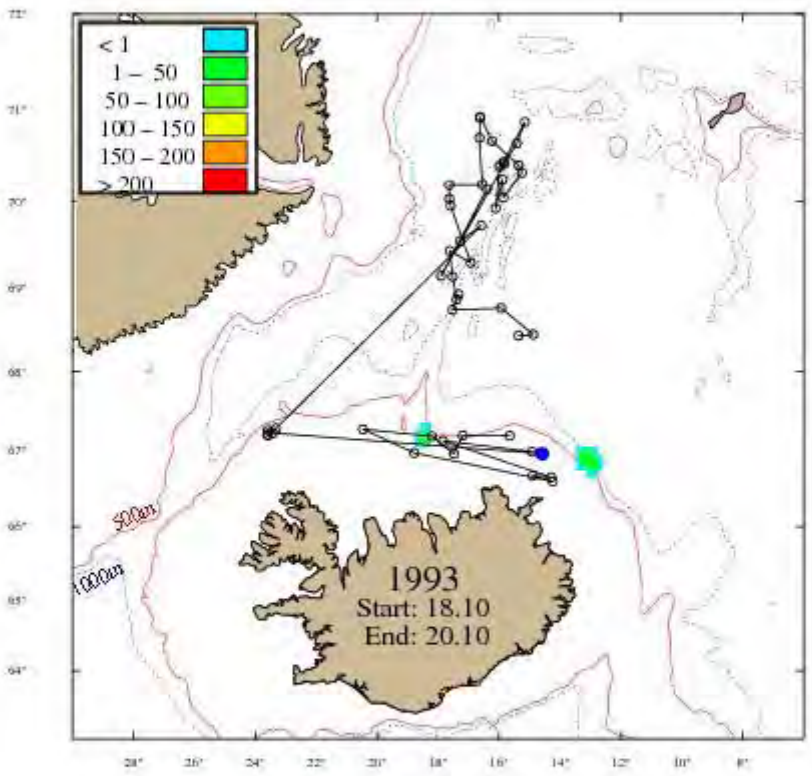
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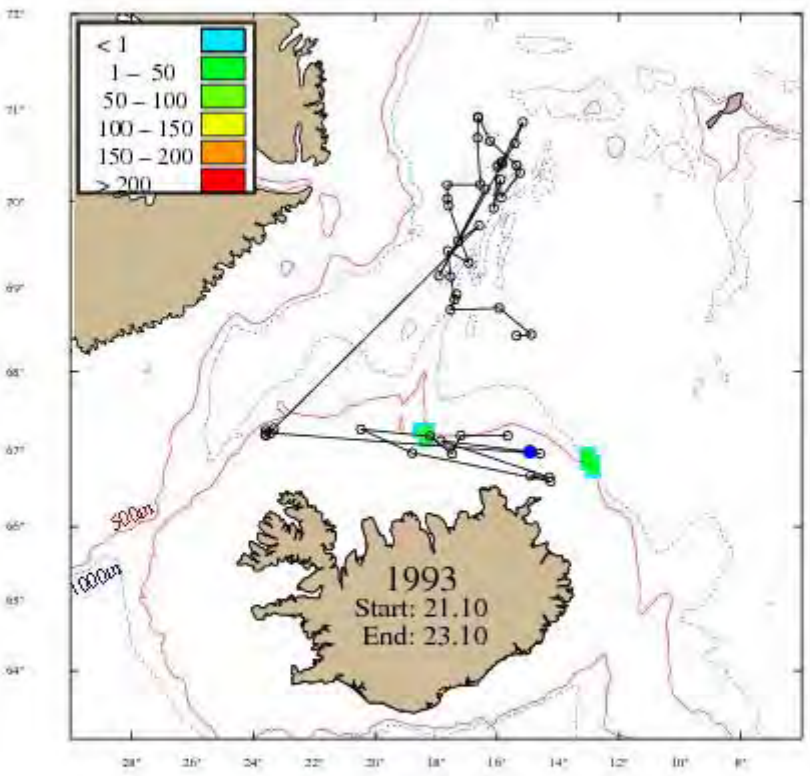
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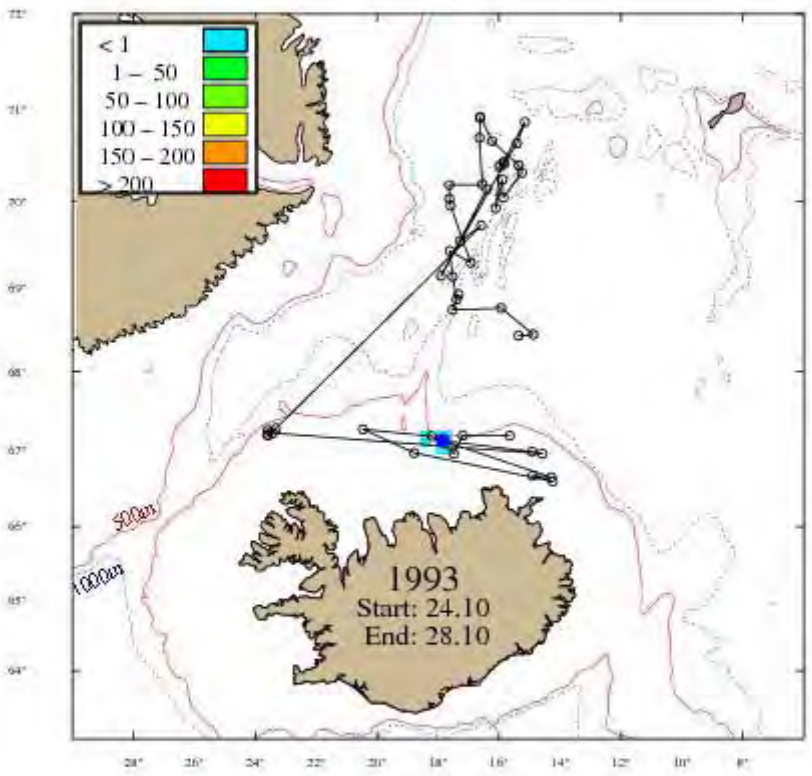
