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How eastern Bering Sea climate variability affects the distribution of walleye pollock early life stages

Colleen Petrik

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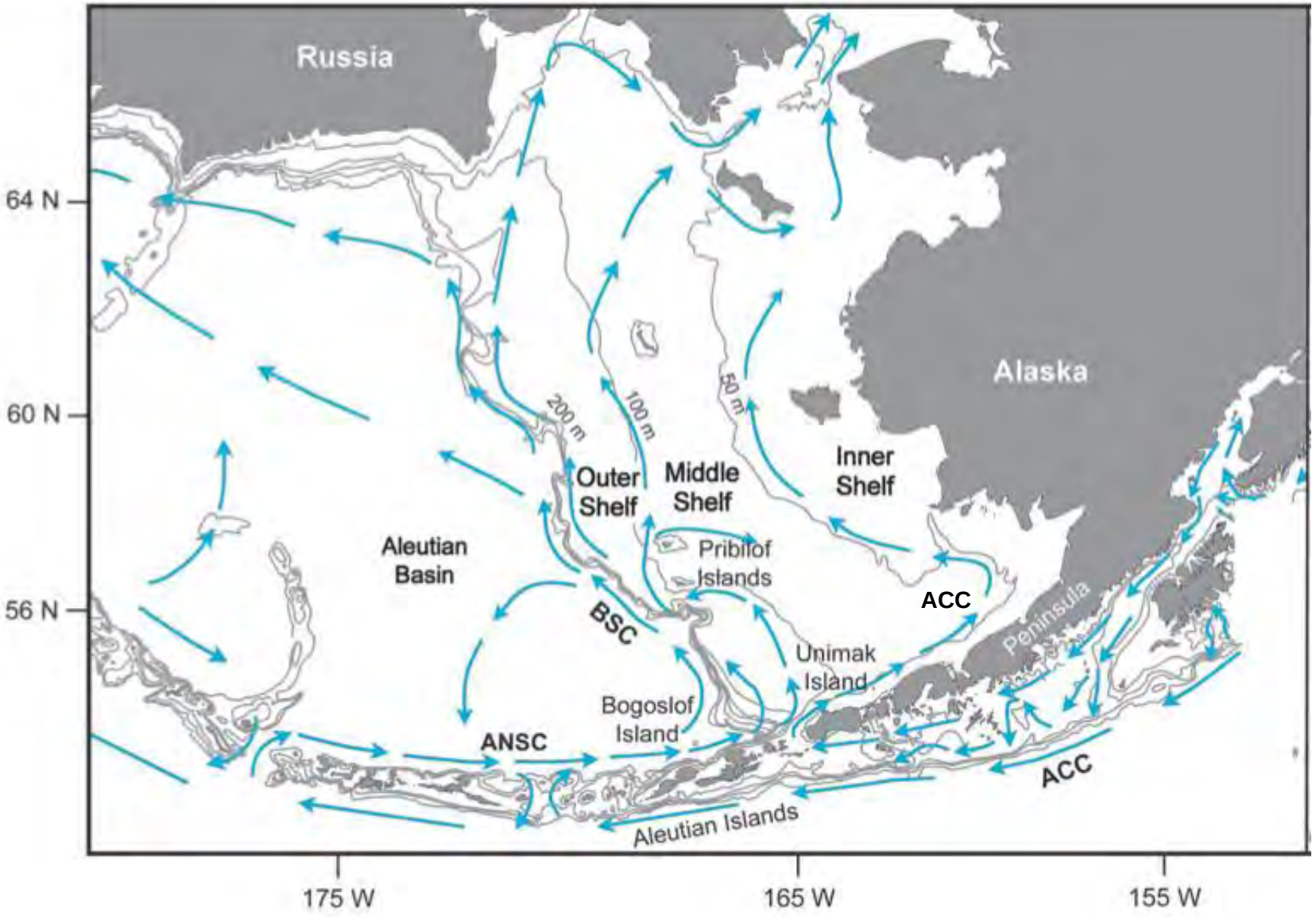
PICES ASC 2013 Nanaimo

UAF UNIVERSITY OF ALASKA FAIRBANKS

PICES

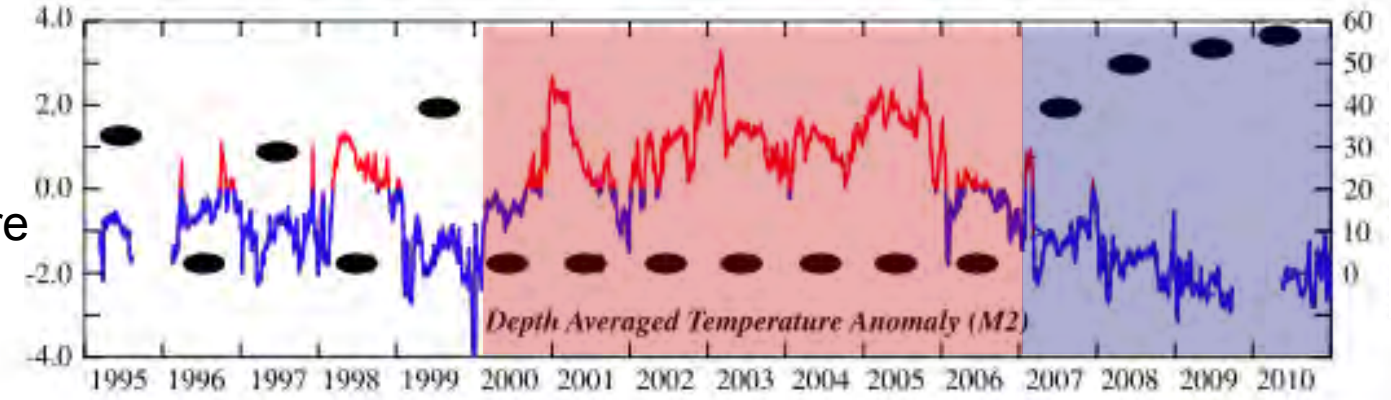
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

EASTERN BERING SEA



SEA ICE AND WATER TEMPERATURE

Depth-averaged temperature



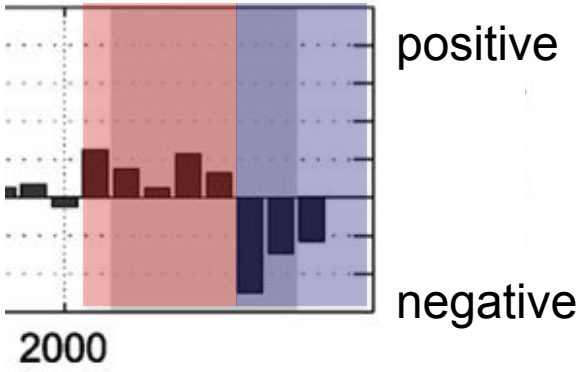
Percent ice cover

Year

Stabeno et al. 2012

WINDS AND CURRENTS

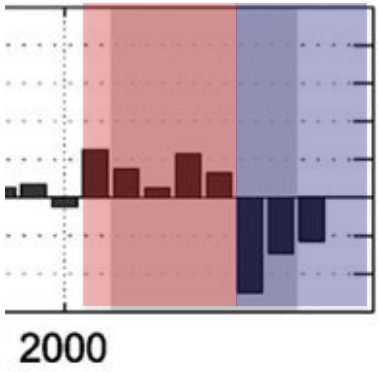
Oct-May wind direction anomaly = Winter cross-shelf Ekman transport



