BEST-BSIERP Bering Sea Project

bsierp.nprb.org

What Controls Trophic Interconnectivity in the eastern Bering Sea?

Bering Sea Project

Bering **E**cosystem **St**udy (BEST) +

Bering **S**ea **I**ntegrated **E**cosystem **R**esearch **P**rogram (BSIERP)

Alaska Marine Science Symposium
Anchorage, Alaska
January 22nd, 2014

Mike Sigler (NOAA) & Rodger Harvey (ODU)
(on behalf of the larger program)

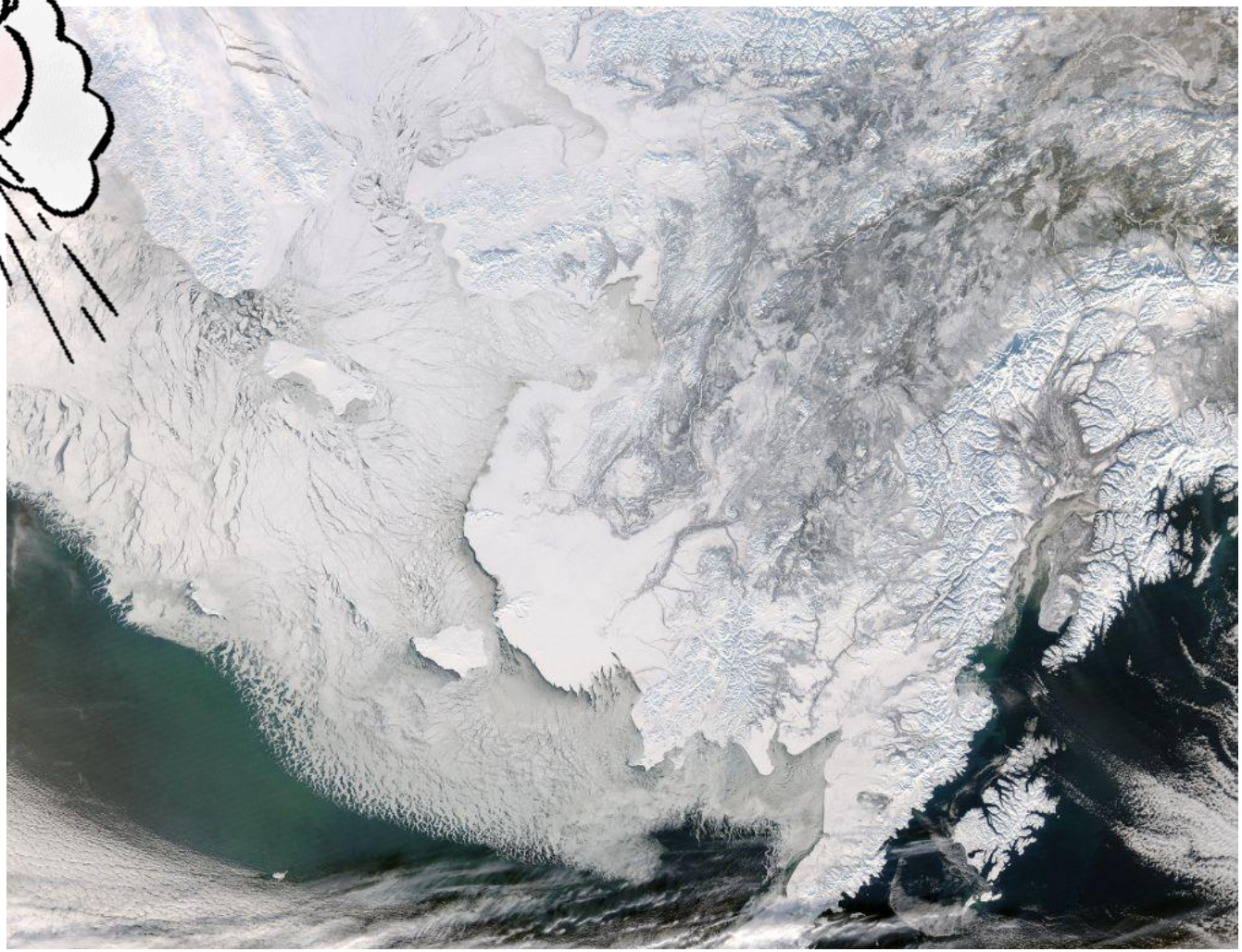
Program scope and chronology

- **2007 – 2010** Field Work
- **2011 – 2013** Synthesis
- **24,205** person-days of fieldwork
- **119** publications to date

A story reviewing the major findings of the Bering Sea Project

- Prologue: Seasonal ice and the cold pool
- Chapter 1: Primary and secondary production and top-down control
- Chapter 2: Location matters for fur seals and fishermen
- Chapter 3: The eastern Bering Sea in the future

Prologue: Icy winters occur when winds are from the north



Satellite image climate.gov, wind image jacksmumontherun.wordpress.com

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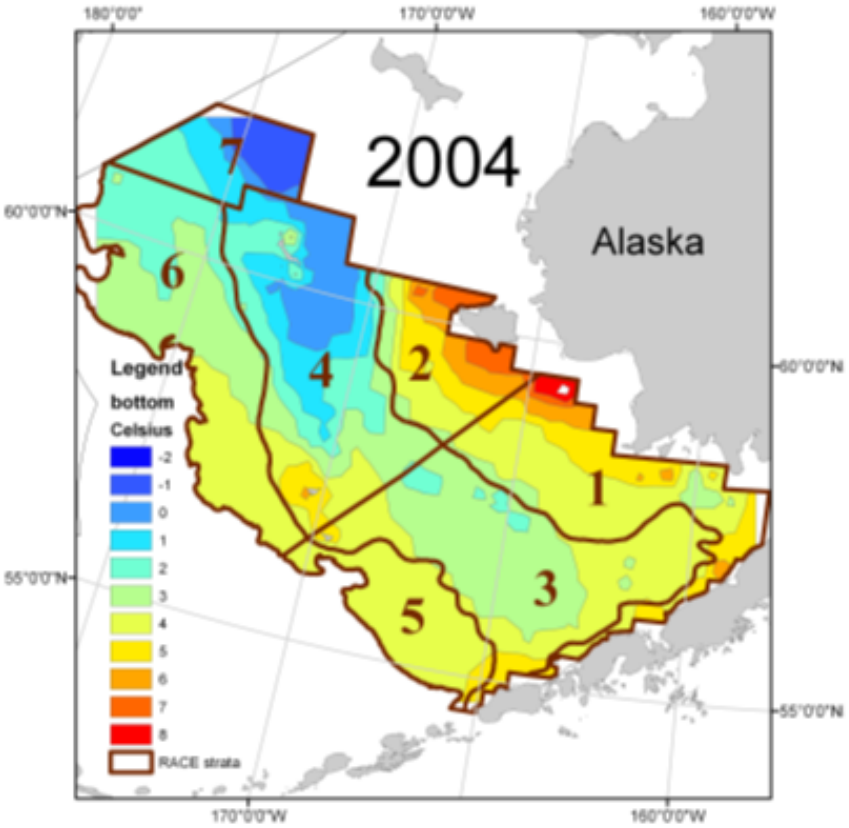
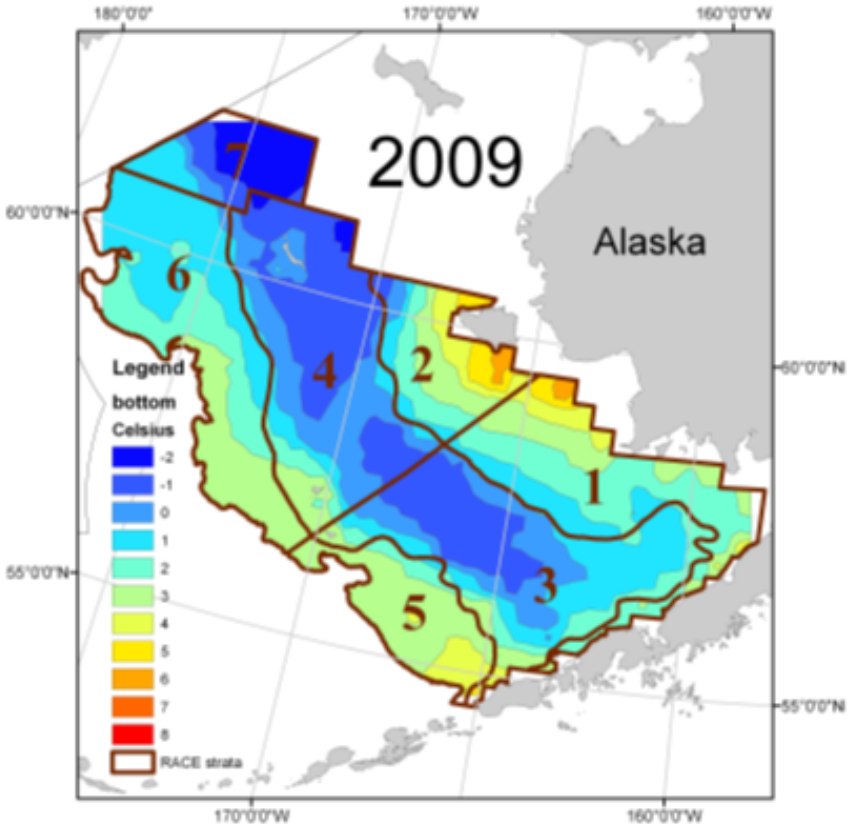
Icy winters increase the size of the 'cold pool' (<2 °C)