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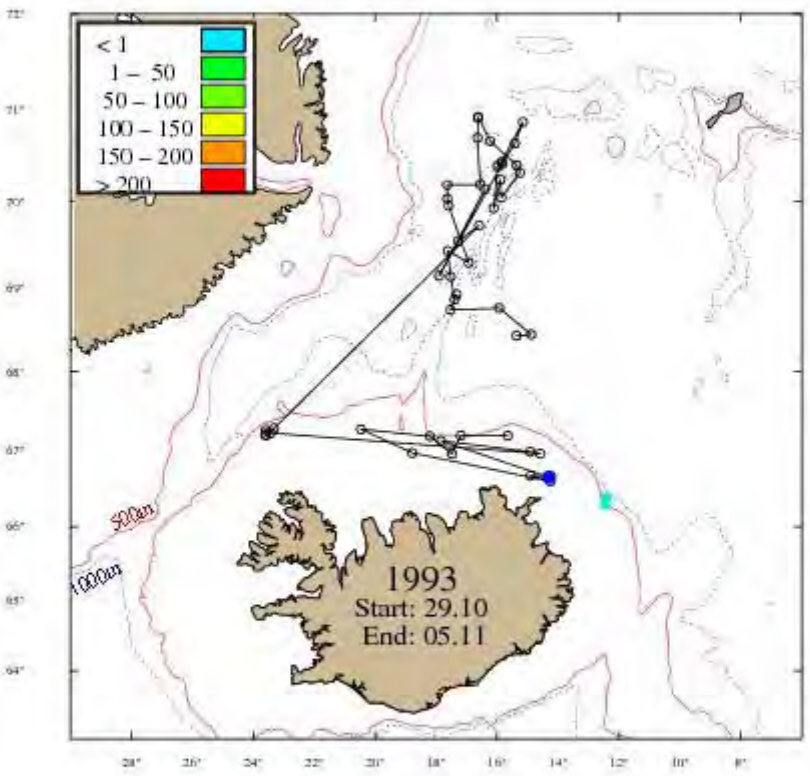
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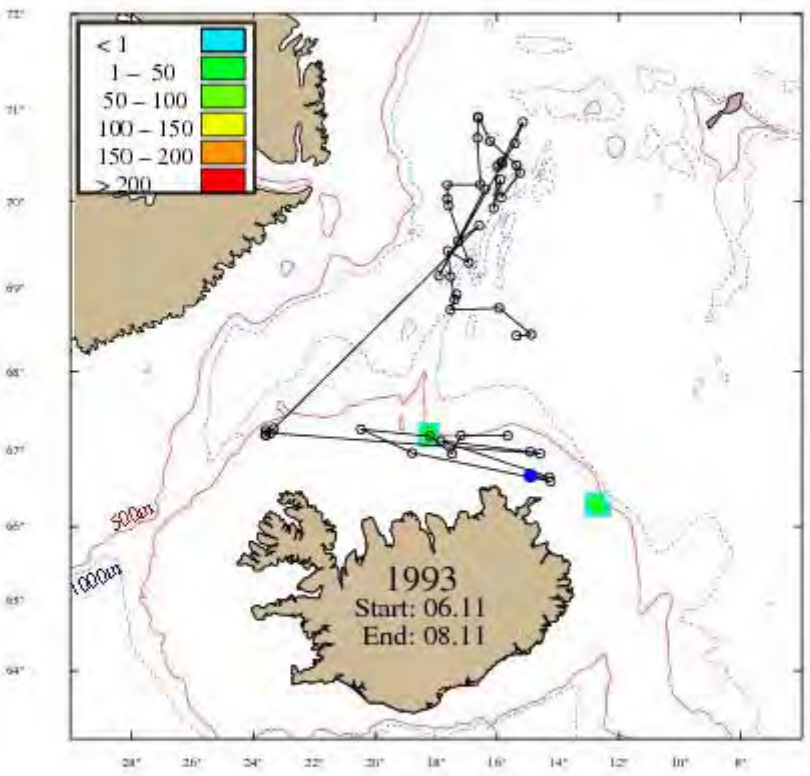
