Pacific and Atlantic gateways to the Arctic for plankton and fish

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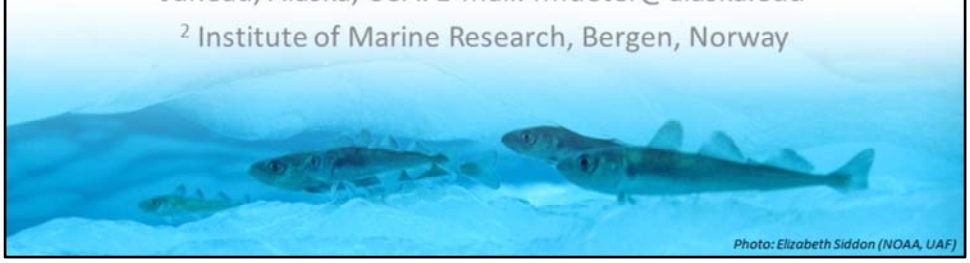
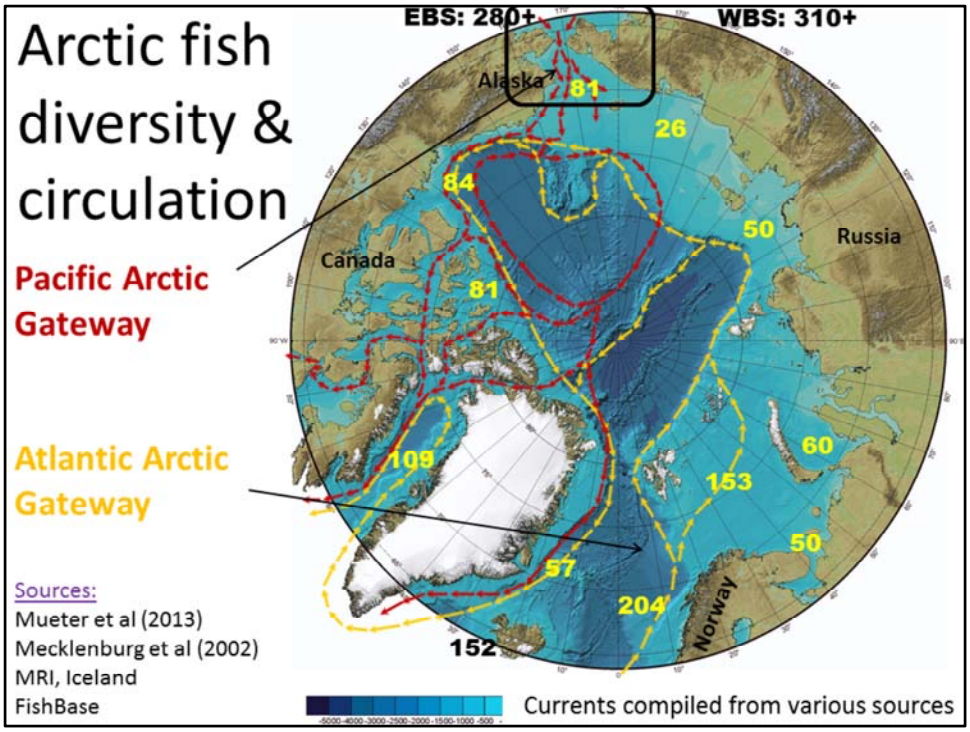


Photo: Elizabeth Siddon (NOAA, UAF)

Goals

- Compare processes driving advection from the Subarctic into the Pacific and Atlantic Arctic
- Compare how fish have adapted to these advective processes in each region
- Assess potential for species expanding into the Arctic in the Pacific and Atlantic

Photo: Elizabeth Siddon (NOAA, UAF)


