EcoFOCI: A 30 year partnership between NOAA Research and NOAA Fisheries

Speakers: Carol Ladd and Phyllis Stabeno

EcoFOCI Program Leads:
Phyllis Stabeno (OAR) and Janet Duffy-Anderson (Fisheries)

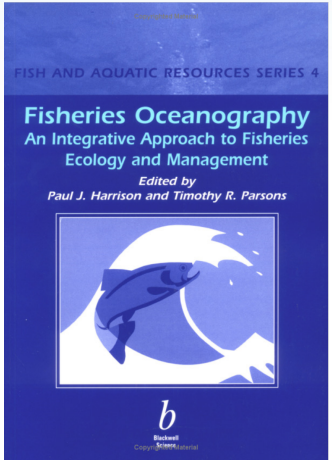
Background

EcoFOCI

Ecosystems and Fisheries Oceanography Coordinated Investigations

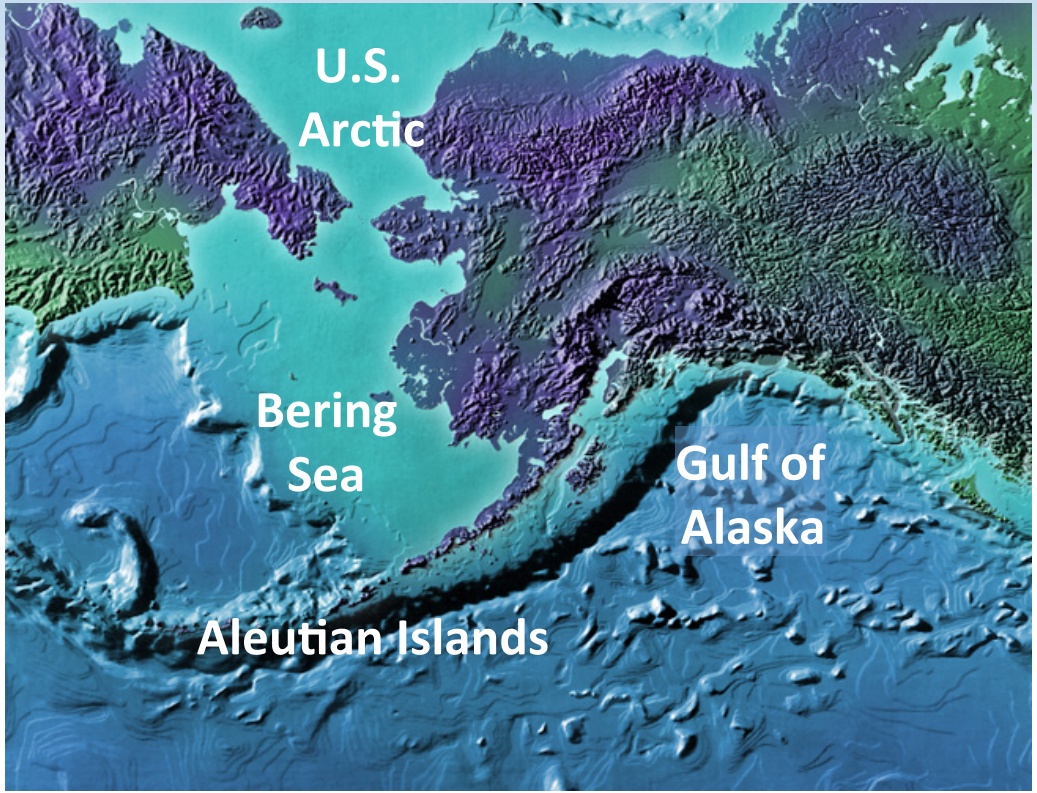
- Fisheries Oceanography:
  - "The study of oceanic processes affecting marine ecosystems and the relationship of these ecosystems to the abundance and availability of fish."

Parsons and Harrison, 2000



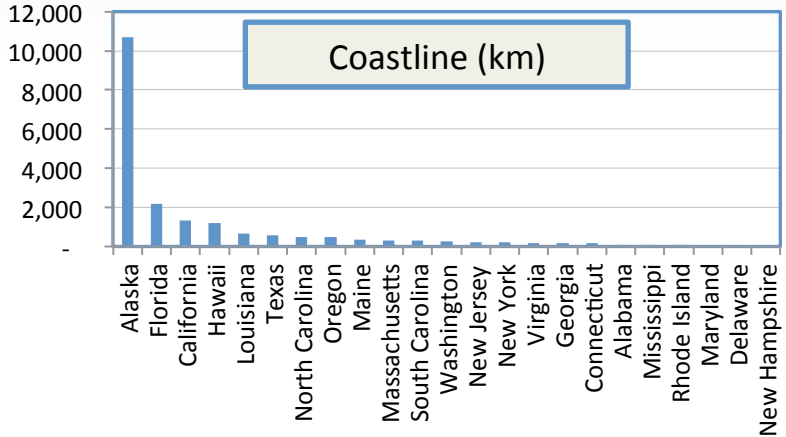
Background

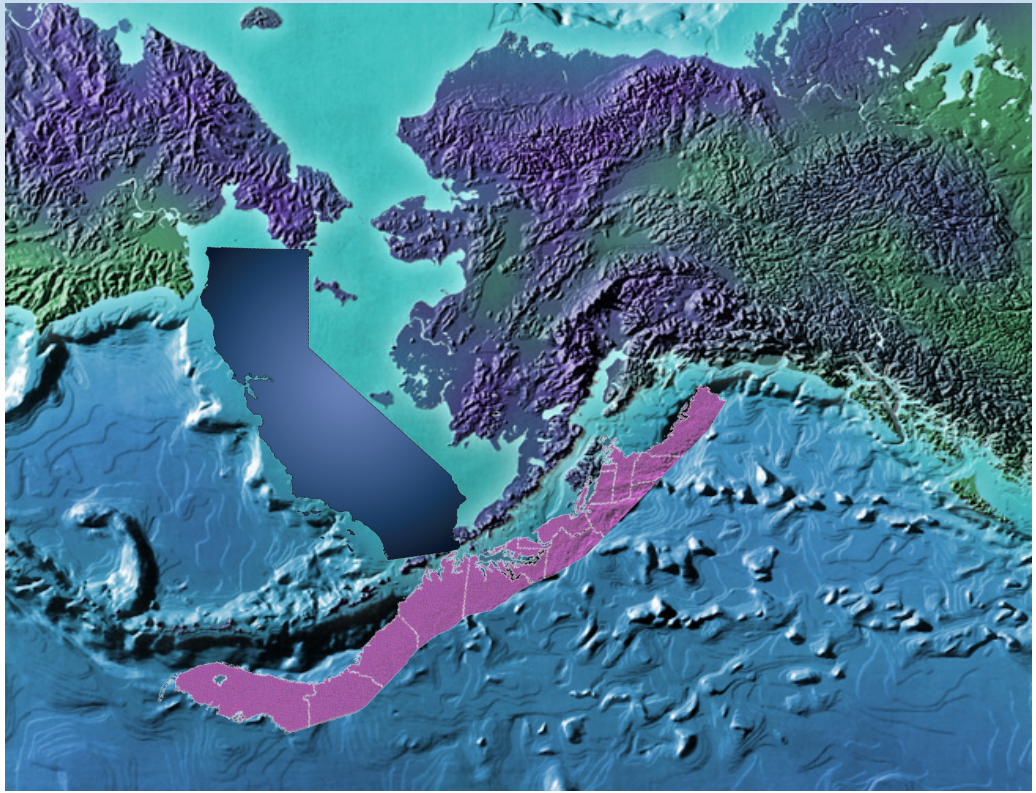
- Ecosystem research in the following regions:
  - Gulf of Alaska
  - Bering Sea/ Aleutian Islands
  - U.S. Arctic



Background

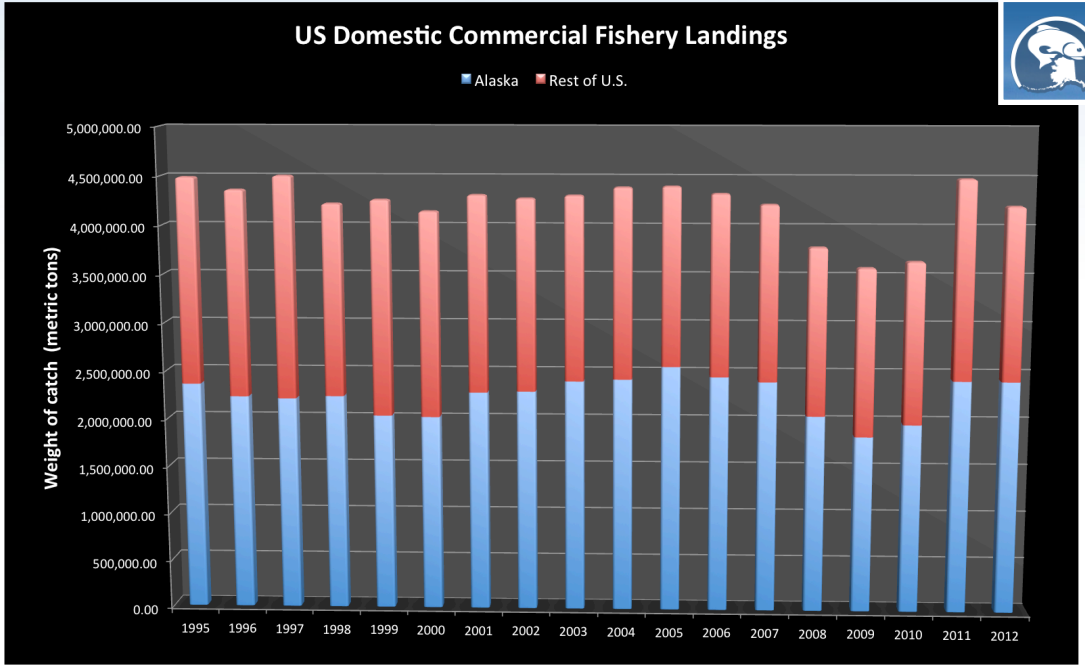
- Alaska's coastline measures ~10,700 km (more than all other states combined)
- Bering Sea shelf has larger area than the state of California
- Alaska Peninsula/Aleutians has longer coastline than entire eastern U.S.





Relevance

Alaska provides > 50% of US commercial fisheries catch (> $1.5b).
It is NOAA's responsibility to sustainably manage U.S. fisheries.



NORTH PACIFIC Fishery Management Council

Products for ecosystem-based fisheries management

- Indices and assessment tools
- Climate-forced models
- Environmental and ecosystem data

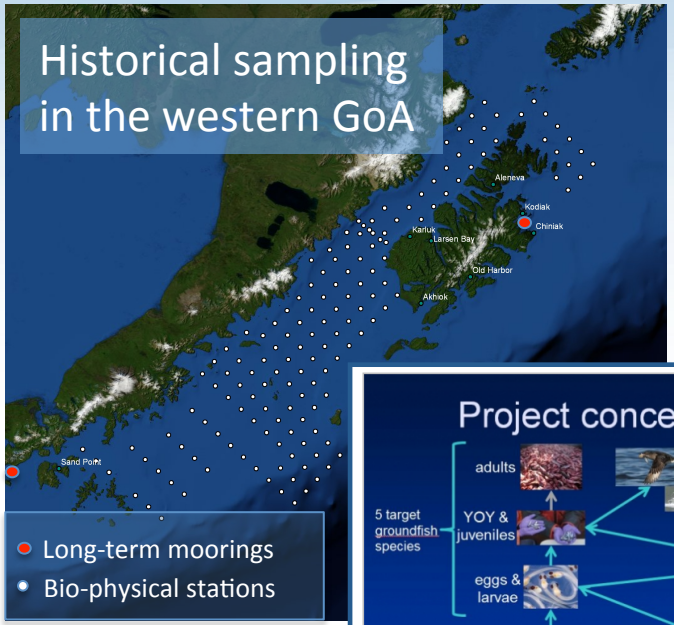
Relevance

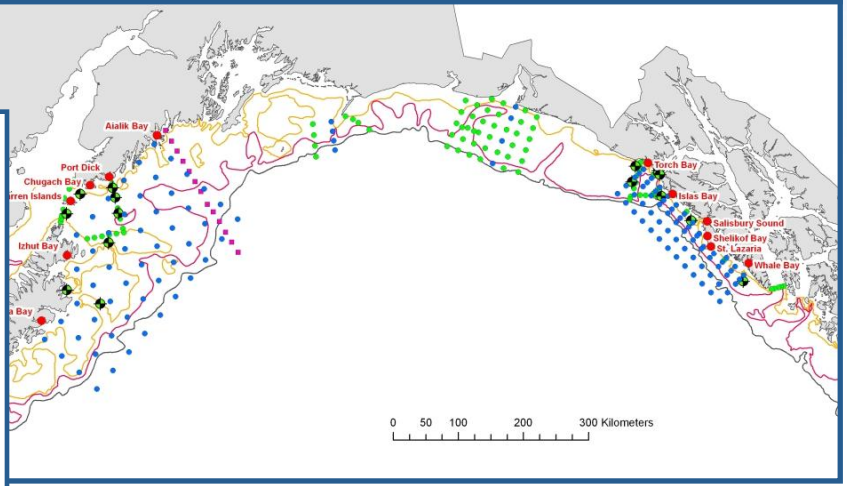
Protected, Endangered, & Threatened Species

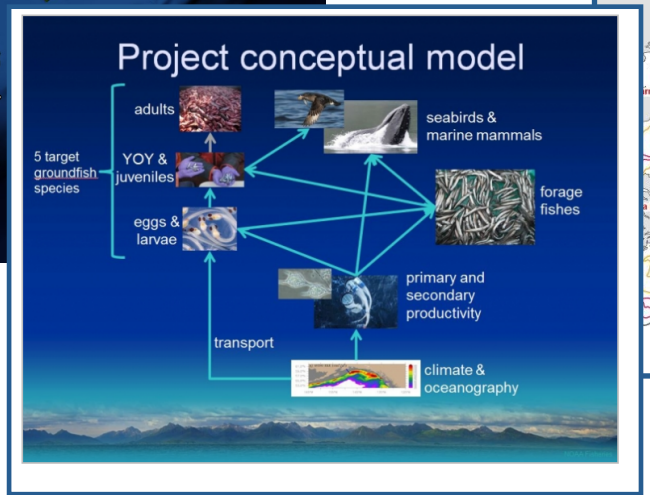
NOAA's responsibility to manage endangered and threatened marine species

- **Climate needs to be considered for ESA listing**
- **EcoFOCI data and expertise have been valuable in ESA considerations:**
  EcoFOCI scientists projected that annual sea ice will continue to be available to Ribbon Seals in the northern Bering Sea for the next 50 years.
- **Moorings of opportunity:**
  Acoustic data are monitoring the Bering and Chukchi Seas for marine mammal activity.