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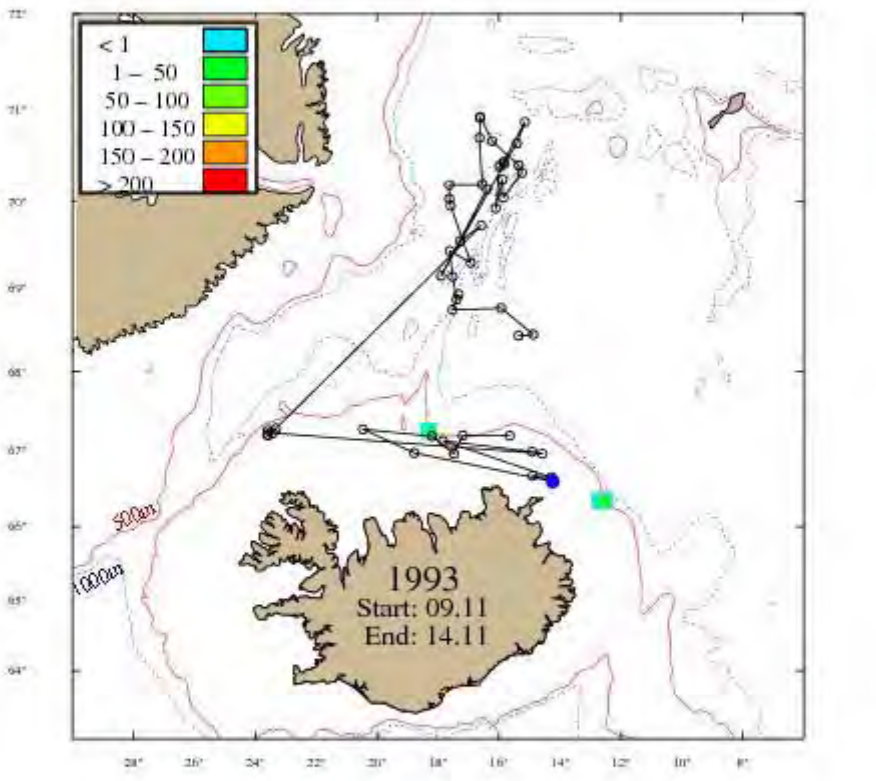
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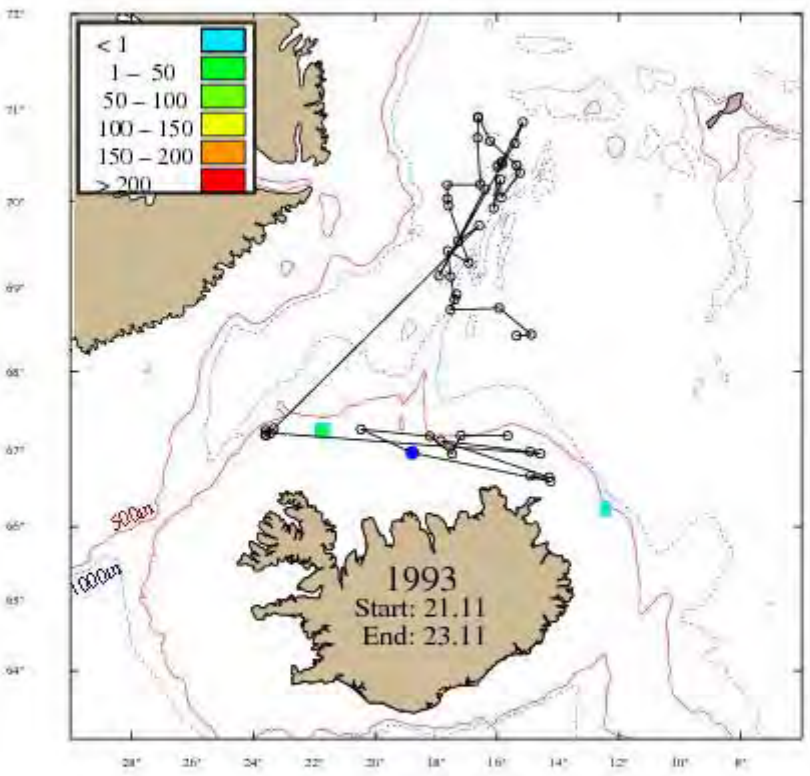
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