Arctic fish diversity & circulation
Pacific Arctic Gateway
Atlantic Arctic Gateway
Sources:
Mueter et al (2013)
Mecklenburg et al (2002)
MRI, Iceland
FishBase
EBS: 280+
WBS: 310+
Alaska
Canada
Russia
Norway
81
26
84
50
81
109
153
60
50
57
204
152
Currents compiled from various sources

Pacific Arctic Gateway

- Northward flow from subarctic to the Arctic Ocean
- Seasonal ice cover
- <u>Shallow shelf</u>

→ System is "reset" each winter with persistent cold pool into summer

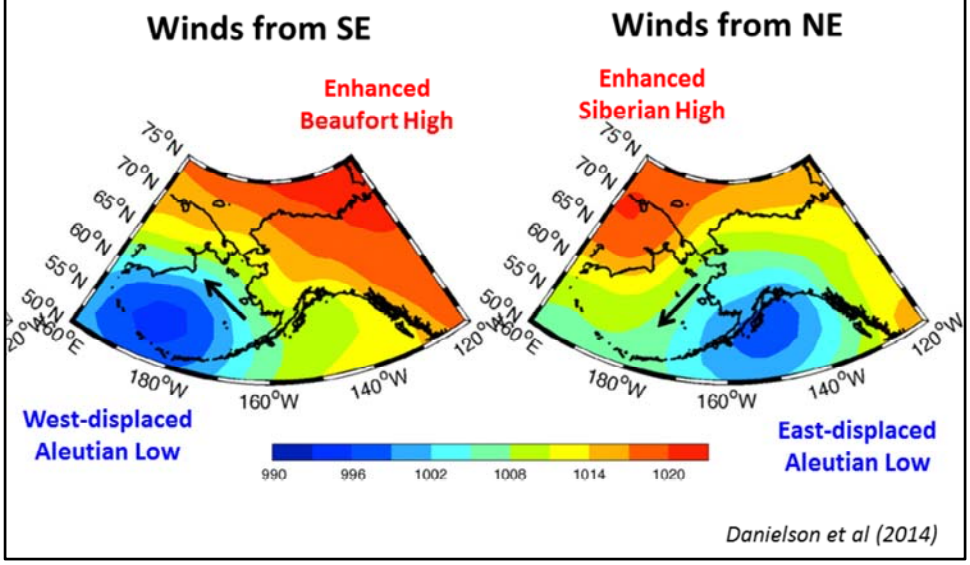
What drives northward flow and its variability?

- Steric height difference between Arctic & North Pacific Ocean
- A combination of local & remote wind forcing

Photo: Elizabeth Siddon (NOAA, UAF)

Atmospheric forcing

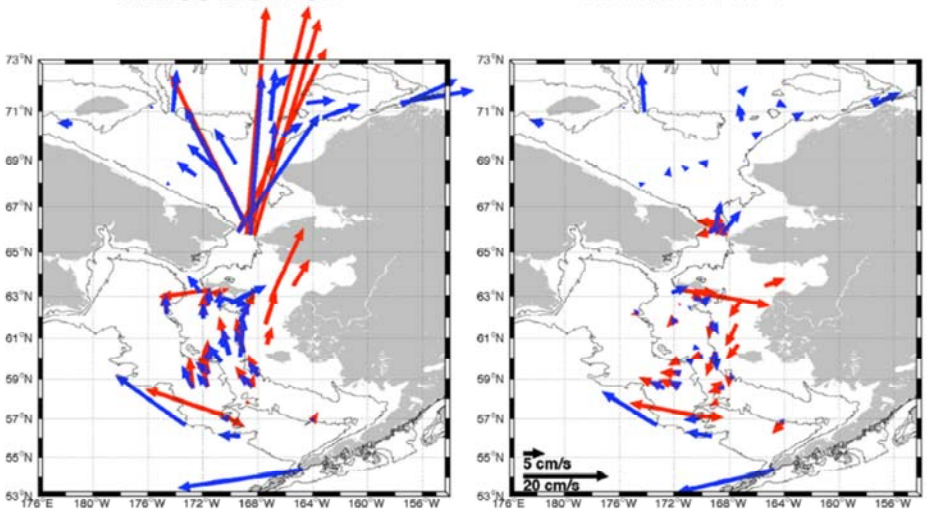
October- April Mean Sea level pressure



Danielson et al (2014)