Quality/Performance
Gulf of Alaska

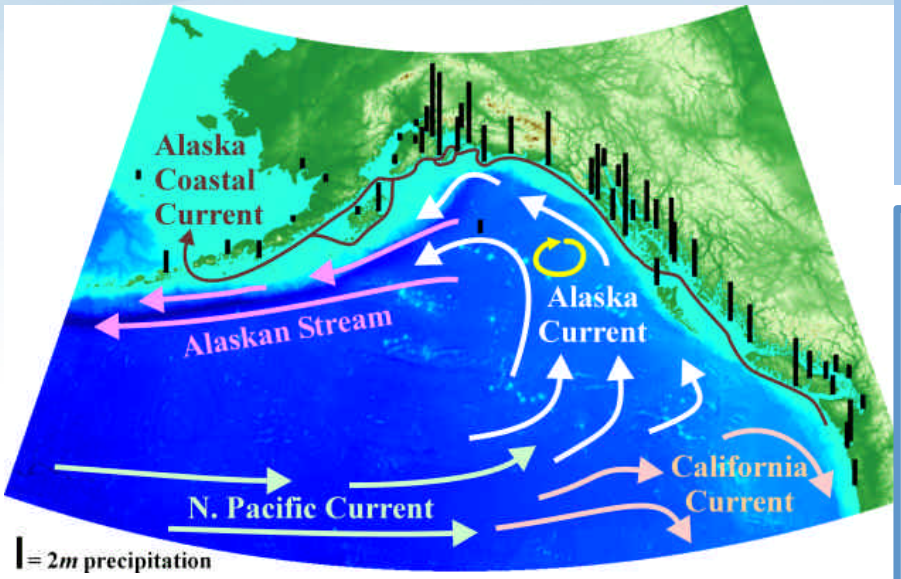




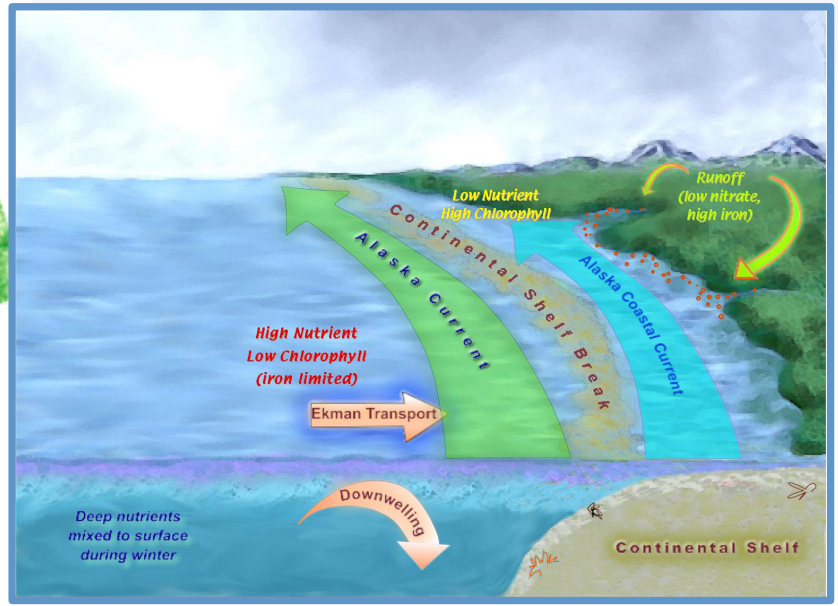


http://nprb.org/gulf-of-alaska-project

Gulf of Alaska



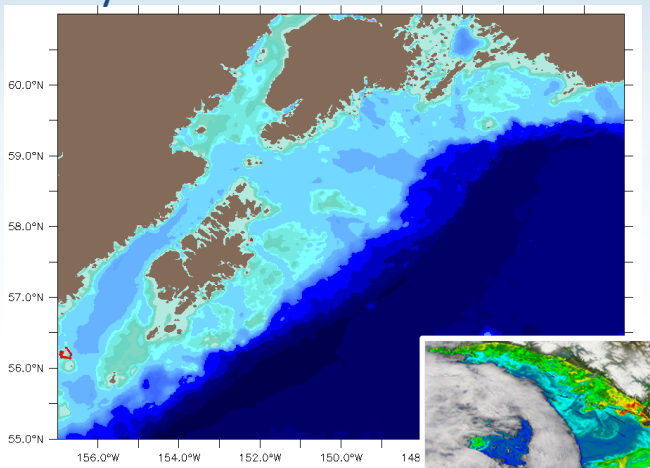
Cross-shelf exchange mixes
basin water: high nutrient, iron-limited
shelf water: high iron, nutrient limited.



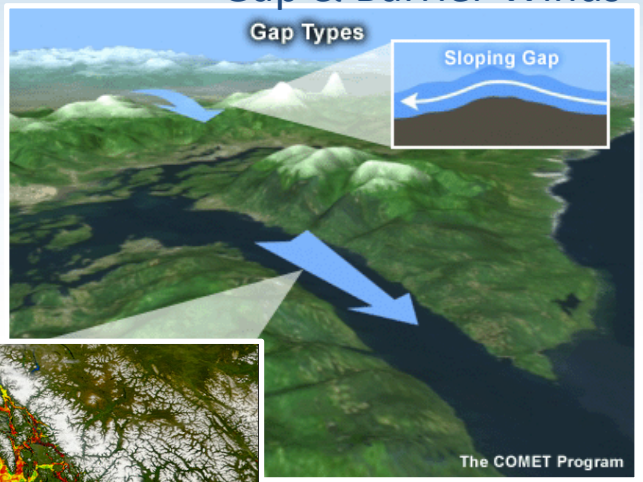
Gulf of Alaska

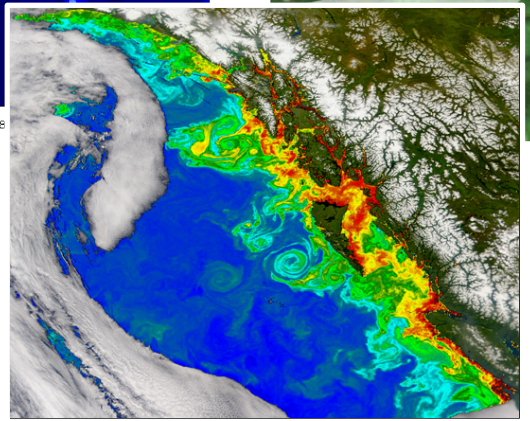
Mechanisms influencing nutrient supply to the shelf

Canyons and Banks



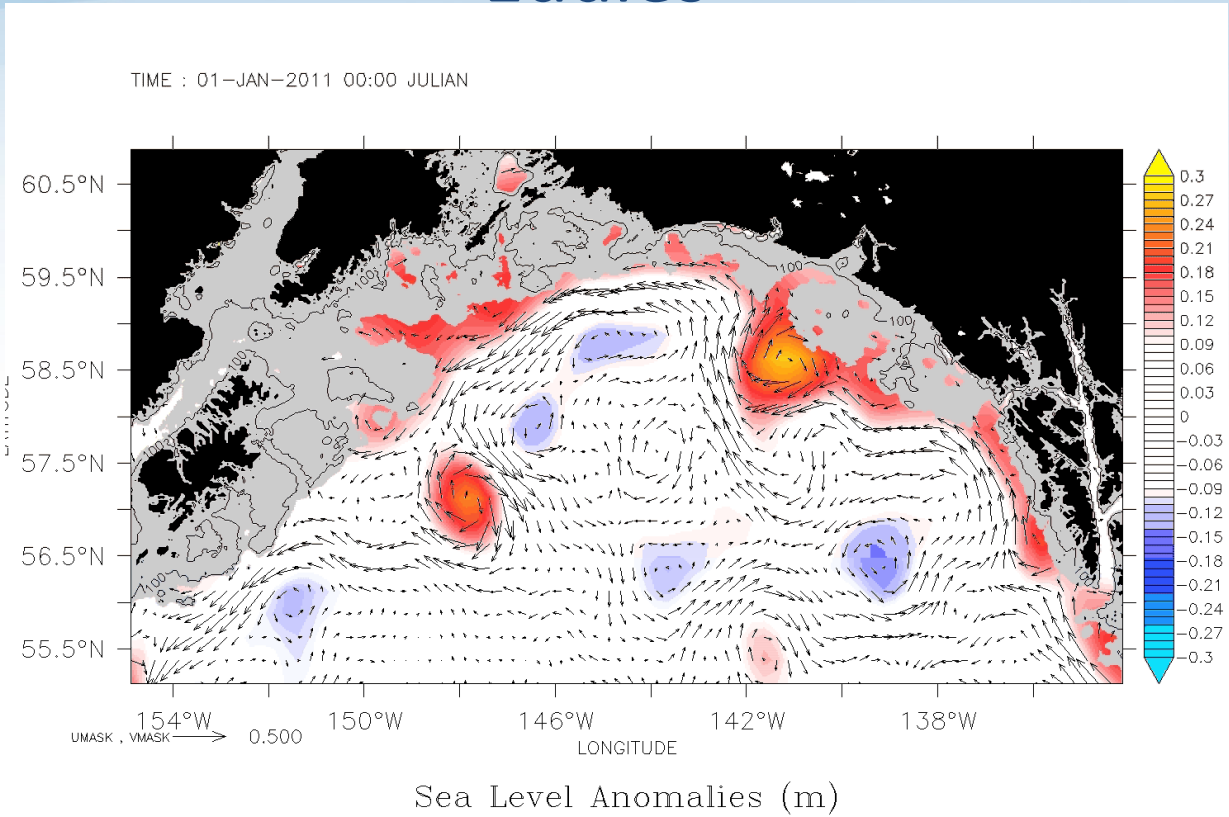
Gap & Barrier Winds





Eddies

Gulf of Alaska
Eddies



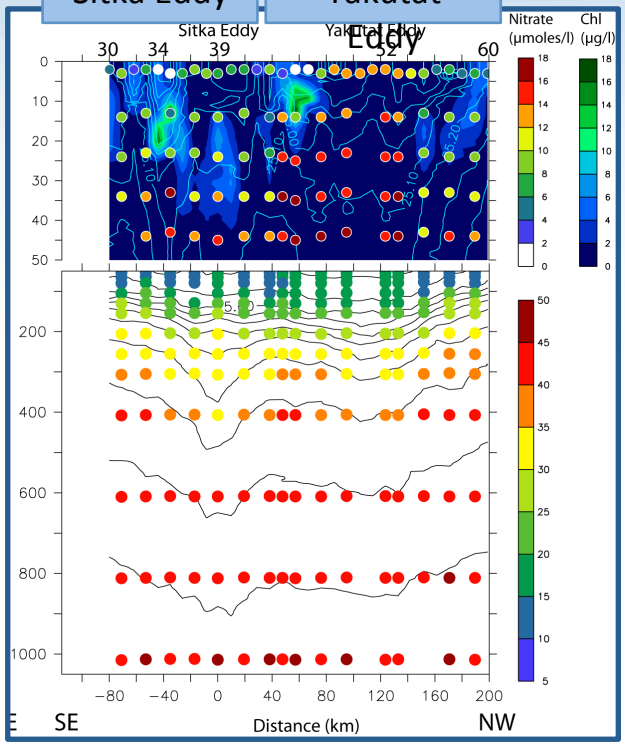
Movie

- sea surface height anomalies (color)
- drifter trajectories (black lines)

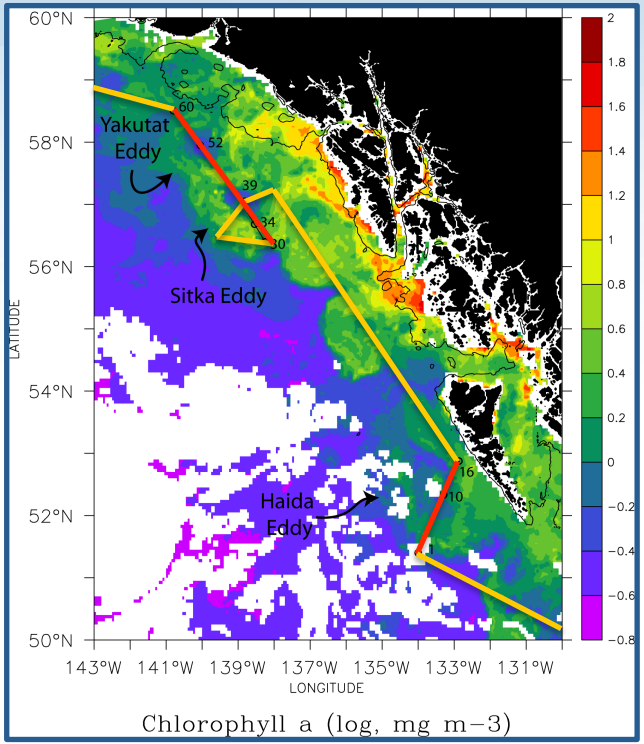
Gulf of Alaska
Eddies

Post-bloom Sitka Eddy

Pre-bloom Yakutat Eddy



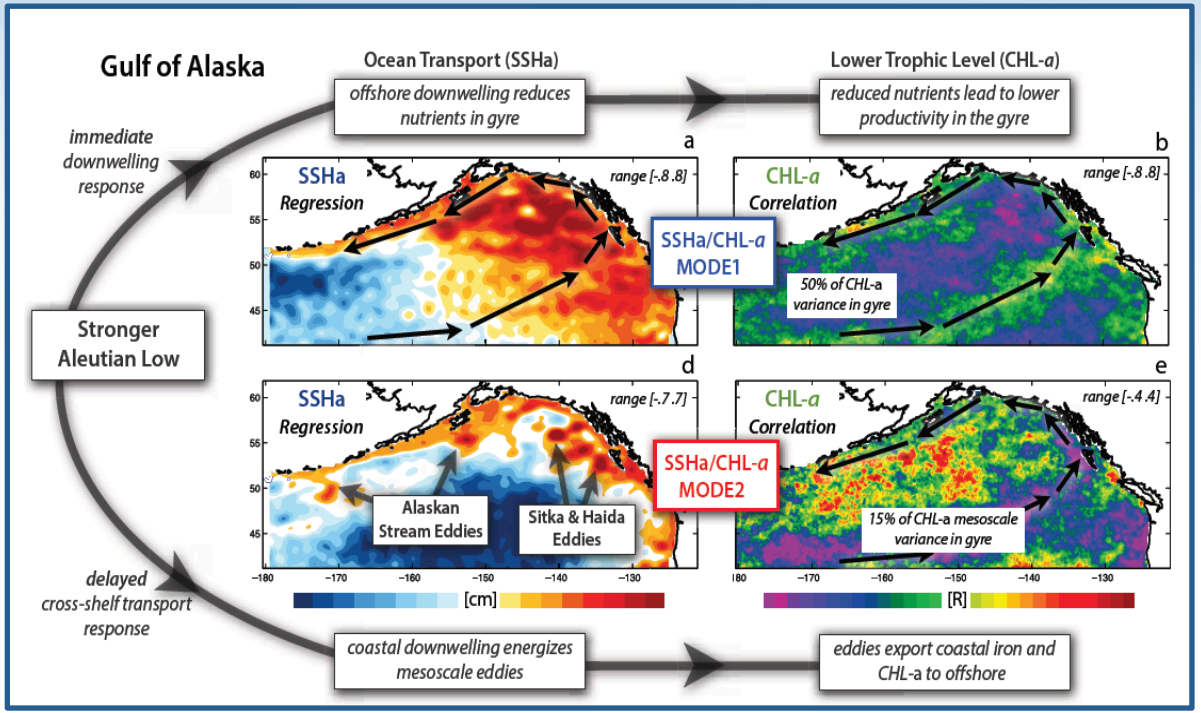
- First cruise ever to compare 3 different types of GOA eddies synoptically
- High nutrients in eddy core waters.
- Transport of coastal chlorophyll off-shelf.
- Shallow formation region for Yakutat eddy – sediment derived iron in core.



