# North Pacific Research Board & National Science Foundation

## Biological processes on the Eastern Bering Sea shelf ecosystem and impacts of climate change

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# Outline

1. **Why study climate impacts on arctic marine ecosystems**

2. **NPRB-NSF Bering Sea integrated research program**

3. **Our March 2008 cruise on icebreaker Healy**

# Why Study Northern Marine Ecosystems?

**Intergovernmental Panel on Climate Change February 2007**

**Arctic Climate Impact Assessment 2005**

**Many Other Studies of Climate Change in Northern Marine Regions**
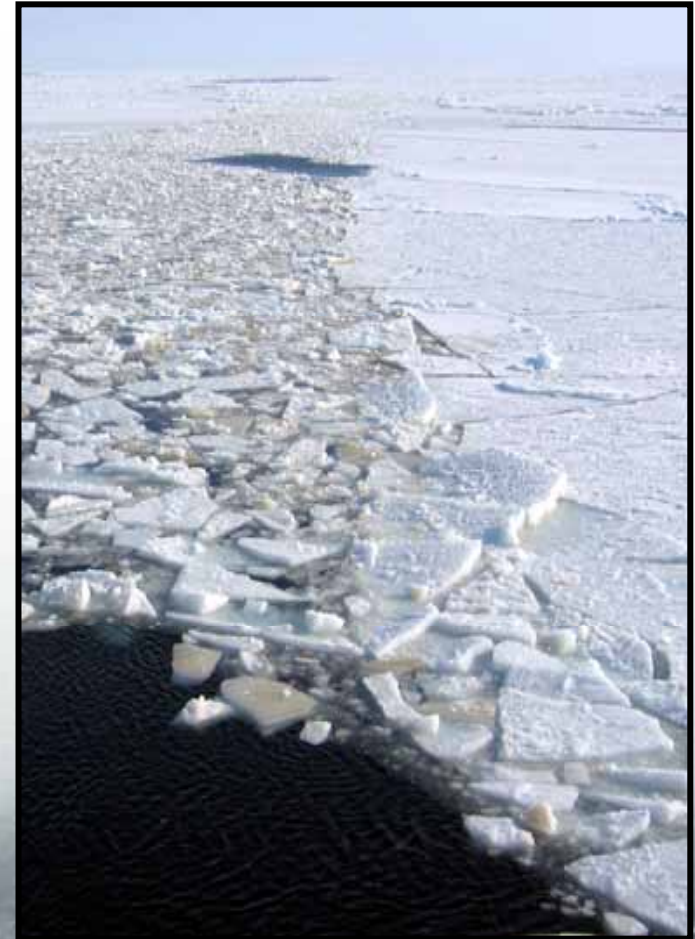
# Projected Changes

Long term changes at ocean basin scales

Arctic temperatures increased at almost twice
global average rate in past 100 years

4-5 C temperature increase over most of Arctic
by 2080

Sea ice extent decreased by 2.7% each decade
since 1978 and could disappear in
summer by 2100

Bering Sea likely will be ice free by 2050

# Lower Trophic Levels

**Lack of sea ice - defining feature**

**More light and longer growing season**

**Increased mixing, nutrients and primary production**

**Timing, location and species composition of phytoplankton and zooplankton populations may change**

**Production could sink to bottom rather than cycle through pelagic forage fishes**

**Direct loss of sea ice-related animal communities and foraging opportunities for marine mammals and seabirds**

# Fish - Bering Sea supports largest fishery in U.S.

**Higher water temperatures may have broad impacts:**

• **Change metabolism, growth, and distribution of fish populations**

• **Indirect food web effects on feeding and predators**

• **Changes in spawning time, fecundity, larval survival, and food availability will impact recruitment**

• **Abundant species like herring, halibut, cod and pollock may move north past cold pool**

• **Cold-related species such as polar cod, capelin and Greenland Halibut may decline and recede north**