Oceanographic response

(current meter moorings: surface / bottom layer)

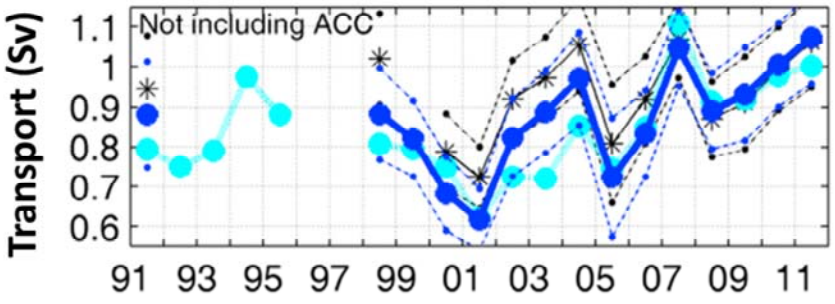


Danielson et al (2014)

Flow through Bering Strait

- Range: 0.6 – 1.1 Sv
- Increased transport 1998-2011

(estimated from 2 different moorings)



Woodgate et al (2014)

Biological fluxes through Bering Strait

- Phytoplankton
- Zooplankton (incl. euphausiids)

} Contribute to high productivity in Chukchi Sea

- Fish eggs, larvae, and juveniles

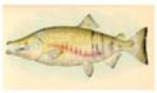
Photo: Elizabeth Siddon (NOAA, UAF)

Eggs and larvae

- Limited ichthyoplankton collections (summer)
- Little evidence of larval concentrations in Bering Strait region