Ladd et al. (2009)

Gulf of Alaska
Eddies

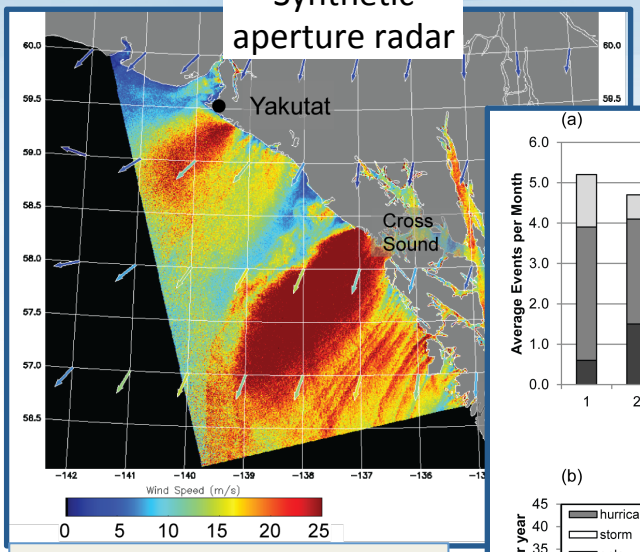
Covariability between SSHA and Chlorophyll-a from combined EOF analysis

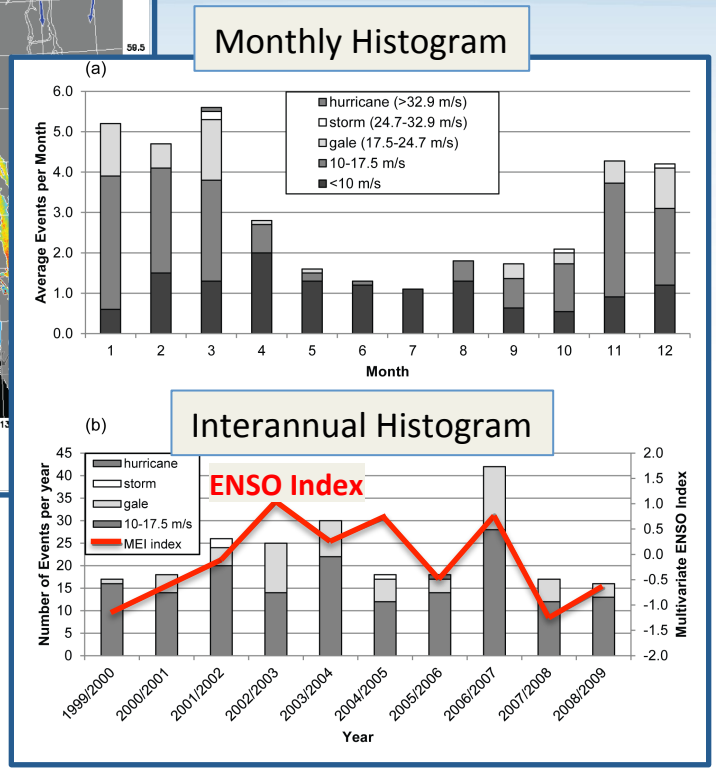


DiLorenzo et al. (2013)

Gulf of Alaska

Gap Winds





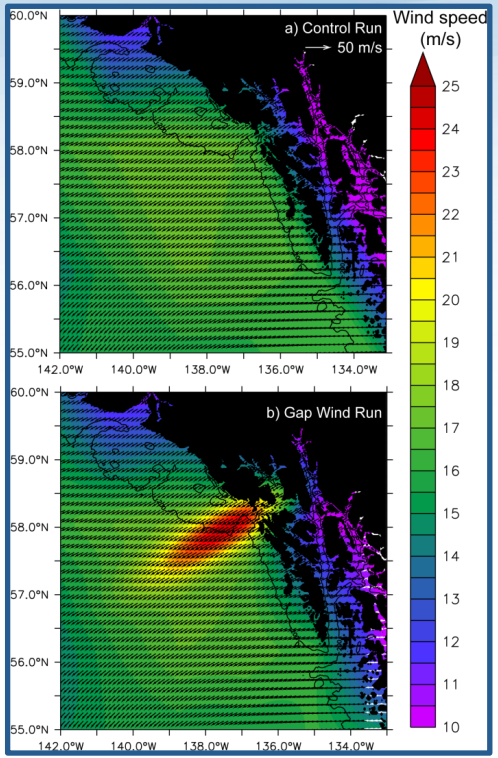
In the eastern GOA:

- Offshore directed winds occur ~10% of the time.
- Offshore directed winds more common during winter.
- The number of strong offshore directed wind events each year is correlated with El Niño.

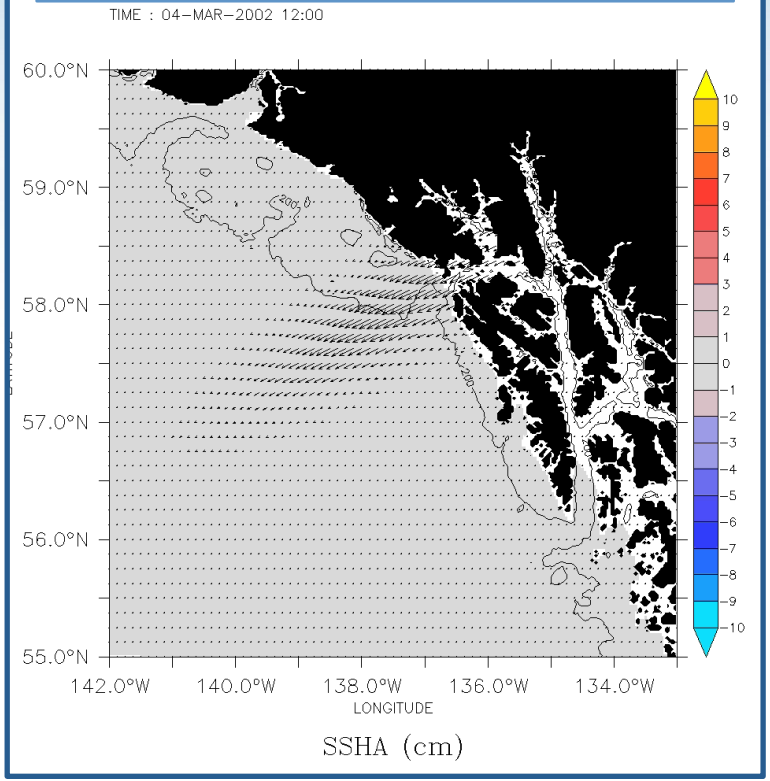
Ladd et al. (submitted)

Gulf of Alaska

Gap Winds



Wind Forcing (black) and SSHA (color)



Effect of Gap Wind event on regional oceanography

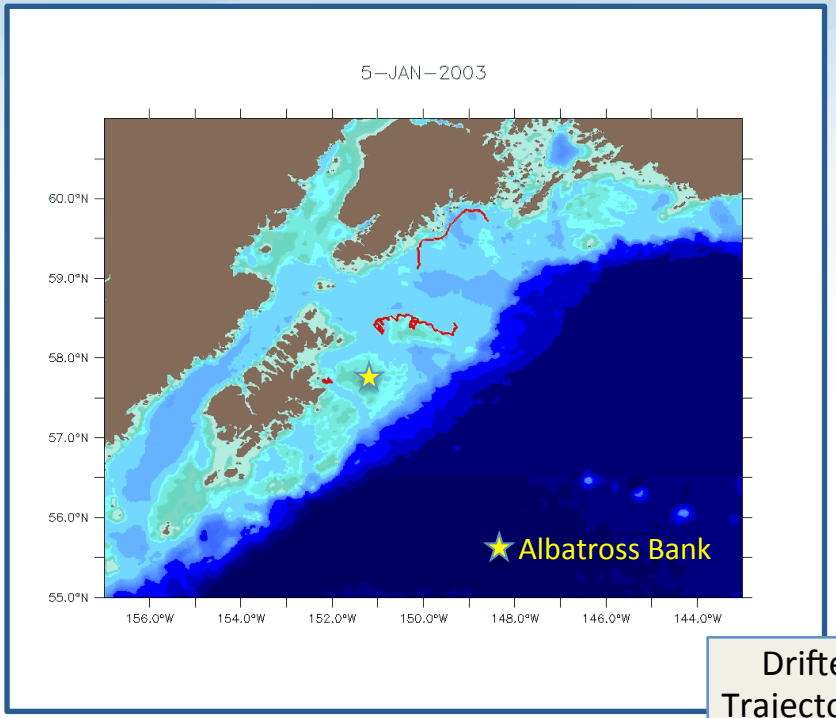
Model Results

- Changes in coastal current
- Localized upwelling of nutrients
- Formation of eddies

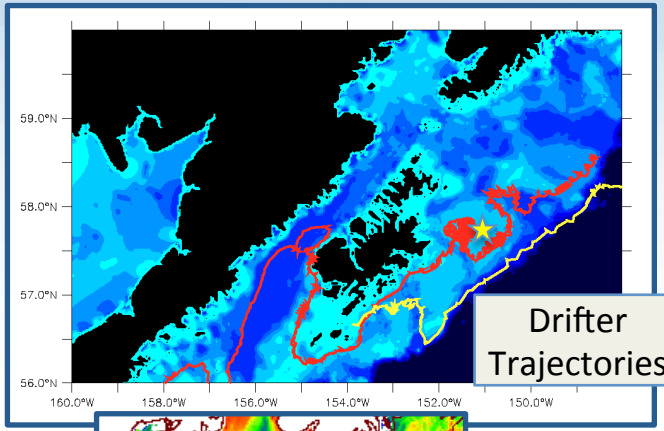
Ladd et al. (submitted)

Gulf of Alaska

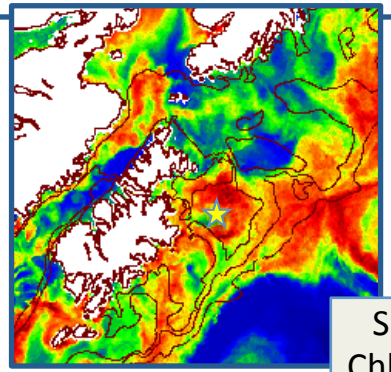
Canyons & Banks



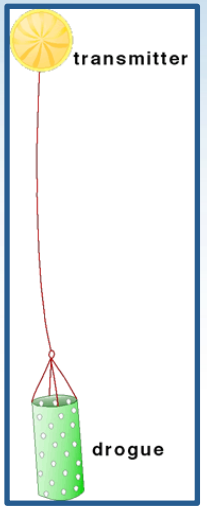
Drifter Trajectories



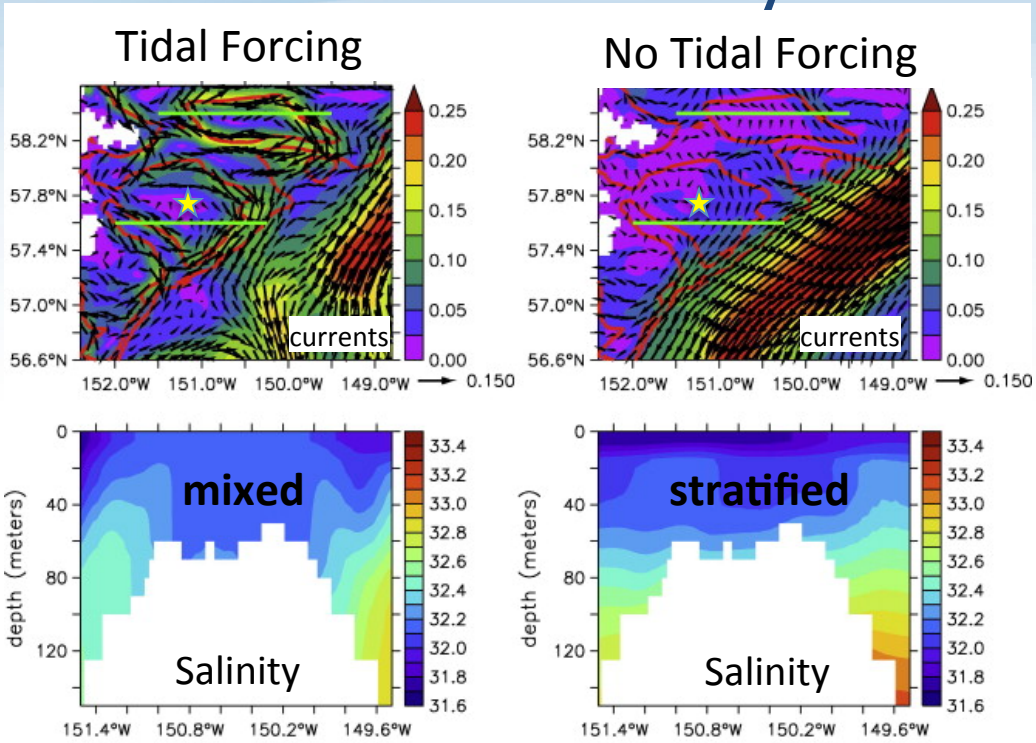
Drifter Trajectories



Satellite Chlorophyll



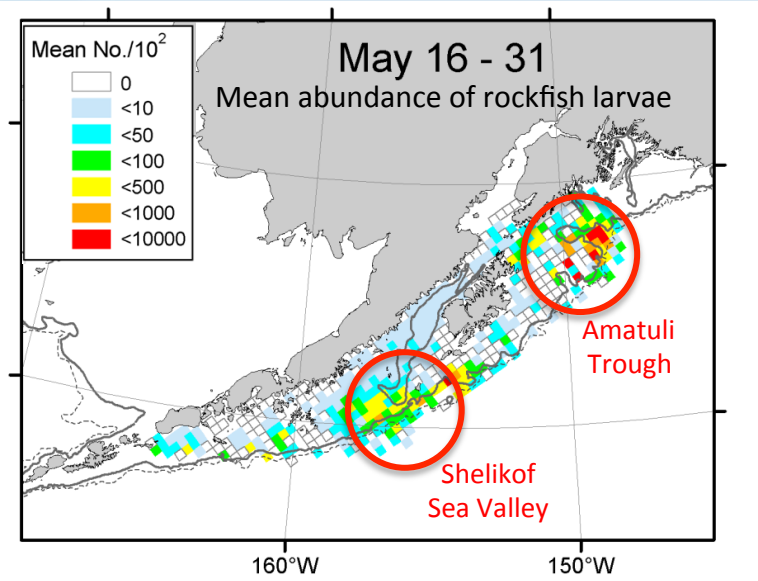
Gulf of Alaska
Canyons & Banks



Modeling work demonstrates the importance of interaction between bathymetry and tides for supplying nutrients to the euphotic zone.