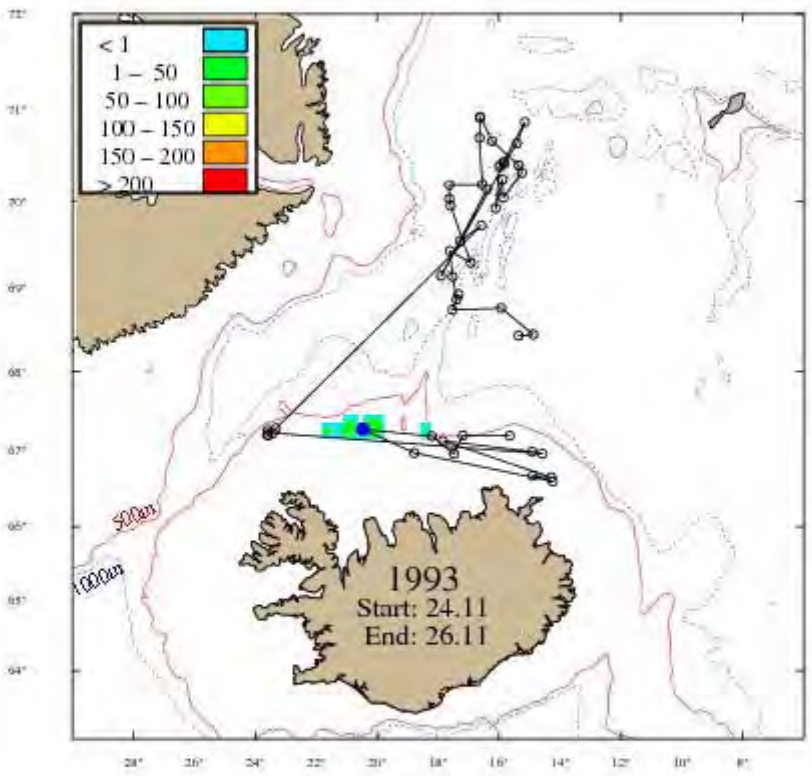
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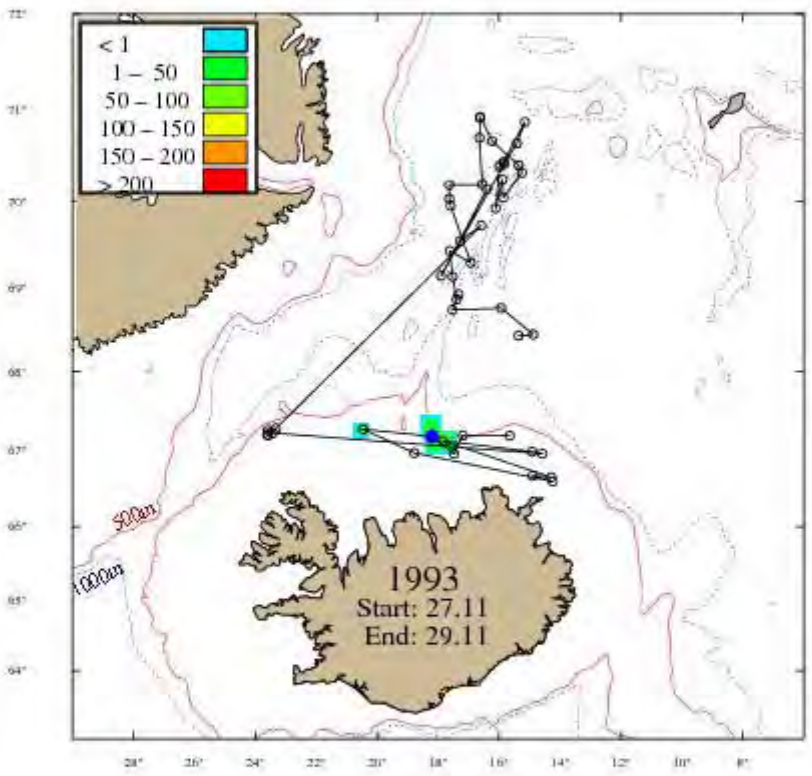
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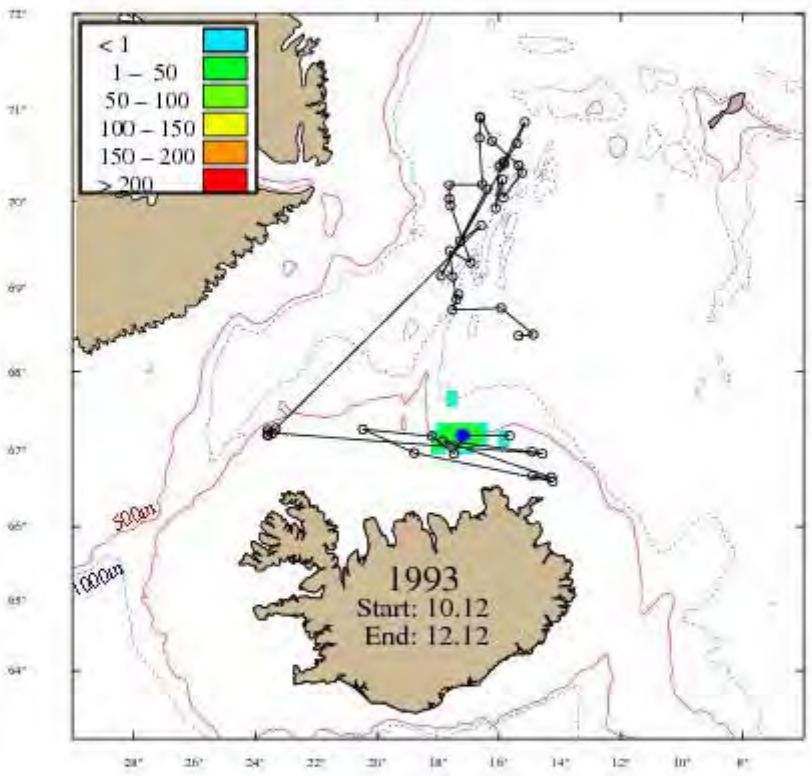