WARM YEAR



COLD YEAR



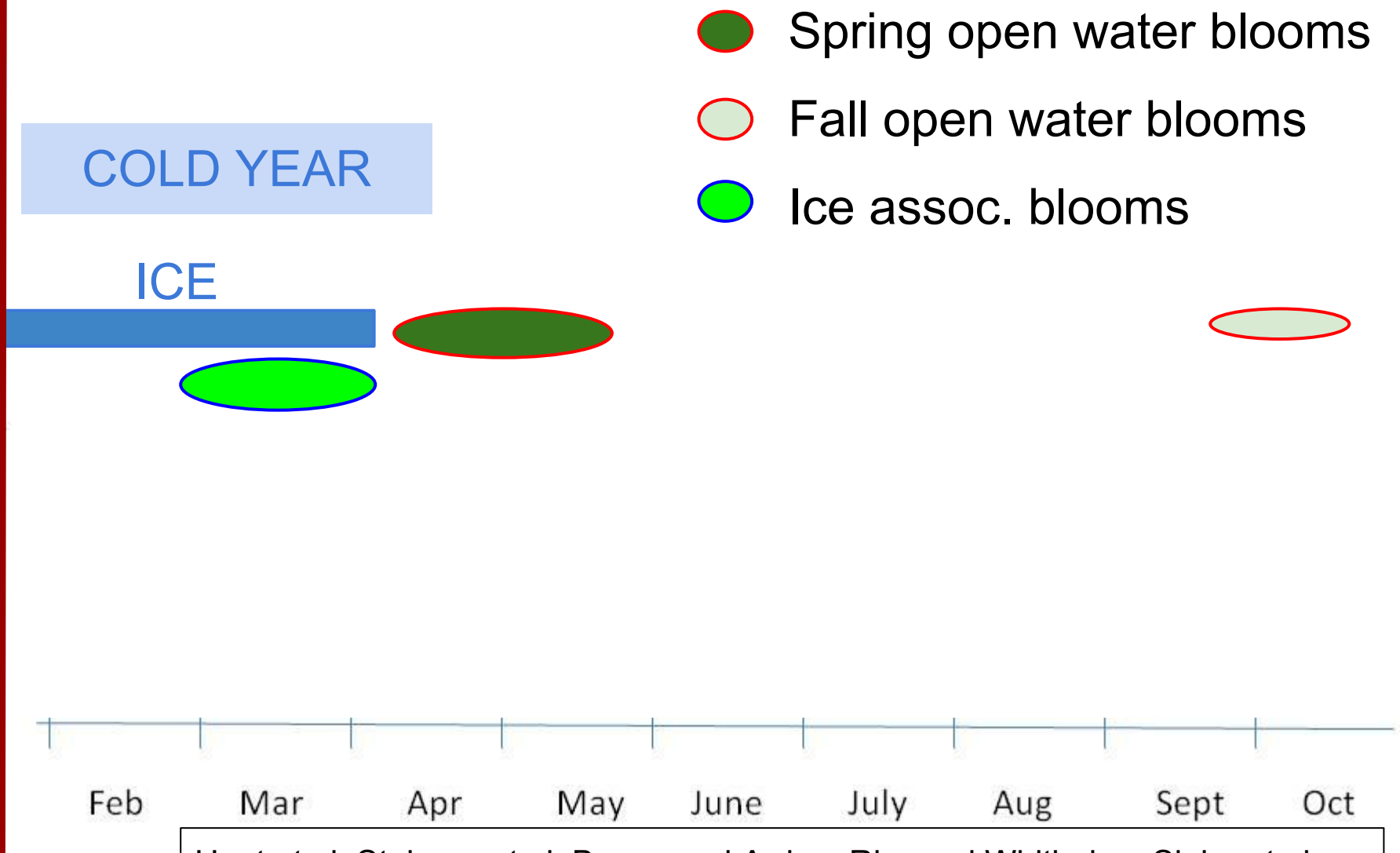
Lauth

Chapter 1: Primary and secondary production and top-down control

What Limits Transfer of Primary to Secondary Production?

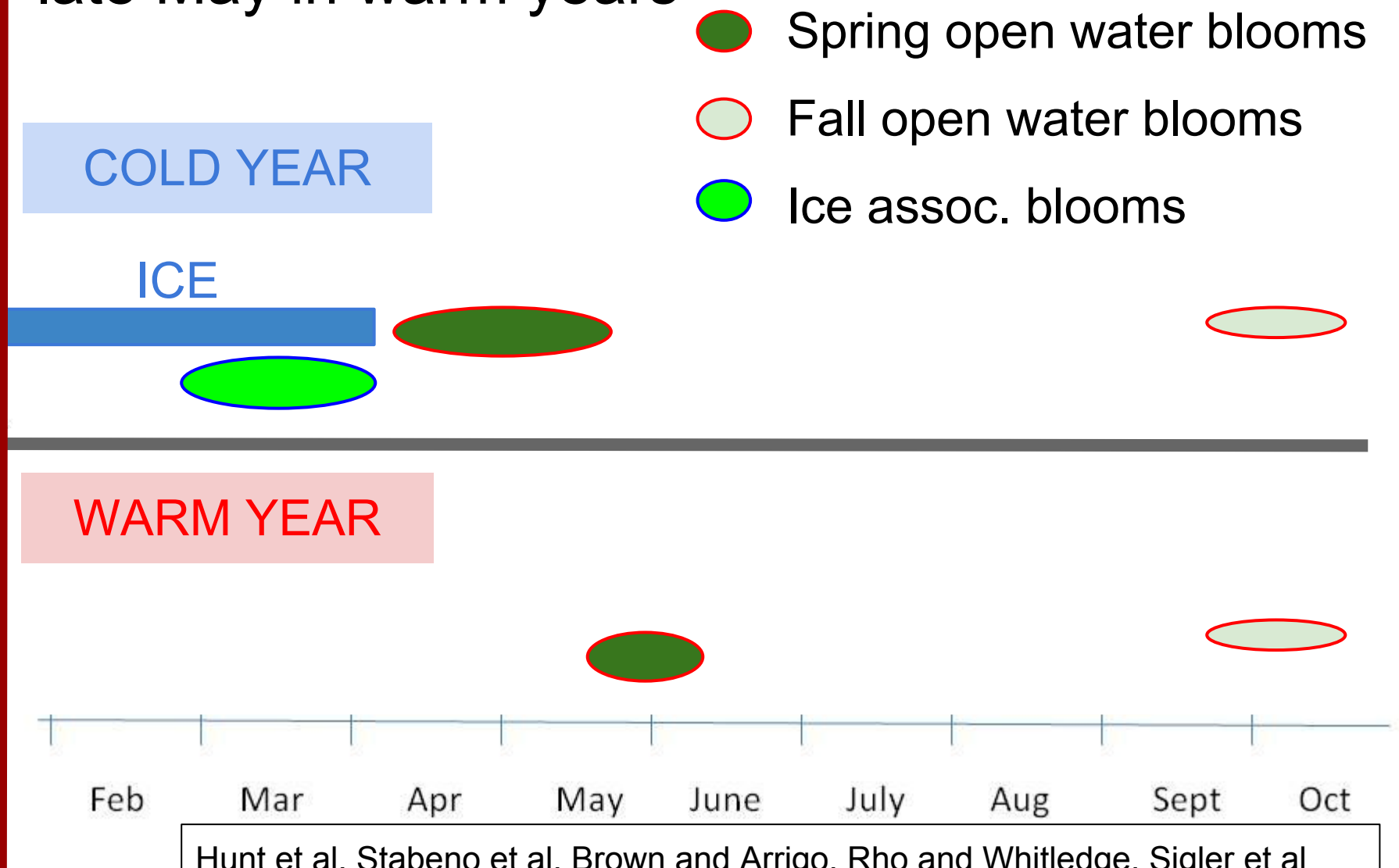
- Does primary production limit secondary production in cold or warm years? NO
- Is timing more important than the amount of primary production? YES
- Does top-down control of secondary production occur? MAYBE NOT

Primary production peaks as ice retreats in cold years (ice remains after March 15)



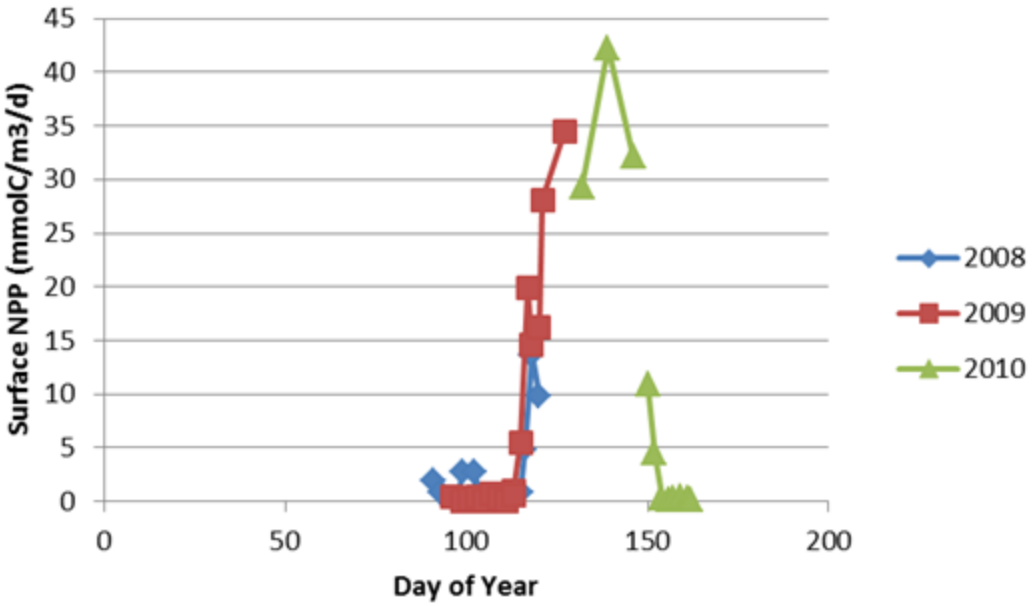
Hunt et al, Stabeno et al, Brown and Arrigo, Rho and Whitledge, Sigler et al

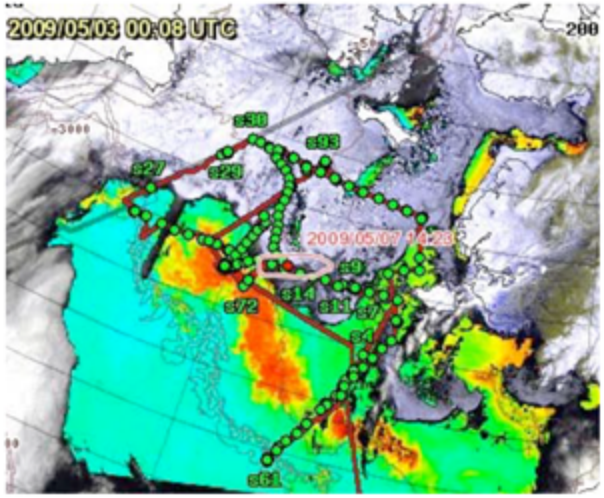
Primary production peaks as ice retreats in cold years (ice remains after March 15) but peaks in late May in warm years



Hunt et al, Stabeno et al, Brown and Arrigo, Rho and Whitledge, Sigler et al

Cold years with extensive sea ice result in a punctuated bloom with higher daily primary production in spring.

