NMFS Climate Science Strategy

Southeastern Bering Sea

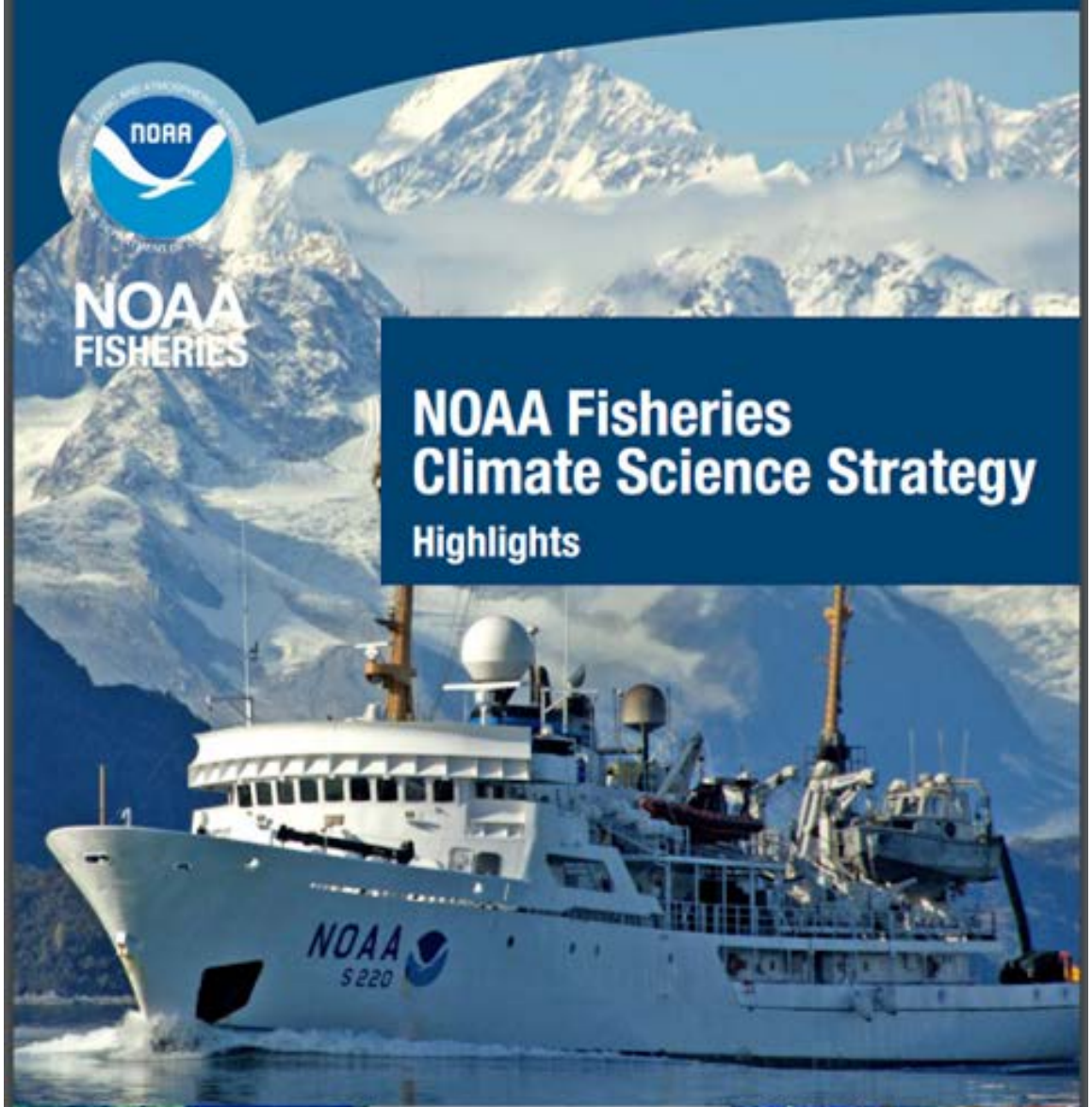
Alaska Fisheries Science Center

Mike Sigler, Alan Haynie, Amber Himes-Cornell, Anne Hollowed, Kirstin Holsman, Phil Mundy, Phyllis Stabeno, Stephani Zador, Steve Davis, Brandee Gerke