Cheng et al. (2012)

Gulf of Alaska
Canyons & Banks

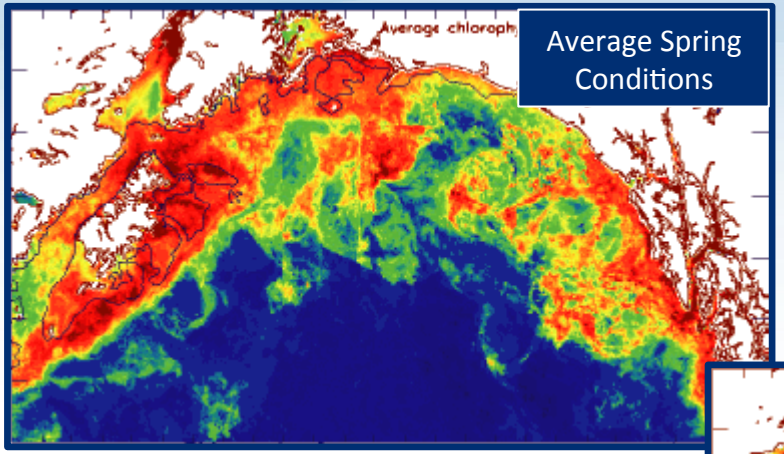


***Sebastes* spp. (Rockfish) Larvae**

- Larvae are released over the slope
- Hot spots associated with Amatuli Trough and Shelikof Sea Valley
- Onshore surface transport associated with these features

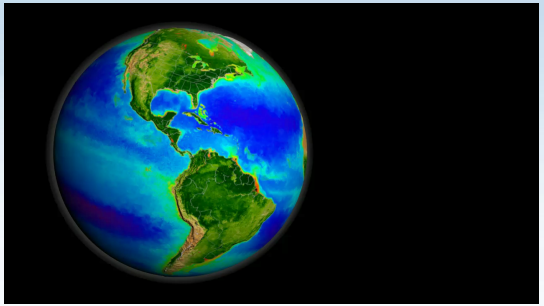
Doyle and Mier (submitted)

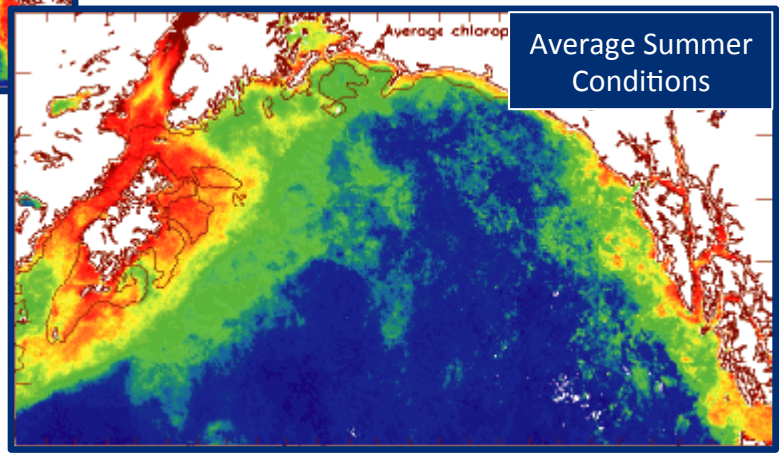
Gulf of Alaska



Spring:

- Plenty of light
- Plenty of nutrients
- Bloom over most of shelf

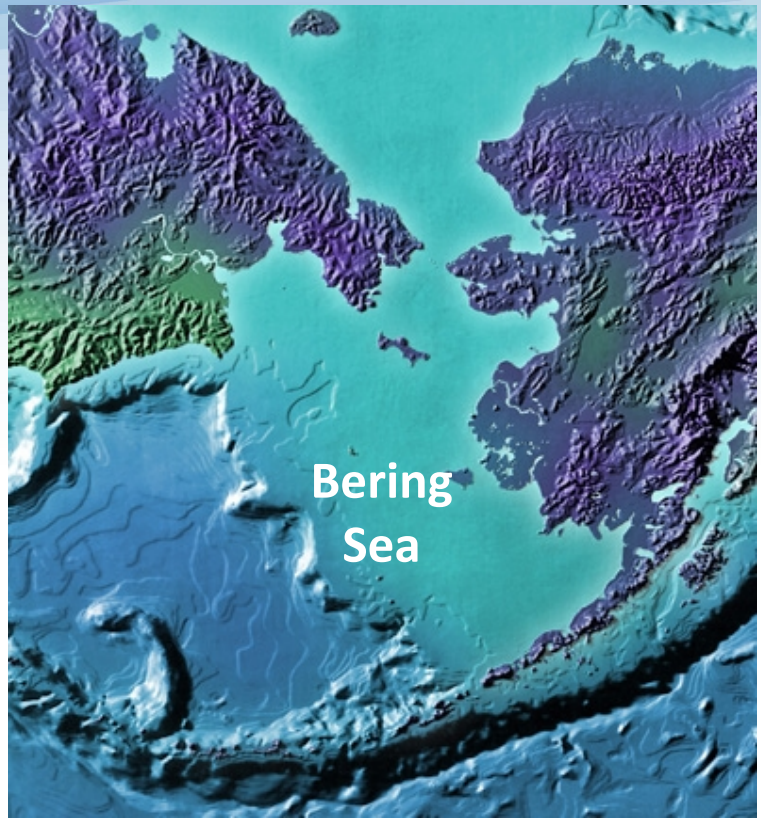




Summer:

- Plenty of light
- Lower nutrients (nutrient limitation)
- But still high phytoplankton concentrations around Kodiak.

Bering Sea

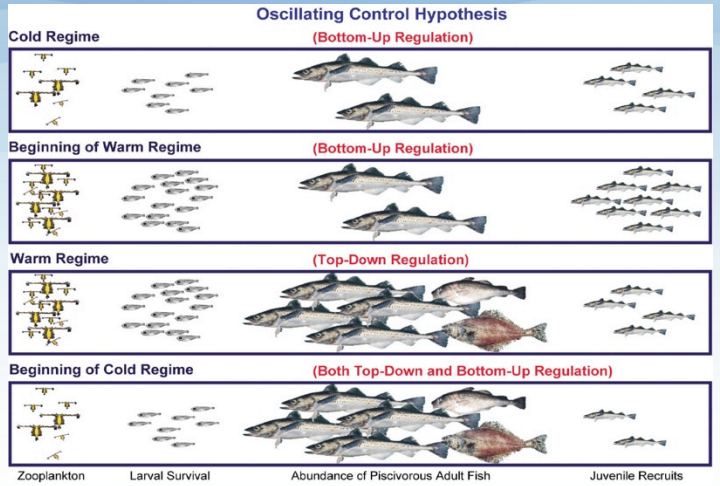


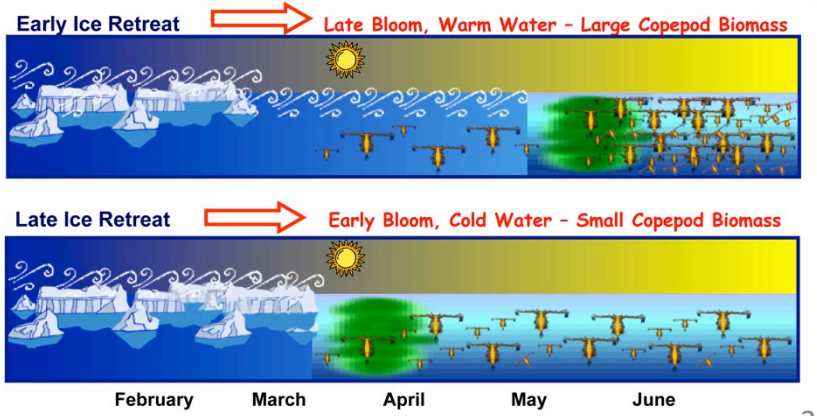
The old paradigm

Bering Sea

Warming would result in:

- **Reduction of sea ice**
- **Uniform warming of eastern shelf**
- **An expansion of the southern ecosystem northward**
- **Marked increase in catch, particularly subarctic species of fish**





Road to a new paradigm

Bering Sea

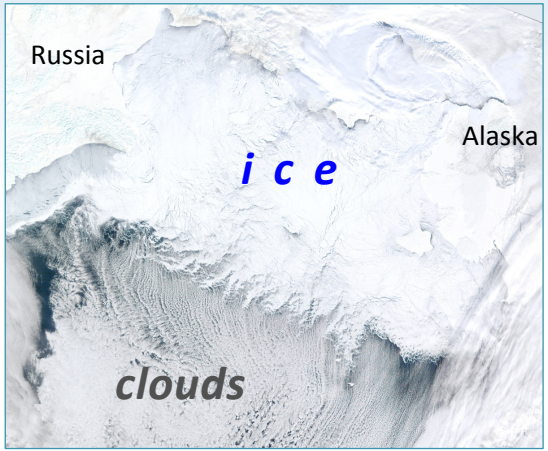
Beginning in 2001, a series of warm years had a profound impact on the Bering Sea ecosystem. It soon became evident that our paradigm needed to be modified.

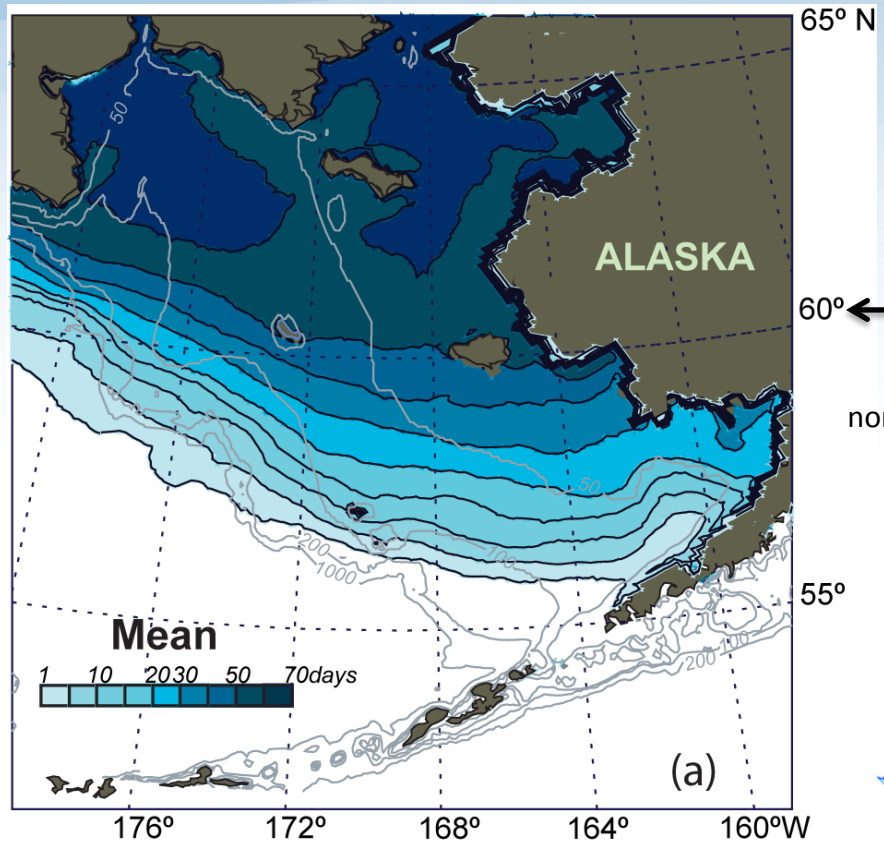
Bering Sea Project – NSF, NPRB and NOAA partnership – was the pathway to this goal.