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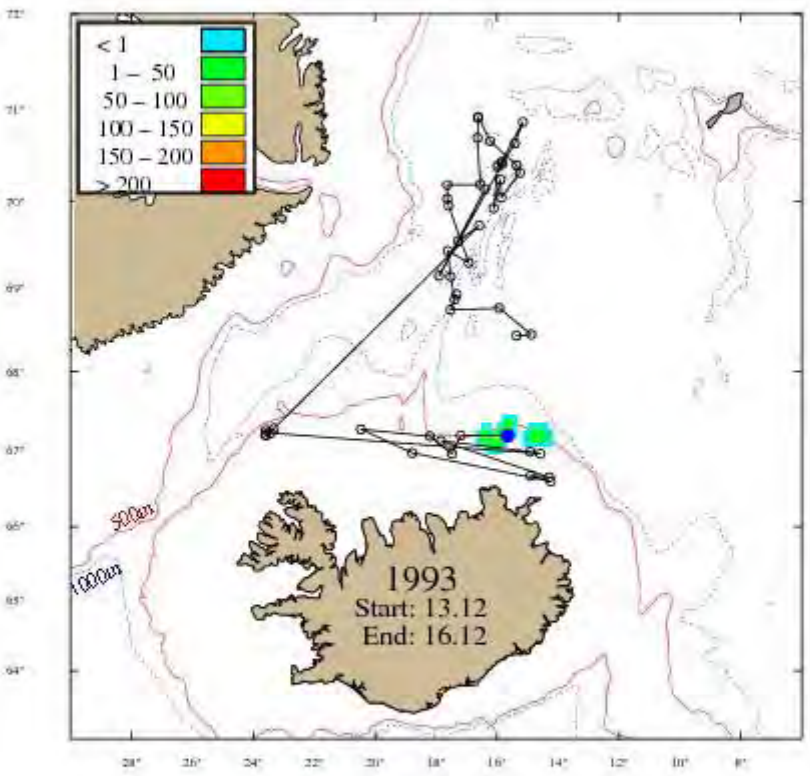
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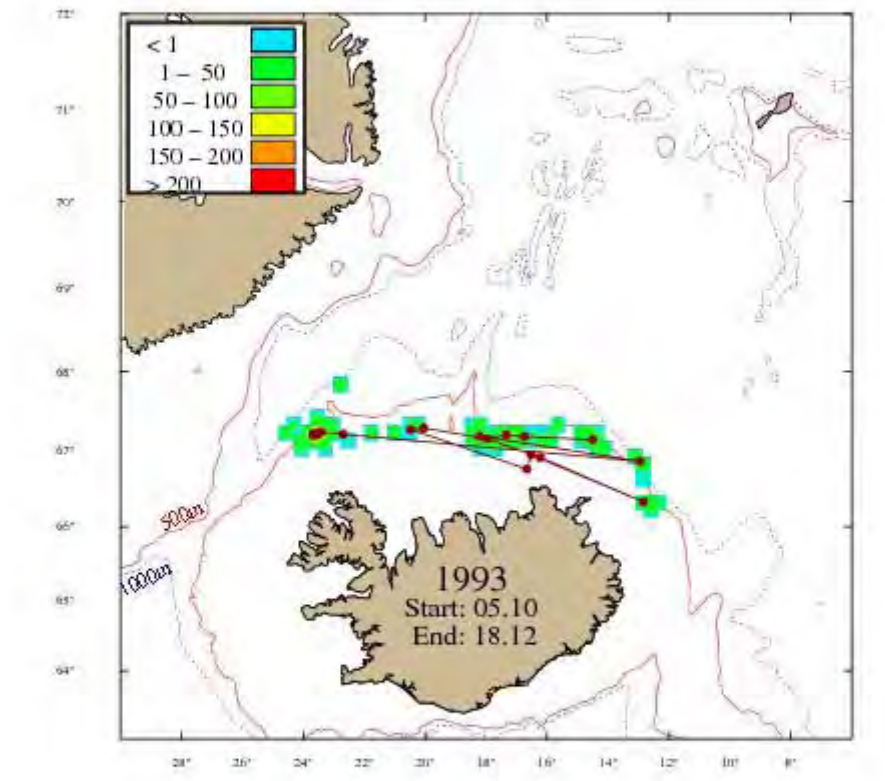
1993
Start: 13.12
End: 16.12

