Climate and Fisheries

EXPLAIN THIS:
Walleye pollock abundance dramatically fell in the early 2000’s, leading to a 40% drop in the quota for the largest single fishery in the US, and then rebounded.

EXPLANATION:
Due to bloom timing, large crustacean zooplankton benefit from icy winters, providing prey for age-0 pollock to enter their first winter fat (and happy?)

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Forecast pollock abundance

INTEGRATED ECOSYSTEM RESEARCH

Modeling

- Ecosystem monitoring
- Identify mechanisms

Climate informed management
Goals, objectives, prioritization, and strategy (TOR 1)

<table>
<thead>
<tr>
<th>Overall strategic plan:</th>
<th>Annual update:</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFSC Science Plan</td>
<td>2016 Guidance Memo</td>
</tr>
</tbody>
</table>

Ecosystem goals and objectives

- Recruitment Processes Alliance White Paper
- Essential Fish Habitat Research Plan
- Loss of Sea Ice Research Plan
- Alaska Ocean Acidification Research Plan
AFSC Science Plan 2.0

Organized around the following three themes:

- Monitor and assess fish, crab, and marine mammal populations, fisheries, marine ecosystems, and the associated communities that rely on these resources.
- Understand and forecast effects of climate change on marine ecosystems.
- Achieve organizational excellence in our administrative activities through innovation and the use of best practices.
Guidance memo

Funding priorities in FY16 (ecosystem-related):
(3) research on process studies related to linking recruitment of commercially important species to environmental change, including climate change;
(6) 20-year climate forecasts for commercially-important fish and shellfish populations, including the development of a Regional Action Plan to address species vulnerability to climate change;
For example, Alaska Ocean Acidification Research Plan (Sigler et al., 2015)

- Commercially important calcareous species (crab) are first priority because of their economic value and because these species are likely to suffer direct effects of reduced CaCO3 availability.
- Second priority is commercially important fish species; this research will screen for early life history effects and effects mediated by prey.
- Third priority is coldwater corals whose ecological importance includes sheltering marine organisms (e.g., rockfish), providing focal areas for foraging, and increasing the biodiversity of seafloor habitats.
Overarching objectives of AFSC climate research

1. Understand climate impact on physics and lower trophic level species.
2. Understand how upper trophic level species are regulated by top-down (e.g., predator-prey, fishing) and bottom-up mechanisms.
3. Understand climate and ecological mechanisms sufficiently to make 20-year forecasts of fish, crab, and marine mammal abundance.
Ecosystem-based fisheries management

Six Guiding Principles outlined in the EBFM Policy Statement (NMFS 2016):

1. Implement ecosystem-level planning
2. Advance our understanding of ecosystem processes
3. Prioritize vulnerabilities and risks of ecosystems and their components
4. Explore and address trade-offs within an ecosystem
5. Incorporate ecosystem considerations into management advice
6. Maintain resilient ecosystems
Alaska IEA Program

- Delivers key products from ecosystem research to management.
- Transitions integrated ecosystem research programs to ongoing operational products.
- Strong interactive relationship with North Pacific Fisheries Management Council.
- LME-based
  - Bering Sea IEA program “maturing”
  - Gulf of Alaska IEA program “scoping and development”
Ecosystem-related science integration (TOR 1)

- Cross-Divisional science
  - Recruitment Processes Alliance
  - Habitat and Ecological Processes Research Program
Recruitment Processes Alliance
The Recruitment Processes Alliance was formed in 2011 to grow existing collaborations on integrated ecosystem research and recruitment processes research.

Bering Sea Integrated Ecosystem Study (BSIERP) and Bering Ecosystem Study (BEST)

2007-2014
Recruitment Processes Alliance

• Formed in 2011 to grow existing collaborations on integrated ecosystem research and recruitment processes research
• Encompasses 7 Alaska Fisheries Science Center and Pacific Marine Environmental Laboratory research programs
<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMEL Ocean Environment Research (FOCI)</td>
<td>Oceanography</td>
<td>Stabeno</td>
</tr>
<tr>
<td>Recruitment Processes (FOCI)</td>
<td>Fisheries oceanography</td>
<td>Duffy-Anderson</td>
</tr>
<tr>
<td>Ecosystem Monitoring and Assessment</td>
<td>Fisheries oceanography</td>
<td>Farley</td>
</tr>
<tr>
<td>Resource Energetics and Coastal Assessment</td>
<td>Bioenergetics</td>
<td>Heintz</td>
</tr>
<tr>
<td>Status of Stocks and Multispecies Assessment</td>
<td>Stock assessments</td>
<td>Hollowed</td>
</tr>
<tr>
<td>Marine Ecology and Stock Assessment</td>
<td>Stock assessments</td>
<td>Heifetz</td>
</tr>
<tr>
<td>Resource Ecology and Ecosystem Modeling</td>
<td>Ecosystem modeling</td>
<td>Aydin</td>
</tr>
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</table>

Encompasses 7 AFSC and PMEL programs
**Hypotheses**

• $H_0$: Climate change and variability have predictable effects on the bottom-up and top-down mechanisms which regulate fisheries recruitment in Alaska.