Juvenile salmon

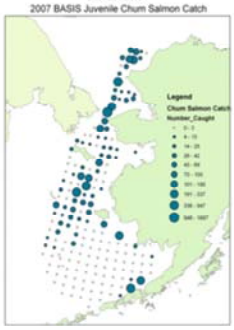
Chum salmon

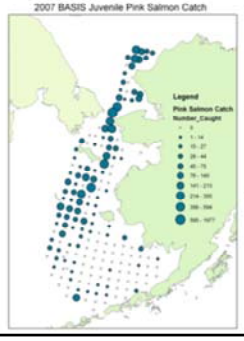


Pink salmon

Eisner et al. 2012

2007





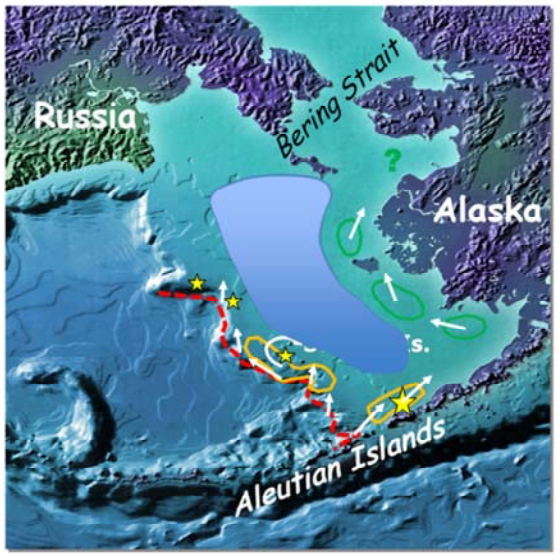
2012

2013

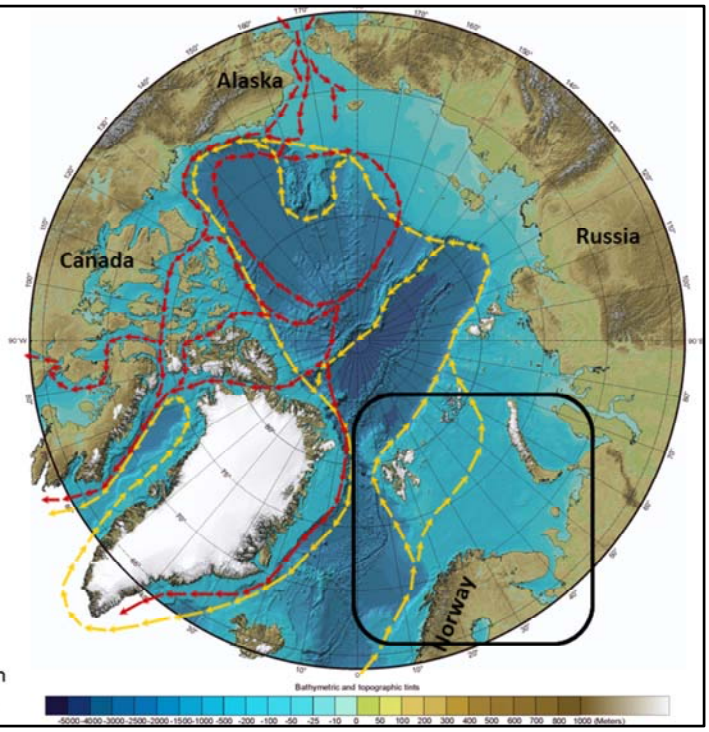
Arctic Ecosystem Integrated Survey
Figures by Alex Andrews, NOAA

Generalized spawning locations

- Pollock (Barbeaux et al 2013, Petrik et al 2014)
- Yellowfin sole (Wilderbuer et al 1992)
- Deepwater flatfish, rockfish (various sources)
- Pacific cod (Neidetscher et al. In Press)

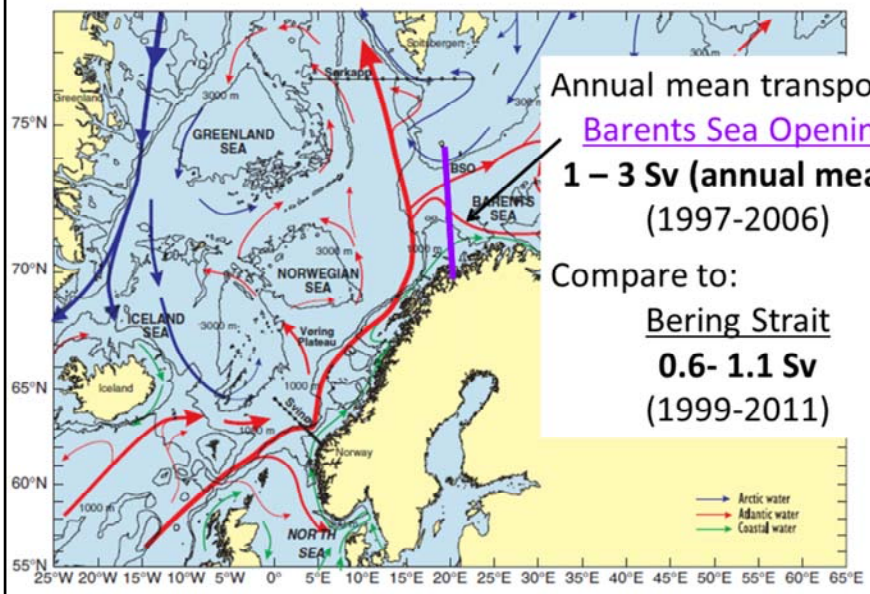


Atlantic Arctic Gateway



Currents compiled from various sources, based on E. Carmack, pers. comm.