• **Northward shift of benthic species is 2-3 faster than terrestrial mean**
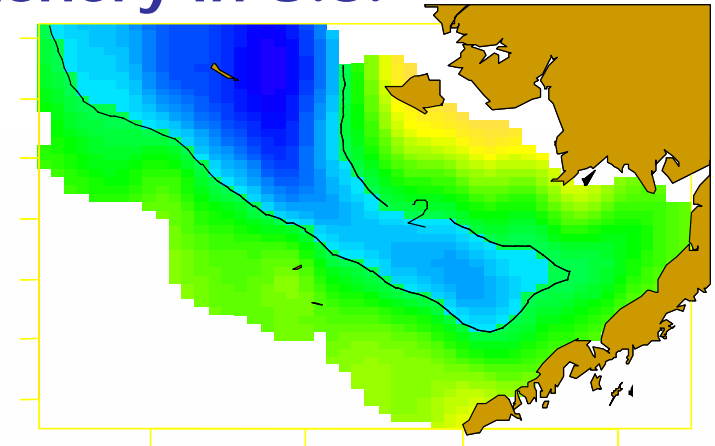


**SE Bering:1982-1986**

175    170    165    160
°W
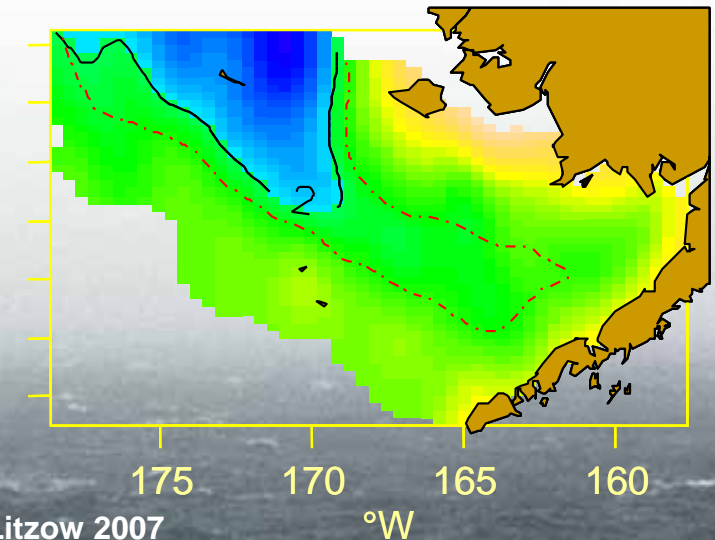
Franz Mueter and Mike Litzow 2007

Parmesan and Yohe 2003

# Mammals and Birds

**Poleward shift in species**

**Sea ice retreat will impact animals that depend on sea ice for resting, foraging, and breeding**

**Whole populations may be threatened by loss of sea ice**

**Overcrowding in remaining refuges**

**More disease**

**More pollution from higher precipitation and run-off**

**Increased ship traffic – invasive species and pollution**

# Humans will be Impacted by Climate Change



Wave and storm erosion will challenge continued viability of coastal communities

Changes in distribution and migration of fish, mammals and birds will impact availability to subsistence and commercial users