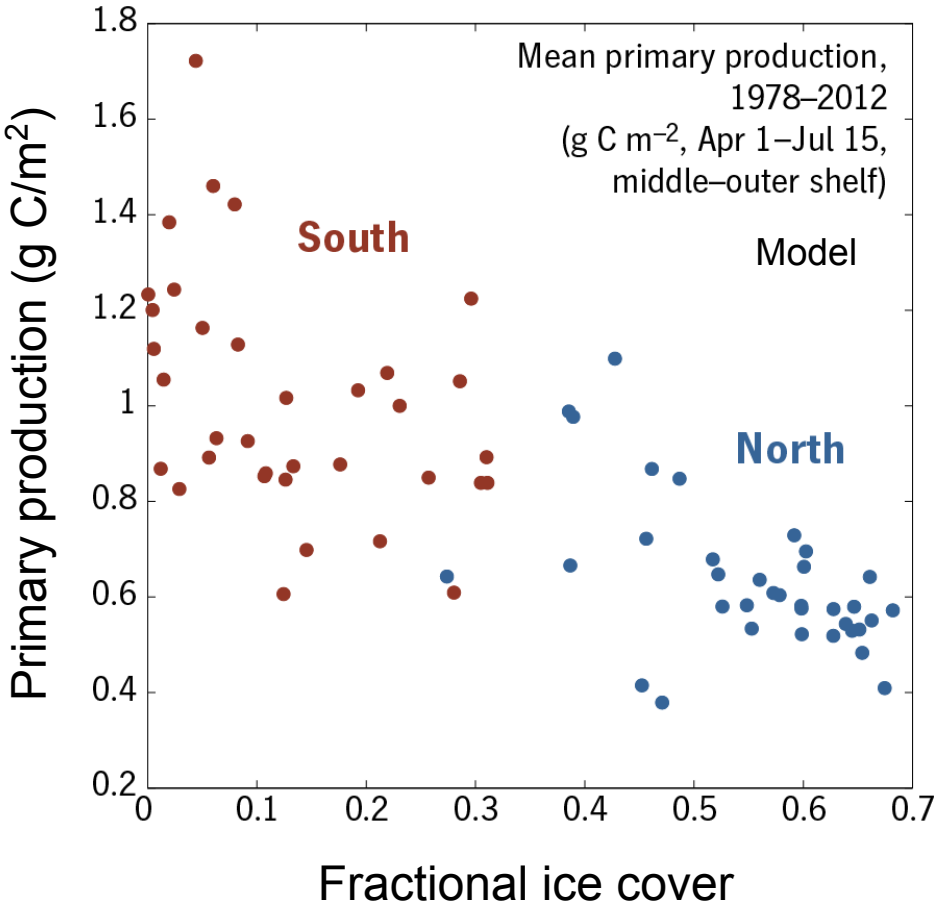




In **warm** years, the spring bloom is more prolonged and the maximum chlorophyll concentration is less (Rho and Whitledge 1997).

Lomas, Moran, Casey, Bell, Tiahlo, Whitefield, Kelly, Mathis, Cokelet

Total spring and summer primary production is less in ice covered areas (modeled)

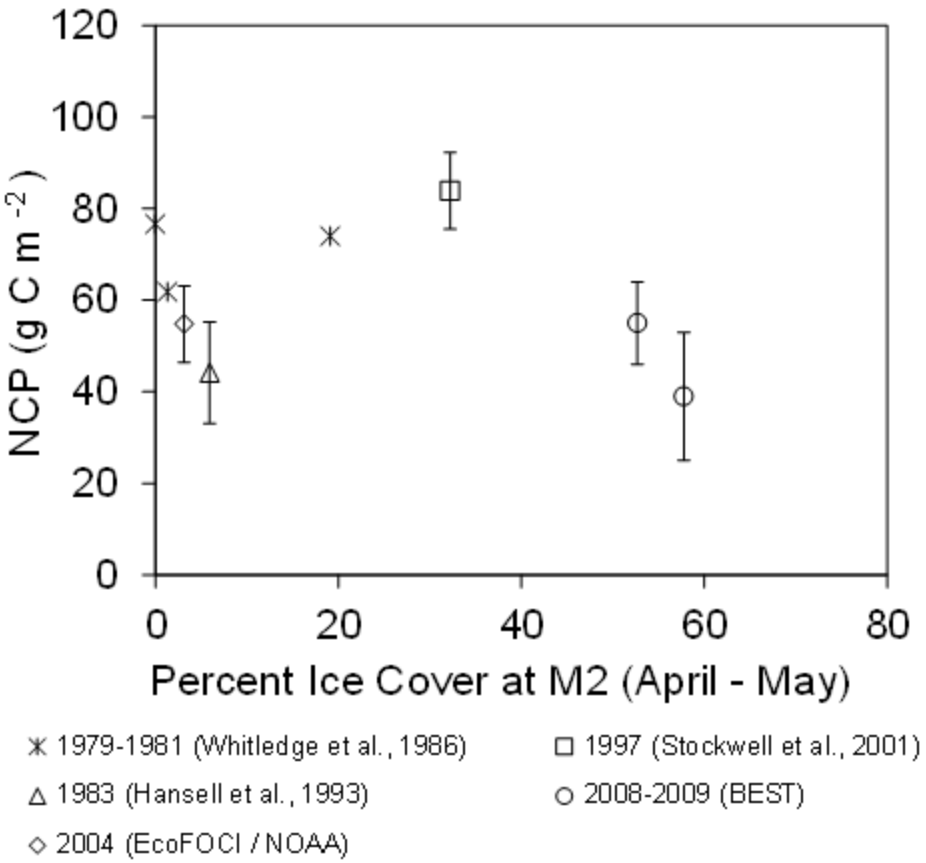


- However, after accounting for plankton respiration, **net primary production** (NPP) is only 10% greater in warm than cold years (**i.e., similar**)
- Total annual NPP may be higher in cold years if ice algae NPP also considered (but few estimates)

Banas, Zhang

Liu, Zhai, Zeeman, Eisner, Gann, Mordy, Moran, Lomas

Net Community Production (NCP) is similar in warm and cold years



- **Ans. 1: NCP does not appear to limit copepod and krill production**
- The percentage (10-20% of NCP) depends on method for estimating krill biomass

Mordy, Cokelet, Ladd, Menzia, Proctor, Stabeno, Wisegarver

Campbell, Ashjian, Lessard, Liu, Zhai, Zeeman, Eisner, Gann, Mordy, Moran, Lomas, Gibson

Ans. 2: Timing appears more important than amount of primary production

Calanus egg production

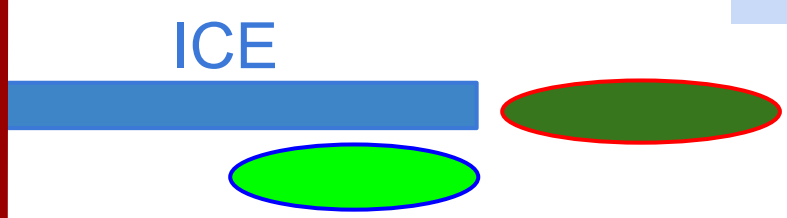
Spring open water blooms

Fall open water blooms

Ice assoc. blooms

COLD YEAR

Low overwinter respiration



Baier and Napp, Hunt et al, Coyle et al

Ans. 2: Timing appears more important than amount of primary production

Calanus egg production

Spring open water blooms

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Ice assoc. blooms

COLD YEAR

Low overwinter respiration

ICE

WARM YEAR

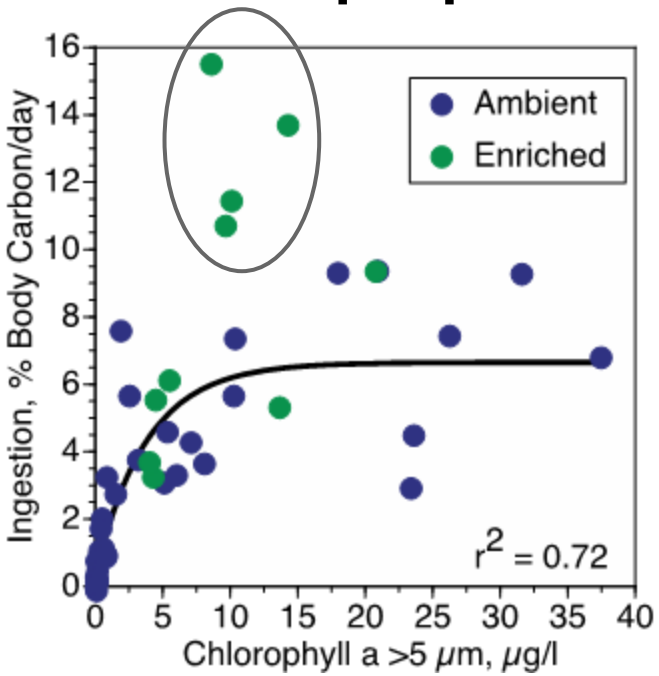
High overwinter respiration

Feb Mar Apr May June July Aug Sept Oct

Baier and Napp, Hunt et al, Coyle et al

Ice algae likely enhances copepod reproduction

Chl a concentration in ice is up to three orders of magnitude higher than in sea water, **per volume**

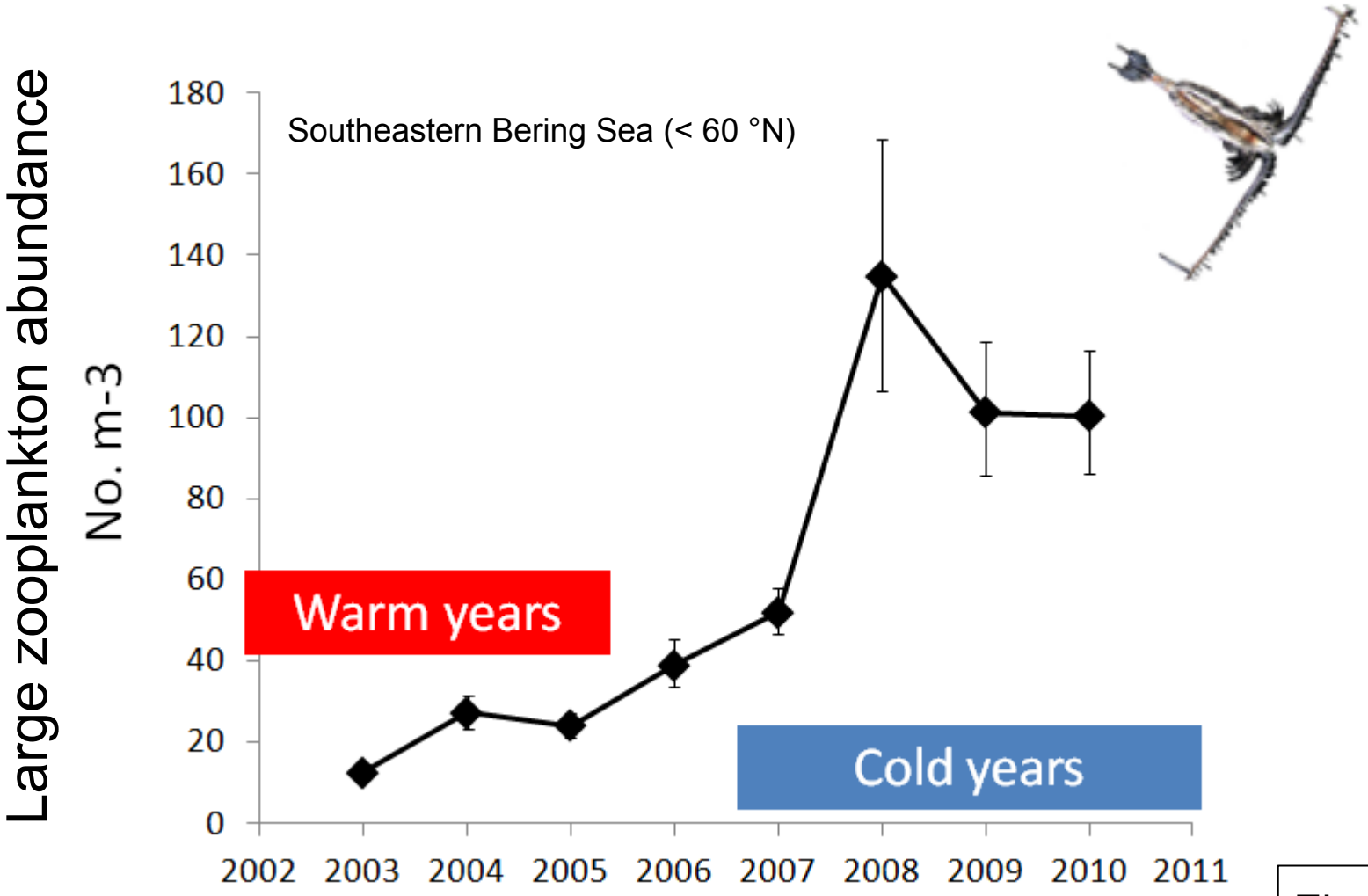


- Higher ingestion rate when feeding on ice algae than water column phytoplankton
- Egg production can occur earlier because of feeding on ice algae