Atlantic Arctic Gateway



Annual mean transport:

Barents Sea Opening

1 – 3 Sv (annual mean)

(1997-2006)

Compare to:

Bering Strait

0.6- 1.1 Sv

(1999-2011)

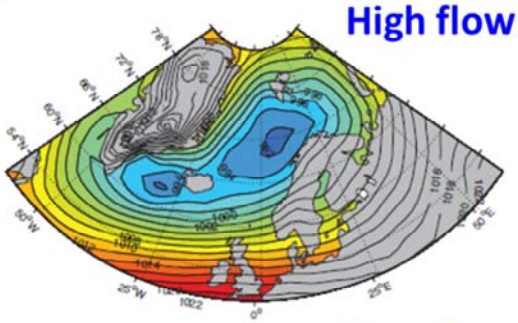
Skagseth et al 2008

Atmospheric forcing

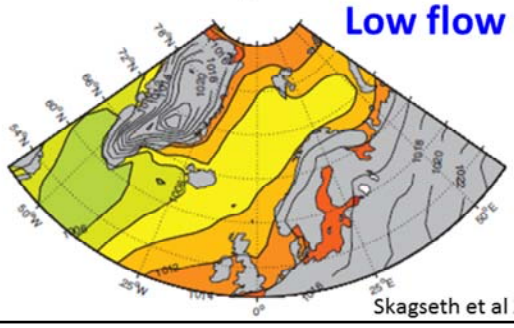
- As in Pacific, variability related to strength & position of major low pressure system and associated storm tracks
- Large-scale forcing

Sea Level Pressure

High flow



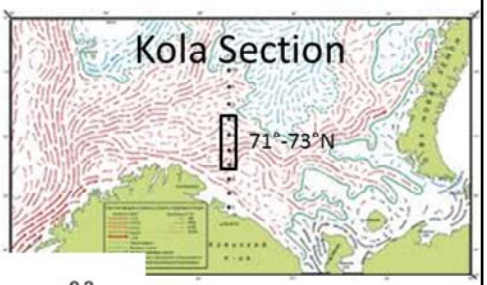
Low flow

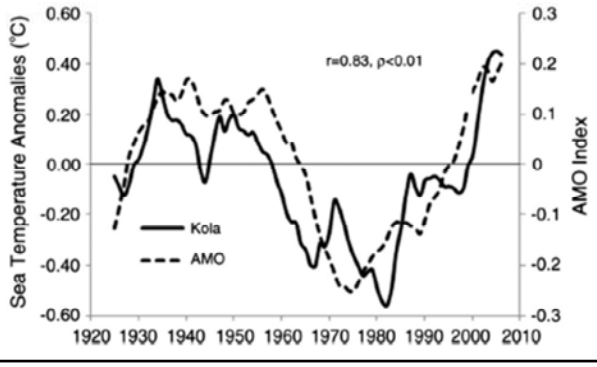


Skagseth et al 2008

Large-scale forcing evident in temperature

- Close association with the Atlantic Multidecadal Oscillation (AMO)

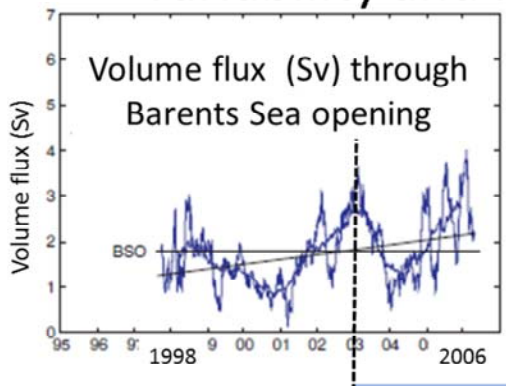




10-yr running means of 0-200 m average Kola temperatures and AMO index.