Final impacts may be complex and indirect, not just whether animals are there or not for the taking
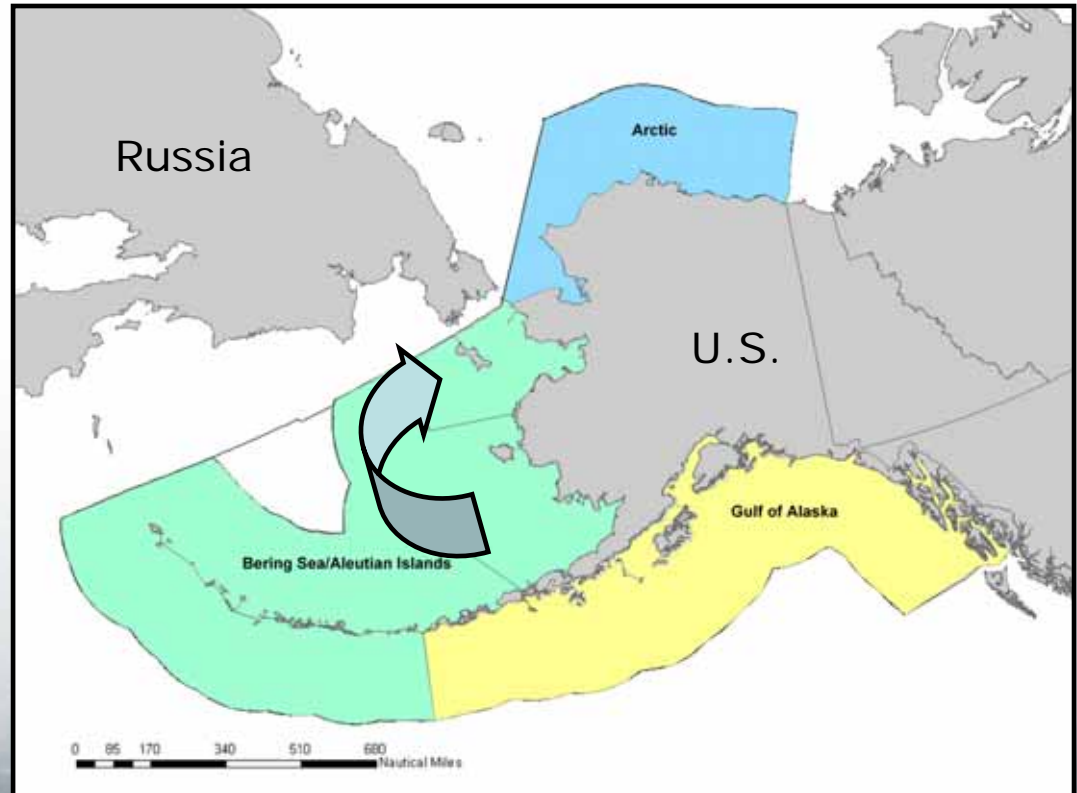




23.09.2006

# Geo-Political Consequences

**Fishing fleets will move north**

**Closer to international boundaries**

**Higher probability for conflicts and interference**

**Endangered species complications**

I don't know why I don't care about the bottom of the ocean, but I just don't!

# We care and here is what we are doing!

## North Pacific Research Board & National Science Foundation

**Partnership for a vertically-integrated study of the Bering Sea ecosystem and its response to climate change in 2008-2012**

# Funding

**National Science Foundation:**                                 **$21 million**

**North Pacific Research Board:**                            **$16 million**

**National Oceanic and Atmospheric Administration:**      **$14 million**

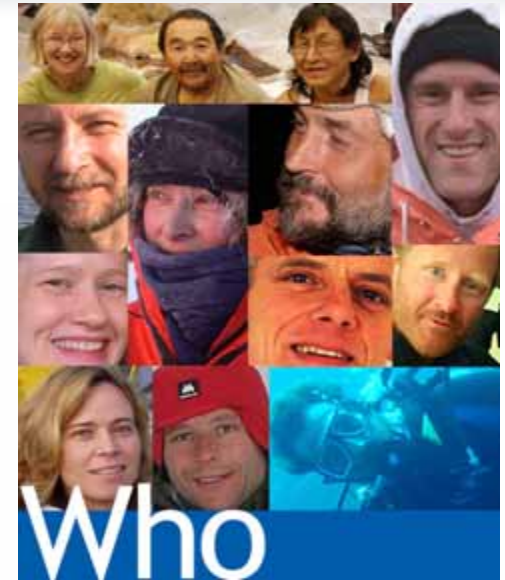**US Fish and Wildlife Service:**                             **$900,000**

## $52 million total!

# Who is involved?

An integrated, multidisciplinary team of
over 90 scientists from across US & Canada!