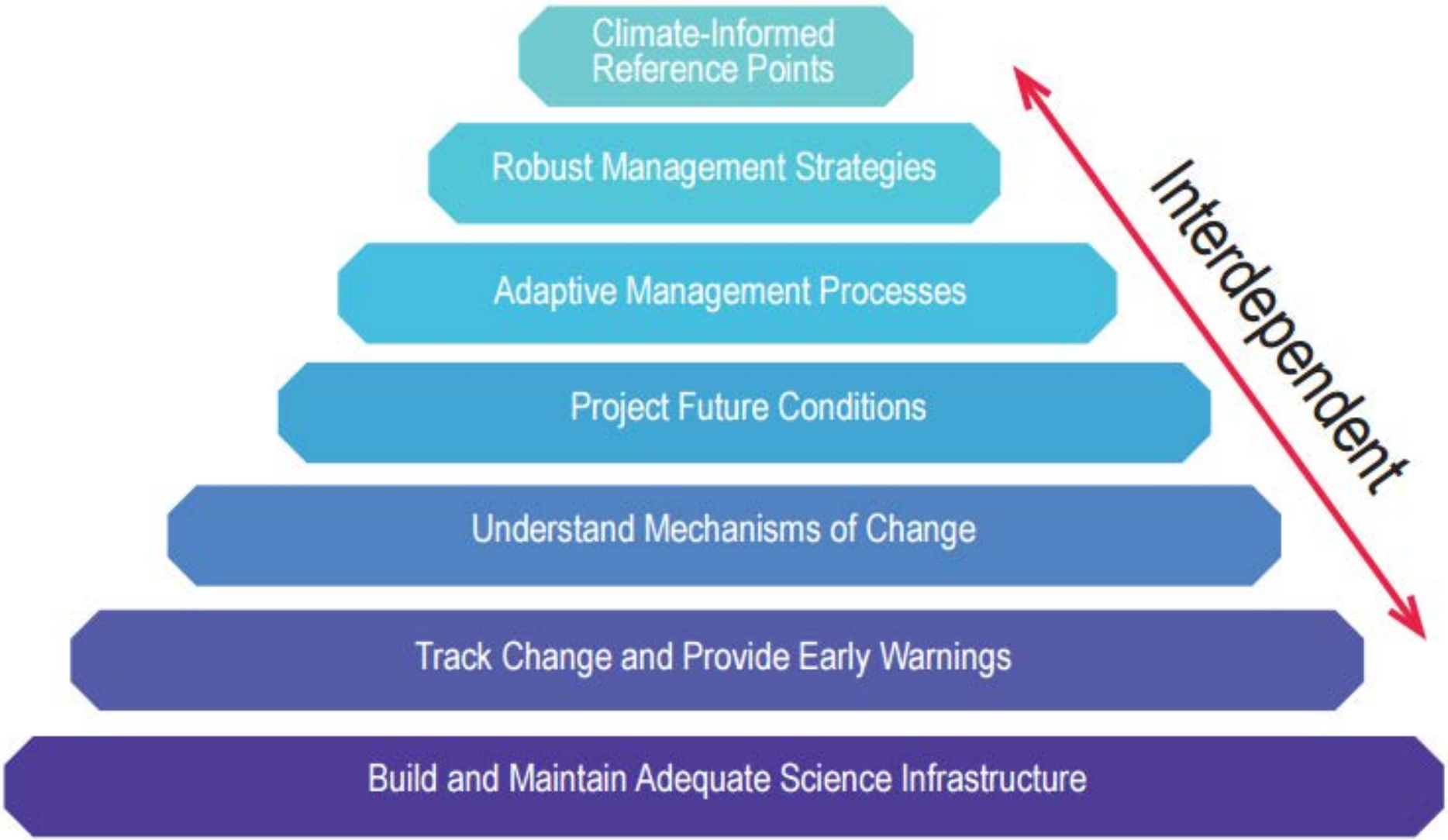
NOAA FISHERIES

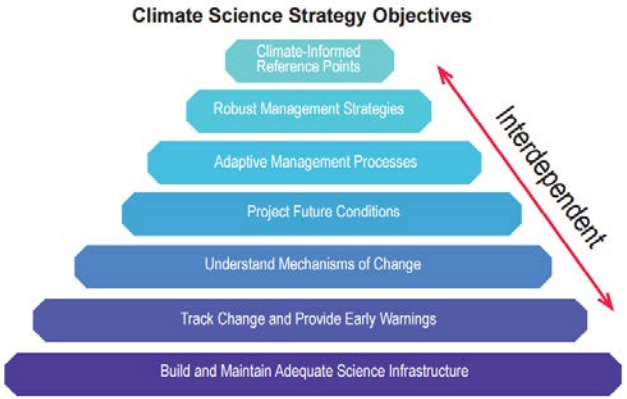
NOAA Fisheries Climate Science Strategy

Highlights



Climate Science Strategy Objectives





Climate informed management

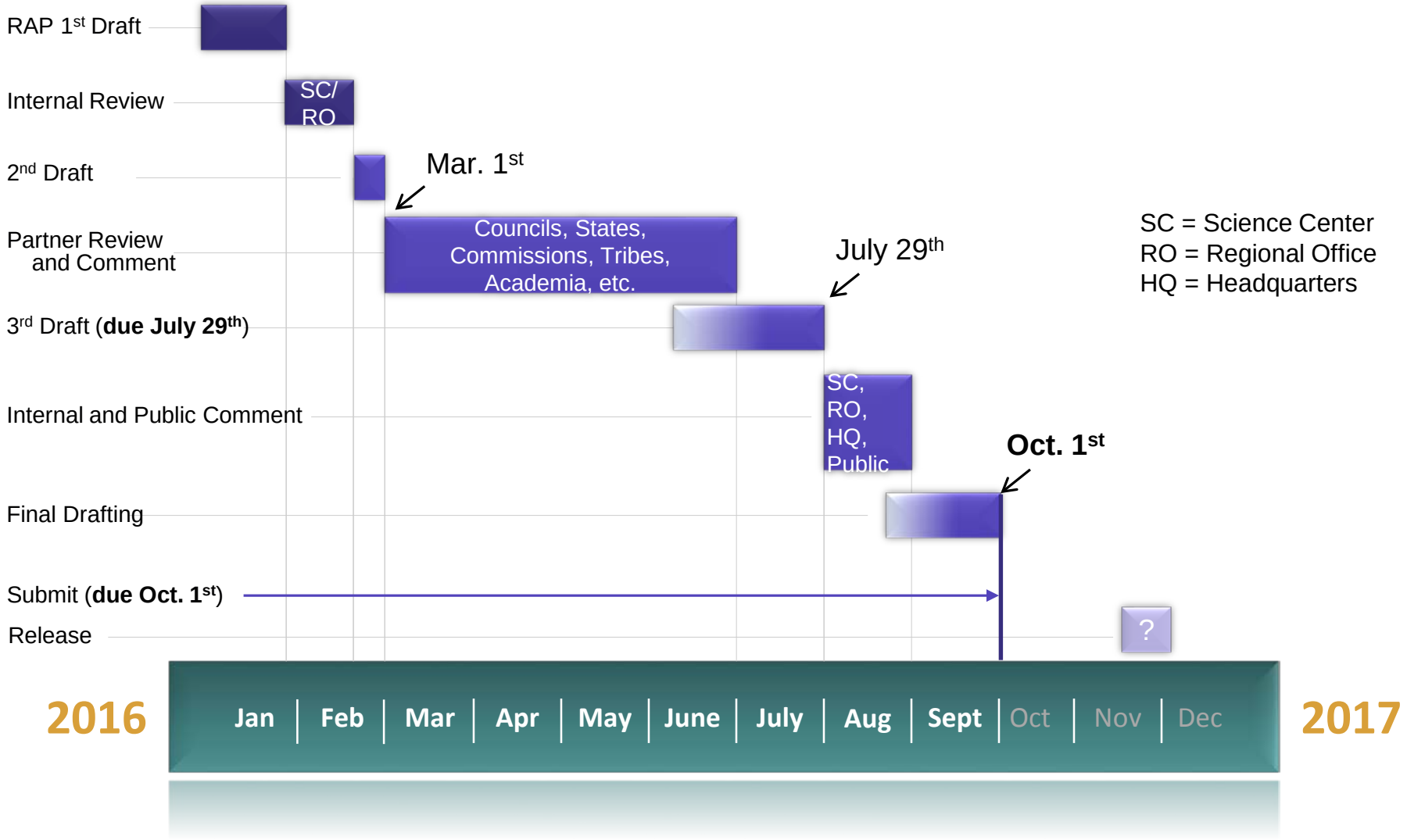
Models (projections and MSE)

Process studies

Ecosystem monitoring

Science infrastructure

Timeline:
RAP Development

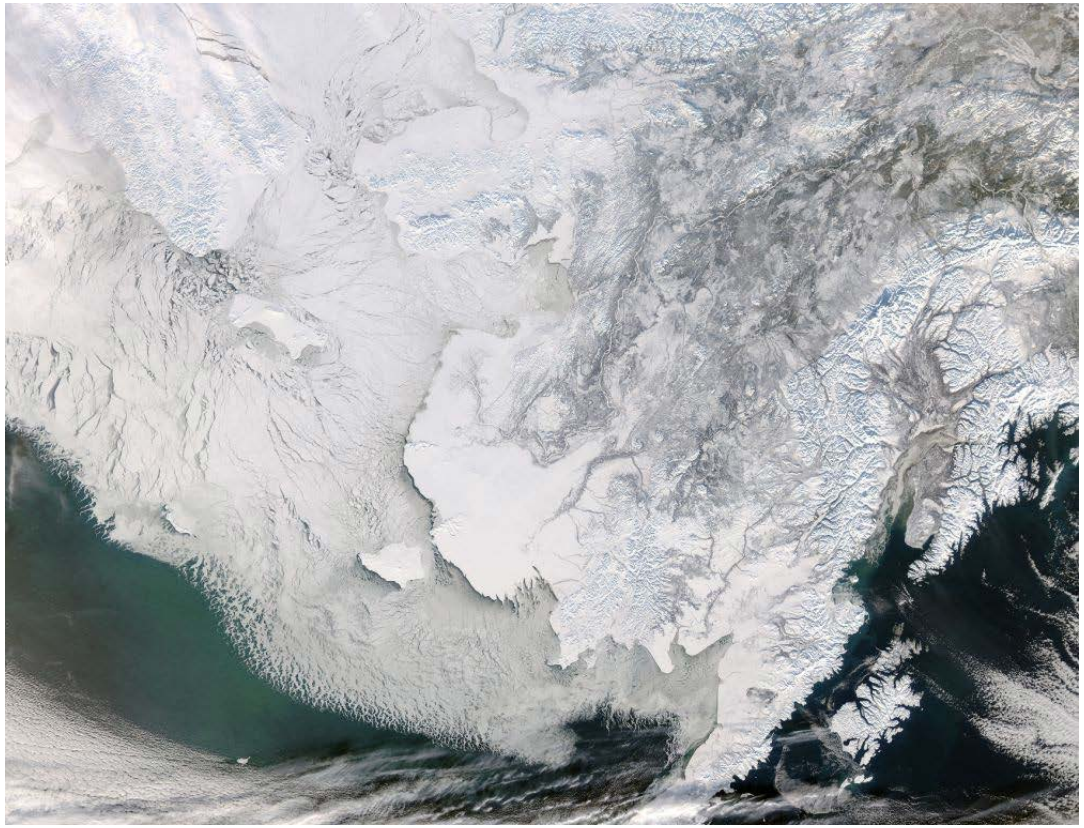


SC = Science Center
RO = Regional Office
HQ = Headquarters

Southeastern Bering Sea Regional Climate Science Strategy

Assessment

Action Plan



Climate-informed management (Obj. 1-3)

Objective 1: Identify appropriate, climate informed reference points for managing living marine resources (LMRs).