Gradinger, Bluhm, Iken, Weems

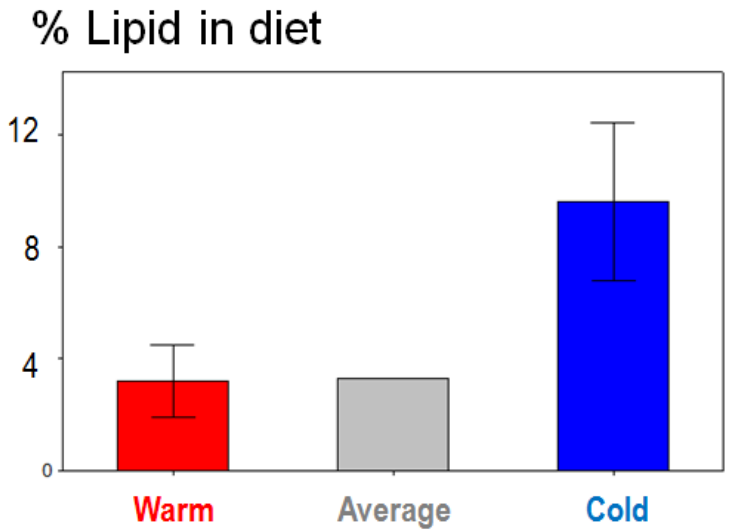
Campbell, Lessard, Ashjian, Durbin, Rynearson, Casas

Due to timing, large crustacean zooplankton benefit from icy winters: This contradicted our expectation (strike 1!)

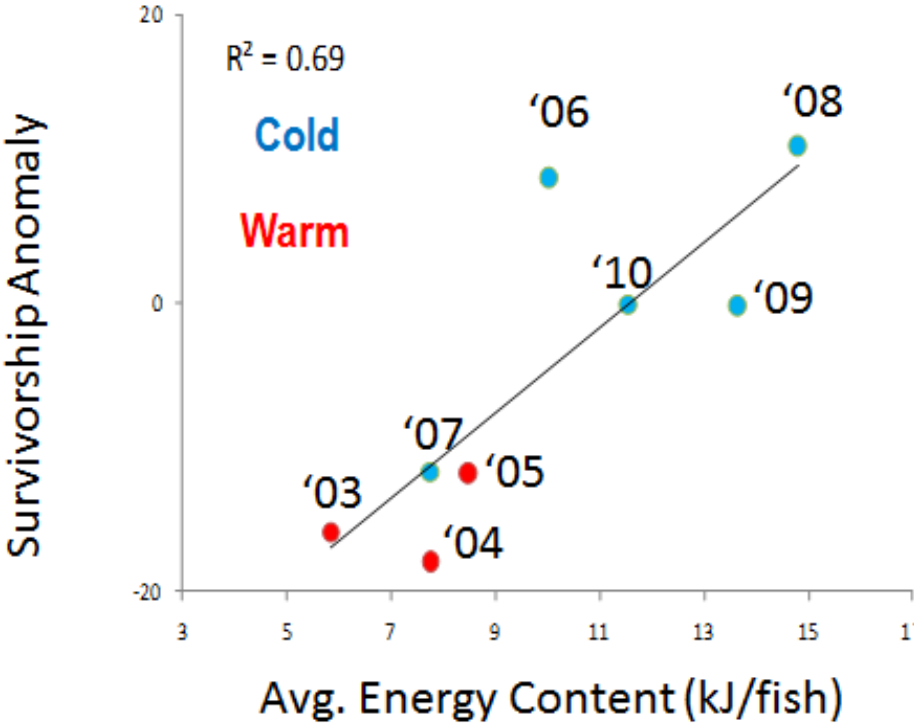


Eisner et al.

As a consequence, age-0 pollock consume richer diets in cold years, better preparing them for their first winter...



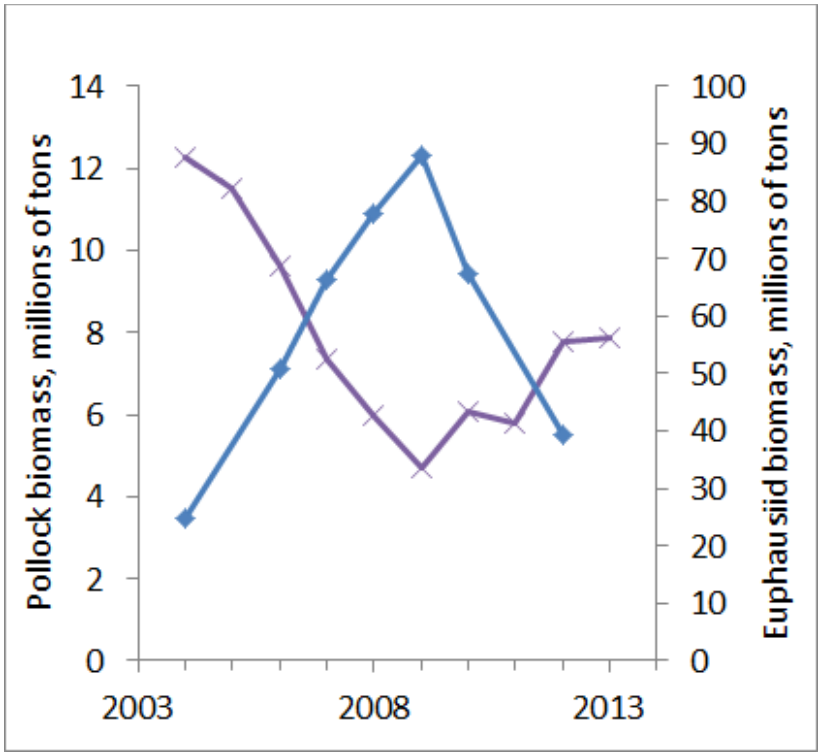
… and enhancing survivorship.

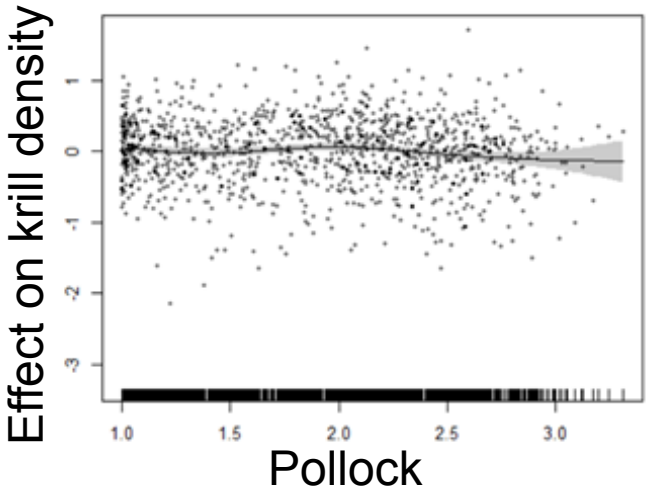


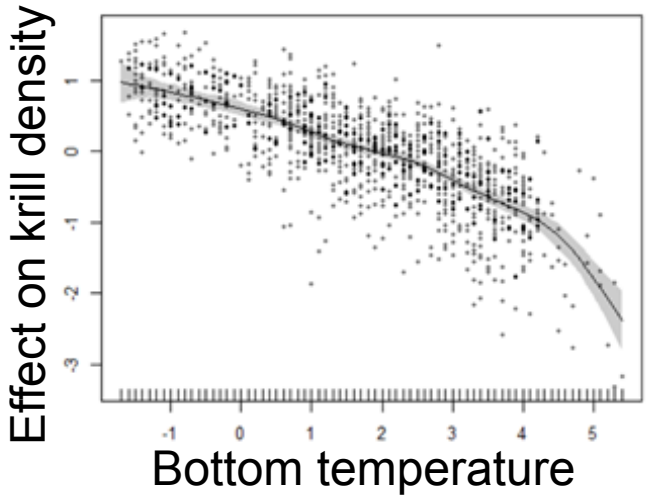
Heintz et al.

Ans 3: Top-down control of secondary production: Maybe not

- Why are biomasses of pollock and krill inversely related?
- Temperature appears more important for predicting krill density than pollock biomass
- Krill production may outpace current pollock consumption



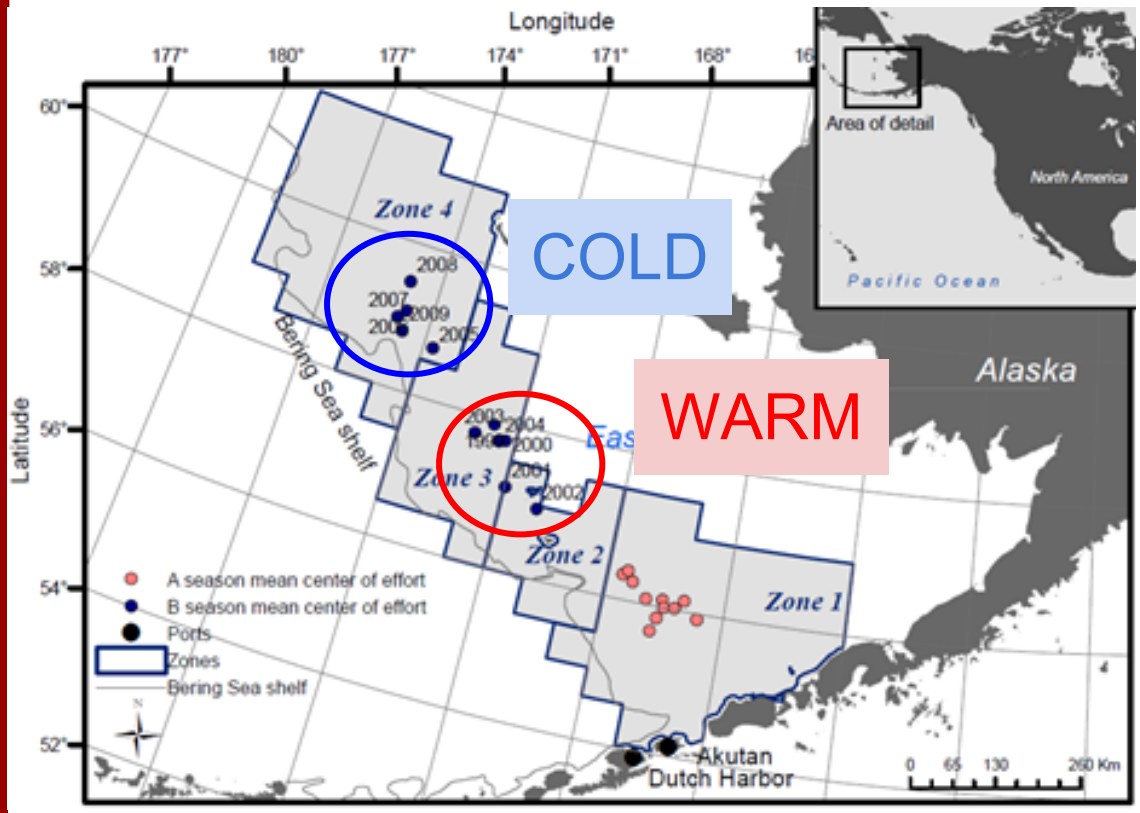




Ressler et al. 2012, 2014

Chapter 2: Location matters for fur seals and fishermen

We predicted fishermen would travel farther north in warm years, but instead the opposite occurred (strike 2!)