Universities: Alaska, Washington, California, Rhode Island
Princeton, Maryland, Oregon State, Rutgers, Columbia, &
British Columbia

NOAA Alaska Fisheries Science Center      NOAA Pacific Environmental Laboratory

Woods Hole Oceanographic Institution      Bermuda Biological Station

Alaska Department of Fish & Game      NOAA Hatfield Marine Science Laboratory

US Fish & Wildlife Service      US Geological Survey      North Pacific Research Board

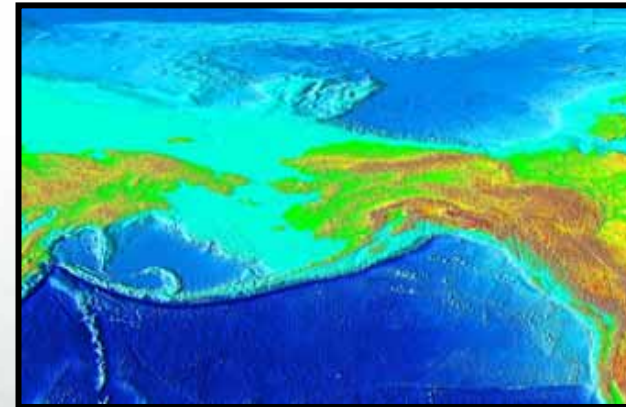Calista Elders Council      Savoogna      St. Paul      Ecotrust      Huntington Consult.

# Study Location

## Bering Sea shelf from Aleutian Islands north to St. Lawrence Island

# Overall Schedule

**Start-up & Planning in late 2007 and early 2008**

**Field seasons and cruises in 2008, 2009, 2010**

- **NOAA Miller Freeman**      **February**
- **USCG Healy**      **March – July**
- **NOAA Oscar Dyson**      **May – August**

**Ecosystem modeling throughout program**

**Annual meetings of principal investigators**
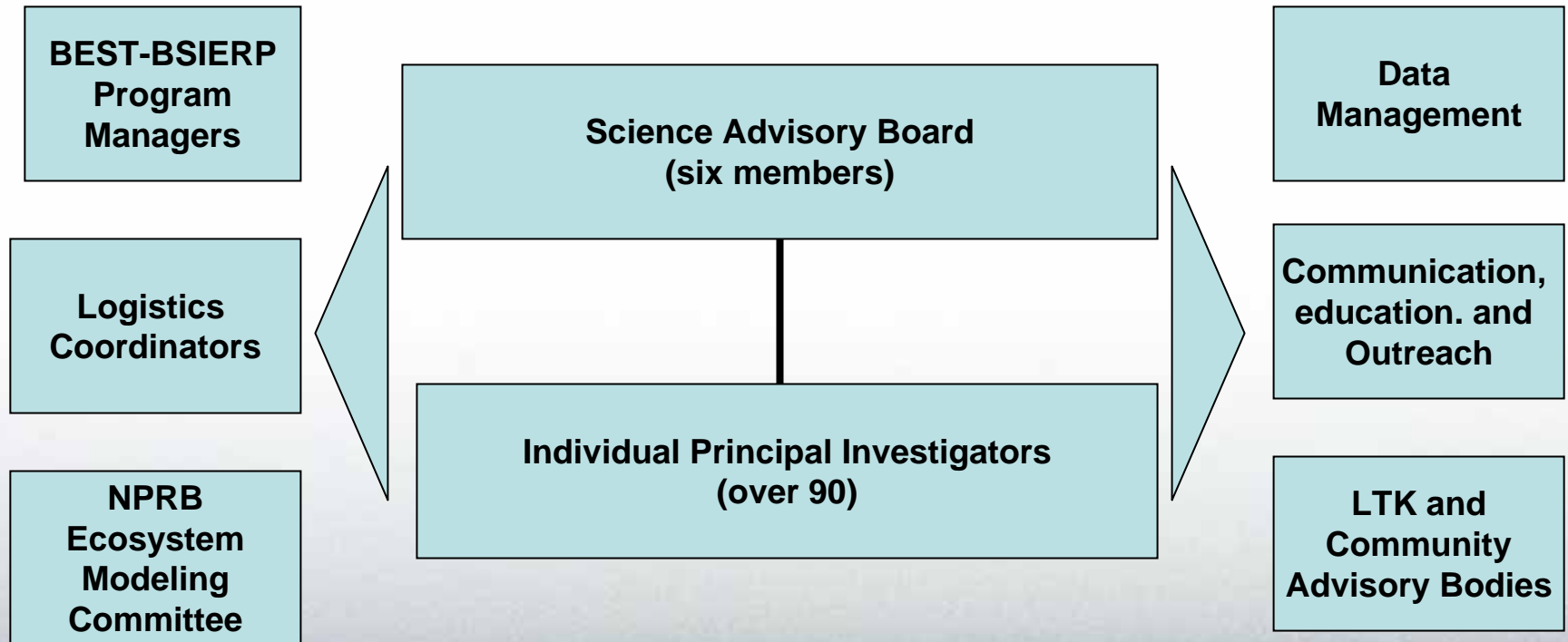
**Data analysis, reporting, program synthesis in 2011-2012**