Objective 2: Identify robust strategies for managing LMRs under changing climate conditions.

Objective 3: Design adaptive decision processes that can incorporate and respond to changing climate conditions.

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Alaska CLIMate Project

Anne Hollowed (AFSC, SSMA/REFM)
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Stephen Kasperski (AFSC ESSR/REFM)
Jim Ianelli (AFSC, SSMA/REFM)
Kerim Aydin (AFSC, REEM/REFM)
Trond Kristiansen (IMR, Norway)
Al Hermann (UW JISAO/PMEL)
Wei Cheng (UW JISAO/PMEL)
André Punt (UW SAFS)

FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity

IPCC Scenarios (x3)

AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5

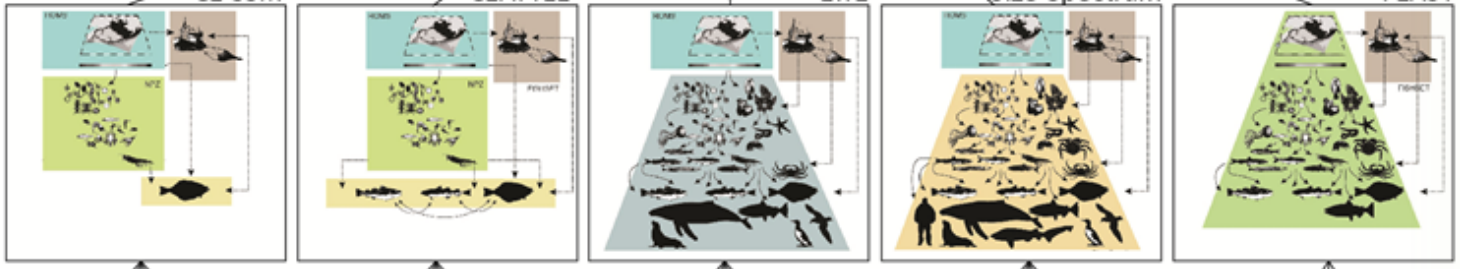
Global Climate Models (x 11)

ECHO-G (AR4 A1B)
MIROC3.2 med res. (AR4 A1B)
CGCM3-t47 (AR4 A1B)
CCSM4-NCAR- PO (AR5 RCP 4.5 & 8.5)
MIROCESM-C- PO (AR5 RCP 4.5 & 8.5)
GFDL-ESM2M*- PO (AR5 RCP 4.5 & 8.5)
GFDL-ESM2M*- PON (AR5 RCP 4.5 & 8.5)

Future Climate Scenarios

Bering Sea Models

CE-SSM | CEATTLE | EwE | Size-Spectrum | FEAST



Climate-enhanced Biological Models

CE-SSM	CEATTLE	EwE	Size-Spectrum	FEAST
By-catch, MSY	By-catch, MSY	By-catch, MSY	By-catch, MSY	Fleet dynamics
Status quo, MEY, No fishing	Status quo, MEY, No fishing	Status quo, MEY, No fishing	Status quo, MEY, No fishing	Status quo, No fishing
Harvest Control Rules (x5)	**Harvest Control Rules (x5)**	**Harvest Control Rules (x5)**	**Harvest Control Rules (x5)**	**Harvest Control Rules (x3)**

Fishing Scenarios

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.

Identify future states (Obj. 4)

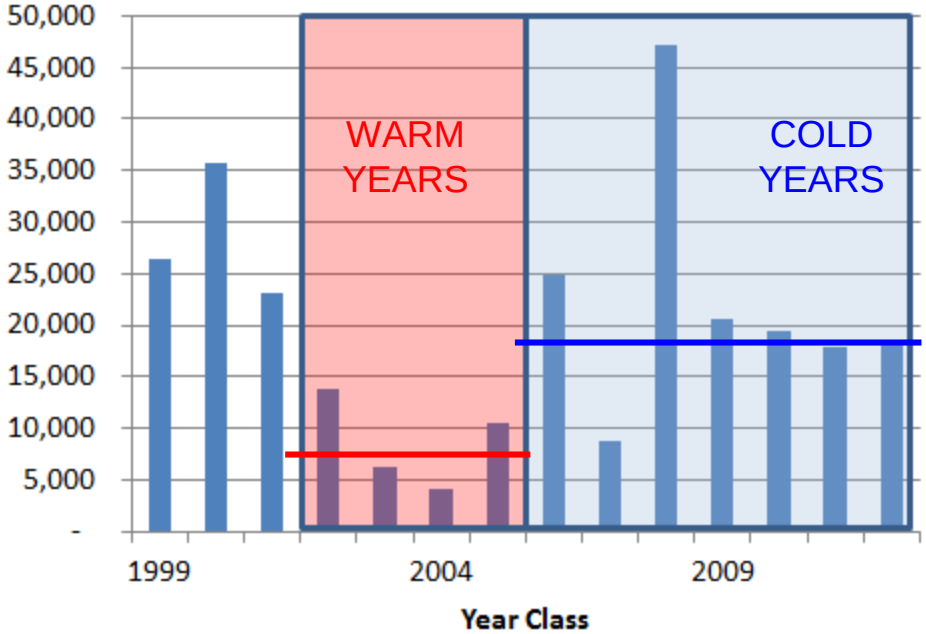
Objective 4: Identify future states of marine and coastal ecosystems, LMRs, and LMR dependent human communities in a changing climate.

Climate and Fisheries

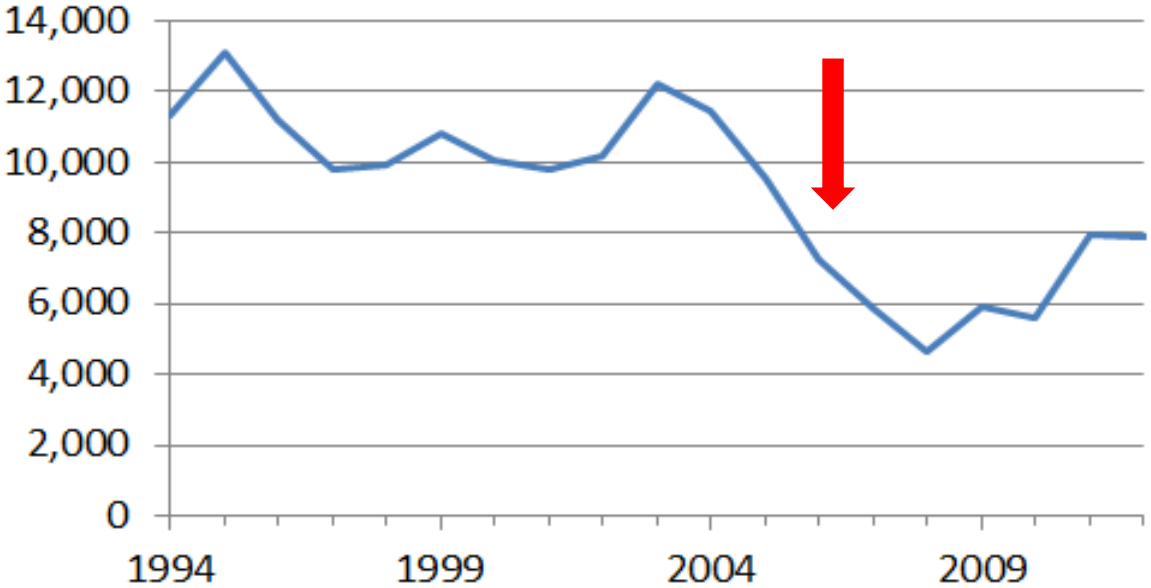
EXPLAIN THIS:

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.