http://bsierp.nprb.org/

Mean number of days of ice cover March -April

Bering Sea



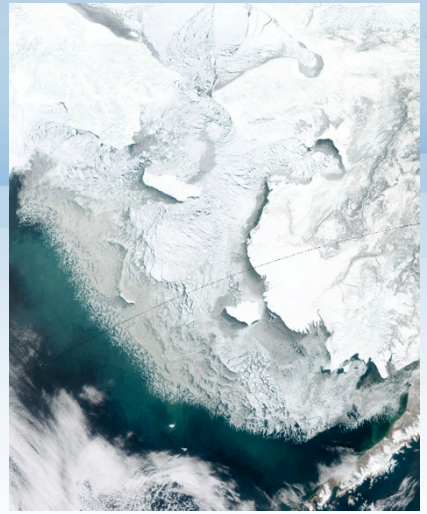


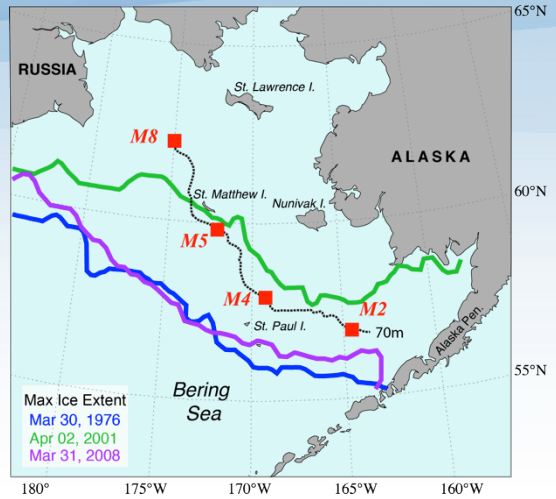
Boundary between northern and southern Bering Sea

Stabeno et al., 2010; 2012

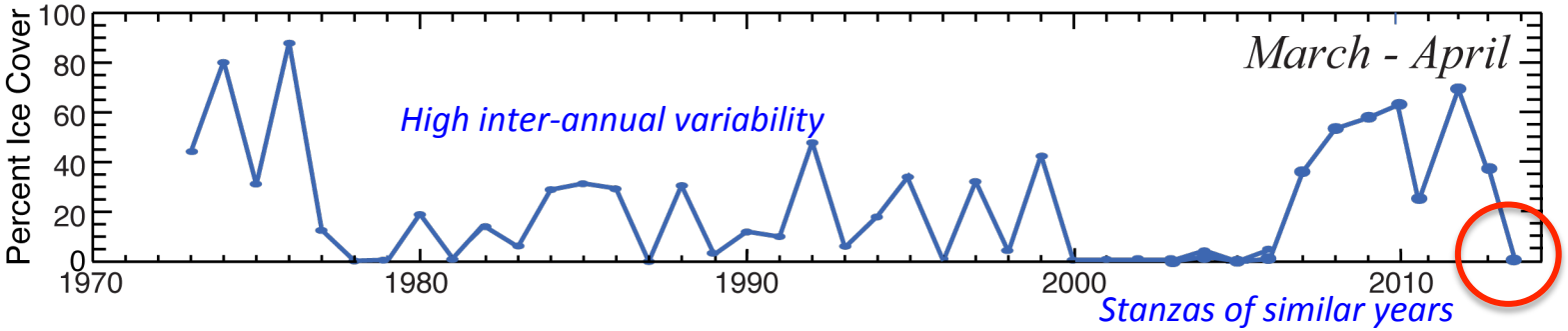
Interannual variability in sea-ice extent

Bering Sea





Sea ice (extent and timing of retreat) is the primary driver of the ecosystem of the southern Bering Sea shelf.

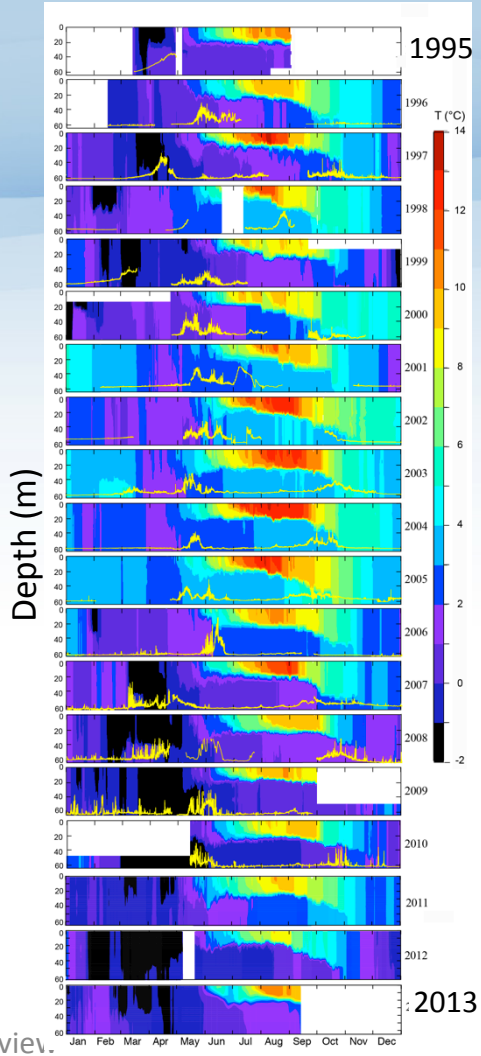


Stabeno et al., 2010; 2012

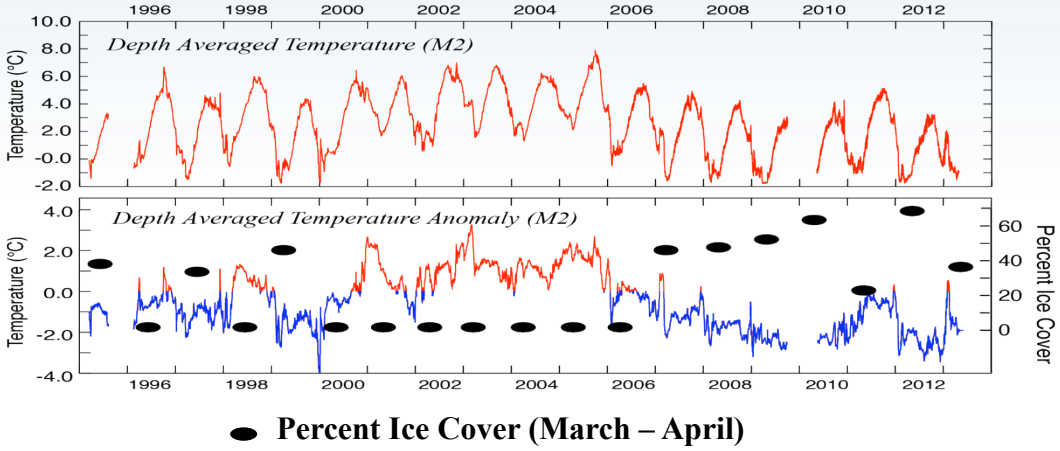
EcoFOCI

Bering Sea

Performance



Measurements on M2: currents, temperature, salinity, O_2, fluorescence, pCO_2, nitrate, sound, zooplankton biovolume, and summer met package



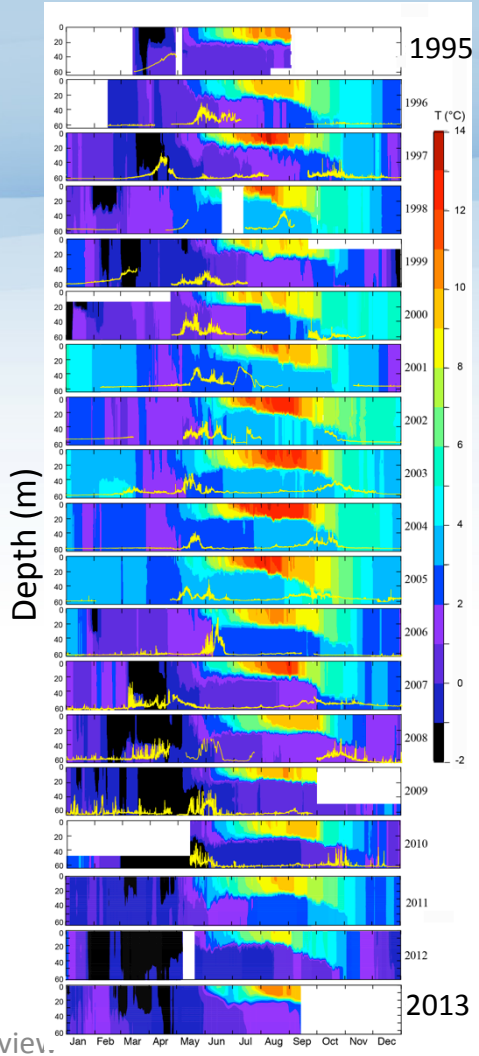
Stabeno et al., 2012

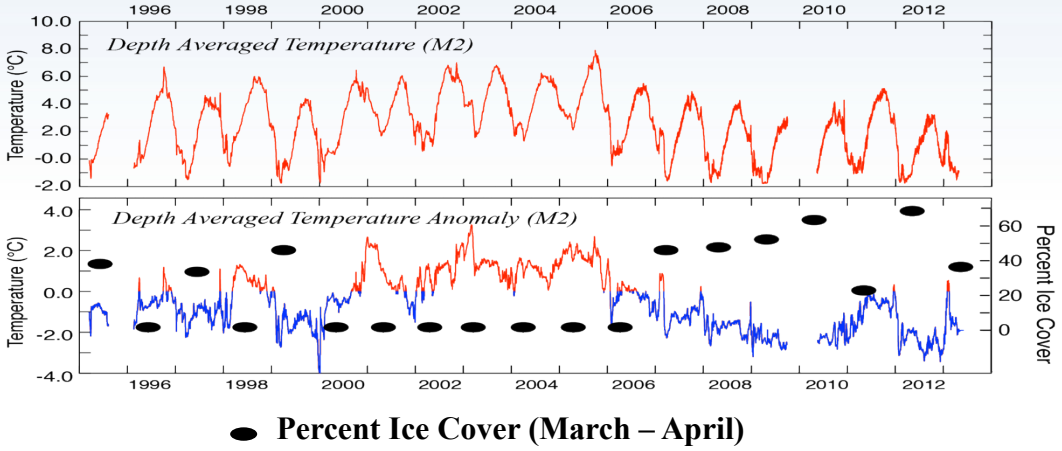
EcoFOCI

Temperature and sea ice at M2

Bering Sea

Quality





Percent Ice Cover (March – April)

Stabeno et al., 2012

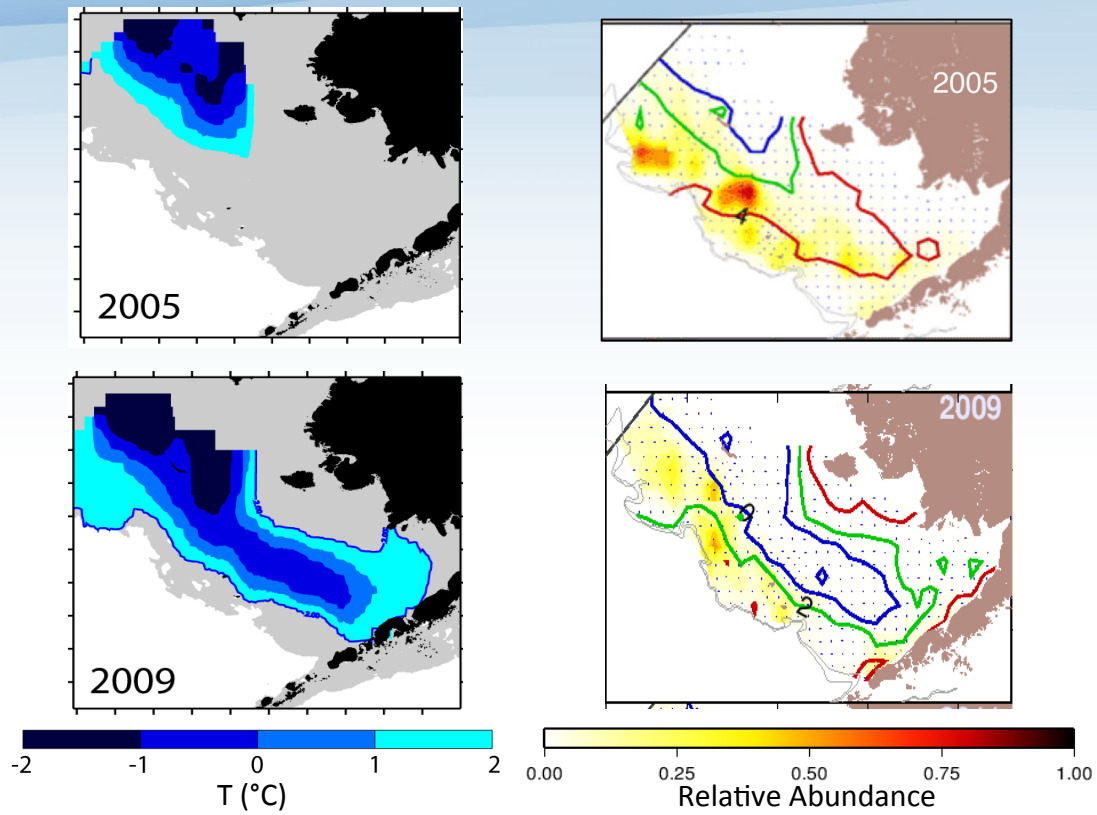
EcoFOCI

Cold pool and its influence on pollock

Bering Sea

Warm (2005)

Cold (2009)

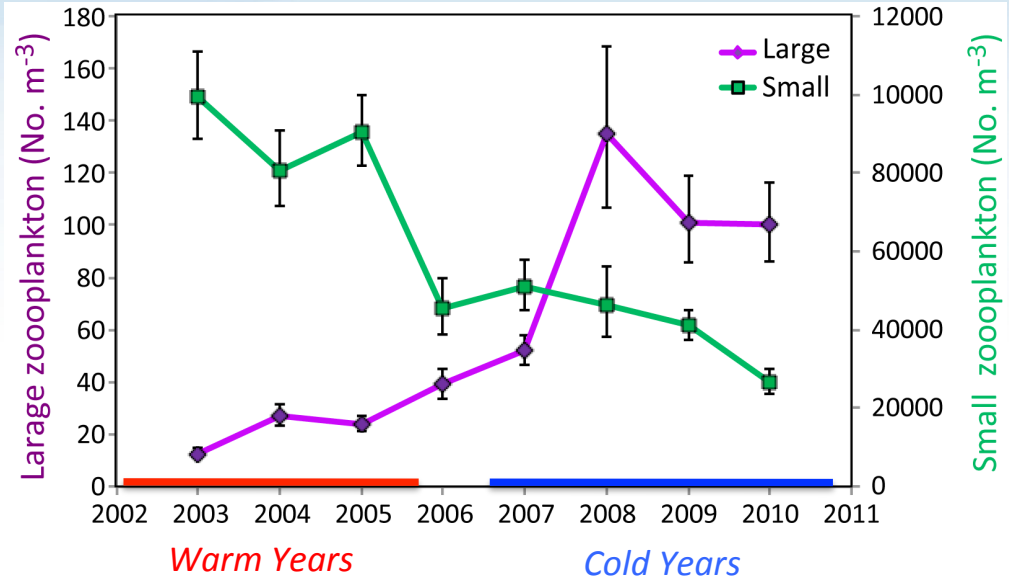


Differences in the extent of the cold pool and relative abundance of pollock in warm and cold years.