**Miller Freeman**



**Healy**



**Oscar Dyson**

# Organizational Structure

**BEST-BSIERP Program Managers**

**Logistics Coordinators**

**NPRB Ecosystem Modeling Committee**

**Science Advisory Board (six members)**

**Individual Principal Investigators (over 90)**

**Data Management**

**Communication, education. and Outreach**

**LTK and Community Advisory Bodies**

# Major Hypotheses

1. Changes in atmospheric and ocean forcing will impact timing and location of food production, domain boundaries, stratification and circulation.

2. Resultant changes in food availability will influence spatial and temporal distribution and feeding dynamics of pelagic fish.

3. Changes in the forage base could impact populations of place-based seabirds and mammals.

4. Some populations of fish, birds and mammals will be reduced or dislocated.

5. These changes will have profound socioeconomic implications for all people who depend on the living resources of the Bering Sea.

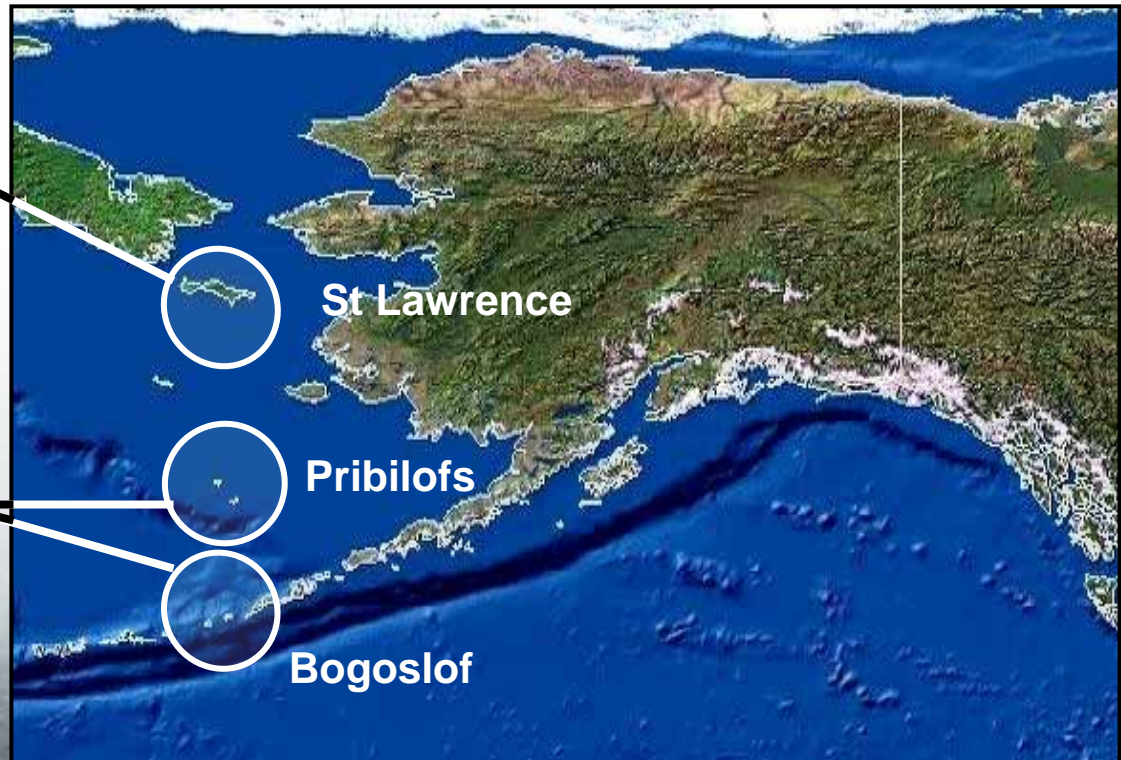# Patch Dynamics Studies

**Emphasize uneveness of habitat within a system and prey patches that could be critical to foraging success. Learn what controls abundance and distribution of top predators.**

**Walrus feeding on benthos near St. Lawrence Island**



**Fur seal foraging from Pribilofs and Bogoslof Islands**





St Lawrence