Danielson et al. 2011

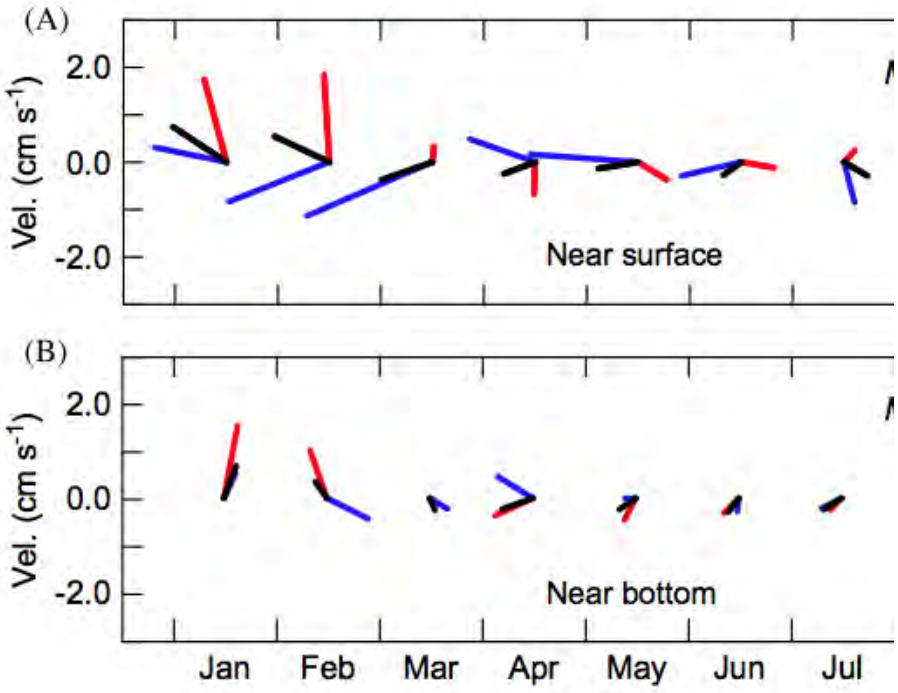
WINDS AND CURRENTS

Oct-May wind direction anomaly
=
Winter cross-shelf Ekman transport



Danielson et al. 2011

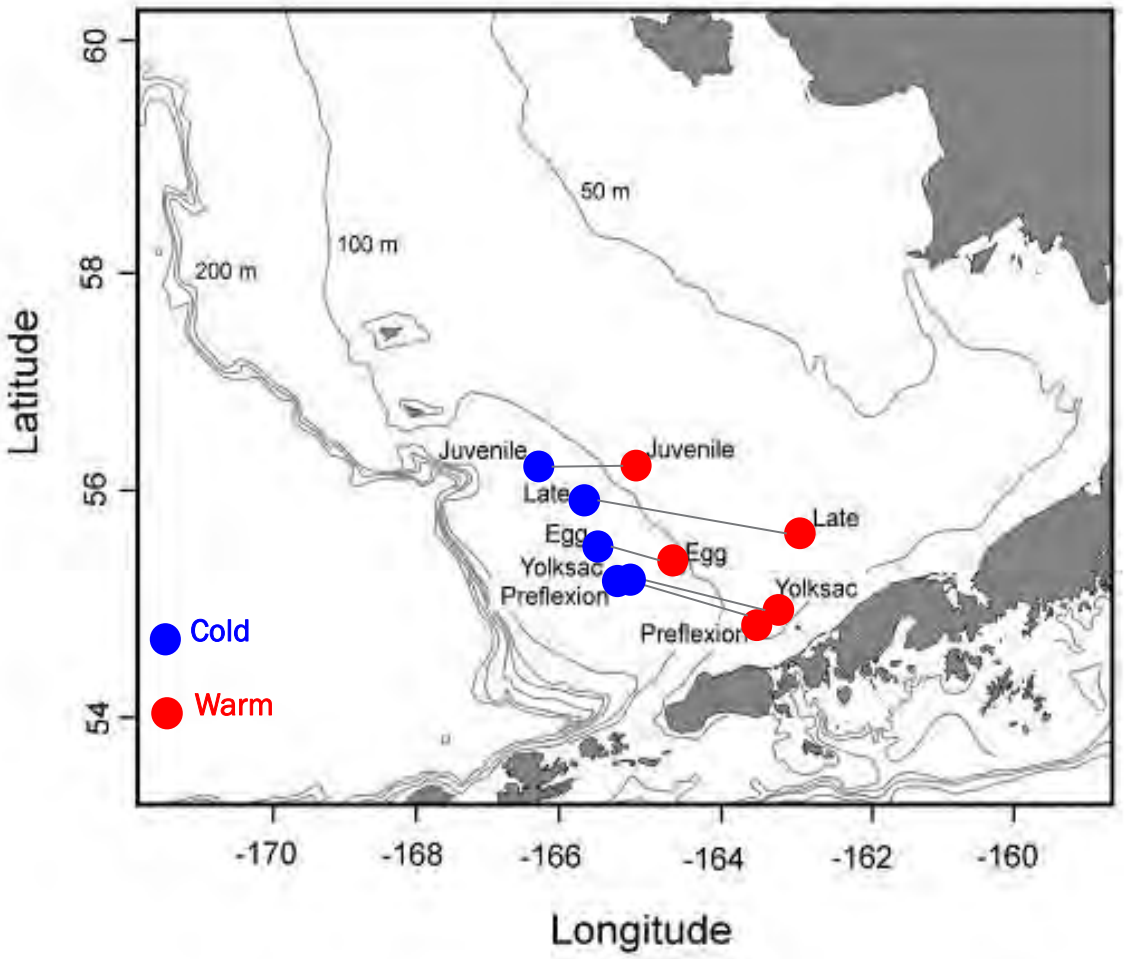
Monthly averaged currents at M2



Stabeno et al. 2012

POLLOCK ELS DISTRIBUTION

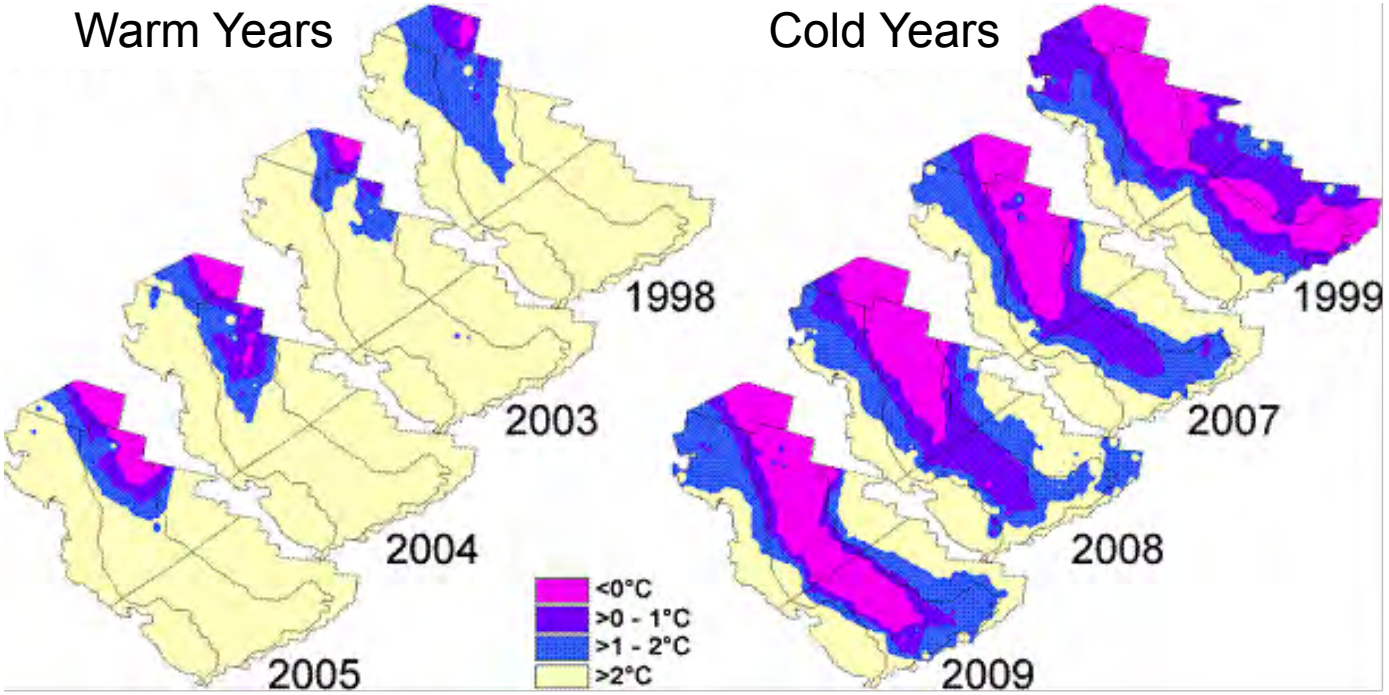
More on-shelf in warm years



Smart et al. 2012

POLLOCK SPAWNING

Adults avoid cold water → Change in spawning areas

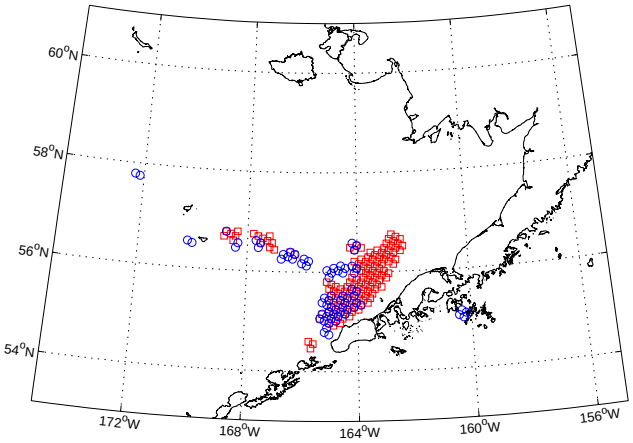


Stabeno et al. 2012

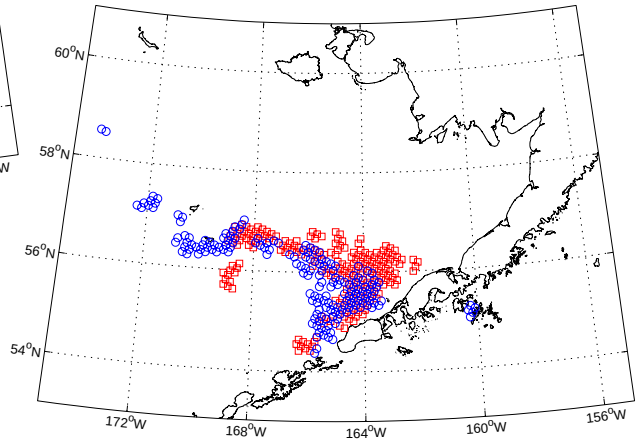
POLLOCK SPAWNING

More on-shelf in warm years

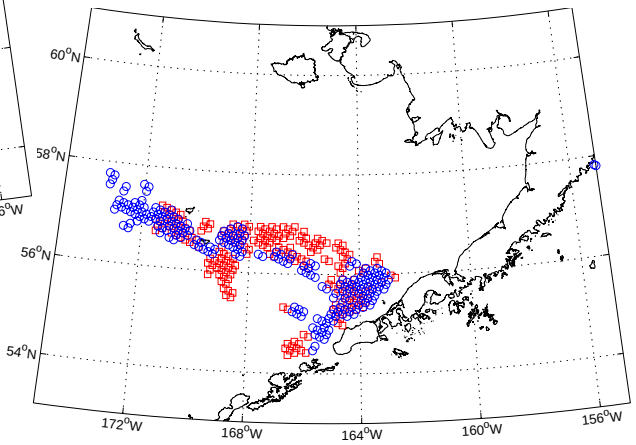
Jan wks 3-4



Feb wks 1-2



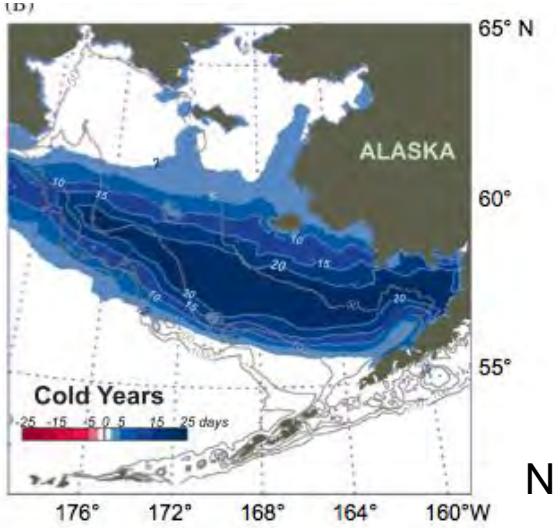
Feb wks 3-4

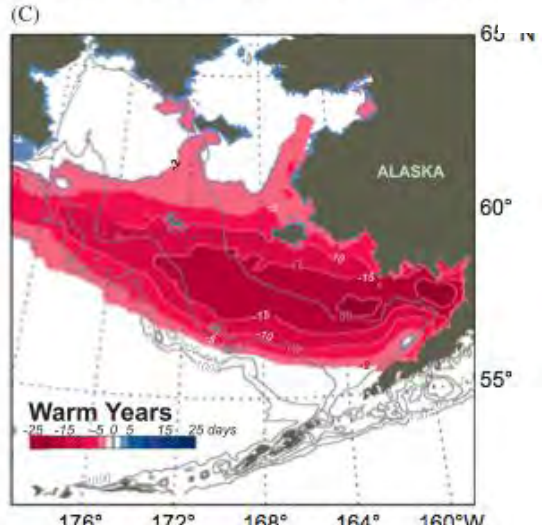


S. Barbeaux unpublished data

POLLOCK SPAWNING

Adults avoid cold water → Change in spawning time





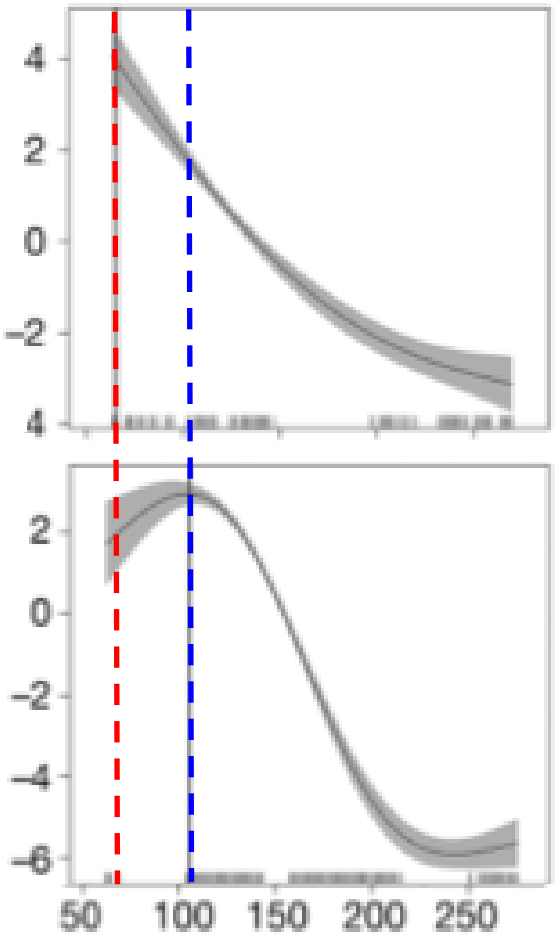
Number of days +/- avg with sea ice in Mar and Apr