Stabeno et al., 2012, Ianelli et al., 2014

Change in abundance of large zooplankton

Bering Sea



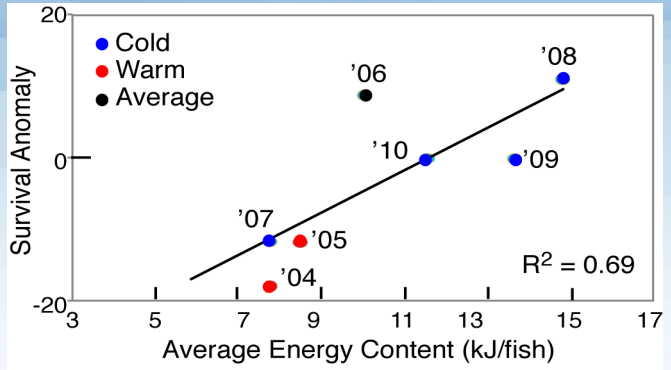
Eisner et al., 2014

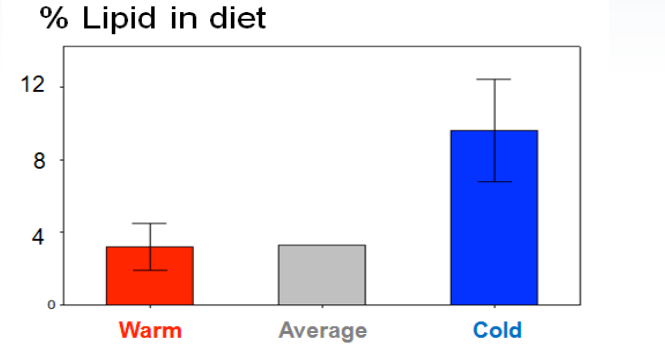
- Cold years increased abundance of large zooplankton
- Successive warm years reduced numbers of zooplankton

Change in survival of young-of-the-year pollock

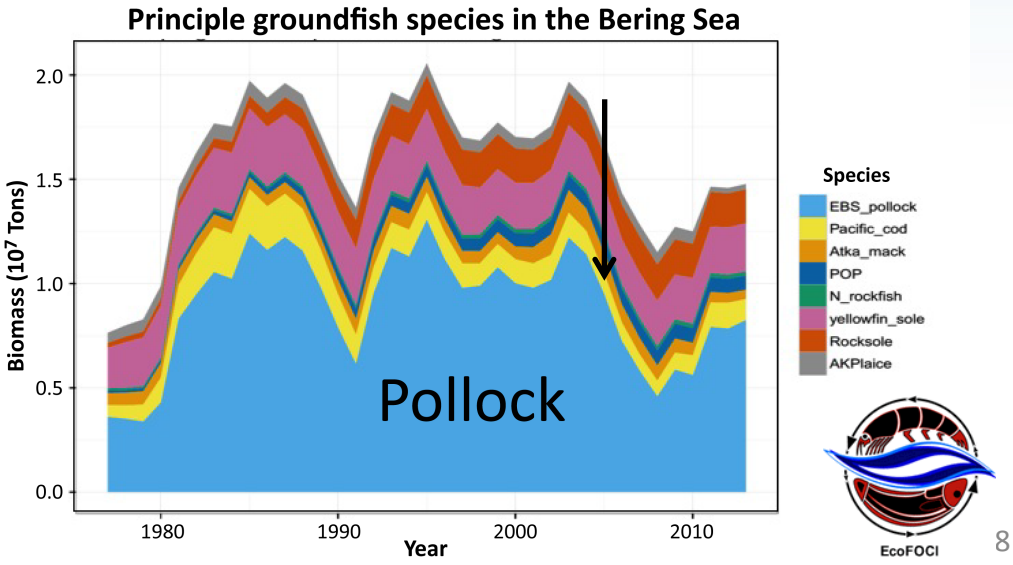
Bering Sea

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., 2014



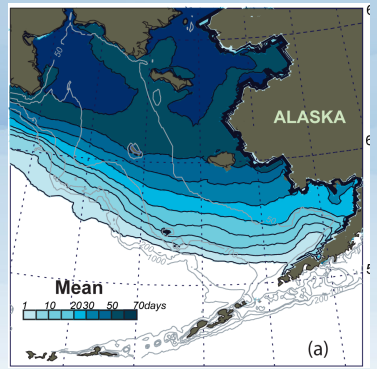
EcoFOCI

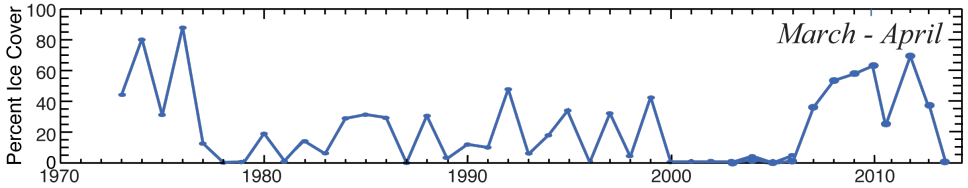
The new paradigm

Bering Sea

Warming would result in:

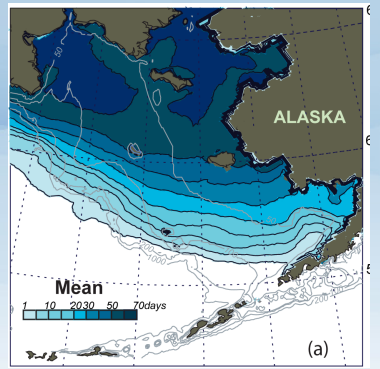
- **Decreased sea ice in the south, but not in the north**
- **The southern ecosystem will not expand northward**
- **Large zooplankton abundance will decrease**
- **Decrease in catch, particularly subarctic species of fish**





The new paradigm

Bering Sea

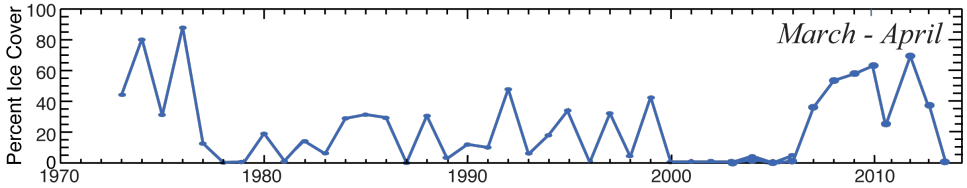


Warming would result in:

- **Decreased sea ice in the south, but not in the north**
- **The southern ecosystem will not expand northward**
- **Large zooplankton abundance will decrease**
- **Decrease in catch, particularly subarctic species of fish**
- **Change from interannual variability to stanzas.**

Mechanism

Multiple years of reduced ice → *Warmer temperature* → *Decrease large zooplankton* → *Poor survival of yoy pollock.*



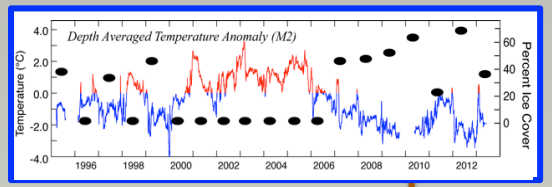
Bering Sea

Relevance

INFORMATION PATHWAY

Quota cut from 1.6 to 0.8 million tons

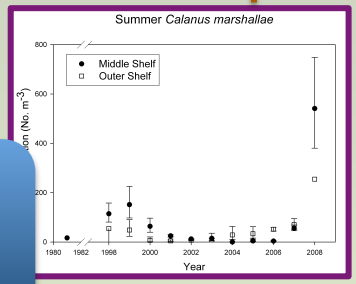
5 SSC supports recommendations to reduce pollock harvest based on assessment and continuation of poor (warm) environmental conditions



NORTH PACIFIC Fishery Management Council

4 Fishery Management Council's Science and Statistical Committee (SSC) receives warning

1 2005 moored temperature and zooplankton data reveal unfavorable ocean conditions for recruitment



2 Stock assessment model reveals low/declining recruitment

3 Stock assessment model reveals low/ declining recruitment

The Arctic

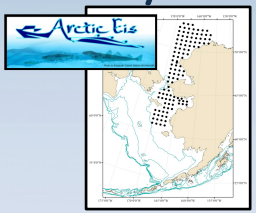
US-ARCTIC SIPS

US Arctic Regional Sea-Ice Predictability Study

National ESPC
EARTH SYSTEM PREDICTION CAPABILITY

ARCTIC EIS

Arctic Ecosystem Integrated Survey



DBO

Distributed Biological Observatory

RUSALCA

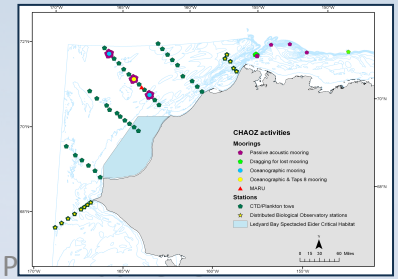
Russian-American Long-term Census of the Arctic