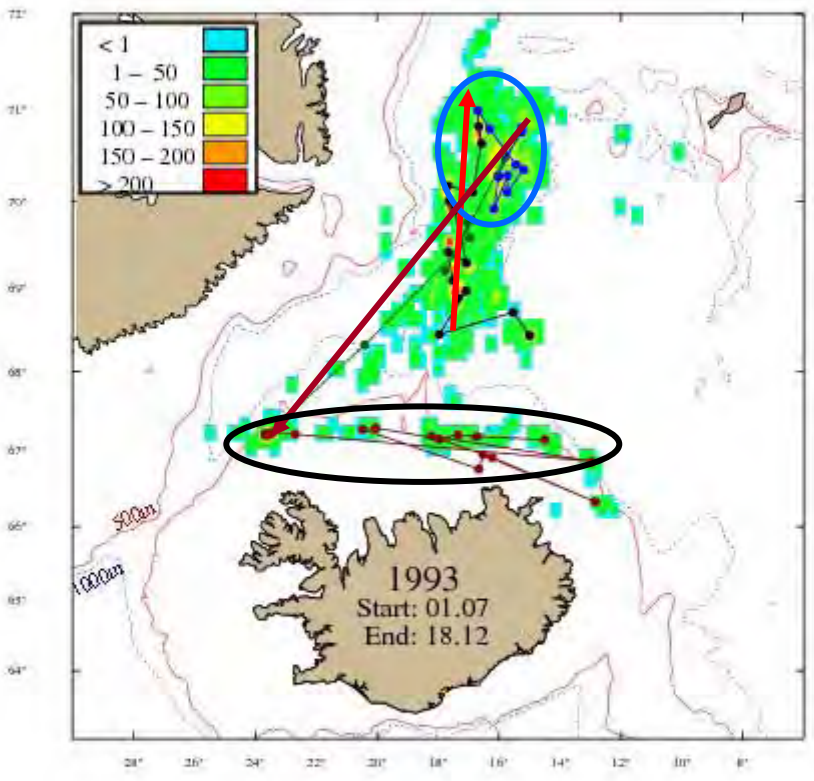
Pre-spawning phase



Late autumn – early winter.