Stabeno et al. 2012

POLLOCK SPAWNING

Later in cold years

Egg count anomaly



Warm

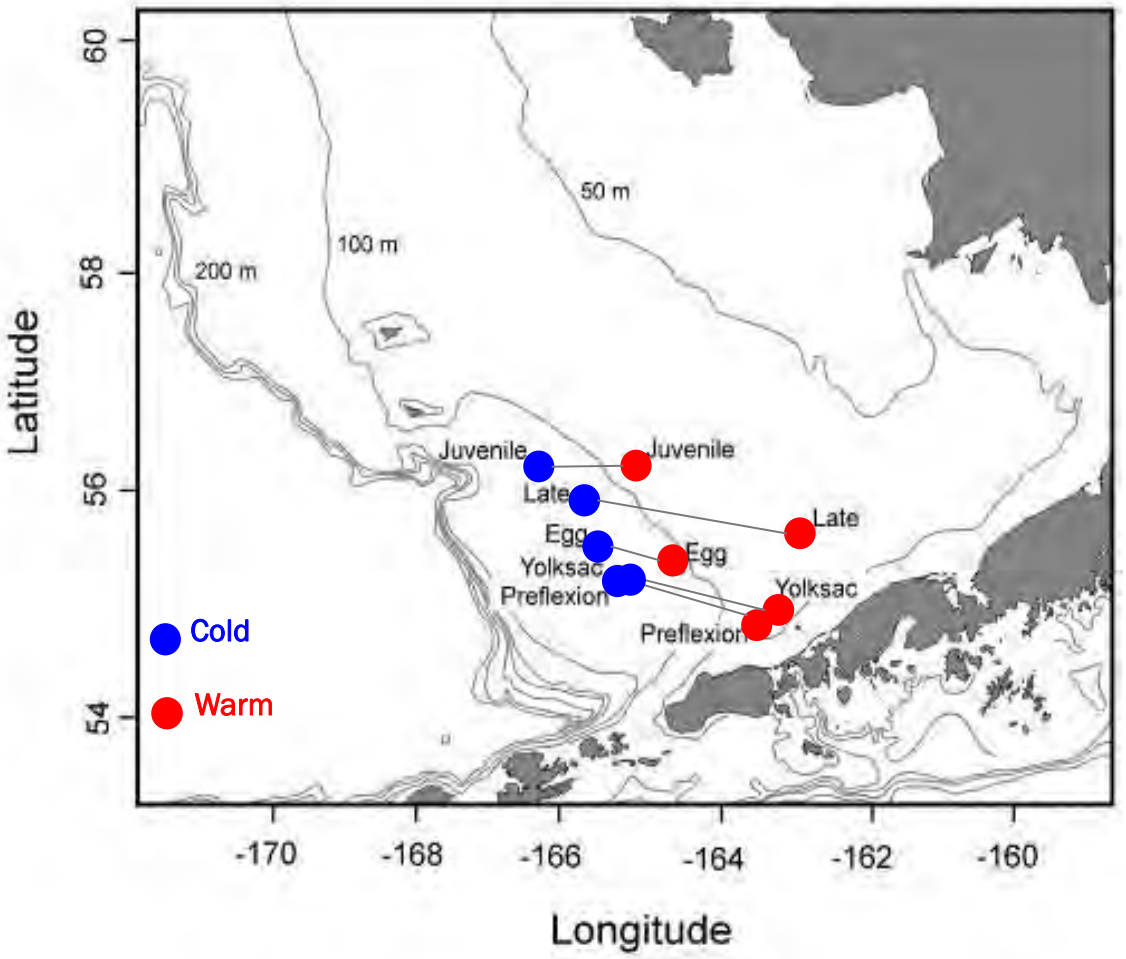
Cold

Julian Day

Smart et al. 2012

POLLOCK ELS DISTRIBUTION

More on-shelf in warm years



Similar to:

Currents

Spawning

Smart et al. 2012

POLLOCK QUESTIONS

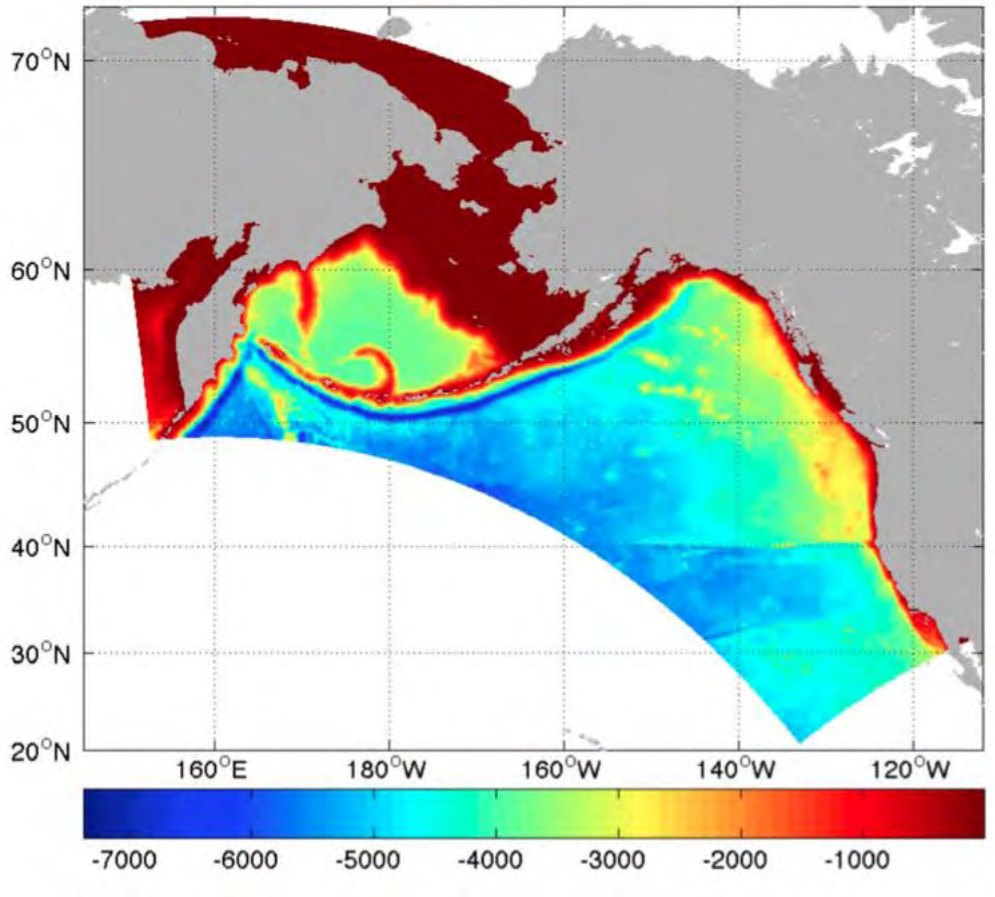
Does interannual climate variability result in different distributions of pollock early life stages?

What are the dominant physical mechanisms responsible for the different distributions?

- Wind effects on transport
- Temperature/ice effects on spawning location
- Temperature/ice effects on spawning time

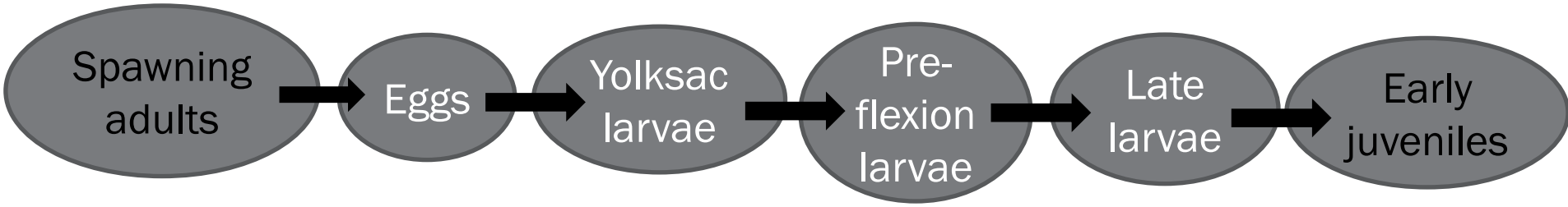
COUPLED MODELS

- ROMS NEP-6
  - Velocities
  - Vertical Diffusivity
  - Light
  - Temperature
- Tracmass
  - Offline particle tracking
  - Diffusion
  - Biological model
    - Development/Growth
    - Vertical behavior



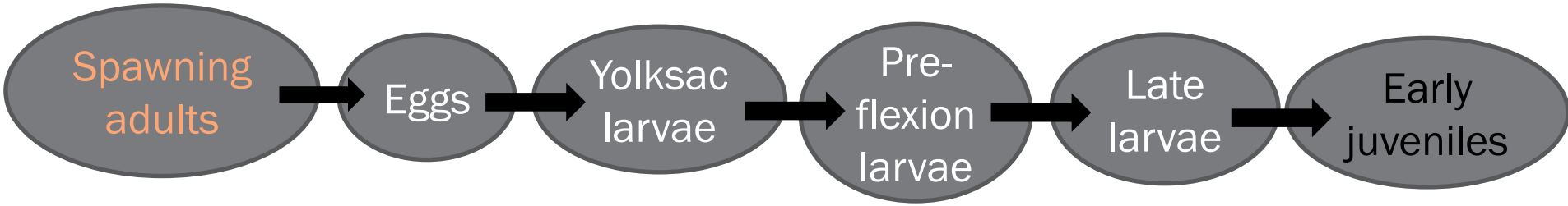
NEP-6 domain with bathymetry (m)

POLLOCK BIOLOGICAL MODEL



- Development/Growth
  - Function of temperature
- Vertical behavior
  - Eggs and yolksac passive (neutrally buoyant)
  - Preflexion and late restricted to mixed layer

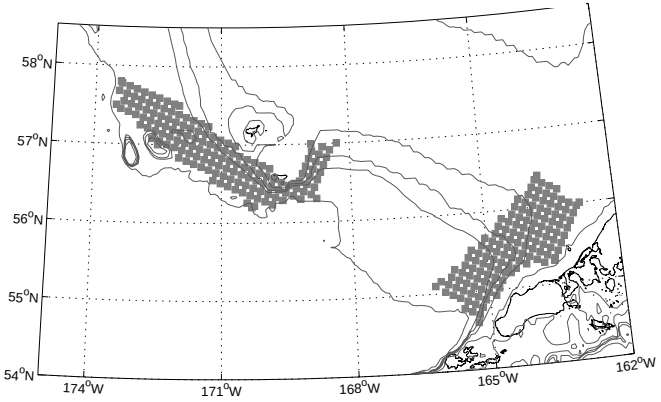
POLLOCK BIOLOGICAL MODEL



Spawning polygons for 2 wk periods based on spawning climatology (e.g. Mar wks 1-2)

