Bering Sea Highlights

Bering Sea Integrated Ecosystem Research Program
2007-2013

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Integration

Humpback and fin whales
Commercial/subsistence fish: Pollock, cod, arrowtooth flounder
Forage species: Juvenile pollock, capelin, myctophids
NPZ: Ichthyoplankton, euphausiids, copepods, phytoplankton
Infauna: Bivalves, gastropods, polychaetes
Atmosphere/ocean
Climate Scenarios
Vertically-Integrated, Coupled Ecosystem Model

Fishing effort allocation (FAMINE)

Management strategies (MSE)

Upper trophic level (FEAST)

Lower trophic level (NPZ)

Physical oceanography (ROMS)

3 climate models

1 Emission scenario
Harvest Surveys and Ethnographic Interviews
A Still Very Cold Bering Sea

M2

Warm Years

Cold Years

Stabeno
The Cold Pool Extends Farther South in Cold Years

Warm

Cold

2004

2009
ROMS Model: Predicts that the Northern Bering Sea will Remain Cold

April Ice Cover (fraction)

July SST (°C)


hindcast aice_clim_0z month 4  forecast aice_clim_0z month 4

hindcast temp_clim_0z month 7  forecast temp_clim_0z month 7
Surprisingly, Upwelling Winds Were Prevalent (64%) Producing Southerly Rather Than Northerly Flow

- Between July 2008 and July 2010, coastal upwelling conditions were prevalent (64%).

- Currents are sensitive to the wind direction: a 90° shift from southward to westward winds changes the system from strong upwelling to strong downwelling conditions.

- Wind direction is determined by the location of Aleutian Low, which also drives changes in ice extent, air temperatures and precipitation.

Sea surface height (SSH) contours from BESTMAS model (Zhang & Woodgate)  
Current meter vectors from moorings (Danielson, Weingartner, Aagaard)
Wind Induced Mixing (Not Ice or Stratification) is Associated with Elevated Net Community Production at M2

- Variability in NCP not controlled by ice cover (left) or stratification (Ladd and Stabeno, in press).
- Higher values of NCP were associated with stronger wind mixing events (right), supporting Sambrotto et al. (1986).

*Mordy et al., in press*
Fish and Epi-benthic Communities Change as a Function of Latitude

Stevenson and Lauth, in press
Large Zooplankton Increased in Cold Years

North: Biomass of large fraction tripled in 2007 (*E. bungii*, *P. elegans*, *Calanus* spp.)
South: Biomass of large fraction doubled in 2008 (*Calanus* spp., *P. elegans*, *E. indicans*)
Model Replicates Observation: More Large Crustacean Zooplankton in Cold Years

Depth-averaged large zooplankton
Aug. to Sep. (ug C/l)

Depth-averaged temperature, March to May (°C)

CFSR hindcast (2003-2009)
IPCC forecast (2003-2040)

Gibson & Hermann
Murres Select Krill by *Patch Density* and *Vertical Accessibility*
Not Patch Size, Krill Abundance, or Biomass

*Benoit-Bird et al., 2011, MEPS*
Temperature Determines the Spatial Pattern of Forage Fish

Predicted spatial surfaces of fish density from General Additive Models

2 °C isotherm, solid lines are 50m and 100m isobaths.

Hollowed et al., in press
Pollock (to Age-1) Have Higher Energy Content And Recruitment in Cold Years

- Diets in cold years are high in lipid → more energy stored before winter.
  → high energy content before winter increases survival.

- Juveniles have a short critical period for lipid storage (Siddon et al.)
The Distribution of Foraging Hotspots for Pollock Change

Food supply for age-0 pollock

Aydin et al.
Pollock Recruitment Will Decline With Increased Temperatures

Temperature scenarios, 2010-2050 (downscaled from IPCC models)

Estimated effects of SST & predation on recruitment

Projection model

Mueter et al (2011, ICES JMS)
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Humans
Kittiwakes and murres, fur seals, walrus
People have a Regional Perception of their Ecosystems

Perceptions of the state of the ecosystem related to environmental health, subsistence production, etc. (i.e., may use different metrics in different communities)

- Savoonga: ecosystem healthy, hunting is good
- Emmonak: many changes, king salmon issues are a major concern
- Togiak: most species in decline (harvests less clear)
- St. Paul: environmental quality generally seen as good, stable
- Akutan: environment okay, some declines/changes

Huntington et al.
Changes relevant to the coast?

- Temperature changes
- Wind changes
- Ice changes
- Changes in ocean productivity
- Changes in communities