Age-1 number (millions)



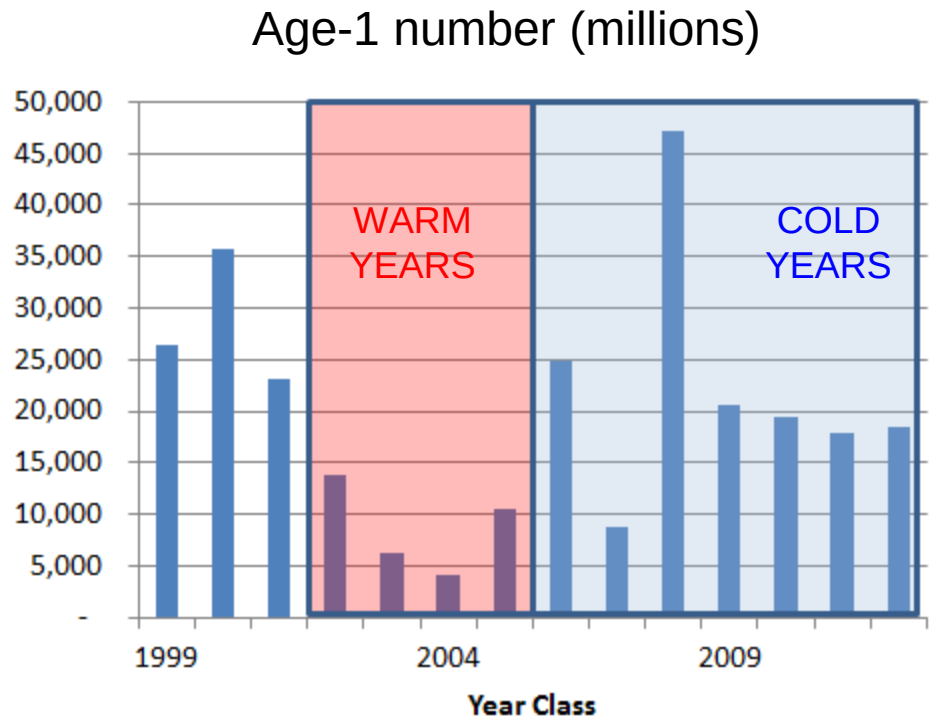
Age-3+ Biomass (thousands t)

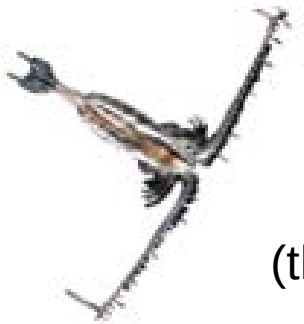


Ianelli, J.N., Barbeaux, S., Honkalehto, T., Kotwicki, S., Aydin, K. and Williamson, N., 2012. Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. Anchorage, AK: North Pacific Fishery Management Council; 2009.*Assessment of the walleye pollock stock in the eastern Bering Sea for*, pp.49-148.

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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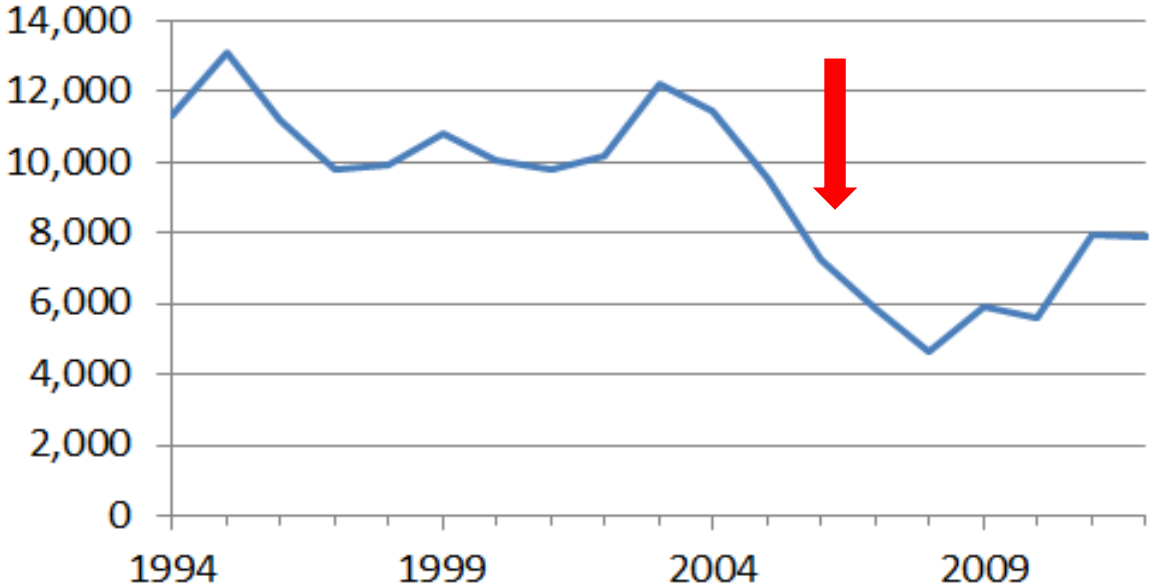
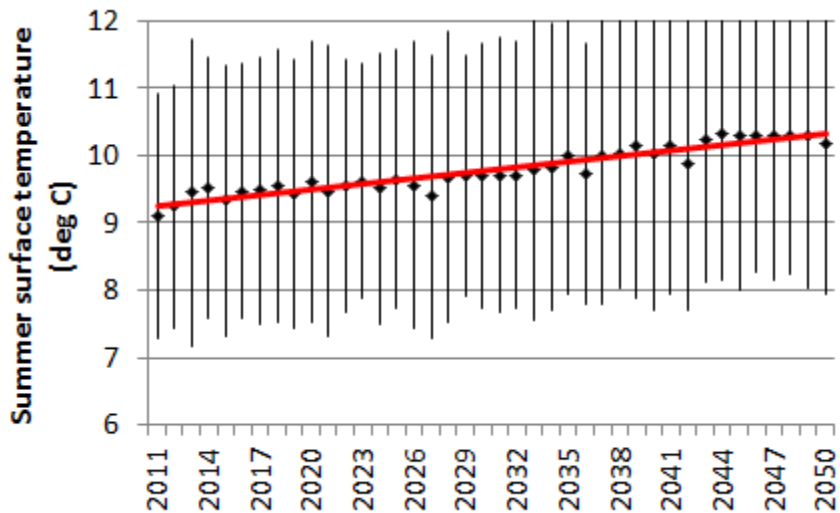


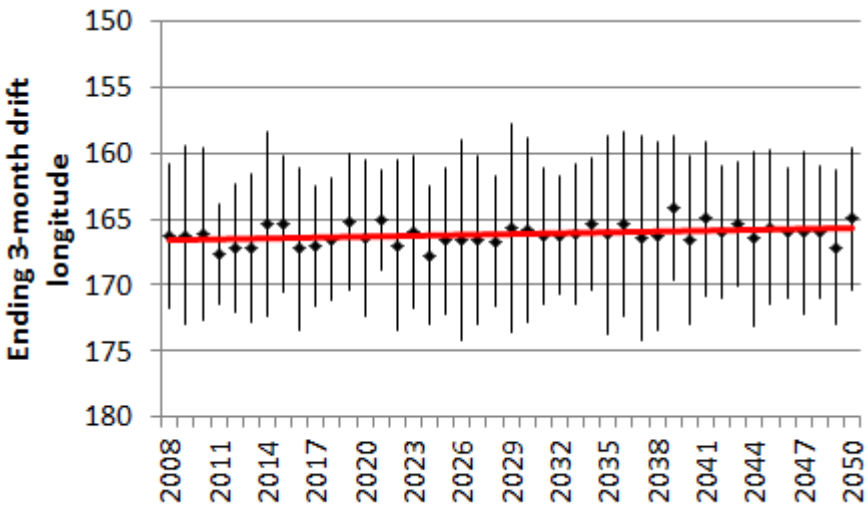
Heintz, R.A., Siddon, E.C., Farley, E.V. and Napp, J.M., 2013. Correlation between recruitment and fall condition of age-0 pollock (Theragra chalcogramma) from the eastern Bering Sea under varying climate conditions. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, pp.150-156.