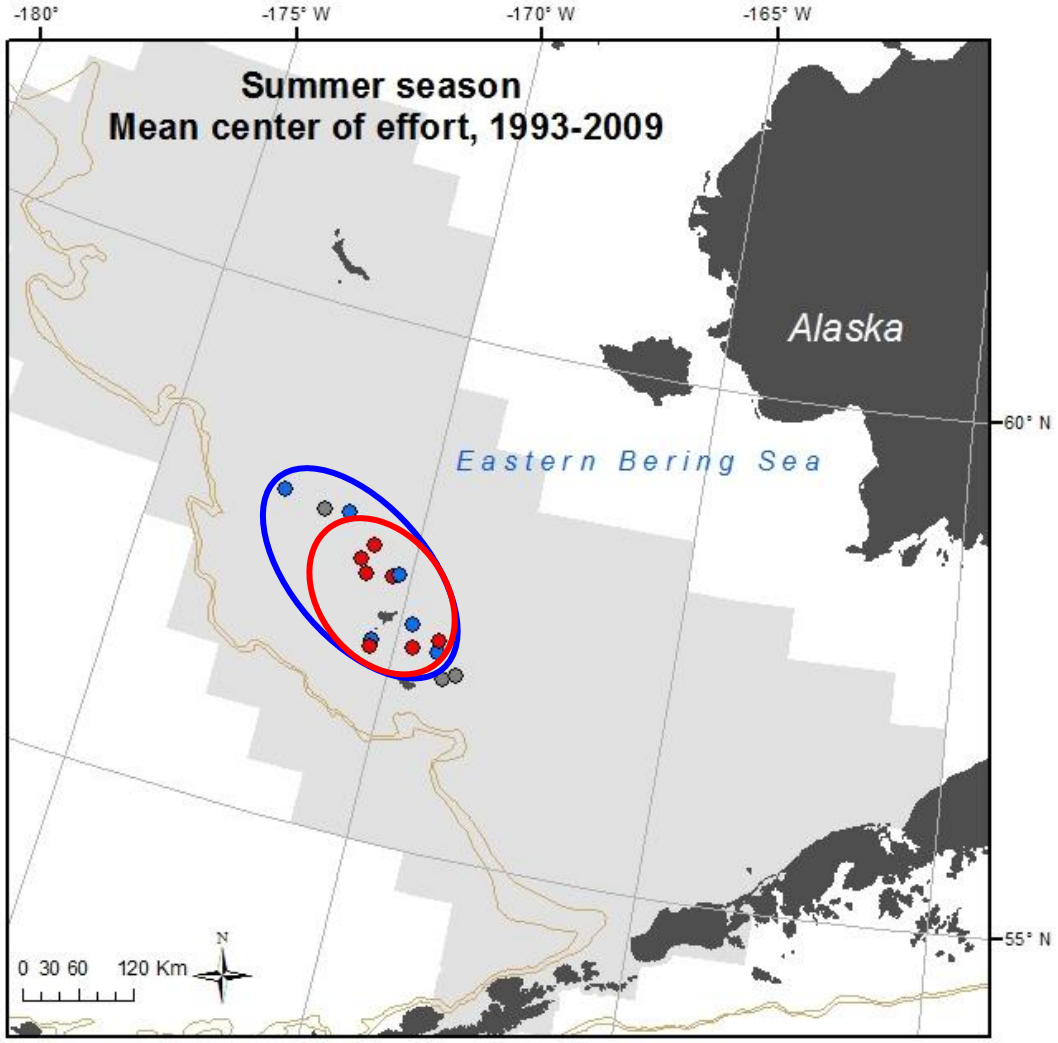


Pollock catcher/ processor fleet, center of fishing effort:

In summer, a northward and off-shelf shift correlated with colder conditions and larger cold pool

Haynie, Pfeiffer

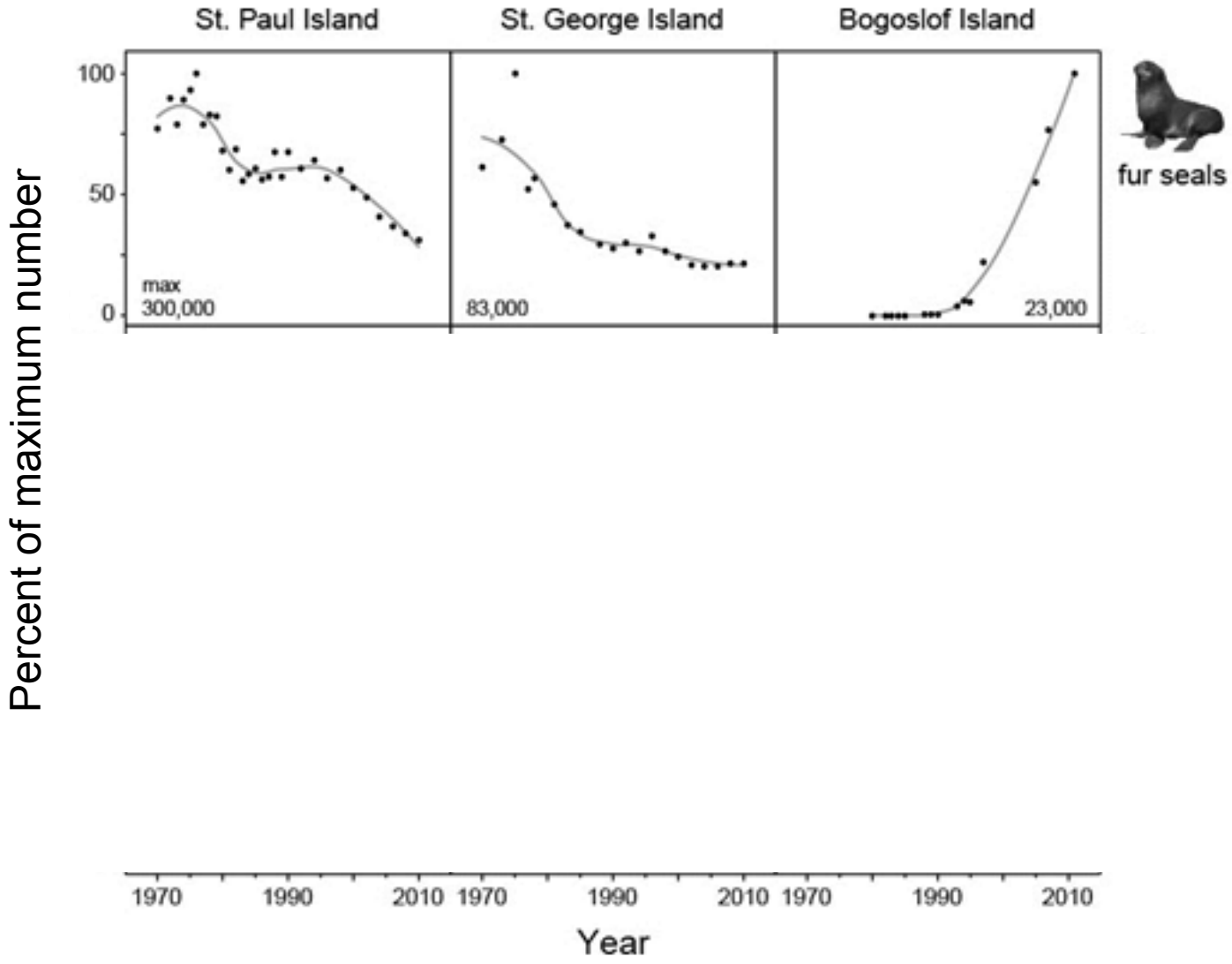
Even with negligible temperature-related shift, some cost effects can occur



Summer/fall cod longline fishery: Vessels traveled farther (29 vs 20 km/ton catch) and set their gear more often during a trip (39 vs 33) in warm vs. cold years.