Drinkwater et al. 2014

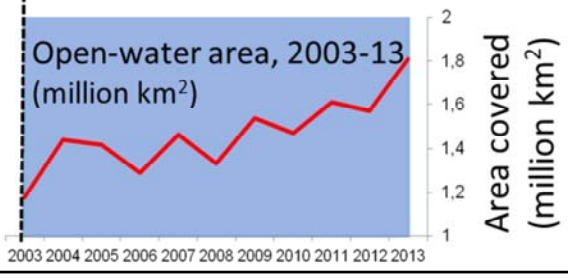
Variability and recent trends



Skagseth et al 2008

- Decadal-scale changes in transport
- Recent increase in transport into Barents Sea & associated warming

- Increasing ice-free area



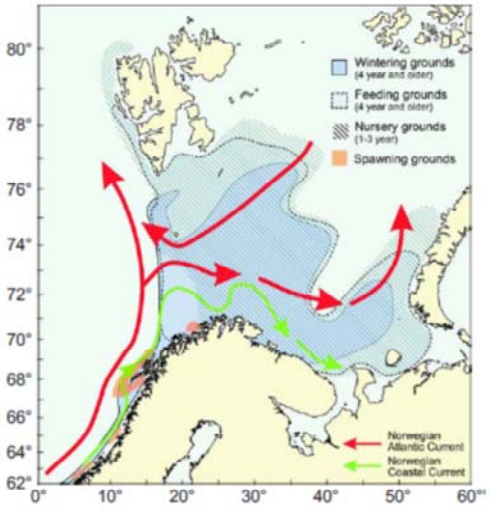
Harald Loeng, IMR

Biological fluxes

- Advection contributes about 1/3 of annual zooplankton production in southern Barents Sea (Dalpadado et al. 2012)

- Fish eggs and larvae are advected to productive nursery areas in the Barents Sea (Atlantic cod, herring, haddock)
- Adult fish migrate into Barents Sea to feed during summer

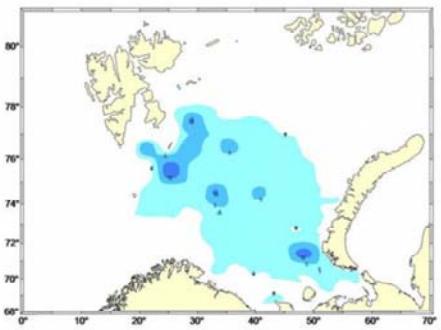
Advection of Arcto-Norwegian cod



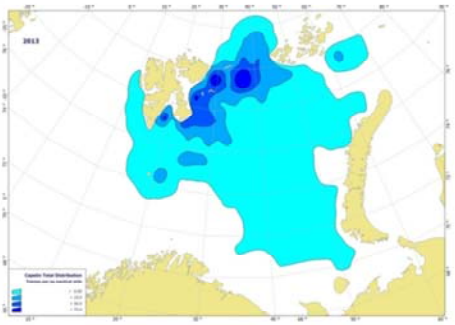
- Major spawning just upstream from Barents Sea
- Advection of eggs and larvae to nursery areas
- Some evidence for a positive relationship between advection and recruitment