RUSALCA

BOEM
Bureau of Ocean Energy Management

CHAOZ

Chukchi Acoustic, Oceanographic, and Zooplankton study



CHAOZ-X

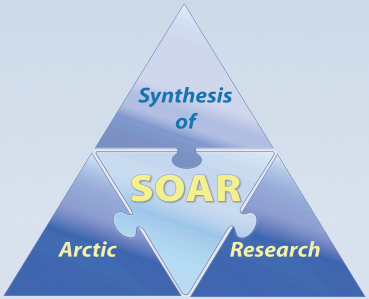
CHAOZ extension to Hanna Shoal

ARCWEST

Arctic Whale Ecology Study

SOAR

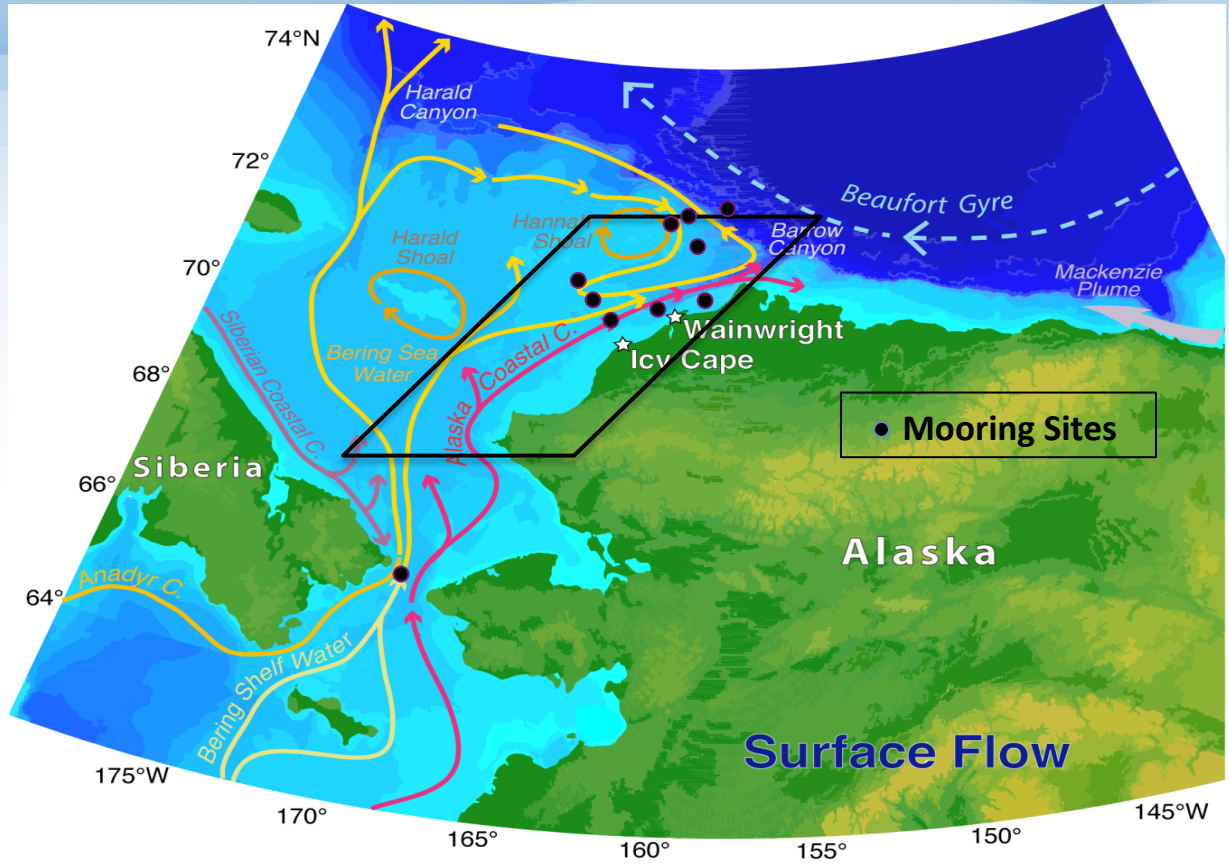
Synthesis of Arctic Research



Currents over the Chukchi and Beaufort Shelves

Arctic

Performance

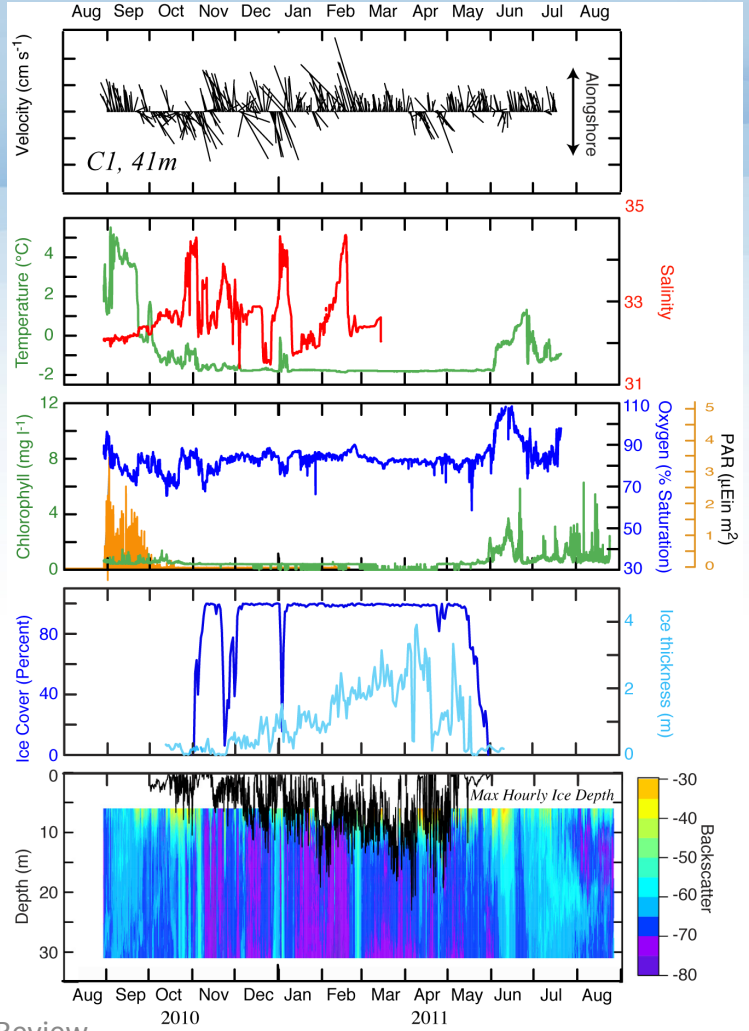


Stabeno et al., submitted, Wood et al., submitted

Mooring Data

Arctic

Quality



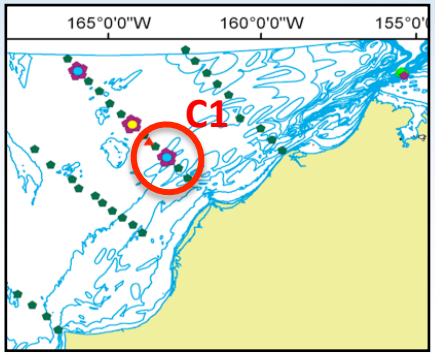
Currents

Temperature
Salinity

O_2 % Saturation
Fluorescence, PAR

Ice Concentration
Thickness

Backscatter
Max. Ice depth



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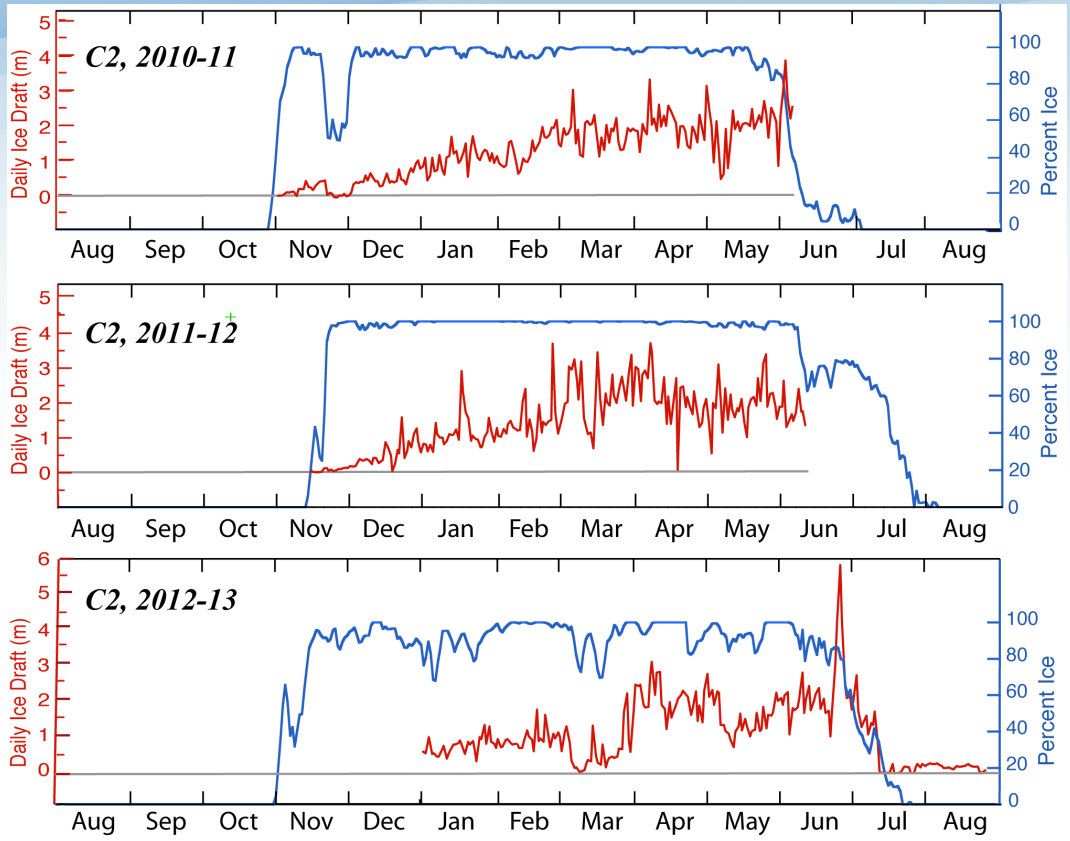
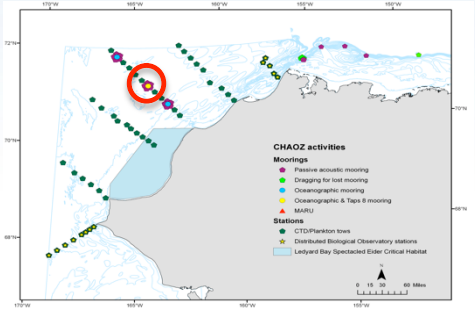
Ice draft and percent ice cover at C2