Haynie, Pfeiffer

Population trends differ among locations



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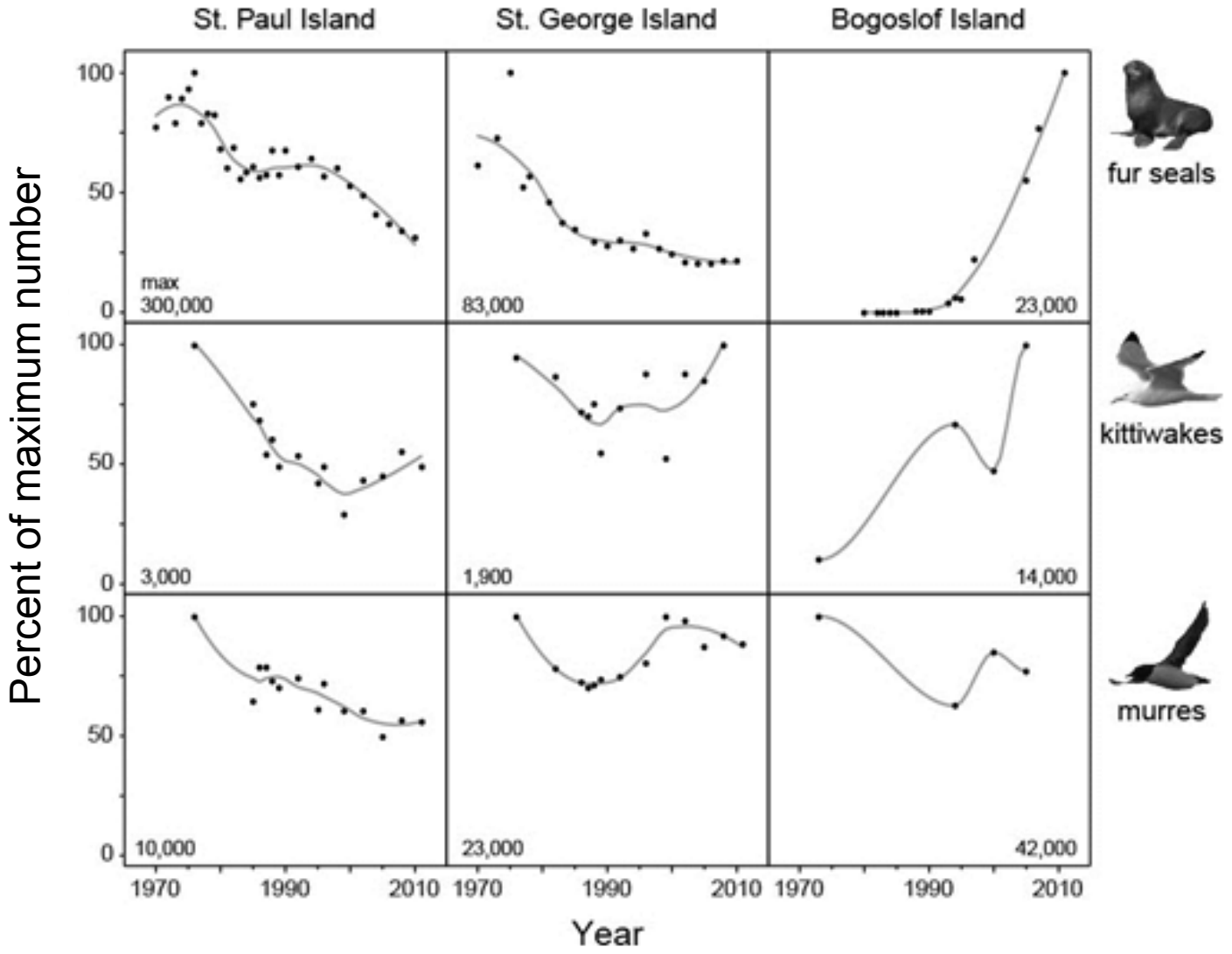

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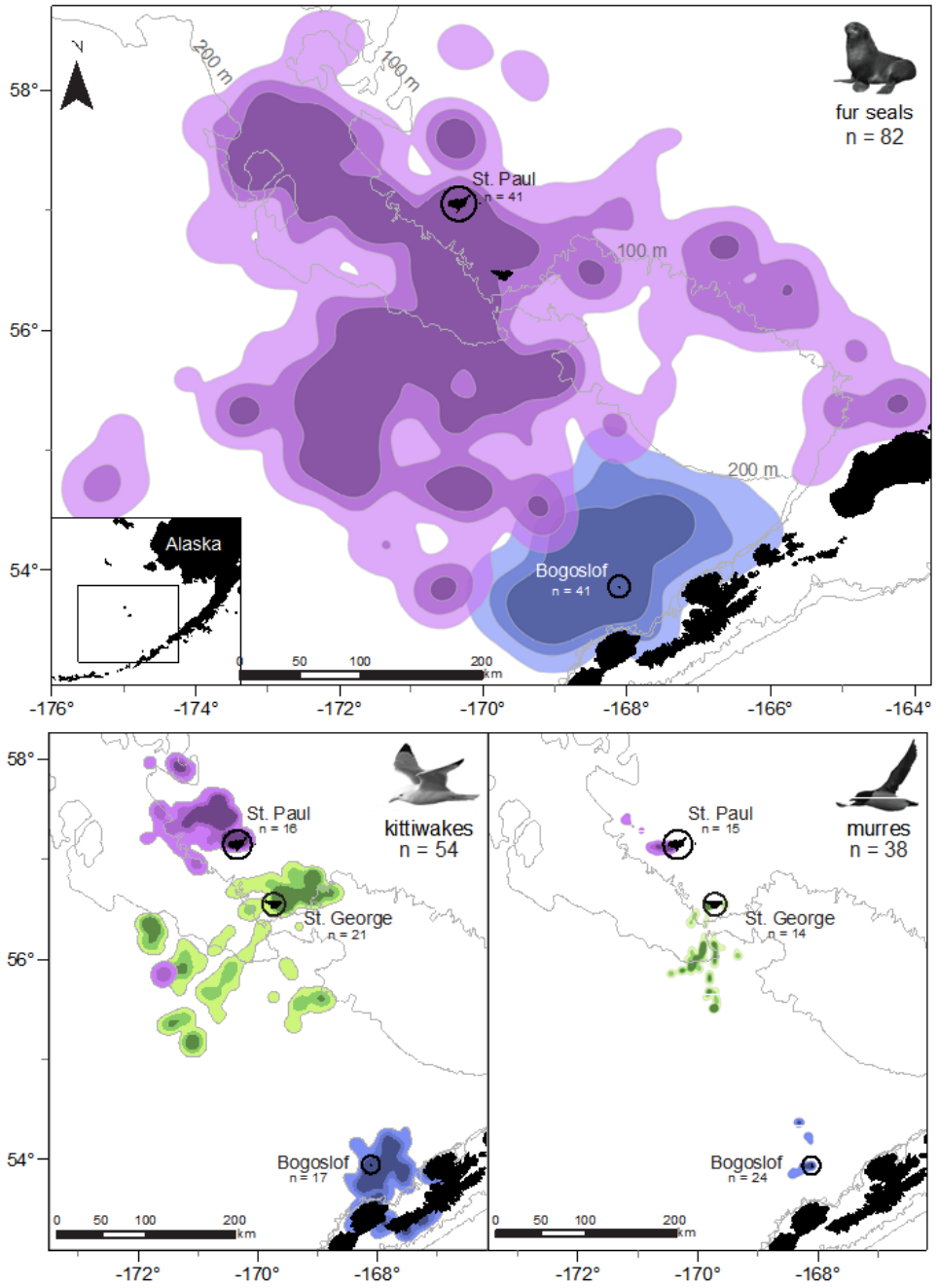
Foraging locations - closer to home is better

- Trip lengths shorter for fur seals and murres at Bogoslof than Pribilofs
- Energy content of diet lower at Pribilofs than Bogoslof because of species consumed

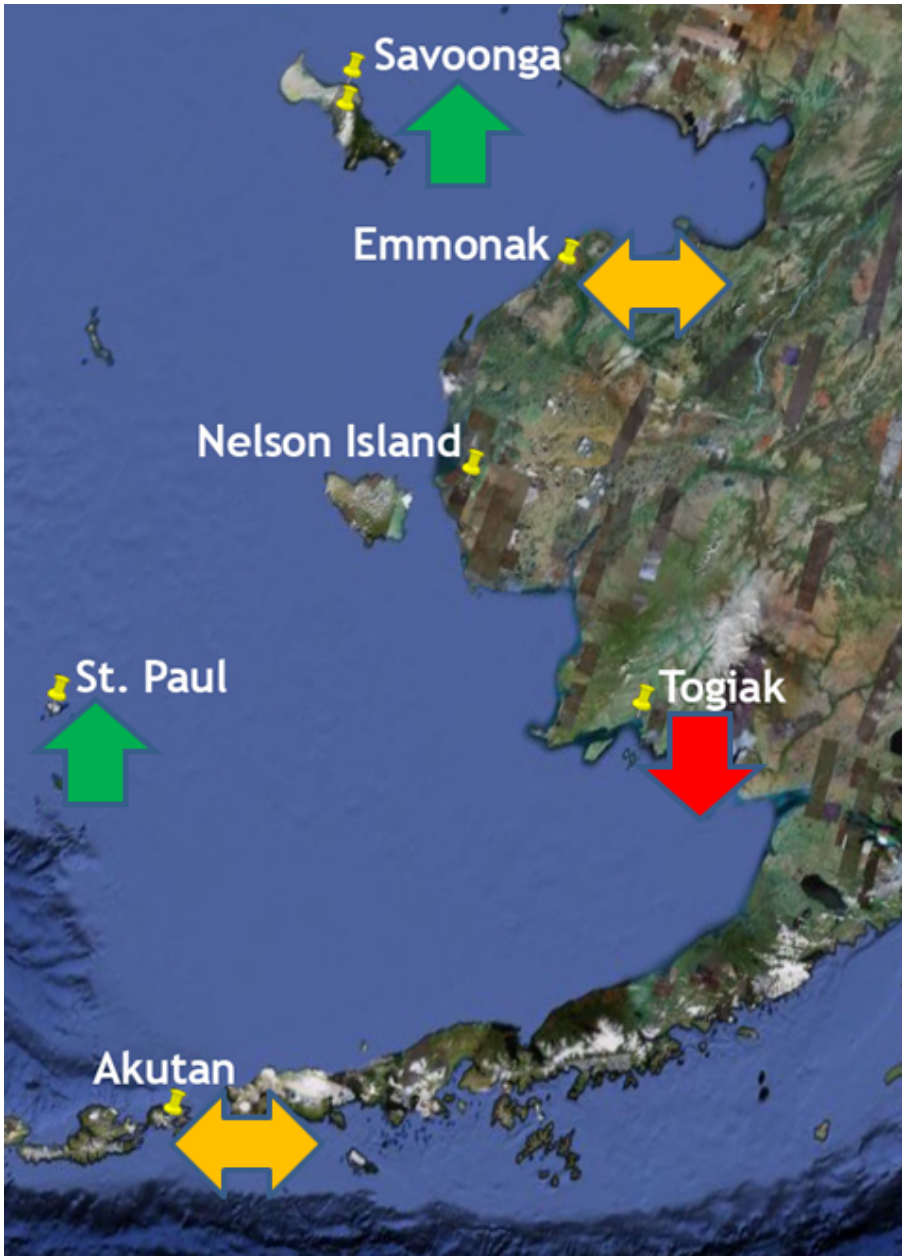
Trites, Battaile, Benoit-Bird, Harding, Heppell, Irons, Kitaysky, Kuletz, Paredes, Renner, Roby



Kernel density use estimates for northern fur seals, blacklegged kittiwakes, and thickbilled murres tagged on St. Paul Island (purple), St. George Island (green) and Bogoslof Island (blue) in 2009. Isopleths are 50, 75, and 95 % use contours with darker colors indicating higher use areas.