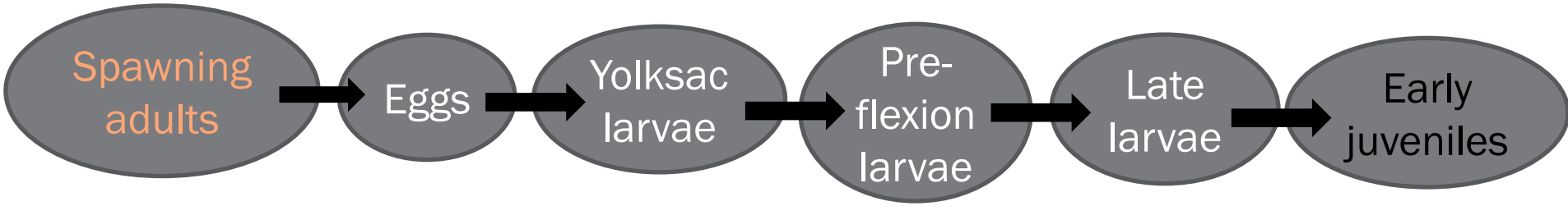
Transport test

Control



Same spawning locations in warm and cold years

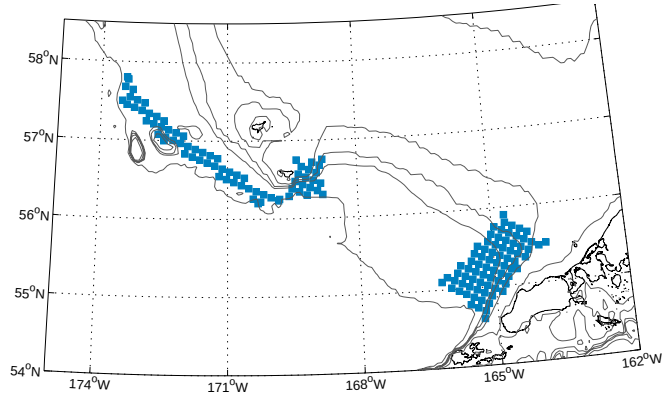
POLLOCK BIOLOGICAL MODEL



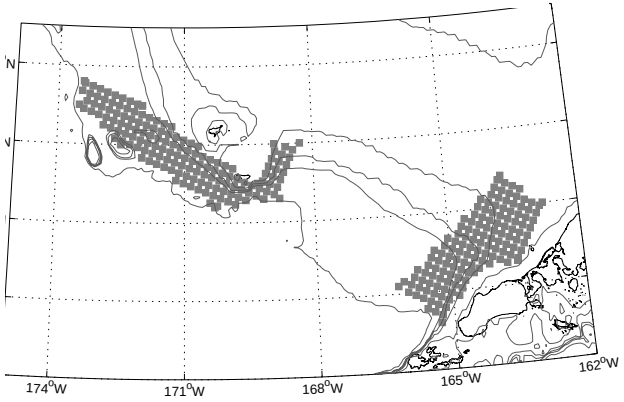
Spawning polygons for 2 wk periods based on spawning climatology (e.g. Mar wks 1-2)

Spawning location test

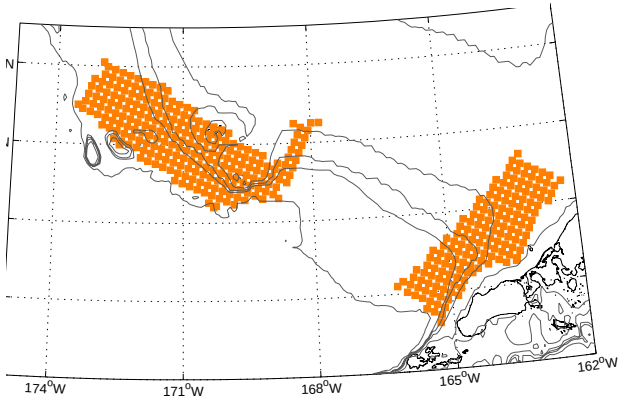
Cold



Control



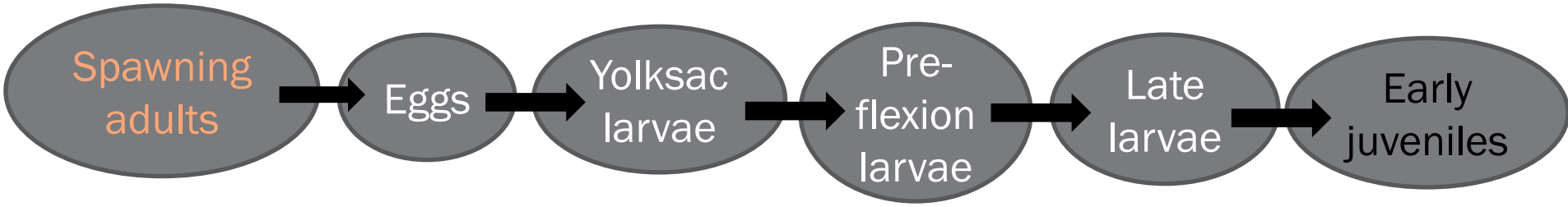
Warm



Contracted off-shelf

Expanded on-shelf

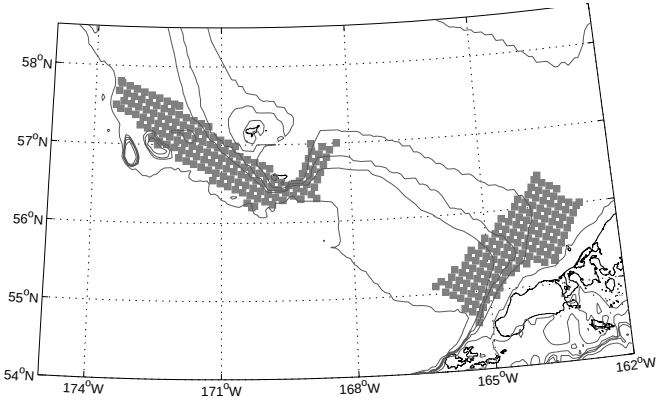
POLLOCK BIOLOGICAL MODEL



Spawning polygons for 2 wk periods based on spawning climatology (e.g. Mar wks 1-2)