Pribilofs

Bogoslof

**Seabird foraging studies at all sites**

# New and Innovative Ecosystem Modeling

**Ultimate Modeling Goals**

- Vertical  links up through food web from climate and oceans to humans

- Improve predictive ability of species production and distributions

- Forecast economic effects for fisheries based on climate scenarios

**Ecosystem Modeling Committee is guiding model development**

- What will model predict?     Is it valuable to fisheries managers?

- Specific measures of  "accuracy" in prediction and usability to managers

- Identifying data available to drive, calibrate, and retrospectively test the model

- Using new data to further quantify predictive power

- **Designated Scientists and Modelers**
- **Tight Coupling between Field Work and Models!**

**Field Work**

## Models

← FIELD DATA FLOW

### Fur Seals

| | |
|---|---|
| **Trites** | **Telemetry and foraging** |
| **Trites** | **Bioenergetics** |
| **Ream** | **Colony studies** |

### Forage Species

| | |
|---|---|
| **Wilson** | **Forage distribution** |
| **Wilson** | **Acoustic surveys** |

Fur Seals

### Plankton

| | |
|---|---|
| **Sherrs** | **Zooplankton** |
| **Moran** | **Primary production** |
| **Coyle** | **Mesozooplankton** |
| **Stoecker** | **Microzooplankton** |
| **Harvey** | **Euphausiids** |
| **Hillgruber** | **Icthyoplankton** |