Ocean model projections

Temperature



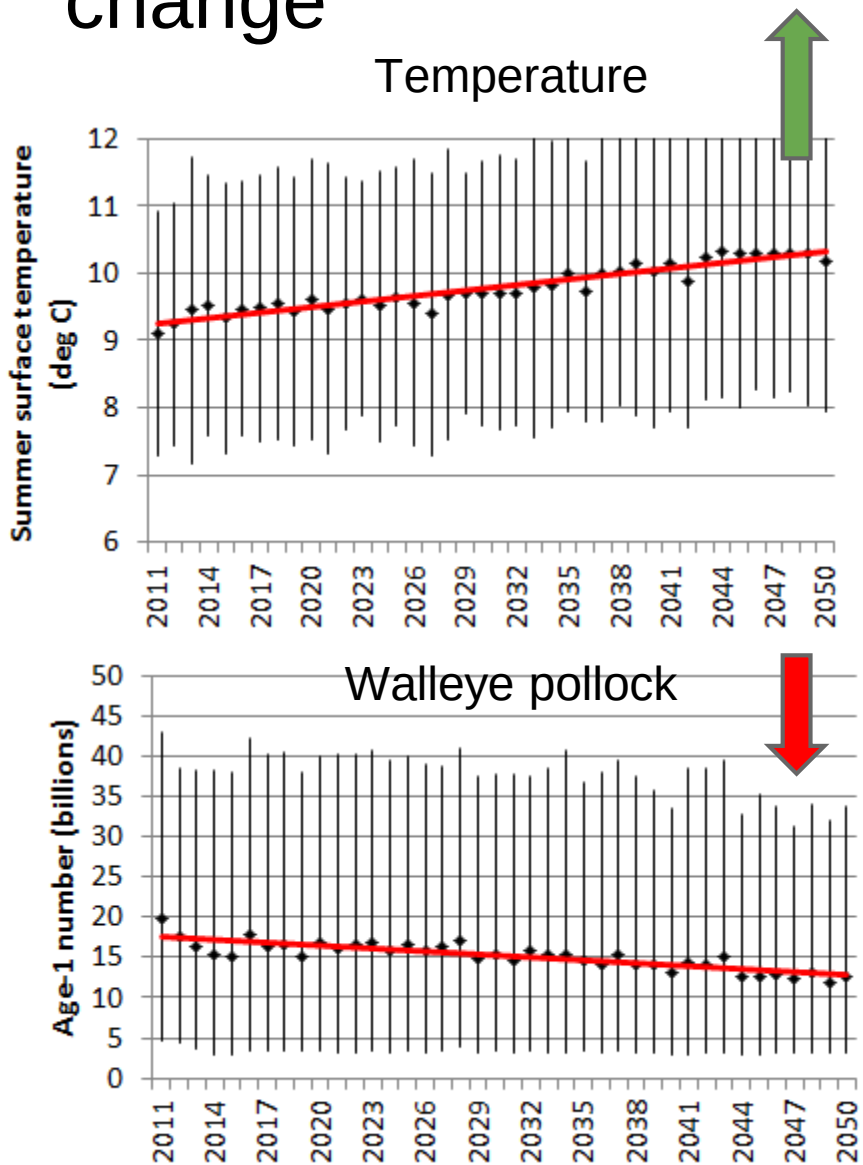
Inshore transport



Mueter, F.J., Bond, N.A., Ianelli, J.N. and Hollowed, A.B., 2011. Expected declines in recruitment of walleye pollock (Theragra chalcogramma) in the eastern Bering Sea under future climate change. *ICES Journal of Marine Science: Journal du Conseil*, p.fsr022.

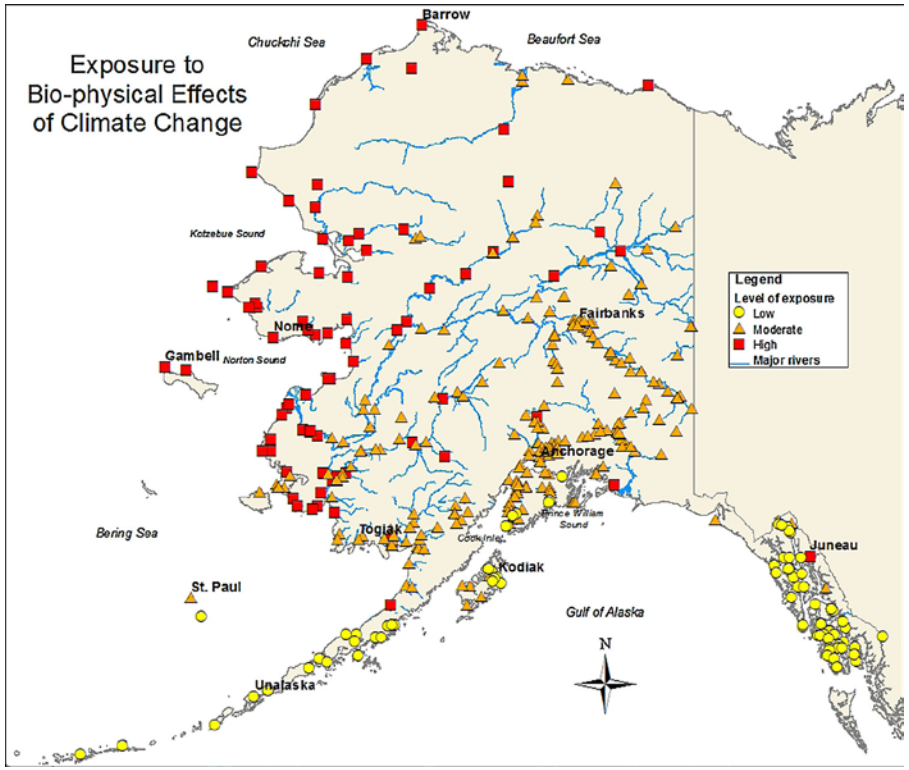
Wilderbuer, T., Stockhausen, W. and Bond, N., 2013. Updated analysis of flatfish recruitment response to climate variability and ocean conditions in the Eastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, pp.157-164.

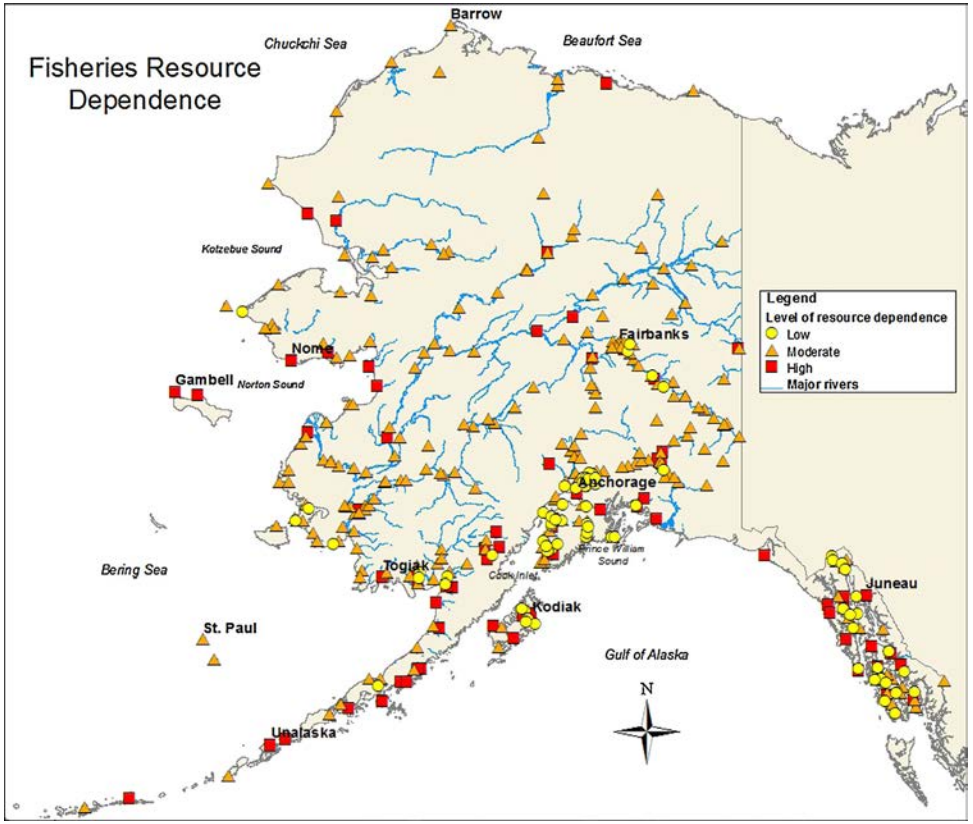
Project pollock abundance under future climate change