Spawning timing test

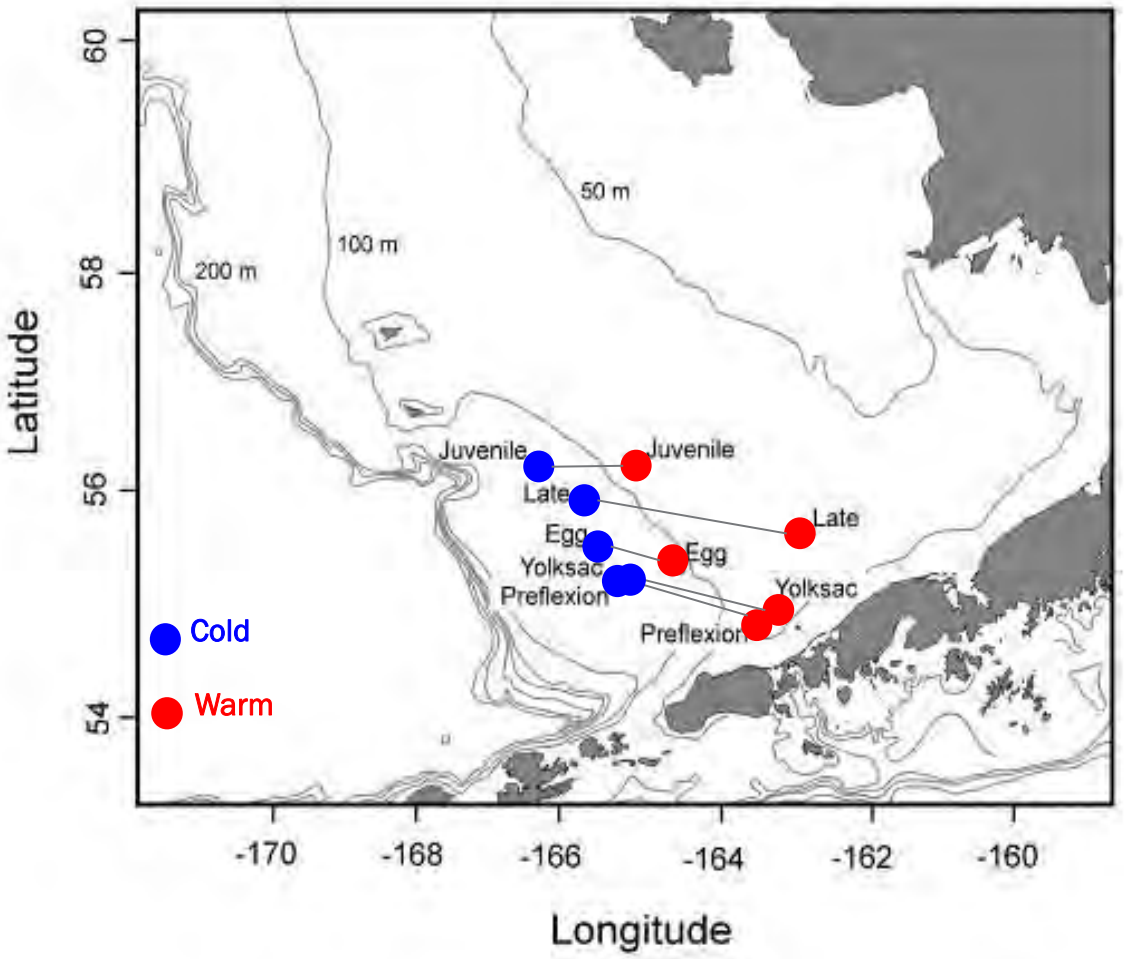
Cold | Control | Warm



Date = Apr 10 | Date = Mar 1 | Date = Mar 1

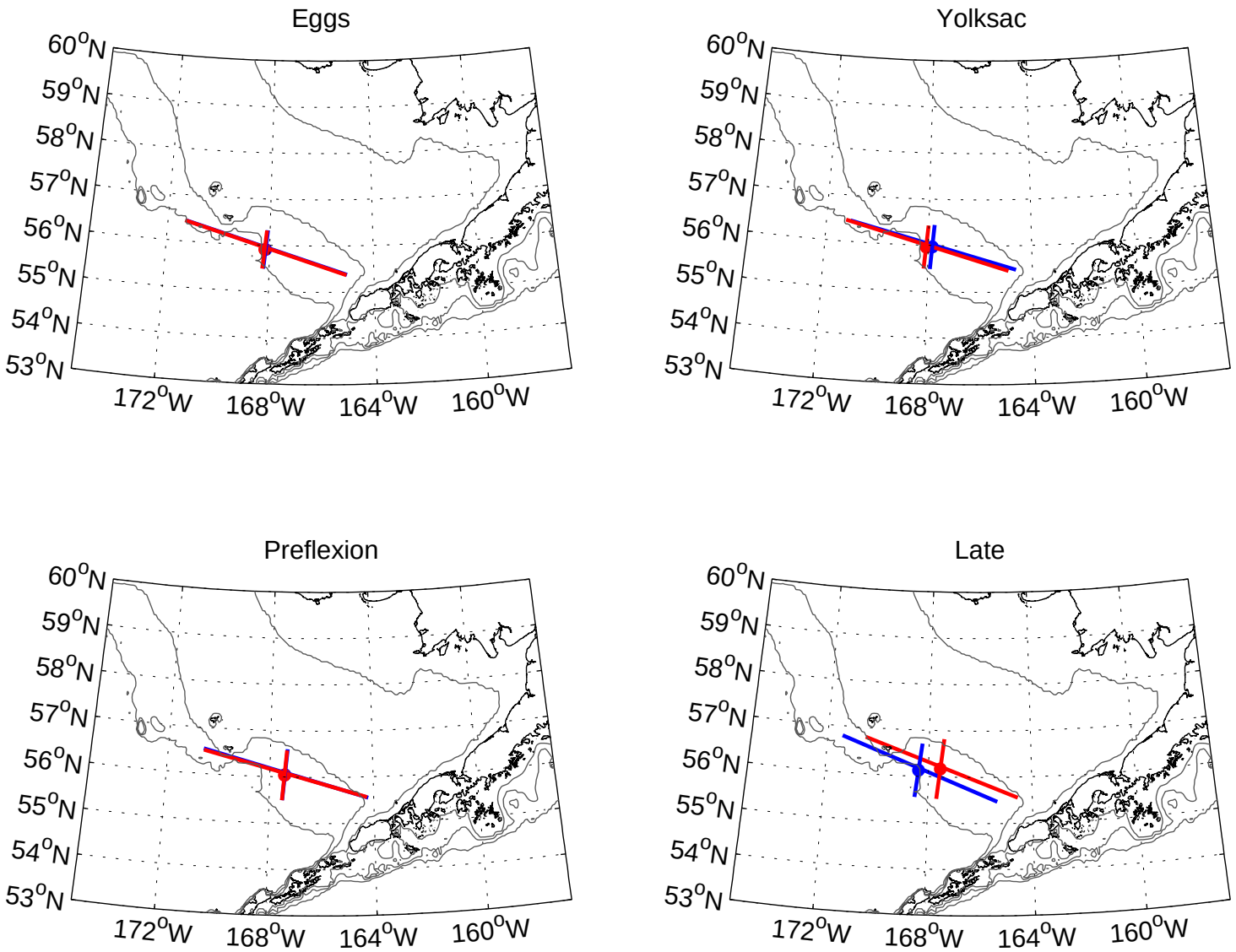
OBSERVED PATTERN

More on-shelf in warm years



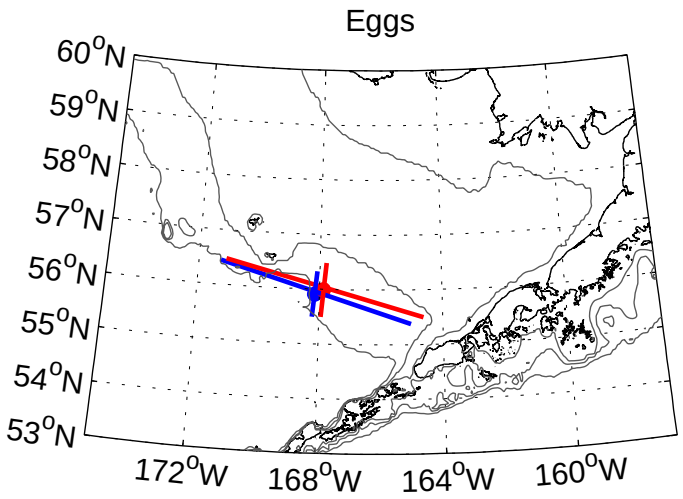
EFFECT OF TRANSPORT

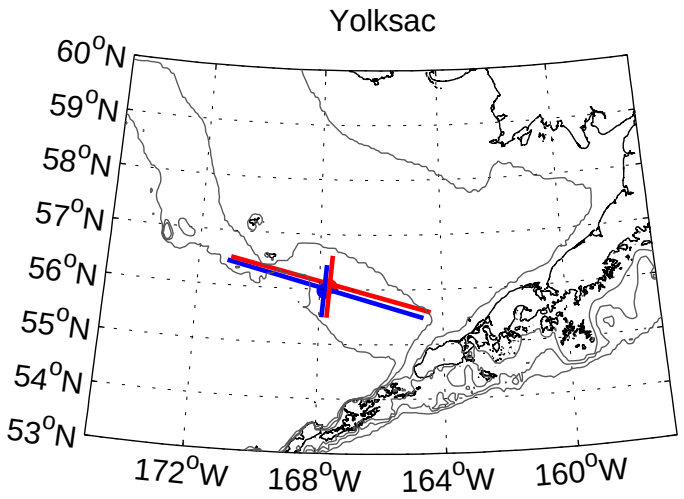
cold warm

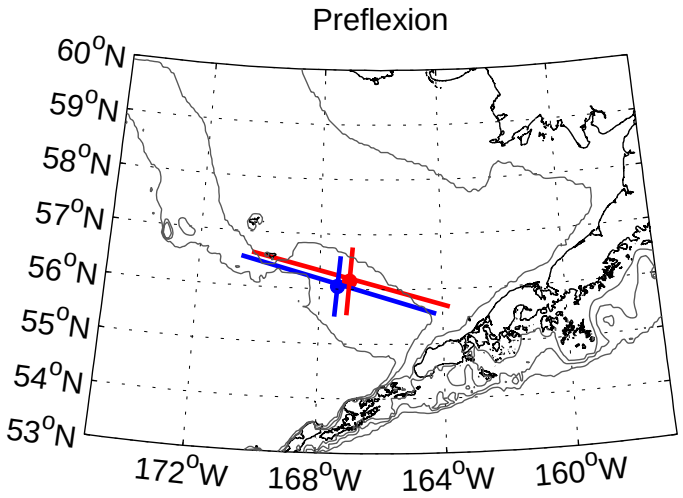


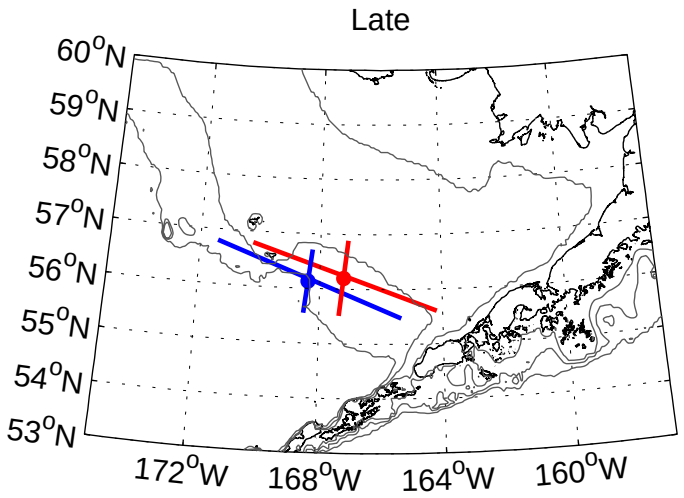
EFFECT OF SPAWNING EXPANSION

cold warm



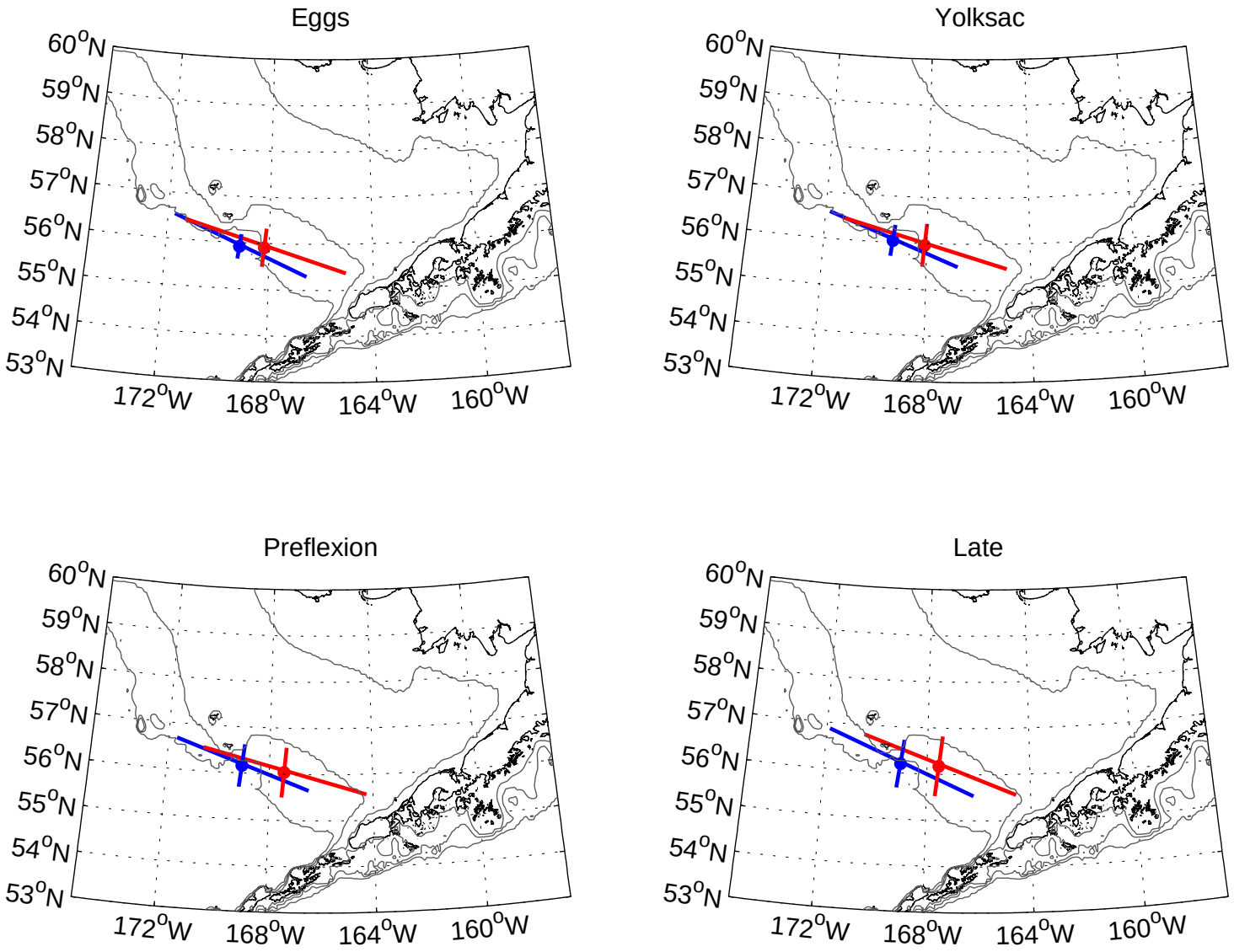






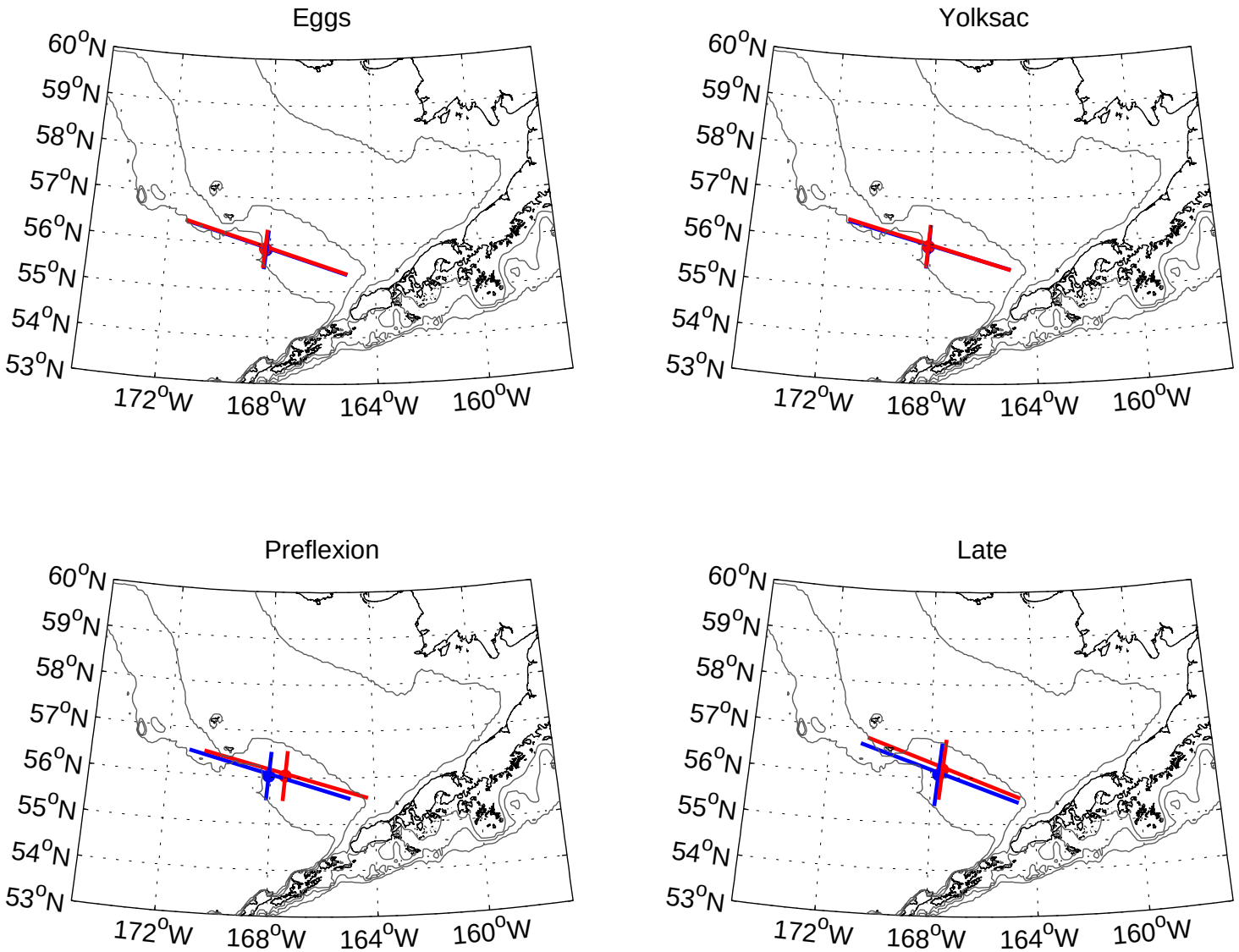
EFFECT OF SPAWNING CONTRACTION

cold warm



EFFECT OF SPAWNING DELAY

cold warm



POLLOCK MODEL RESULTS

Does interannual climate variability result in different distributions of pollock early life stages?

- Yes