Trends observed by communities (local and traditional knowledge, subsistence harvests):

- Location differences between the south (many species in decline) and the north (a productive ecosystem)
- Patterns are consistent with the northern Bering Sea remaining icy during winter and spring and the southeastern Bering Sea more affected by changes in sea ice extent

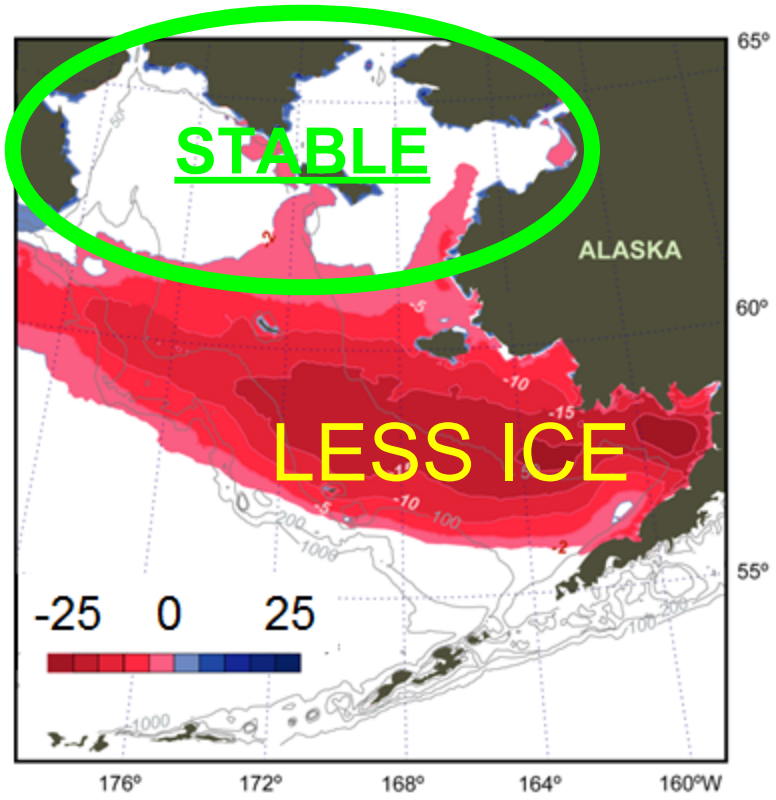


Huntington, Braem, Brown, Hunn, Krieg, Lestenkof, Noongwook, Sepez, Sigler, Wiese, Zavadil

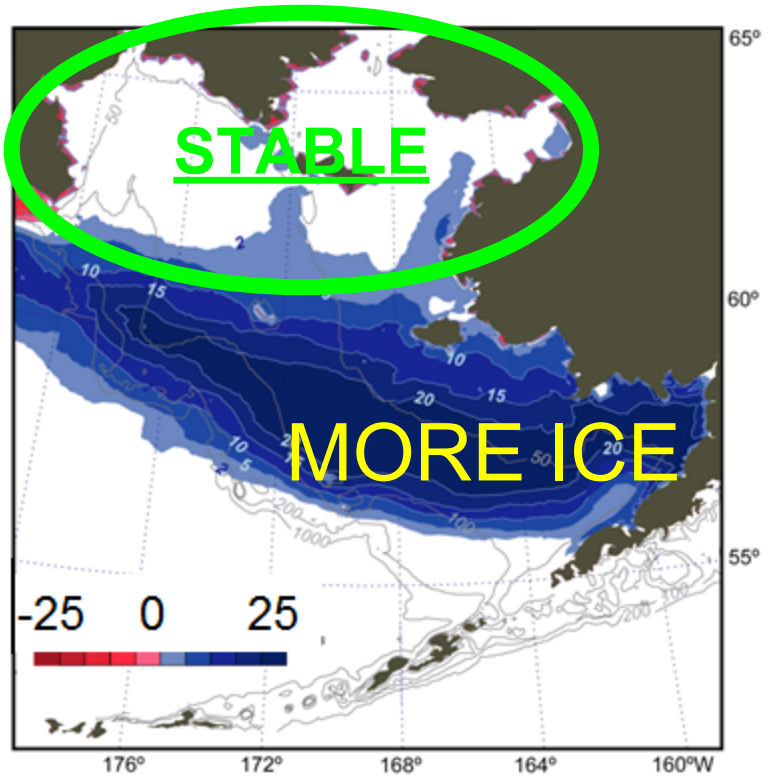
Chapter 3: The eastern Bering Sea in the future

Future ocean conditions: The north will remain cold and dark

Warm years

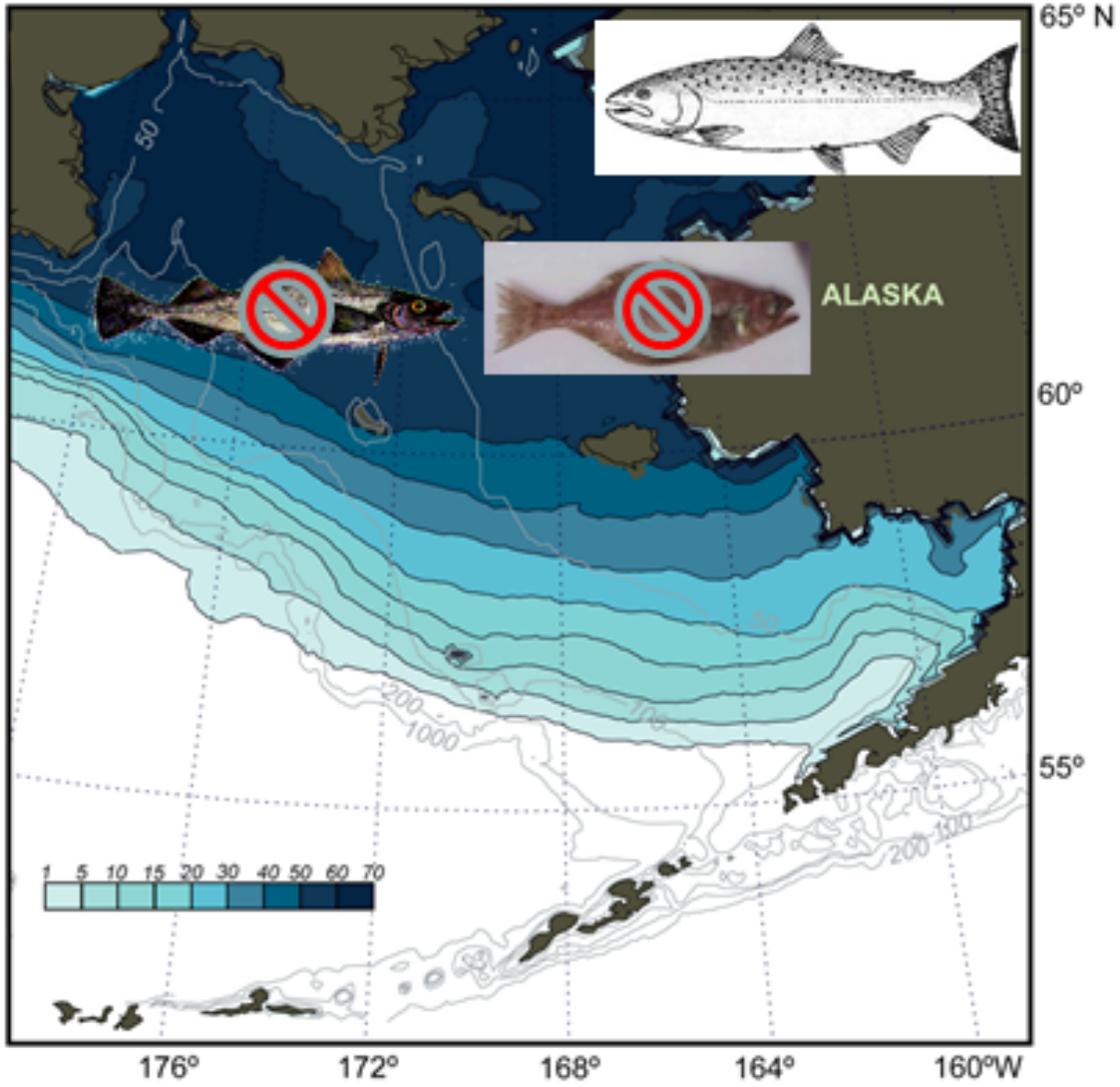


Cold years



The anomalies of sea-ice coverage during March and April during warm years (2001-2005, left) and cold years (2007-2010, right) (Stabeno, Farley, Kachel, Moore, Mordy, Napp, Overland, Pinchuk, Sigler)

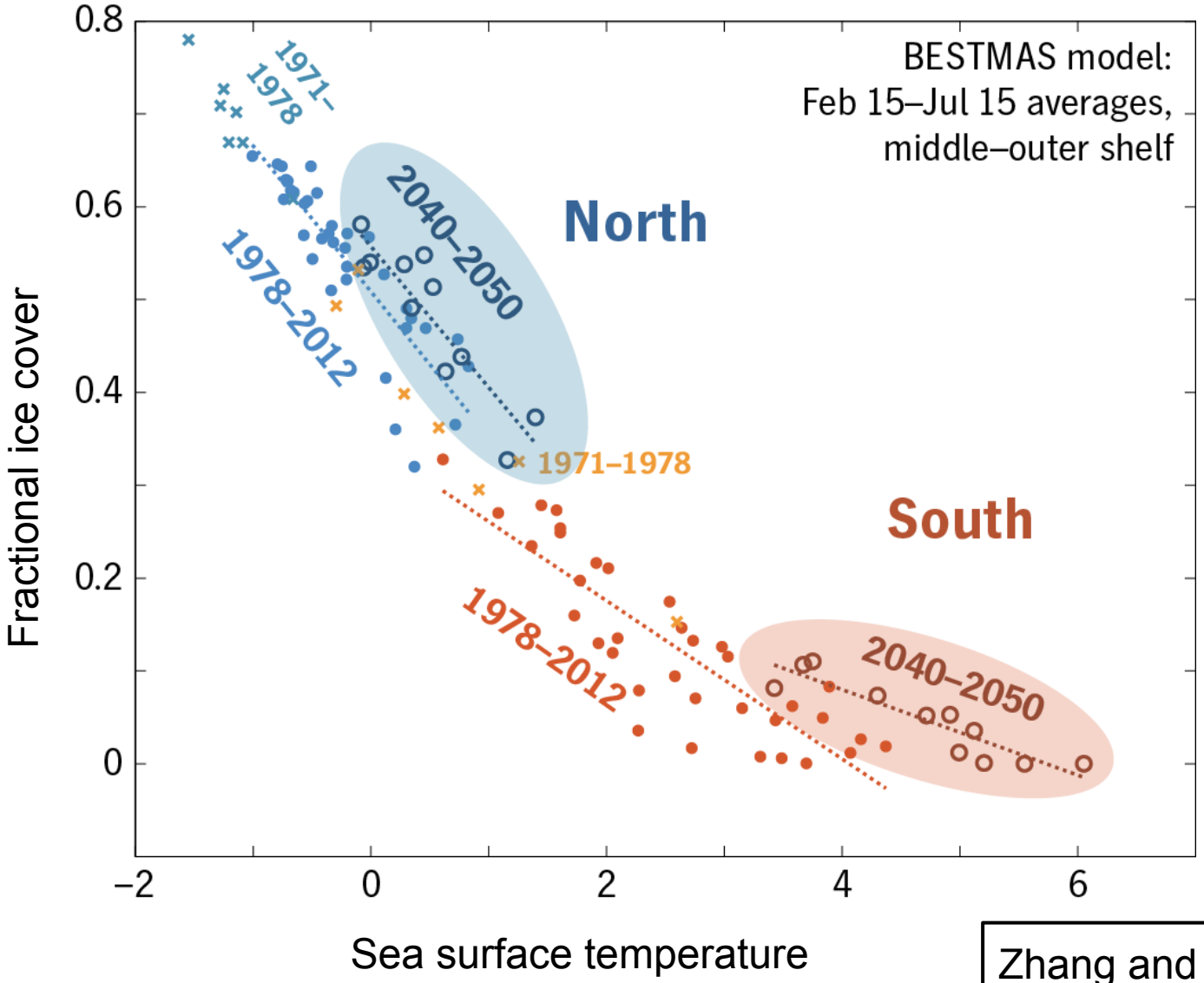
Subarctic fish will not expand into northern Bering Sea shelf, which contradicts our expectation when the program started (strike 3!)