Arctic

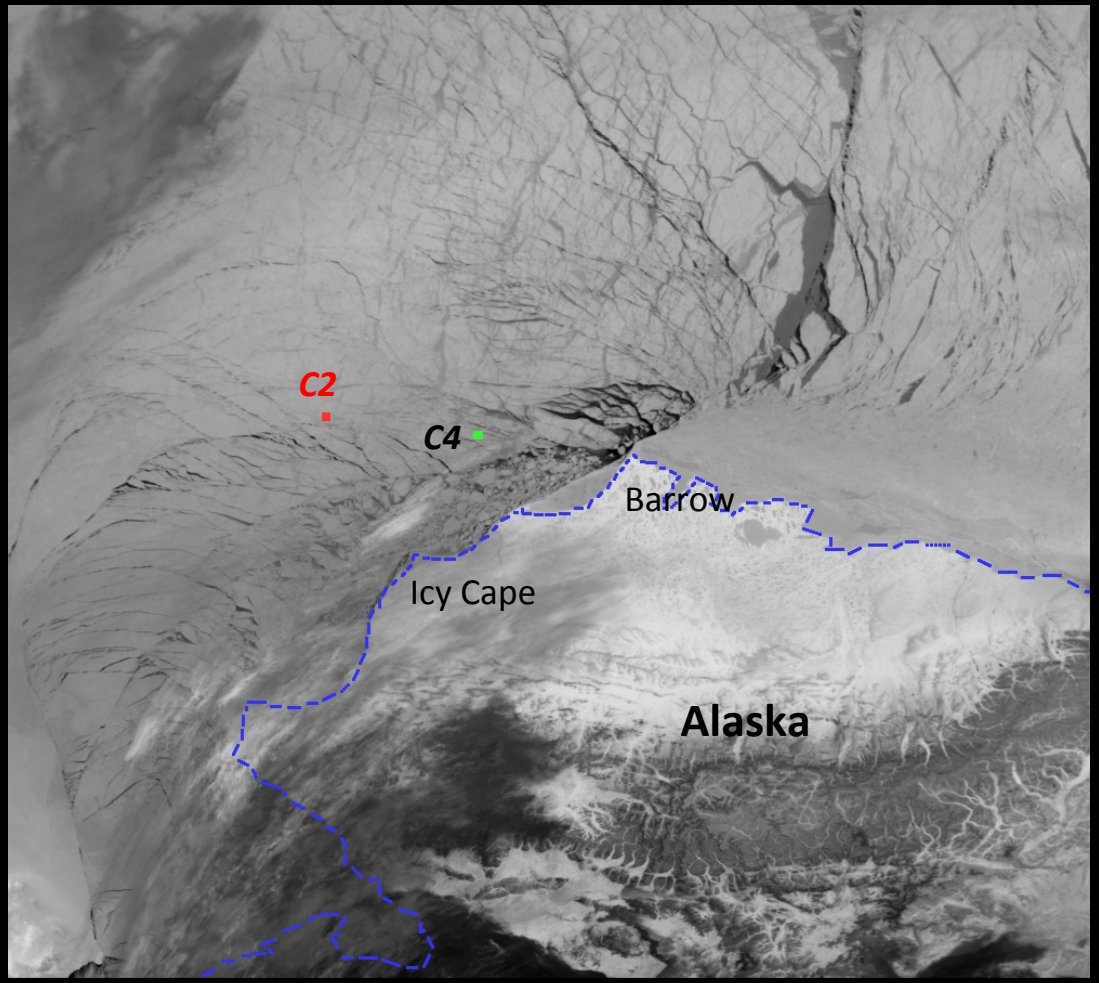
Quality



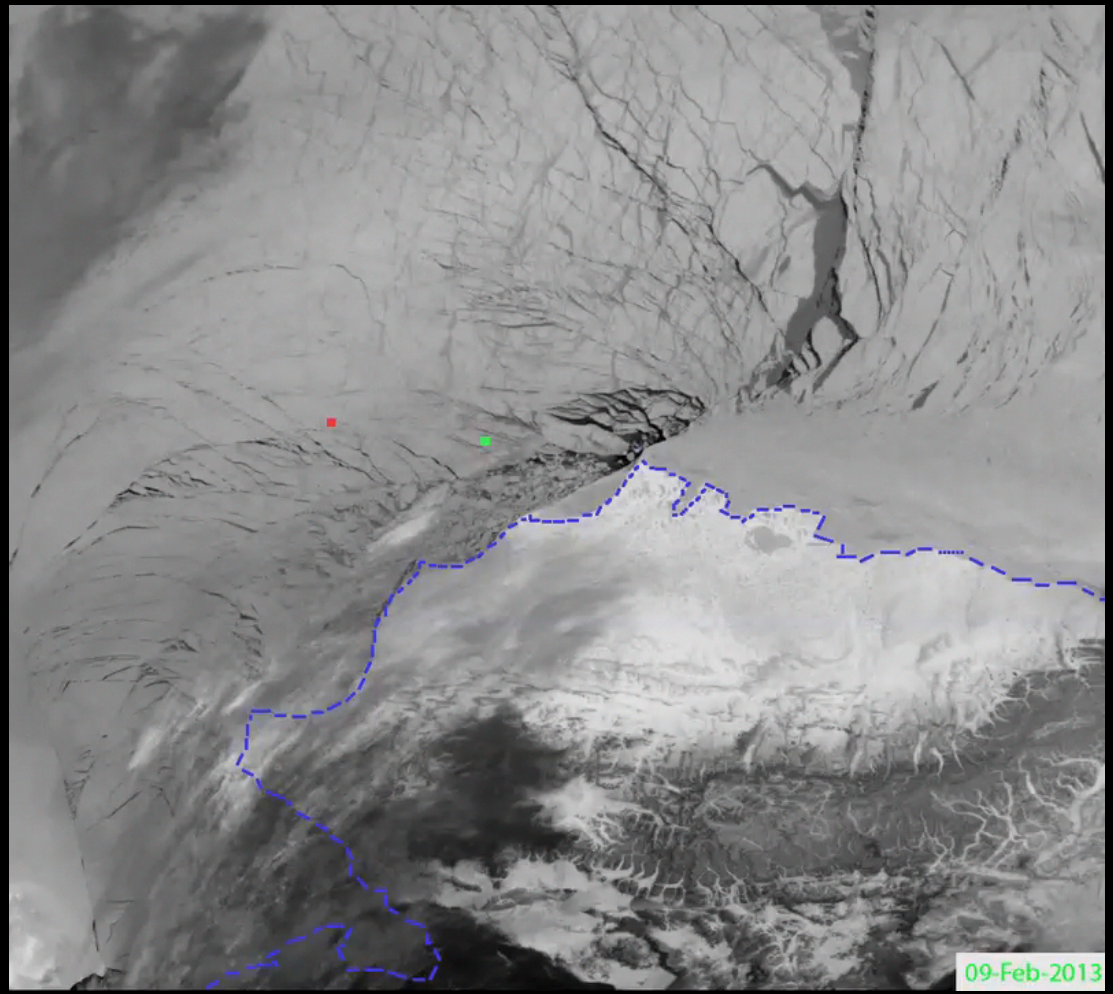


EcoFOCI

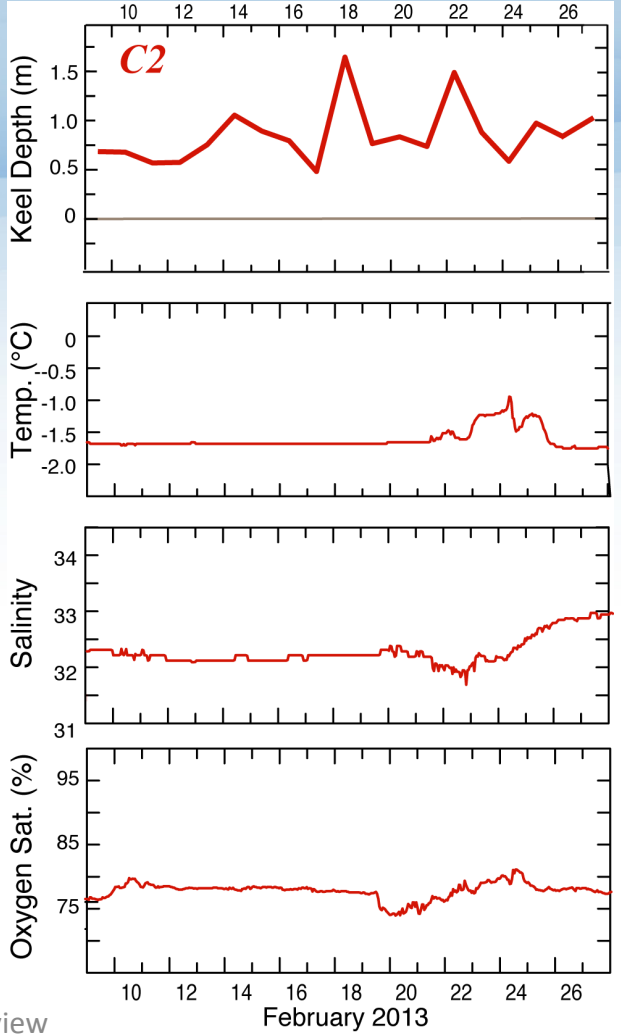
February 9 , 2013

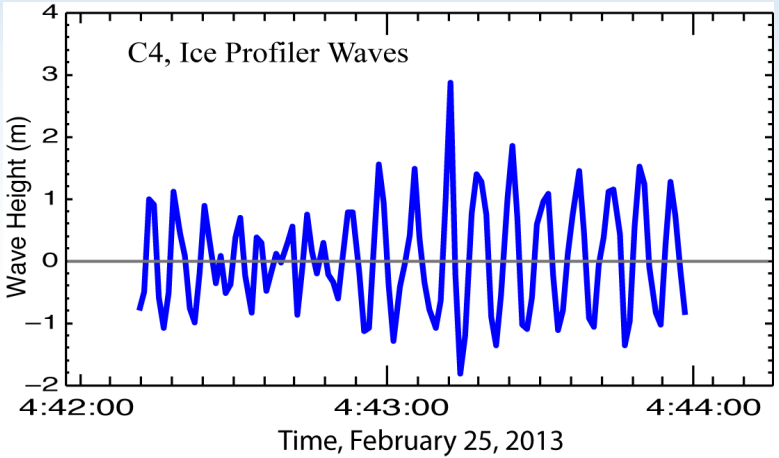


February 9 – 27, 2013



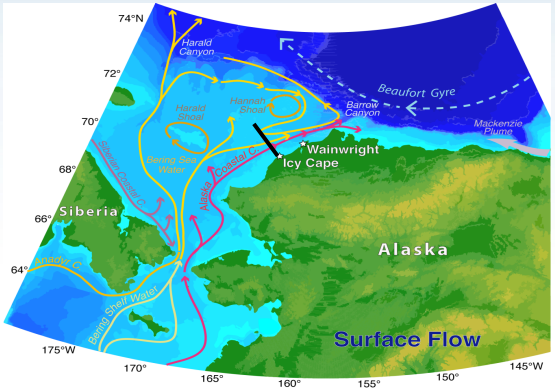
Influence on water properties

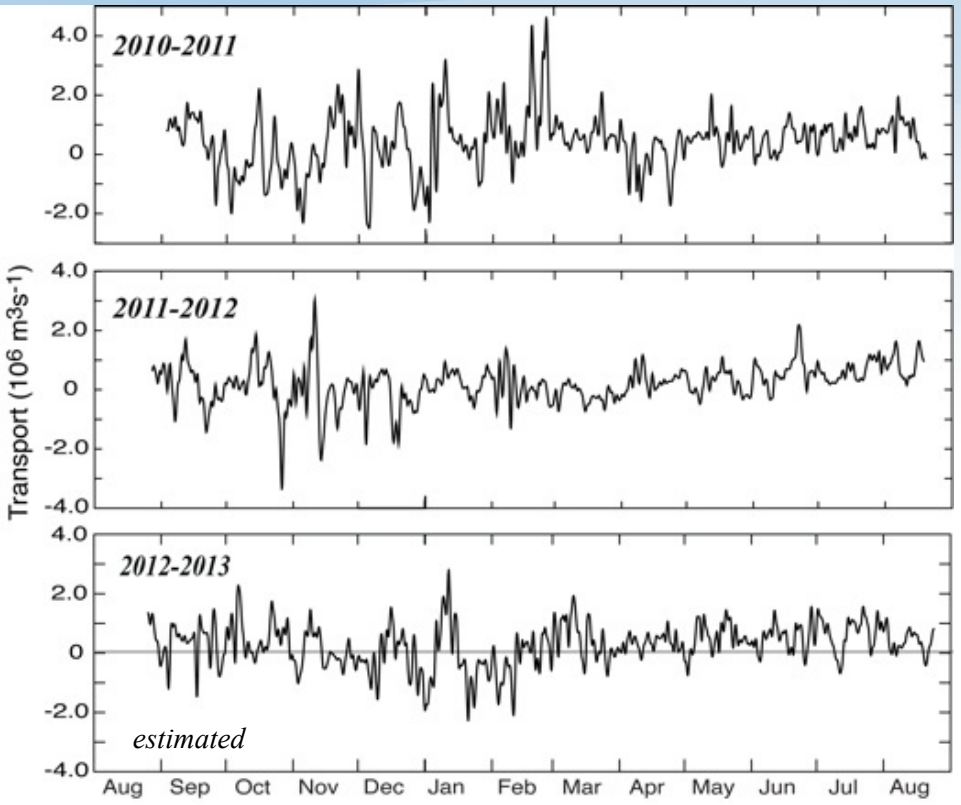




Total transport at Icy Cape

Arctic





0.42 Sv

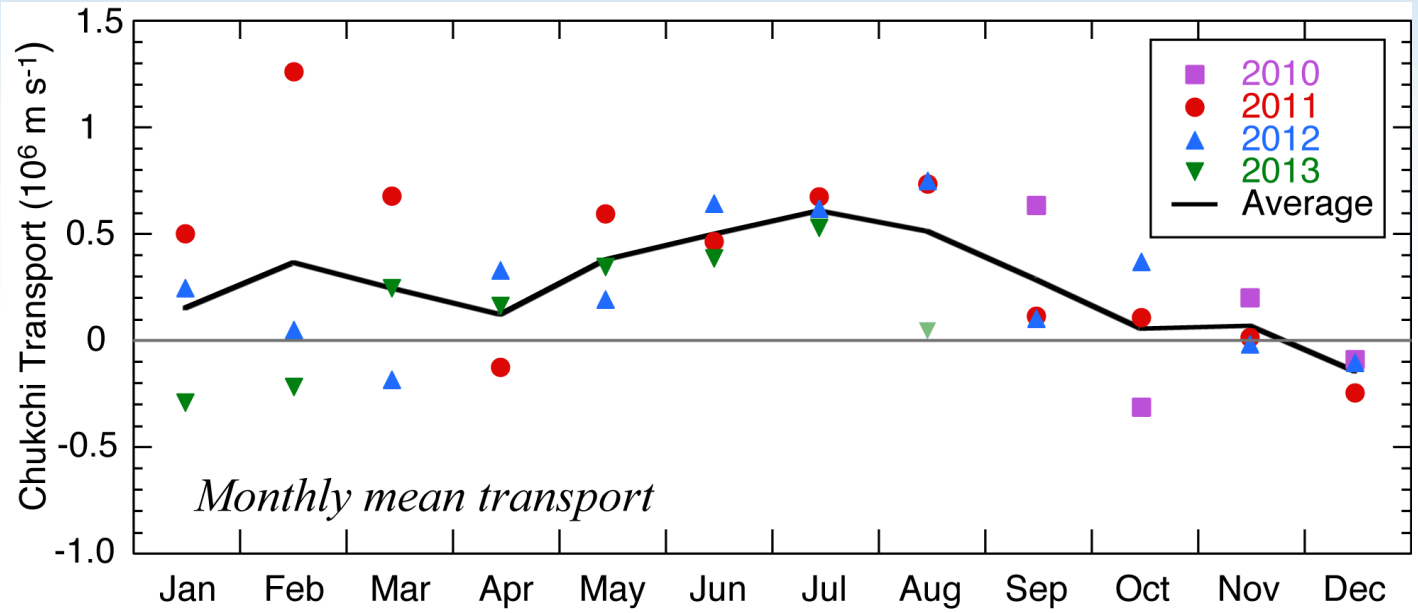
0.21 Sv

0.25 Sv

EcoFOCI

Monthly Mean Transport

Arctic



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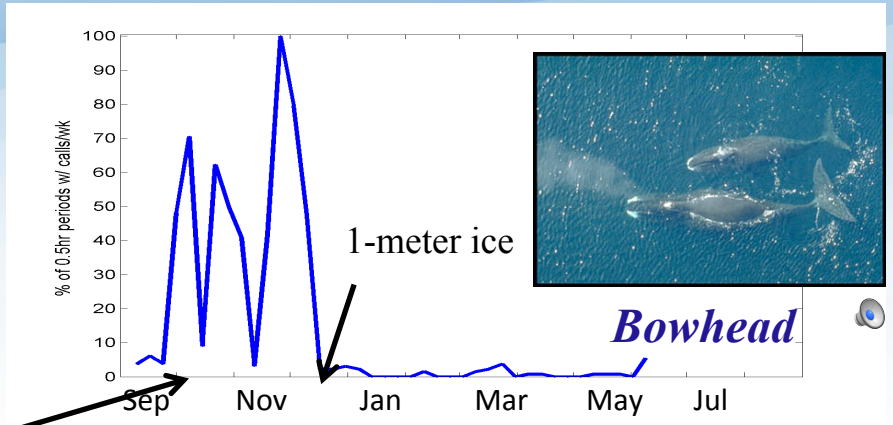
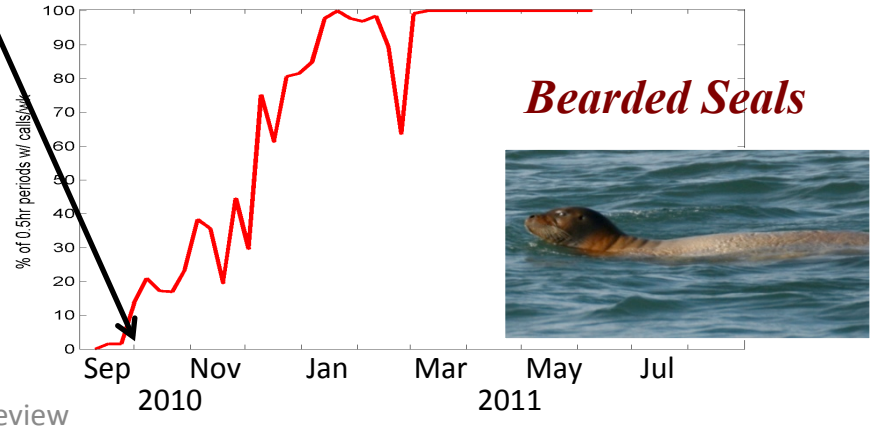
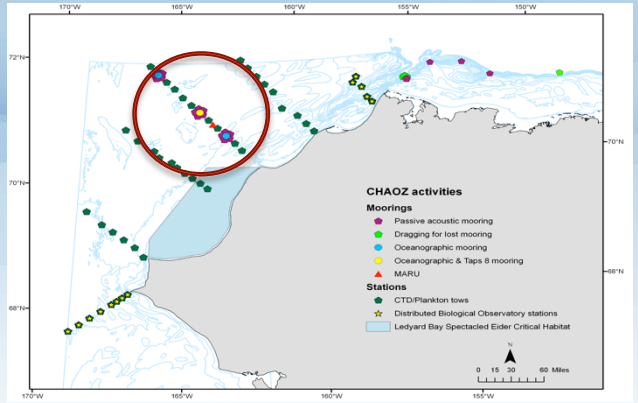
Marine Mammals

Arctic



Ice arrives





Acoustic records at C2:

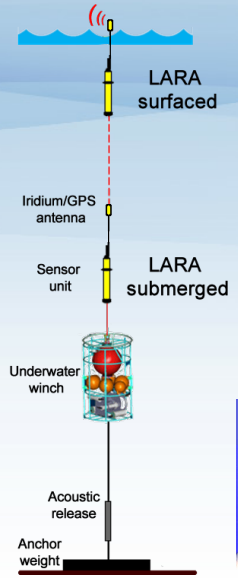
Percent of time with calls each week

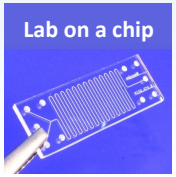
S. Grassia and J. Thompson, NMML

EcoFOCI

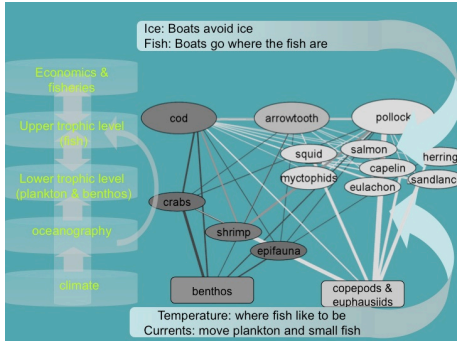
Future: the way forward

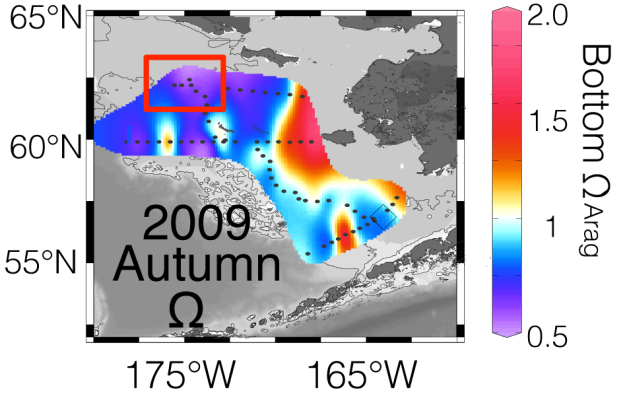
- Improve ecosystem predictions
- Expand partnerships within PMEL (Arctic group, CO2), NOAA (NMML, AFSC, ST) and academia
- Embrace new technology
- Refine indices of ecosystem status to optimize use by resource managers

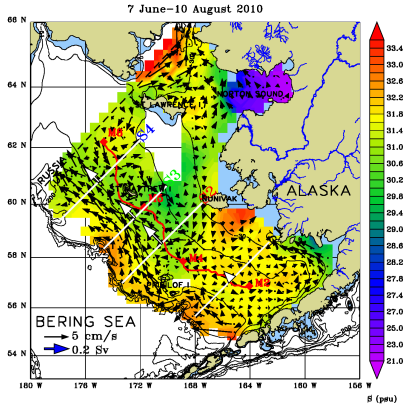




FEAST







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PMEL EcoFOCI

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Kim Martini	Scott McKeever
Sue Moore	Calvin Mordy
Jim Overland	Peter Proctor
Sigrid Salo	Phyllis Stabeno
Dave Strausz	Peggy Sullivan
Muyin Wang	Kevin Wood

And all our partners and colleagues at Alaska Fisheries Science Center