### Upper Trophic Levels
**Aydin      FEAST model**

Juvenile Pollock, capelin, myctophids

### Lower Trophic Level
**Gibson   Nutrient-Phyto-Zoopl Model**

Icthyoplankton, Euphausiids, copepods

### Atmosphere/Ocean
**Bond      Climate model downscaling**

**Hermann   Ocean model ROMS**

Atmosphere/Ocean

Climate Scenarios

### Ocean Data

| | |
|---|---|
| **Stabeno** | **Biophysical moorings** |

**Weingartner, Sonnerup, Hollowed**
**Ocean Conditions**

## Models

MODEL OUTPUT FLOW →
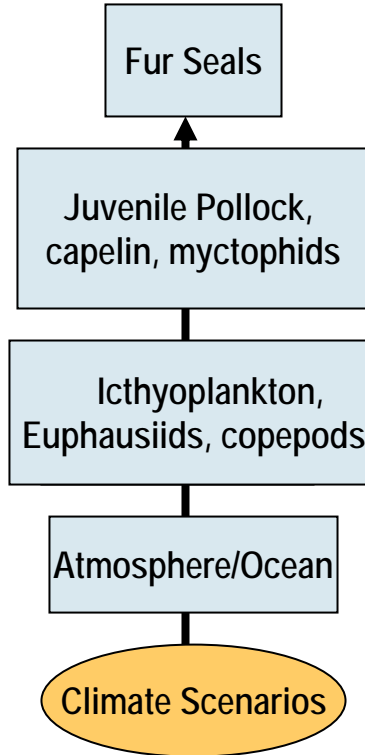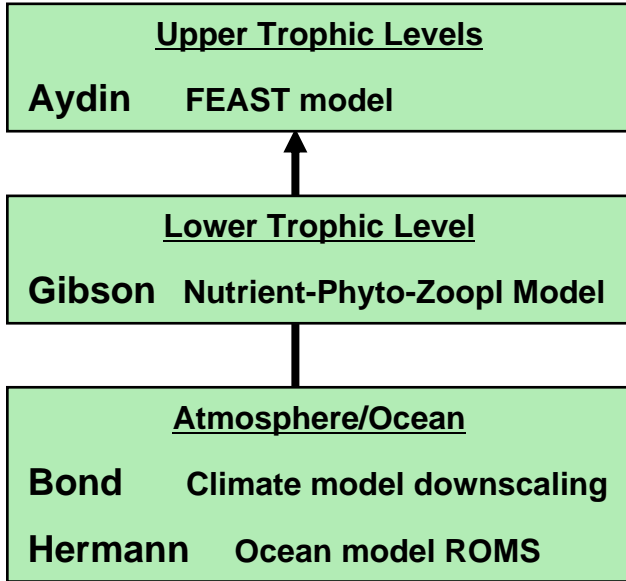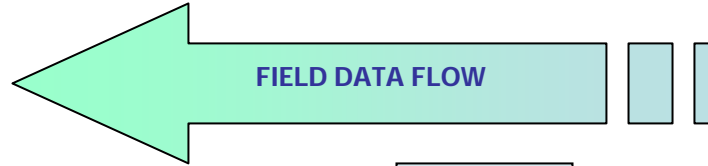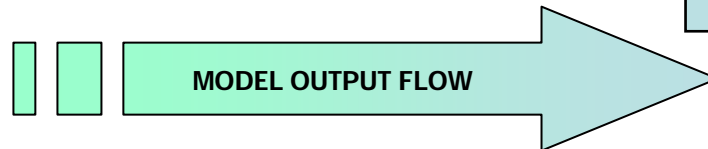
## Field Work

# Robust Education and Outreach Program

- **Define target audiences such as teachers, students, policy makers, resource users, other scientists**

- **Identify important links, contacts and opportunities to interact with others**

- **Determine how scientists can participate in outreach and provide them with materials**

- **Promote community involvement, teachers and students**

# Local and Traditional Knowledge - LTK

**Involve community members in science activities**

- **Help develop research hypotheses**
- **Collaborate on specific projects and analysis of results**
- **Record observations by communities**