What are the dominant physical mechanisms responsible for the different distributions?

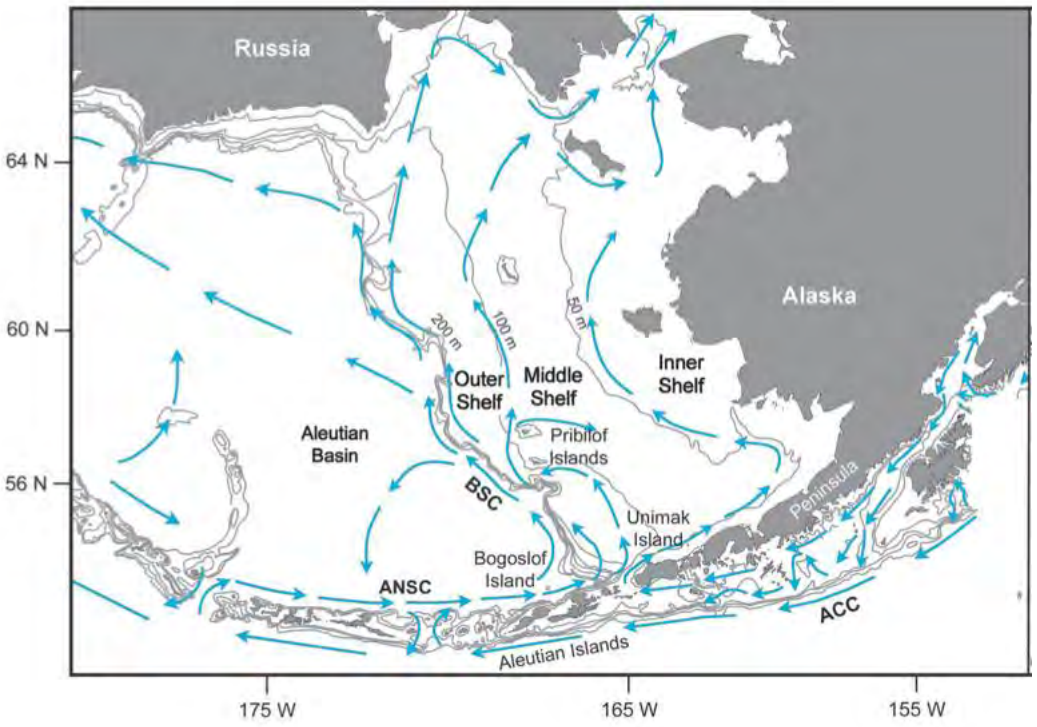
- Wind effects on transport
  - Small
- Temperature/ice effects on spawning location
  - Contraction > Expansion
- Temperature/ice effects on spawning time
  - Small

POLLOCK MODEL CONCLUSIONS

- Why does contraction of spawning areas result in more offshore centers of gravity?

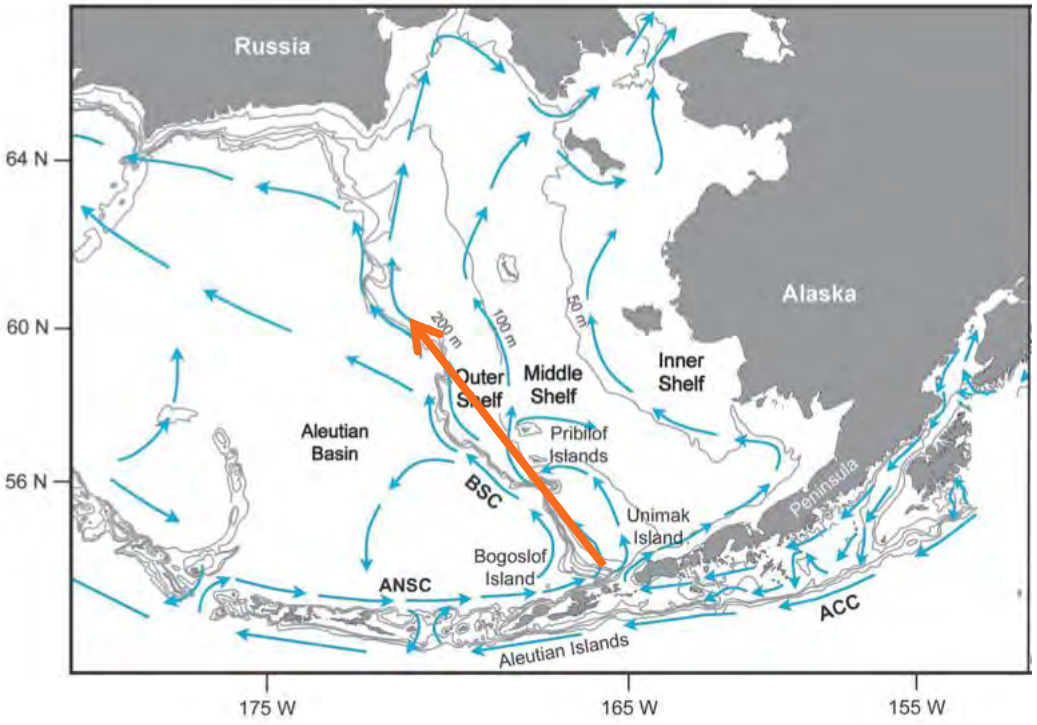
POLLOCK MODEL CONCLUSIONS

- Why does contraction of spawning areas result in more offshore centers of gravity?
- Related to currents



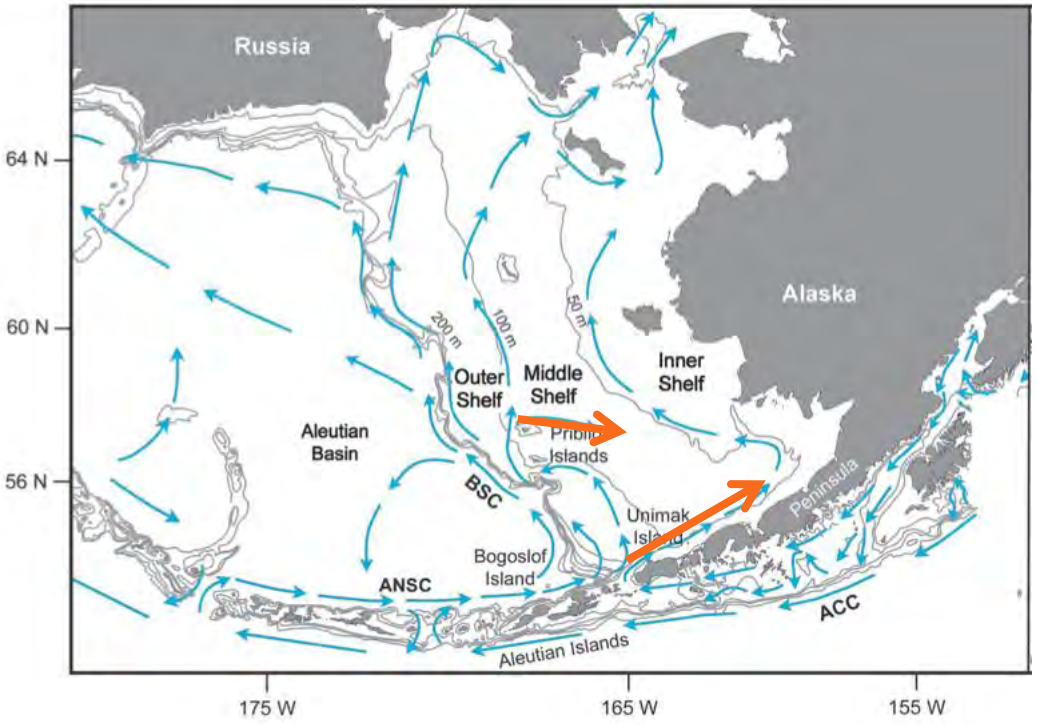
POLLOCK MODEL CONCLUSIONS

- Why does contraction of spawning areas result in more offshore centers of gravity?
- Related to currents
  - Outer shelf currents more alongshelf