Mueter, F.J., Bond, N.A., Ianelli, J.N. and Hollowed, A.B., 2011. Expected declines in recruitment of walleye pollock (Theragra chalcogramma) in the eastern Bering Sea under future climate change. *ICES Journal of Marine Science: Journal du Conseil*, p.fsr022.

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





Himes-Cornell, A. and Kasperski, S., 2015. Assessing climate change vulnerability in Alaska's fishing communities. *Fisheries Research*, *162*, pp.1-11.

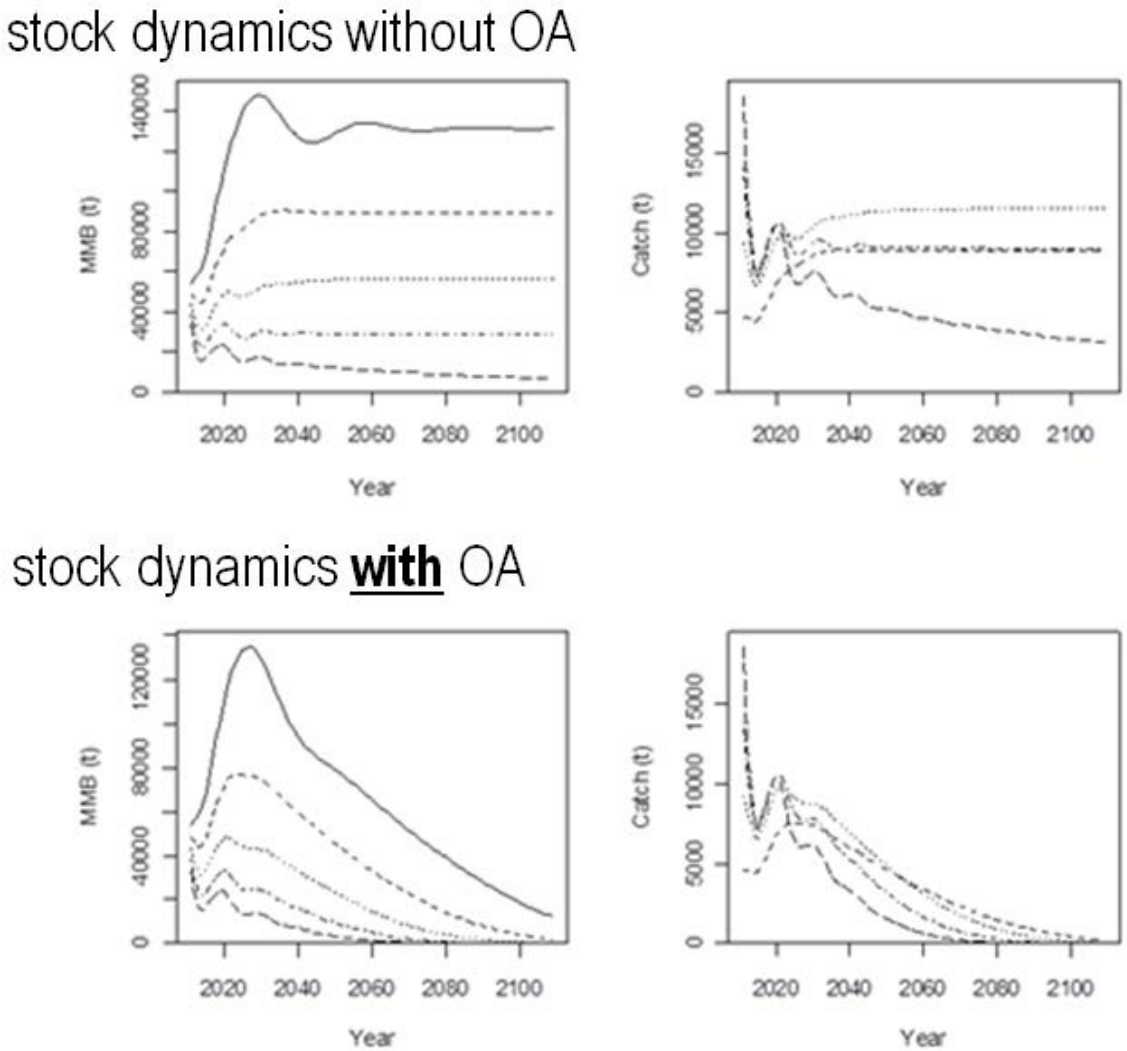
Identify mechanisms (Obj. 5)

Objective 5: Identify the mechanisms of climate impacts on LMRs, ecosystems, and LMR dependent human communities.

Ocean acidification research

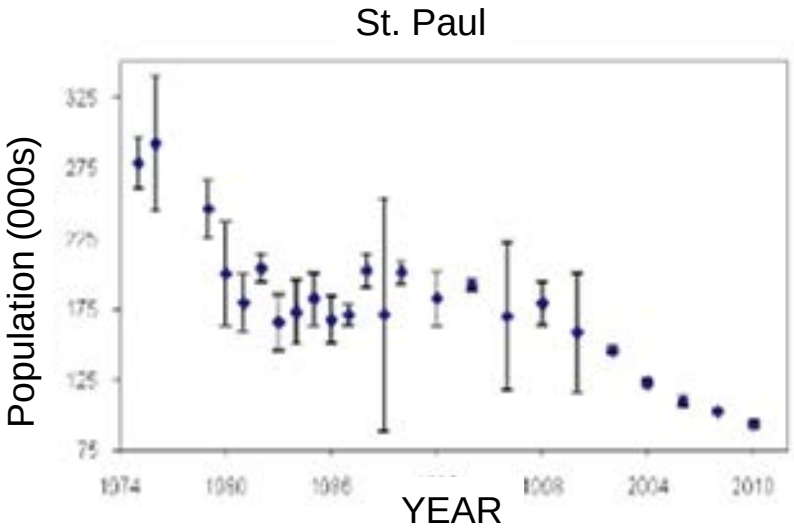
Long, W.C., Swiney, K.M. and Foy, R.J., 2013. Effects of ocean acidification on the embryos and larvae of red king crab, Paralithodes camtschaticus.*Marine pollution bulletin*, *69*(1), pp.38-47.

Punt, Poljak, Dalton, Foy. 2014. Evaluating the impact of ocean acidification on fishery yields and profits: The example of red king crab in Bristol Bay. Ecol. Modeling. 285: 39-53.



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 in 2015 and 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.



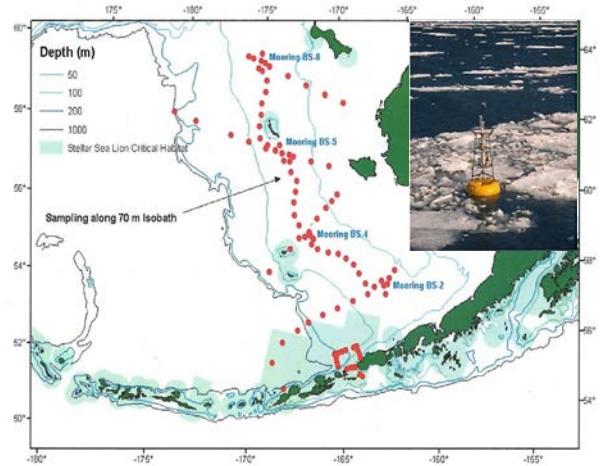
Allen, B.M., Angliss, R.P. and Wade, P.R., 2011. *Alaska marine mammal stock assessments, 2010*.