**Five focal communities**

**Scientists will visit communities**

**Share information with other Bering Sea communities**

# Final Synthesis in 2012  -  Planning Ahead!

**Science Advisory Board  -  develop synthesis structure**

**Goal – everyone will have same expectations for scope of synthesis**

**Synthesis is already budgeted**

**Display new information from individual studies**

**Compile scientific papers**

**Ecosystem modeling results**

**Address specific hypotheses**

**Guide development of next integrated program in Bering Sea: 2015-2021**

# First Icebreaker Healy Cruise 0801 - March 13-26, 2008

**Investigate patch dynamics of apex predators, specifically walrus, and food distribution on sea floor**



BEST-BSIERP
an historic ecosystem research
partnership in the Bering Sea
2008-2012
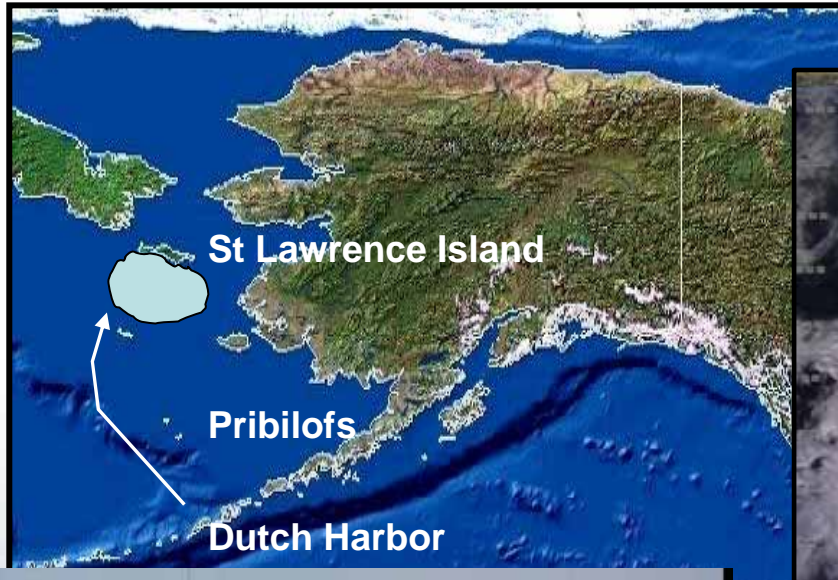
**Sea ice started south of Pribilof Islands**



St Lawrence Island

Pribilofs

Dutch Harbor



St Lawrence Island

# First Icebreaker Healy Cruise 0801 - March 13-26, 2008

**Sue Moore – listening for marine mammals**

**Walrus**

**Bearded seal**

**Ring seals**

# First Icebreaker Healy Cruise 0801 - March 13-26, 2008

**Walrus tagging southwest of St Lawrence Island – Chad Jay and Gay Sheffield**

# First Icebreaker Healy Cruise 0801  -  March 13-26, 2008

**Spectacled Eiders**

# First Icebreaker Healy Cruise 0801

## Shipboard ocean measurements



Marcus Janout

Lee Cooper – Chief Scientist

# First Icebreaker Healy Cruise 0801 - March 13-26, 2008
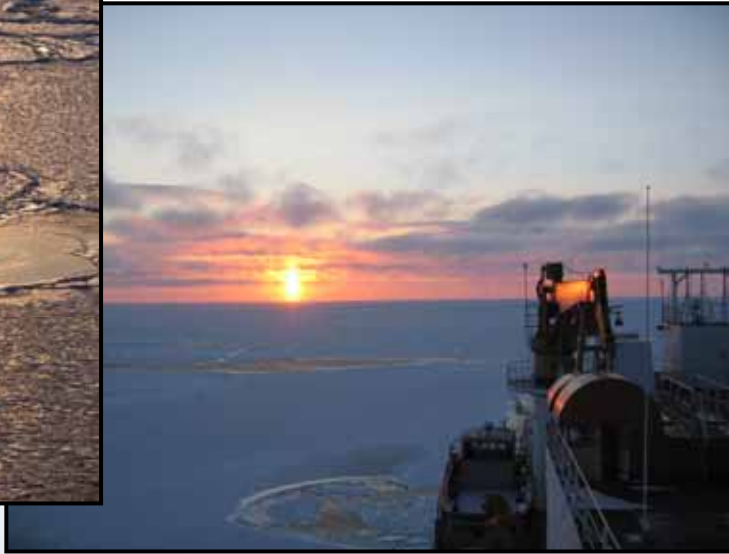
## On ice measurements

Karen Frey

Rolf Gradinger

# Sea Ice!

St Matthew Island

# People!

# PR Shot on the Fantail!

**To learn more, visit:**

# www.BSIERP.nprb.org