POLLOCK MODEL CONCLUSIONS

- Why does contraction of spawning areas result in more offshore centers of gravity?
- Related to currents
  - Outer shelf currents more along-shelf
  - Middle and shelf currents more across-shelf

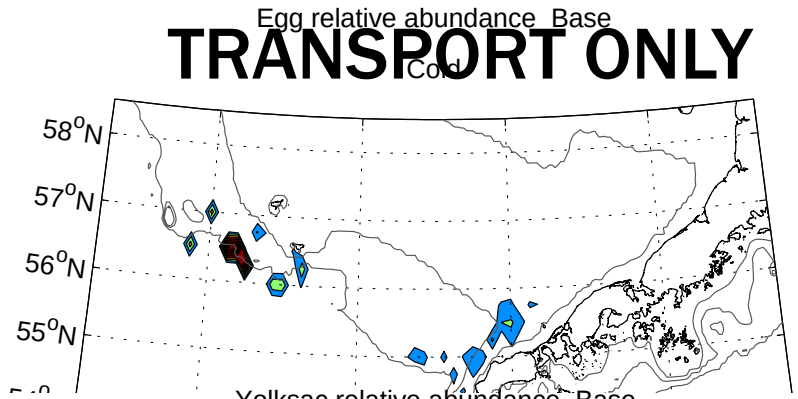


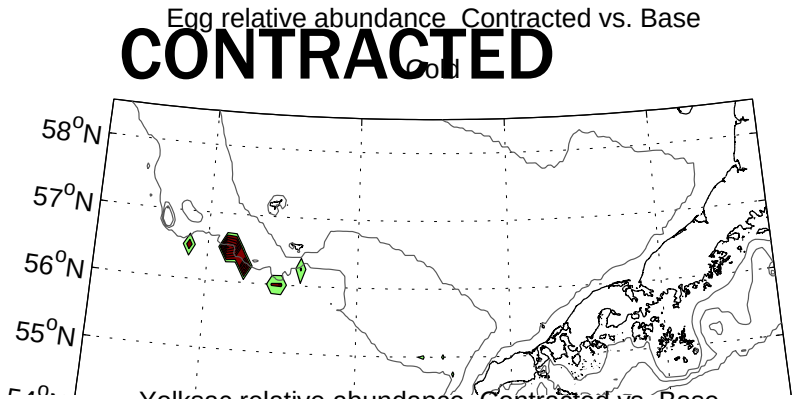
TRANSPORT ONLY VS. CONTRACTED

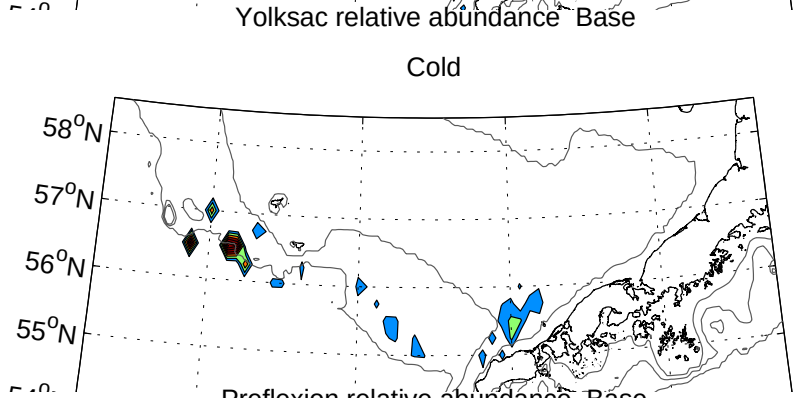
Eggs

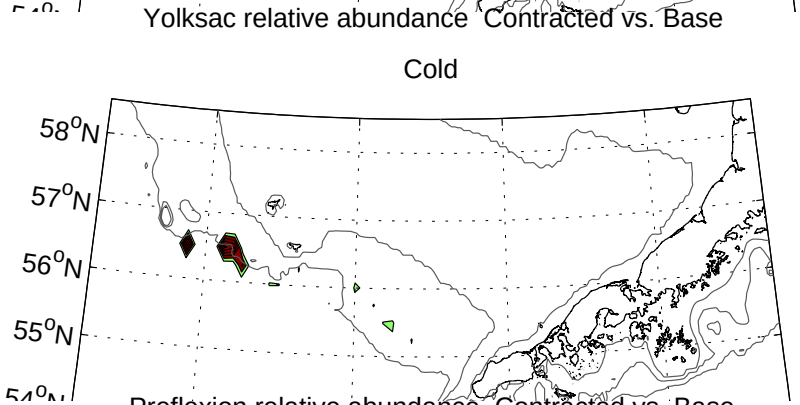
Yolksac

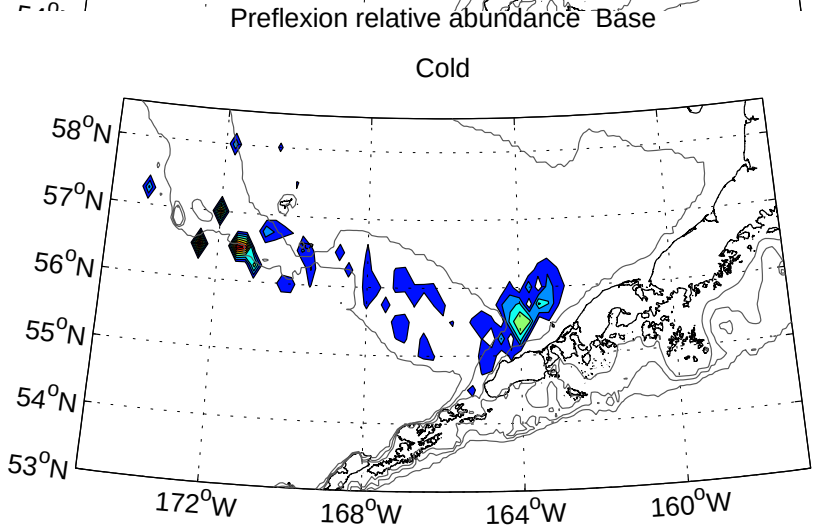
Preflexion

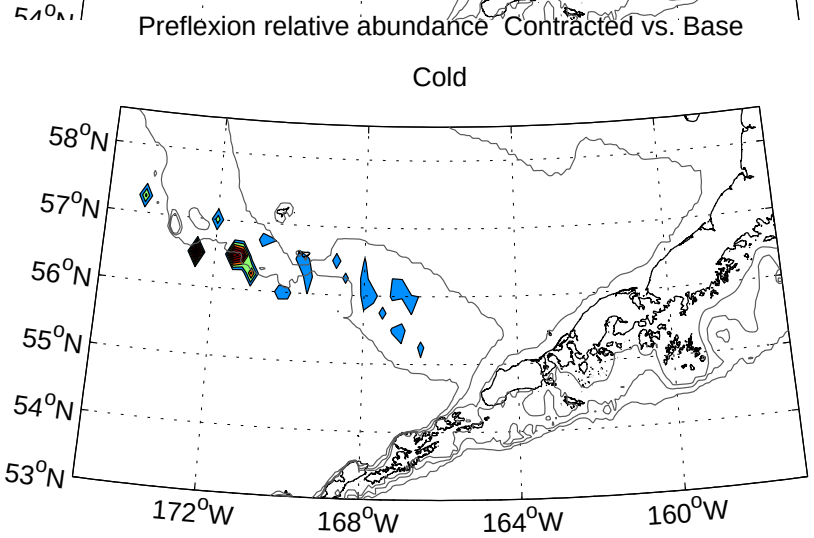










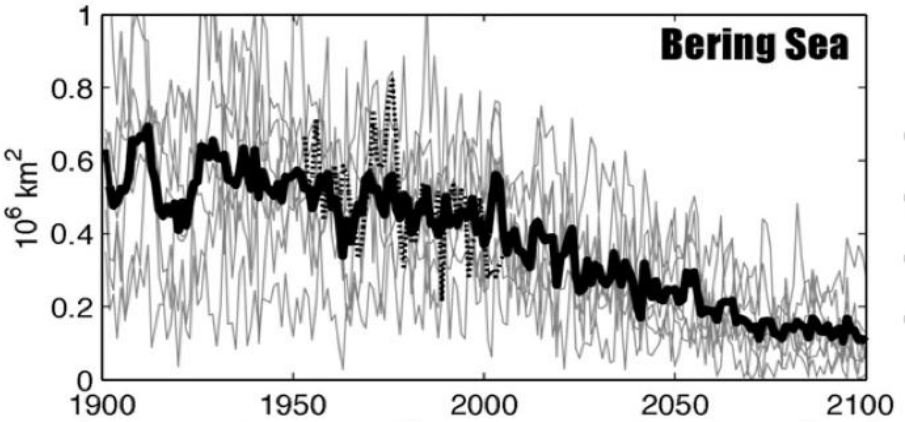


POLLOCK MODEL PERSPECTIVES

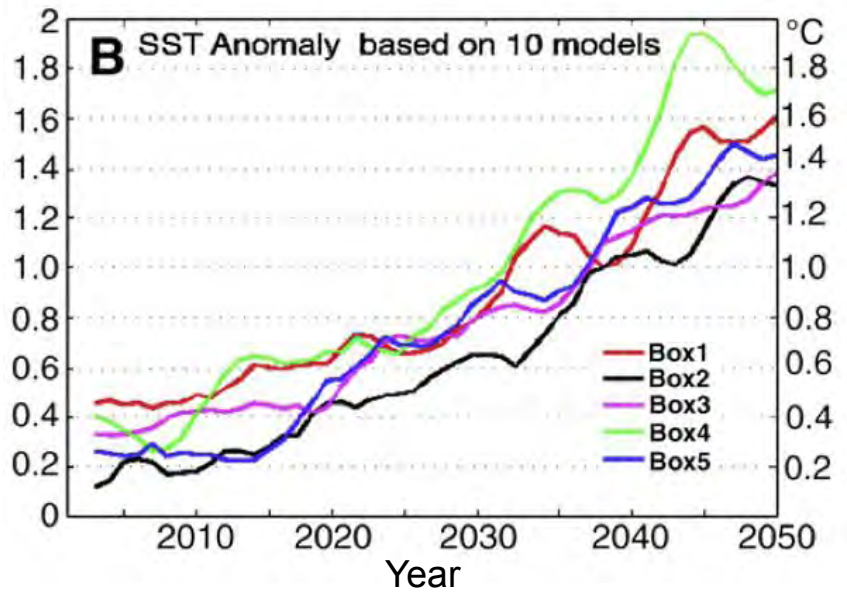
- Expectations with climate change

Decreased sea ice extent; Increased SST

Mean predicted ice extent



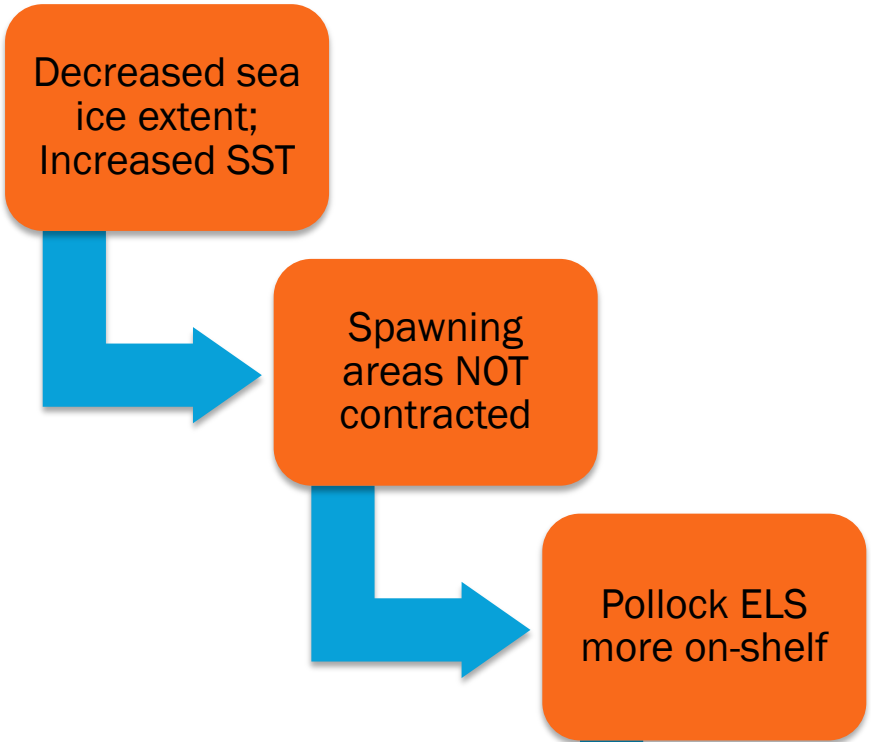
Mean predicted SST anomaly



Wang et al. 2012

POLLOCK MODEL PERSPECTIVES

- Expectations with climate change



POLLOCK MODEL PERSPECTIVES

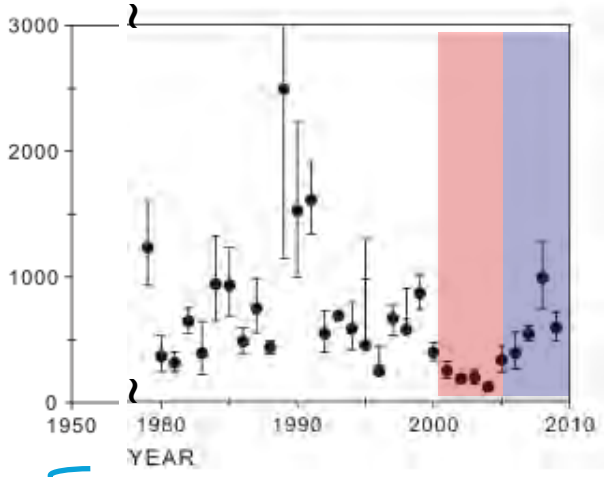
- Expectations with climate change

Decreased sea ice extent; Increased SST

