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
Arctic fish diversity & circulation

Pacific Arctic Gateway

Atlantic Arctic Gateway

Sources:
Mueger et al (2013)
MRI, Iceland
FishBase

Currents compiled from various sources
Pacific Arctic Gateway

- Northward flow from subarctic to the Arctic Ocean
- Seasonal ice cover
- Shallow shelf

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 Lidstrom (NOAA, UAF)
Atmospheric forcing  
October- April Mean Sea level pressure

Winds from SE
Enhanced Beaufort High
West-displaced Aleutian Low

Winds from NE
Enhanced Siberian High
East-displaced Aleutian Low

Danielson et al (2014)
Oceanographic response
(current meter moorings: surface / bottom layer)

Winds from SE

Winds from NE

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)
- Fish eggs, larvae, and juveniles

Contribute to high productivity in Chukchi Sea

Photo: Elizabeth Siddon (NOAA, UA/II)
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

Arctic Ecosystem Integrated Survey
Figures by Alex Andrews, NOAA
Generalized spawning locations

- Yellowfin sole (Wilderbuer et al 1992)
- Pollock (Barbeaux et al 2013, Petrik et al 2014)
- 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
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

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

Skagseth et al. 2008

- Increasing ice-free area

Harald Iong, IMR

Open-water area, 2003-13 (million km²)

Area covered (million km²)
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

Haddock (*Melanogrammus aeglefinus*)

Greenland halibut (*Reinhardtius hippoglossoides*)

Deep-water redfish (*Sebastes mentella*)

Northern Shrimp (*Pandalus borealis*)

*Institute of Marine Research 2013*

*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?

<table>
<thead>
<tr>
<th>Pacific</th>
<th>Atlantic</th>
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<tbody>
<tr>
<td>• History suggests high potential for expansion of shallow-water fish from Pacific into (and through) Arctic.</td>
<td>• Advective patterns, life histories, and “open” Arctic favor expansion of both shelf and slope species into high Arctic and Russian Arctic.</td>
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<td>• Cold pool, advective patterns, and life histories suggest this is unlikely under current and foreseeable future conditions.</td>
<td>• Recent conditions have favored such expansion.</td>
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THANK YOU!