Capelin distribution

2003



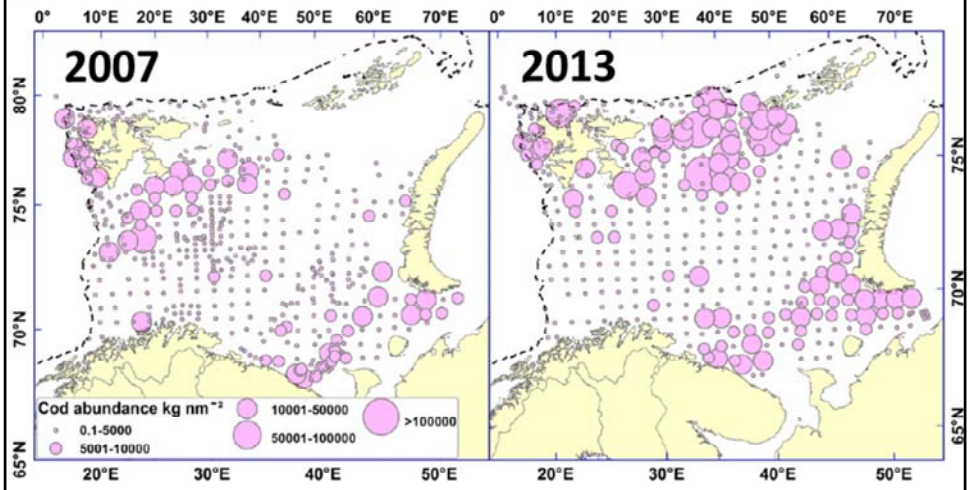
2013



Institute of Marine Research 2014

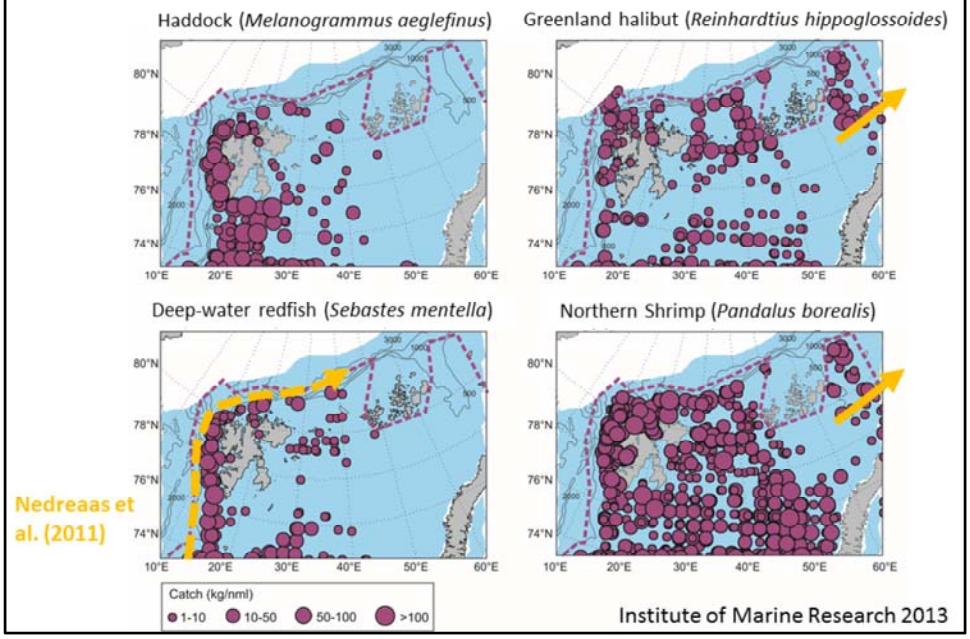
Predators follow their prey

Cod catch rates: 2007 vs 2013



Kjesbu et al 2014

Other species on the rim of the Arctic Ocean



Nedreaas et al. (2011)

Summary & Conclusions

- Approximately 2-3 fold differences in annual volume transport from Subarctic to Arctic
  - driven by local and remote wind forcing (strength & position of major Low Pressure systems)
  - Recent increases in flow through both Pacific & Atlantic Arctic Gateways (linked?)
- Larval fish in both Pacific & Atlantic are advected to favorable feeding areas, but…
  - Pacific: Large demersal fish stocks retained on SE Bering Shelf, unable to exploit high Chukchi Sea production
  - Atlantic: Large pelagic fish stocks adapted to exploit high production in Barents Sea (both advected and local)

Summary & Conclusions

Possible expansion from Subarctic to Arctic?

Pacific

- History suggests high potential for expansion of shallow-water fish from Pacific into (& through) Arctic
- Cold pool, advective patterns, and life histories suggest this is unlikely under current and foreseeable future conditions

Atlantic

- Advective patterns, life histories, and "open" Arctic favor expansion of both shelf and slope species into high Arctic and Russian Arctic
- Recent conditions have favored such expansion


THANK YOU!