Spawning areas NOT contracted

Pollock ELS more on-shelf

Zooplankton wet weight (mg m^{-3})



- Less overlap with big, energy-rich prey
- More overlap with small, energy-poor prey

Stabeno et al. 2012

POLLOCK MODEL PERSPECTIVES

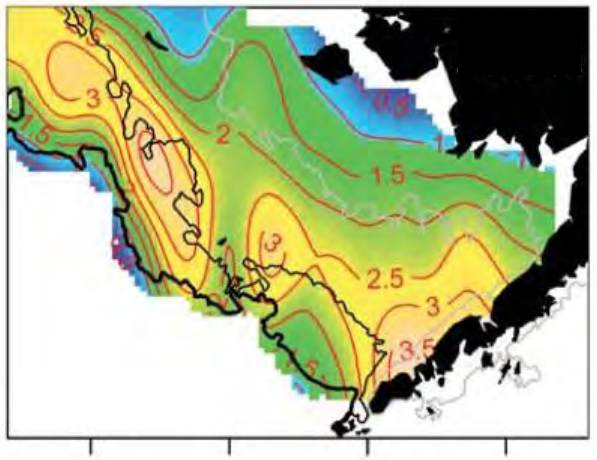
- Expectations with climate change

Decreased sea ice extent; Increased SST

Spawning areas NOT contracted

Pollock ELS more on-shelf

Adult pollock

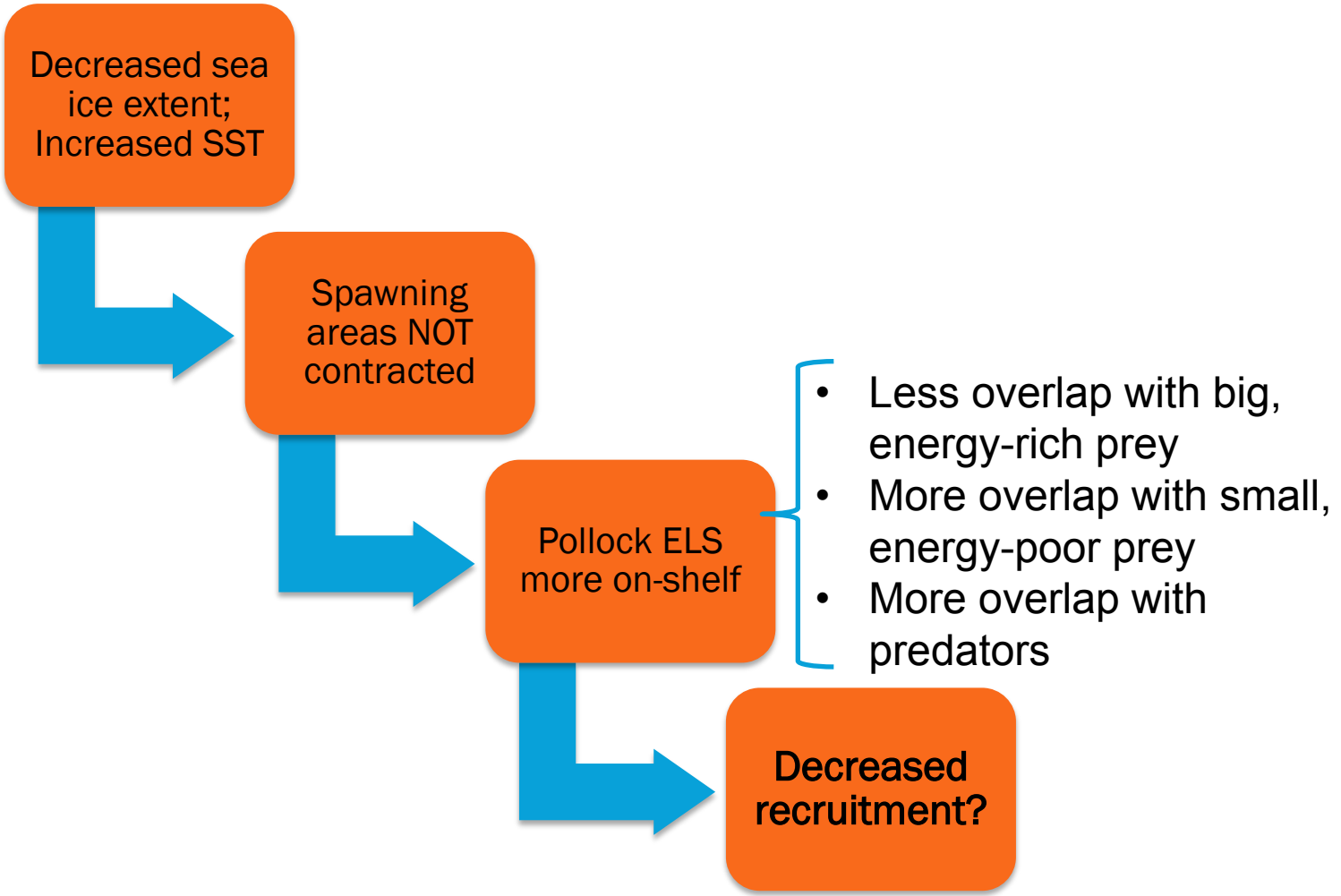


- Less overlap with big, energy-rich prey
- More overlap with small, energy-poor prey
- More overlap with predators

Mueter et al. 2011

POLLOCK MODEL PERSPECTIVES

- Expectations with climate change



POLLOCK MODEL PERSPECTIVES

- Expectations with climate change

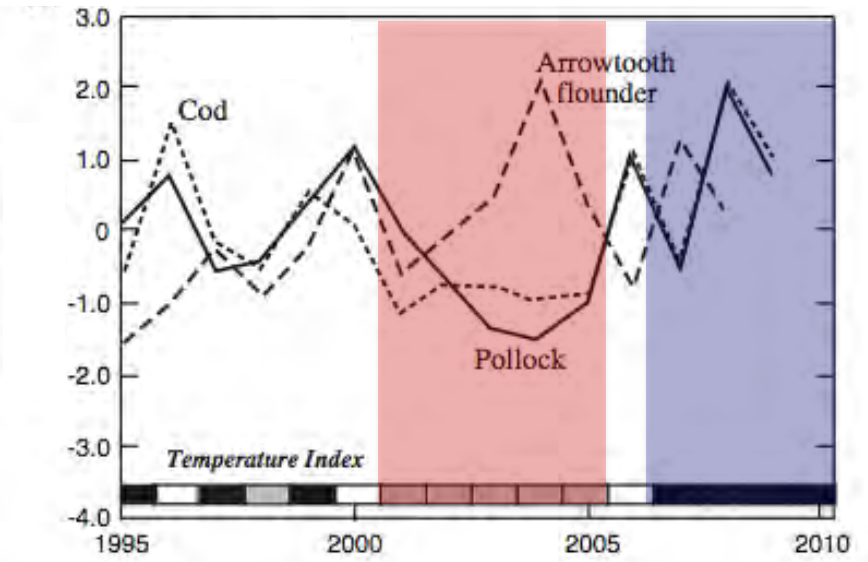
Decreased sea ice extent; Increased SST

Spawning areas NOT contracted

Pollock ELS more on-shelf

Decreased recruitment?

Recruitment residual



ACKNOWLEDGMENTS

BEST Synthesis

- NSF
- Janet Duffy-Anderson
- Franz Mueter
- Kate Hedstrom

FOCI & AFSC

UAF