“Traditional” period and area of acoustic surveying and stock assessment.

Overall distribution and migration path



North migration

~7 weeks

Intensive feeding, ~4 weeks

Return migration

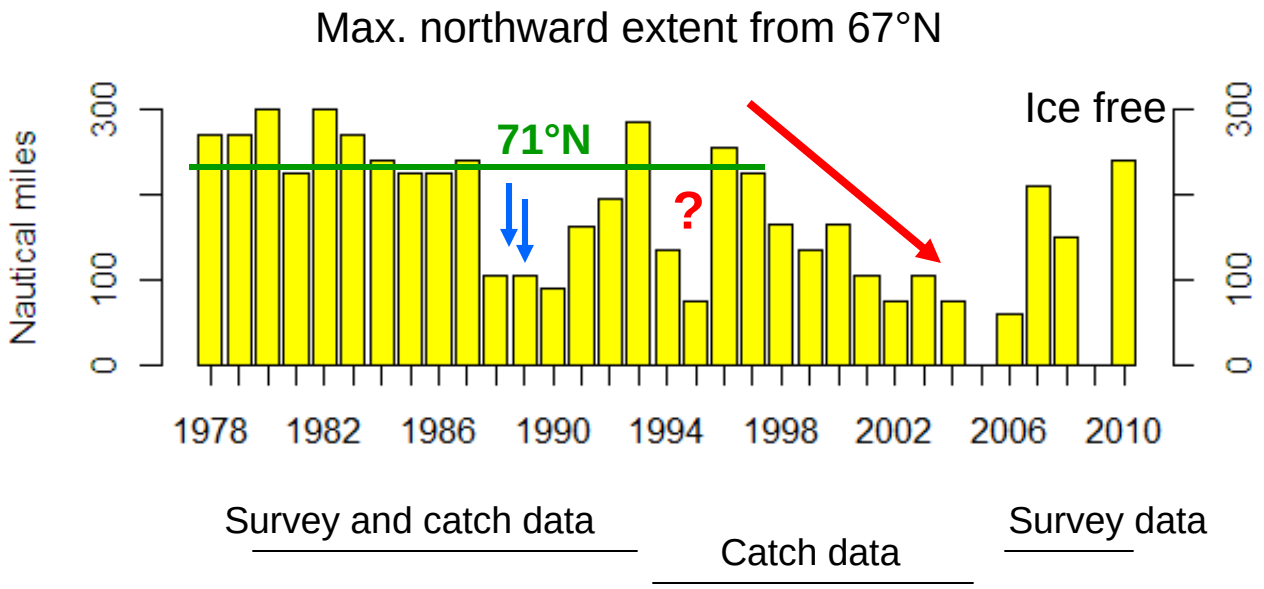
~4 weeks

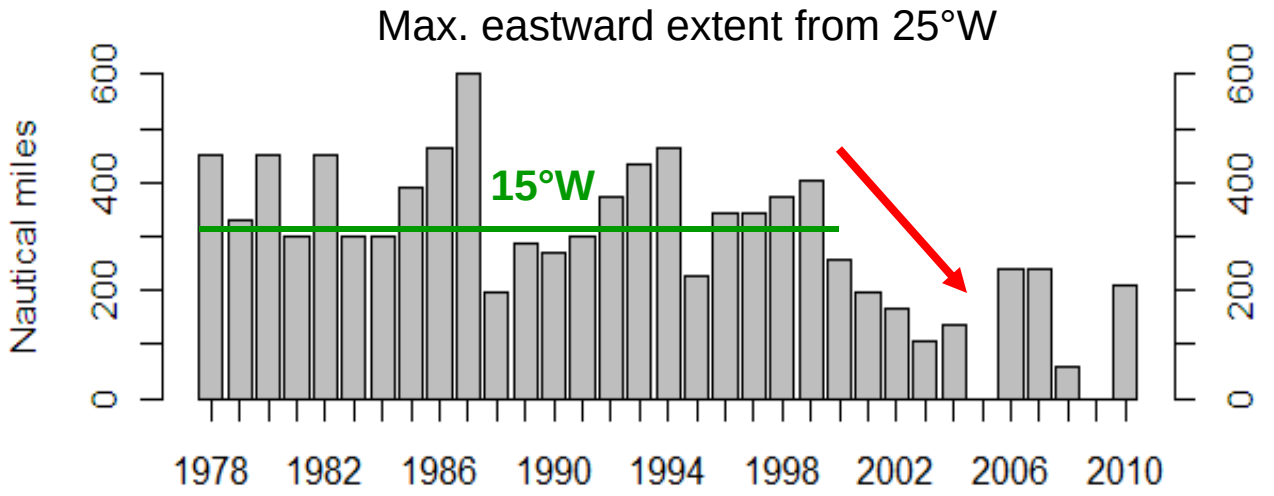
Pre-spawning phase

~8 weeks +

Long-term changes in feeding migration extent 1978-2010

Summer feeding migrations 1978-2010





1988-1989 cold years

Late 1978 – late 1990s "normal" migration pattern

During late 1990s into mid 2000s, declining extent to north and east

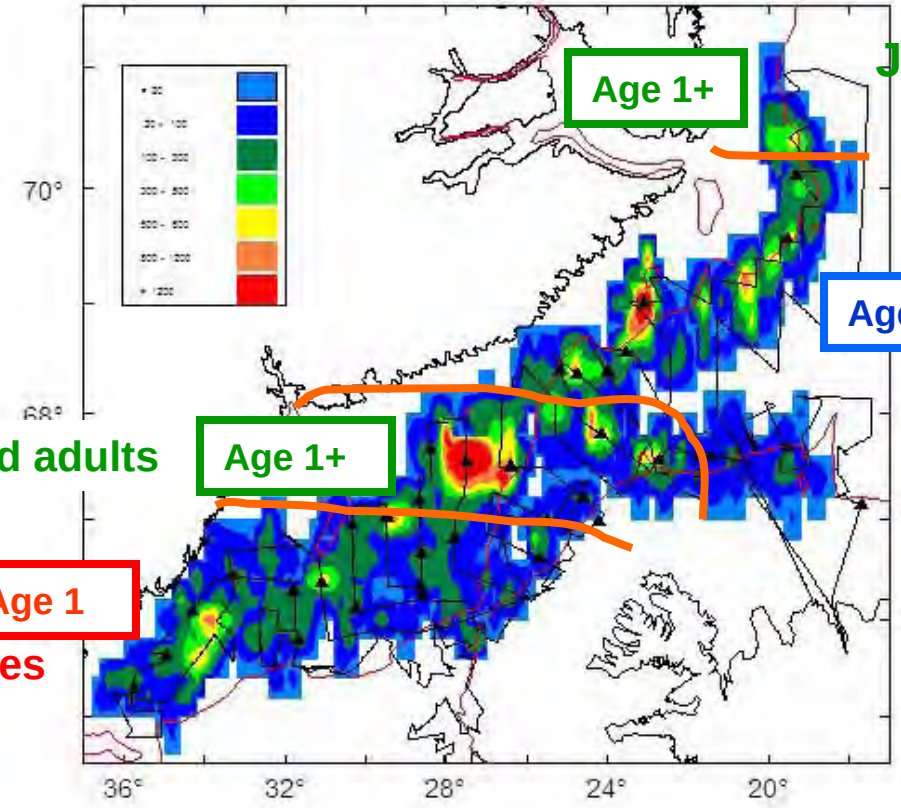
=> Warming ??

Since 2007 no ice in late summer and in autumn.

=> Increased north extent but further west than in previous decades

Current capelin (I+) distributions

September/October 2010



Age 1+

Juveniles and adults

Age 2+

Adults mostly (pre-spawners)

Juveniles and adults

Age 1+

Age 1

Juveniles mostly

Conclusions

Ecosystem structure

1) There are indications – direct and indirect - of a slight warming in the Iceland Sea in recent years.
2) Long-term changes on the primary and secondary ecosystem levels cannot be evaluated because of lack of data.
3) The overall structure of the ecosystem, however, seems “healthy”, except perhaps for the reduced level of the capelin stock.
4) The “traditional” ecological function of the Iceland Sea and adjacent waters, as a nursery area and feeding ground for capelin, seems to have changed dramatically in recent years.

Conclusions

Capelin distributions

1) “Traditional” feeding migrations of adult capelin into the northern Iceland Sea have not been as extensive since the mid 1990s as observed before.
2) Even more noticeable is the much shortened eastward extension of the feeding migration.
3) New nursery grounds of juvenile capelin and new and more restricted feeding grounds for adult capelin, in East Greenland waters have been recorded.
4) Reduced capelin recruitment and stock size in recent years may be a consequence of those changes.
5) This may be associated with increased/changed inflow of warmer waters and reduced ice cover.
6) So far, however, we have not been able to verify such hypotheses.