Track trends in ecosystems (Obj. 6)

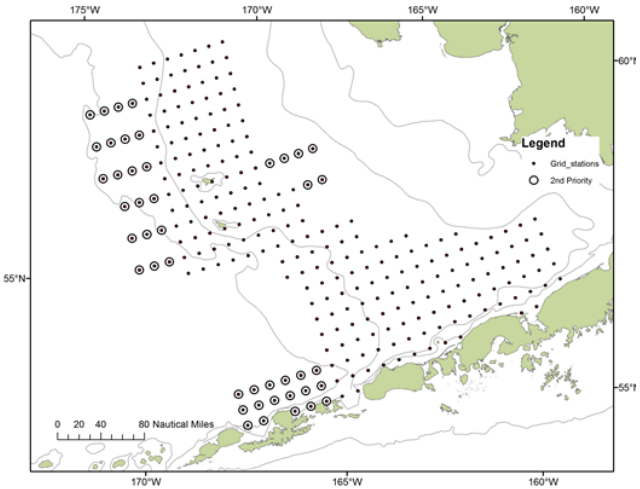
Objective 6: Track trends in ecosystems, LMRs and LMR dependent human communities and provide early warning of change.

Seasonal surveys

April-May & Sept-Oct physics

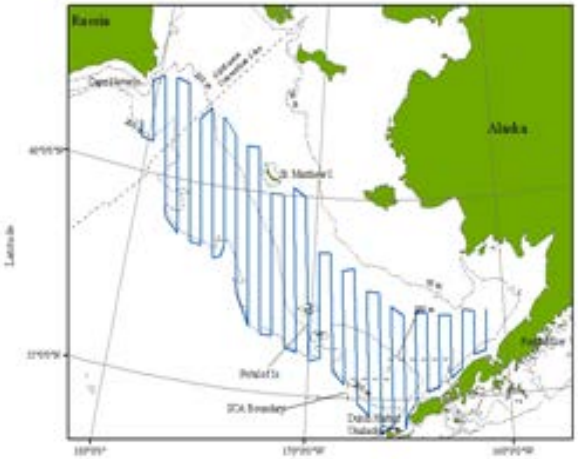


May, larval

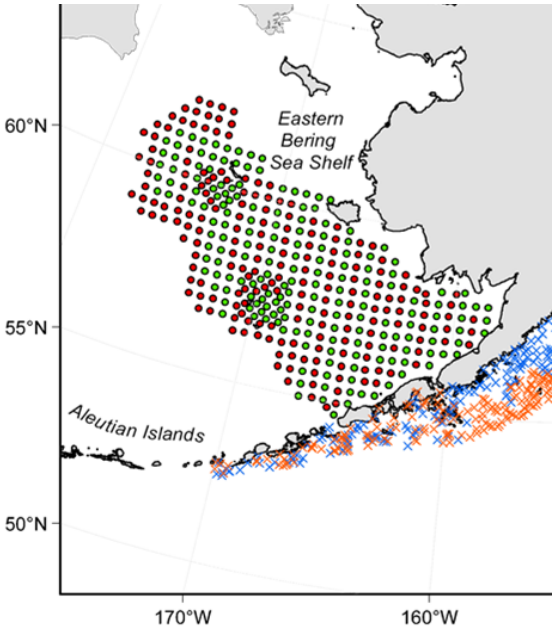


August-September, age-0

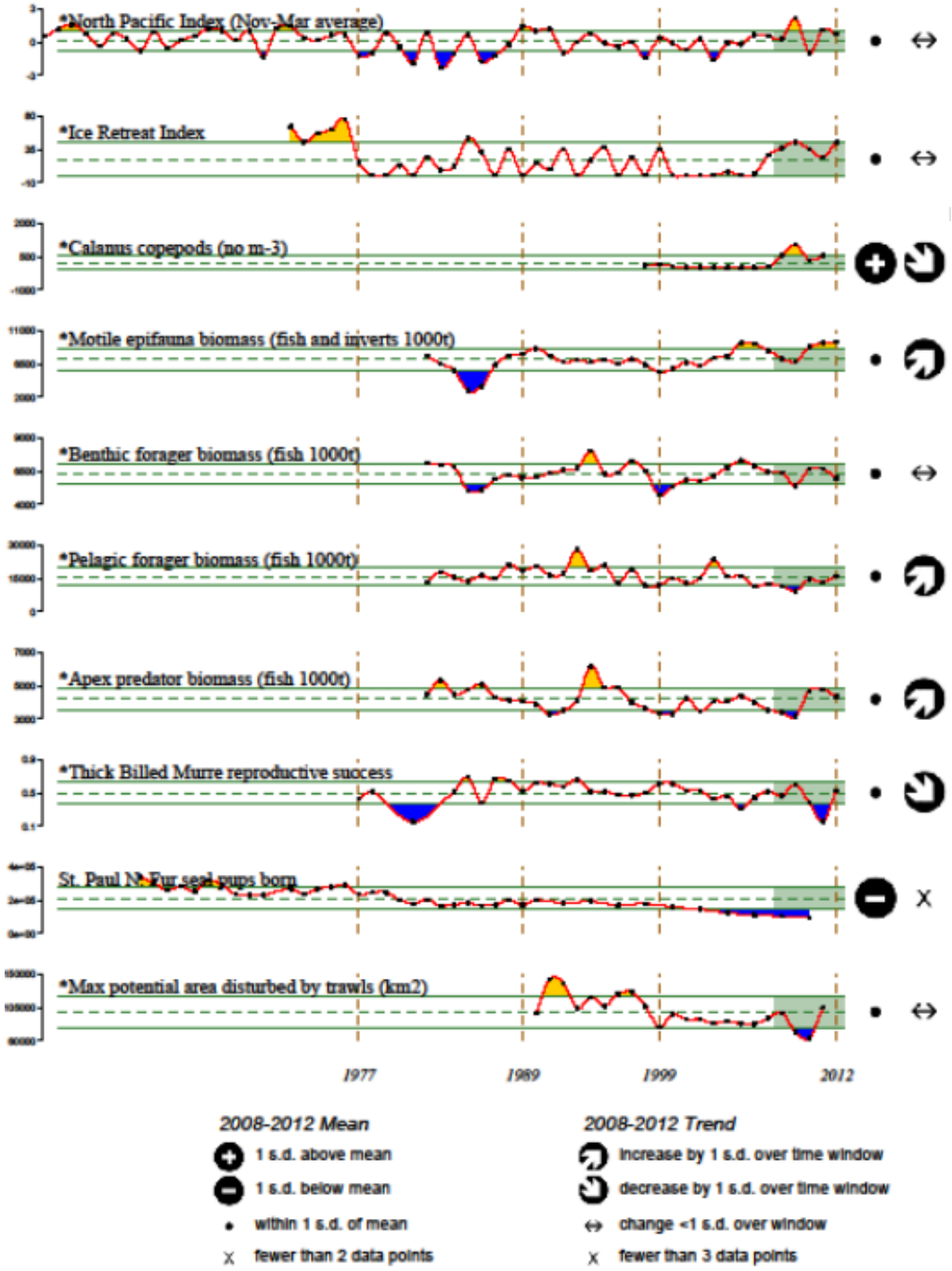
June-July, age-1



June-July, age-3+



Alaska Marine Ecosystem Considerations



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 ↔

Mueter, F.J., Bond, N.A., Ianelli, J.N. and Hollowed, A.B., 2011. Expected declines in recruitment of walleye pollock (Theragra chalcogramma) in the eastern Bering Sea under future climate change. *ICES Journal of Marine Science: Journal du Conseil*, p.fsr022.