The average number of days in which sea-ice was present in March and April during 2001-2010.

Stabeno, Farley, Kachel, Moore, Mordy, Napp, Overland, Pinchuk, Sigler

Models also forecast that the north will remain cold and dark



Zhang and Banas

Forecast fish abundance, climate effects differ

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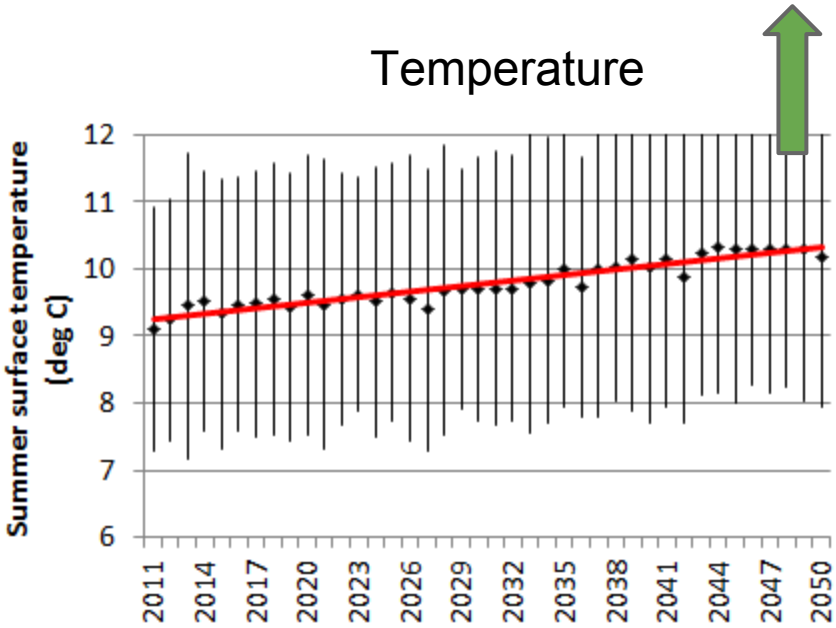
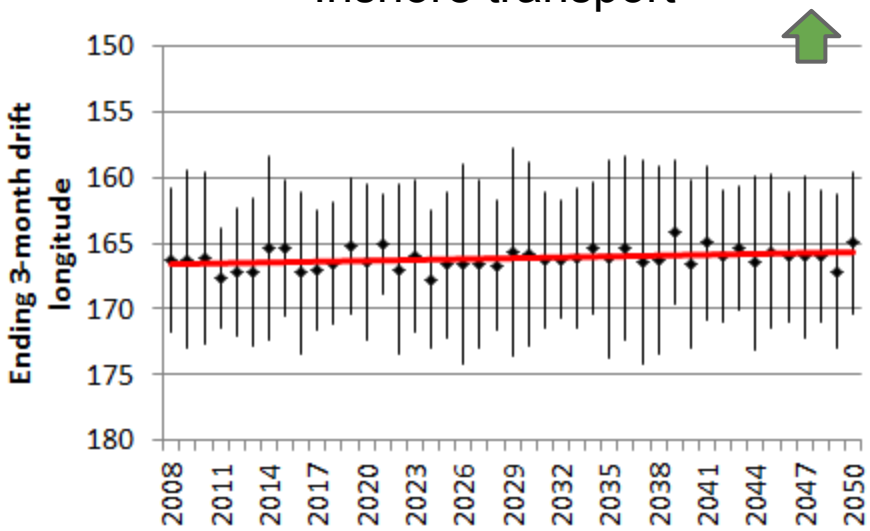
Temperature



Mueter, Bond, Ianelli, Hollowed

Inshore transport



Wilderbuer, Stockhausen, Bond

Forecast fish abundance, climate effects differ

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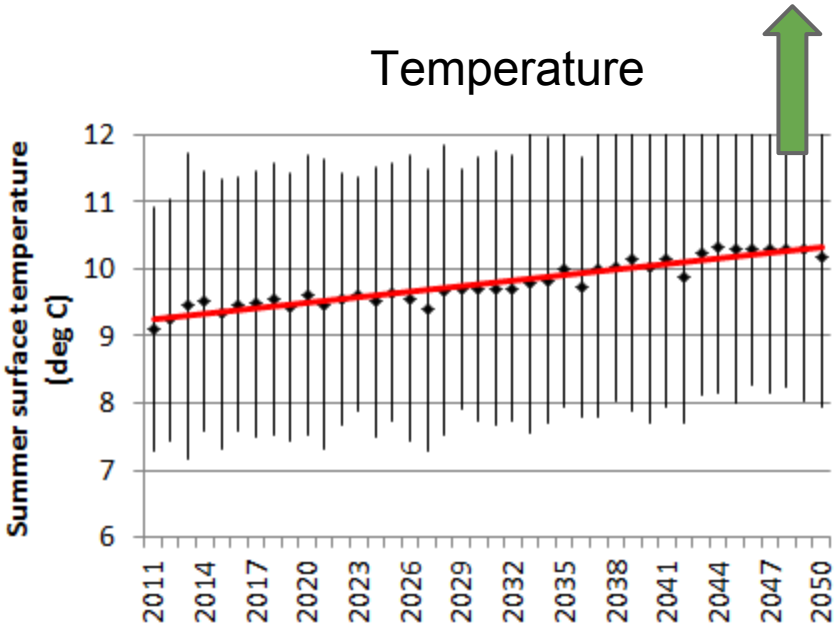
Temperature



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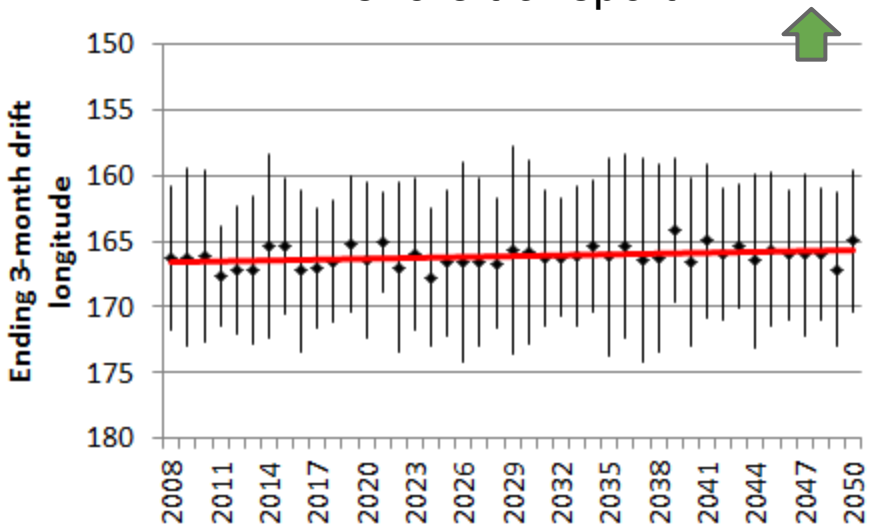
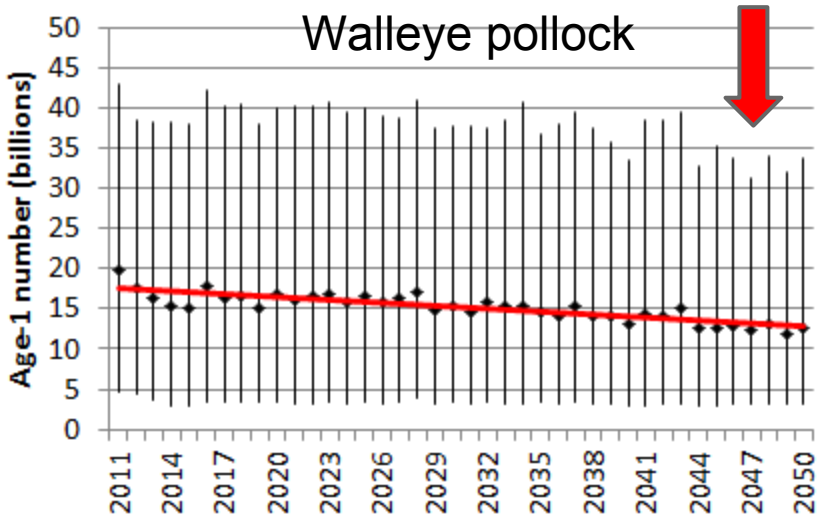
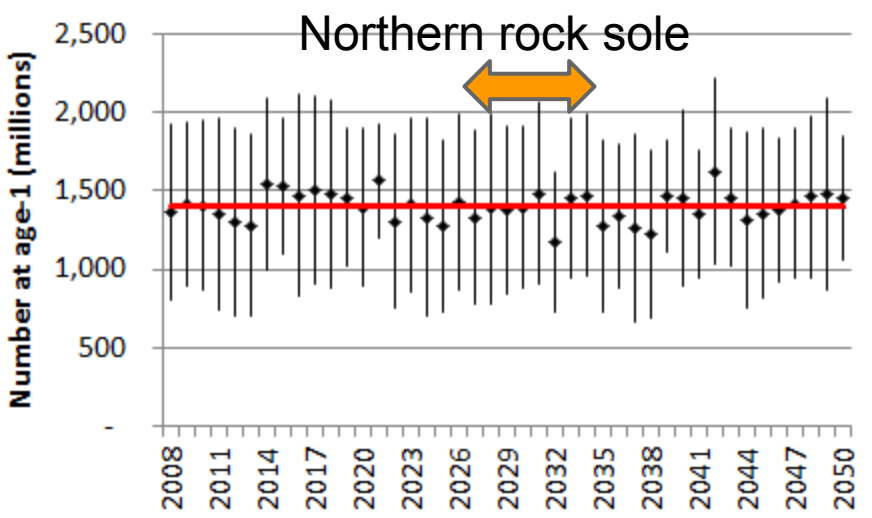


Walleye pollock



Northern rock sole



Mueter, Bond, Ianelli, Hollowed

Wilderbuer, Stockhausen, Bond

Epilogue

- 4th special issue of Deep Sea Research II
- Bering Sea headlines and magazine
- Bering Sea Project photo exhibit at Snow City Cafe (then Sea Life Center)
- Bering Sea Open Science Meeting
- Ocean Sciences meeting Feb 2014

www.nprb.org/beringseaproject