• $H_0$: The effects of climate and ecosystem function on fish recruitment are most evident during two critical periods: 1) the early to late larval stage when mortality is a function of growth rate, and 2) the first winter when mortality is a function of size and energetic status obtained during the previous summer and fall.
Seasonal surveys

April-May & Sept-Oct physics

May, larval

August-September, age-0

June-July, age-1

June-July, age-3+
Laboratory analyses and experiments

Nutritional energy

Laurel et al in review
Models

- GFDL ESM
- Bering Sea – high resolution Regional Ocean Model
- FEAST – Coupled end-to-end Model
- Stock Projection Models
- Ecosystem models
- Representative Fishing Pathways
  - Multispecies projection model
  - Spatially Explicit Stock Projection Models
  - Food-web models
  - Individual Based Models
  - Size Spectra Models
  - Single species projection model
Products:
Ecosystem report cards
Products: Mechanisms affecting pollock recruitment

Age-0 pollock in late summer


Heintz et al 2013
Habitat and Ecological Processes Research Program

● The HEPR Program focuses on integrated studies that combine scientific capabilities and create comprehensive research on habitat and ecological processes.

● Teams of AFSC and Pacific Marine Environmental Laboratory (PMEL) scientists collaborate in new research, proactively identify emerging management issues and draw expertise from fishery, habitat, and protected resource managers at the Alaska Regional Office.
Habitat and Ecological Processes Research Program

- Loss of Sea Ice
- Essential Fish Habitat
- Ocean Acidification
- Bering Sea Project
Loss of Sea Ice

Northern Bering Sea bottom trawl surveys

Ice seal surveys

Loss of Sea Ice Research Plan
Essential Fish Habitat

- Annual RFP
- Science panel review
- Management prioritization by habitat managers (Alaska Regional Office)
- $400K-$500K is spent on up to ten EFH research projects each year
- $5M spent, 70 projects, 75 publications since 2005

Essential Fish Habitat Research Plan
Climate science strategy regional action plan (TOR 3)
Climate Science Regional Action Plan

Southeastern Bering Sea

Mike Sigler, Alan Haynie, Amber Himes-Cornell, Anne Hollowed, Phil Mundy, Phyllis Stabeno, Stephani Zador, Steve Davis, Brandee Gerke
Regional Action Plan for Southeastern Bering Sea Climate Science

Assessment

Action Plan

Public review version
Monitor ecosystems
April-May & Sept-Oct physics

May, larval

Seasonal surveys

August-September,
age-0

June-July, age-1

June-July, age-3+
Alaska Marine Ecosystem Considerations
Identify mechanisms
(process studies)
Ocean acidification research


Fur seal research

- Pup production on the Pribilof Islands decreased by approximately 45% since 1998. Cause unknown, but may include direct and indirect effects of fishery competition as well as climate.
- Satellite telemetry from 1992 to 2016 is being used to understand effects during the winter migration and summer foraging.
- This project will link fine-scale changes in fur seal foraging behavior with measures of pollock distribution and abundance in real time.

Modeling: Forecast models and management strategy evaluations (MSE)
Ocean model projections


Identify human community dependence on LMRs and effects of climate change.

NPFMC Fisheries Ecosystem Plan. Approved by the Council in December 2015, the FEP includes a climate module that would:
1) synthesize current climate change project outcomes;
2) prioritize species for MSE evaluation; and
3) run MSEs on specific species and scenarios identified by the Council.
Challenge 1

Our ability to project future impacts is limited by our understanding of ecological processes. Understanding is sufficient for **only 3 of 21** comprehensively assessed stocks in the southeastern Bering Sea.

- Walleye pollock (through loss of sea ice)
- Red king crab (through increased CO2)
- Northern rock sole


Climate vulnerability assessment

A climate vulnerability assessment for the southeastern Bering Sea, which will qualitatively assess species vulnerabilities to climate change and provide guidance on research prioritization, currently is underway. The vulnerability assessment uses expert elicitation methods to quantify a species’ exposure and sensitivity to expected climate change.

Spencer, Hollowed, Nelson, Sigler, In prep.. Climate Vulnerability Assessment for the southeastern Bering Sea.
Recruitment Processes Alliance

- Research is conducted to understand processes affecting recruitment strength, including effects of climate.
- To date, understanding of these ecological mechanisms sufficient only to quantify effects on 3 fisheries (pollock, red king crab, northern rock sole).
- A significant fraction of AFSC resources are invested in this effort (e.g., ~15% of labor).
The NPFMC currently has a process that adapts harvest actions to changing measurements from fishery independent surveys. What is not well worked out is how and when the North Pacific Fishery Management Council should react to climate-induced reference point changes.
NMFS Climate Science Strategy

Regional Action Plan for Southeastern Bering Sea Climate Science

Northeast US

Southeast US

Pacific Islands

California Current

Gulf of Mexico
Most important steps to improve efforts to identify and adapt to climate change impacts on fisheries:

- Identify winners and losers and adjust management programs (i.e., catch share programs) as necessary
- Identify and monitor thresholds in ecosystem parameters that signal the need to adjust management strategies
Presenters addressing TOR 1 and 3 (Mike)

TOR 1. Do the Centers/ST have clear goals and objectives for an ecosystem-related science program? Is ecosystem-related science integrated with the other science activities across Divisions within the Center/ST? Are the Center's/ST's ecosystem science and research activities appropriately prioritized and evaluated as part of an overall strategic plan?

TOR 3. Has the Center/ST appropriately established a Regional Action Plan to identify the major climate threats to the ecosystem, identify major vulnerabilities of living marine resources with respect to climate, address the core science needs to address impacts from a changing climate, and integrate this information into management advice, congruent with the NOAA Fisheries Climate Science Strategy1?

Slide titles (for individual slides or sections)
1. Goals and objectives
1. Ecosystem-related science integration
1. Ecosystem science and research prioritization
1. Ecosystem science as part of an overall strategic plan
3. Climate Science Strategy Regional Action Plan
3. Identify the major climate threats
3. Identify major vulnerabilities
3. Address the core science needs
3. Integrate information into management advice