Wilderbuer, T., Stockhausen, W. and Bond, N., 2013. Updated analysis of flatfish recruitment response to climate variability and ocean conditions in the Eastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, pp.157-164.

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Punt, Poljak, Dalton, Foy. 2014. Evaluating the impact of ocean acidification on fishery yields and profits: The example of red king crab in Bristol Bay. Ecol. Modeling. 285: 39-53.

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.

Vulnerability Rank

Sensitivity \ Exposure	Low	Moderate	High	Very High
Very High	Moderate	High	Very High	Very High
High	Low	Moderate	High	Very High
Moderate	Low	Moderate	Moderate	High
Low	Low	Low	Low	Moderate

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

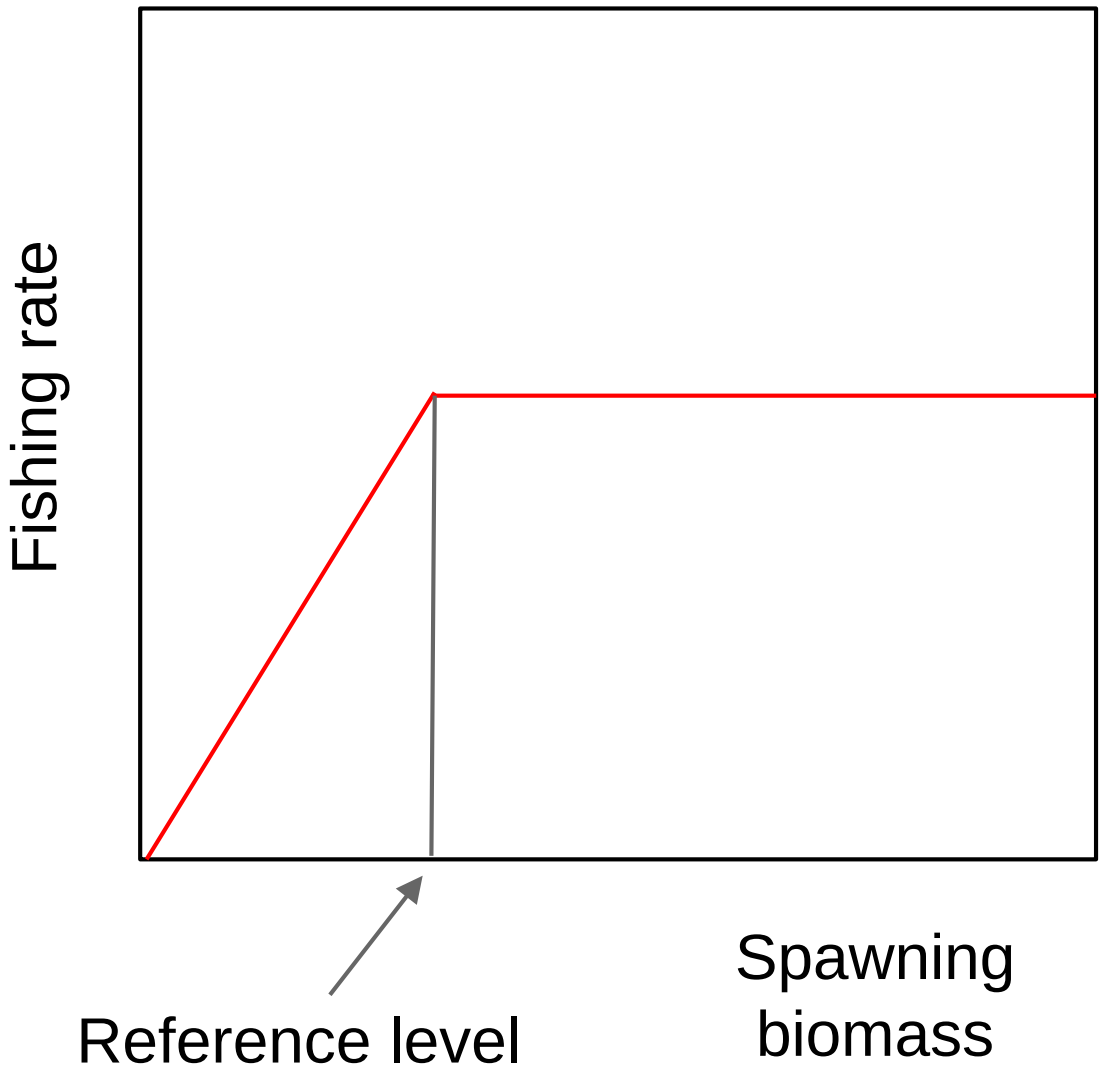
Recruitment Processes Alliance

Research is conducted to understand processes affecting recruitment strength, including effects of climate. This is a partnership between OAR and AFSC that joins six AFSC programs with researchers from the PMEL:
Recruitment Processes,
Ecosystem Monitoring and Assessment,
Recruitment Energetics and Coastal Assessment,
Resource Ecology and Ecosystem Modeling,
Status of Stocks and Multispecies Assessment,
Marine Ecology and Stock Assessments
Pacific Marine Environmental Laboratory

A significant fraction of AFSC resources are invested in this effort (e.g., ~15% of labor).

Challenge 2 (Obj. 3)

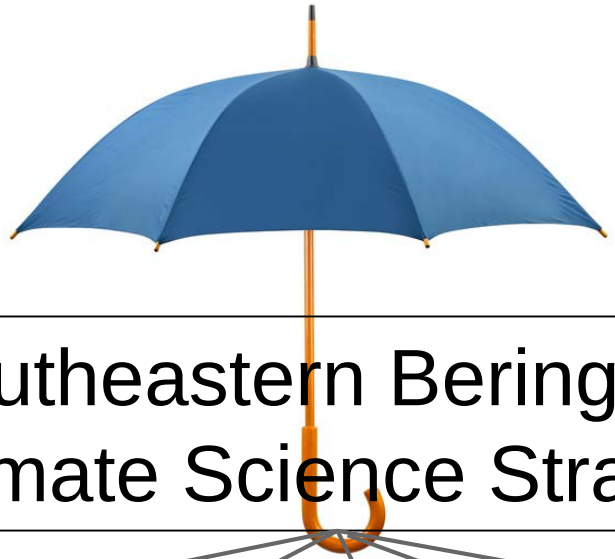
- Setting sustainability goals under changing climate.
- Spatial management under shifts in species distribution.
- Allocation under shifting species composition
- How and when the North Pacific Fishery Management Council should react to climate-induced reference point changes.



NMFS Climate Science Strategy

Pacific Islands

California Current



Gulf of Mexico

Georges Bank

Aleutian Islands

Gulf of Alaska

Southeastern Bering Sea Climate Science Strategy

- Southeastern Bering Sea Vulnerability Analysis
- Recruitment Processes Alliance
- ACLIM
- Shifts in Distribution and abundance, Juvenile & Adult
  - Distribution
  - Phenology
  - Growth
  - Maturity
- Community Profiles, and Vulnerability Analysis

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

Action Plan (with level funding)

- NPFMC Bering Sea Fisheries Ecosystem Plan.
- Alaska CLIMate Project (ACLIM) – Proposed Transition to Operationalize
- Climate vulnerability assessment for the southeastern Bering Sea.
- Belmont Forum project.
- Recruitment Processes Alliance.
- Loss of Sea Ice research.
- Ocean Acidification research.
- Fur seal research.
- Assess economic and human community impacts.
- Alaska Integrated Ecosystem Assessments and Alaska Marine Ecosystems Considerations.
- Standard ecosystem monitoring.
- Advanced technology.

Action Plan

- With some additional funds:
  - Fully support NOAA oceanographic moorings to monitor the ecosystem.
  - Invest in modeling infrastructure.
  - Comprehensive climate assessment completed every five years.
  - Invest in regional and international coordination.
  - Improve communication of the risks of climate change to fishing dependent communities
  - Integrate the evolving tools and data integration work completed by AFSC and PMEL.