Part III: Climate Science Strategy: A Bering Sea Case Study

Alaska Fisheries Science Center

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Science and Research Director

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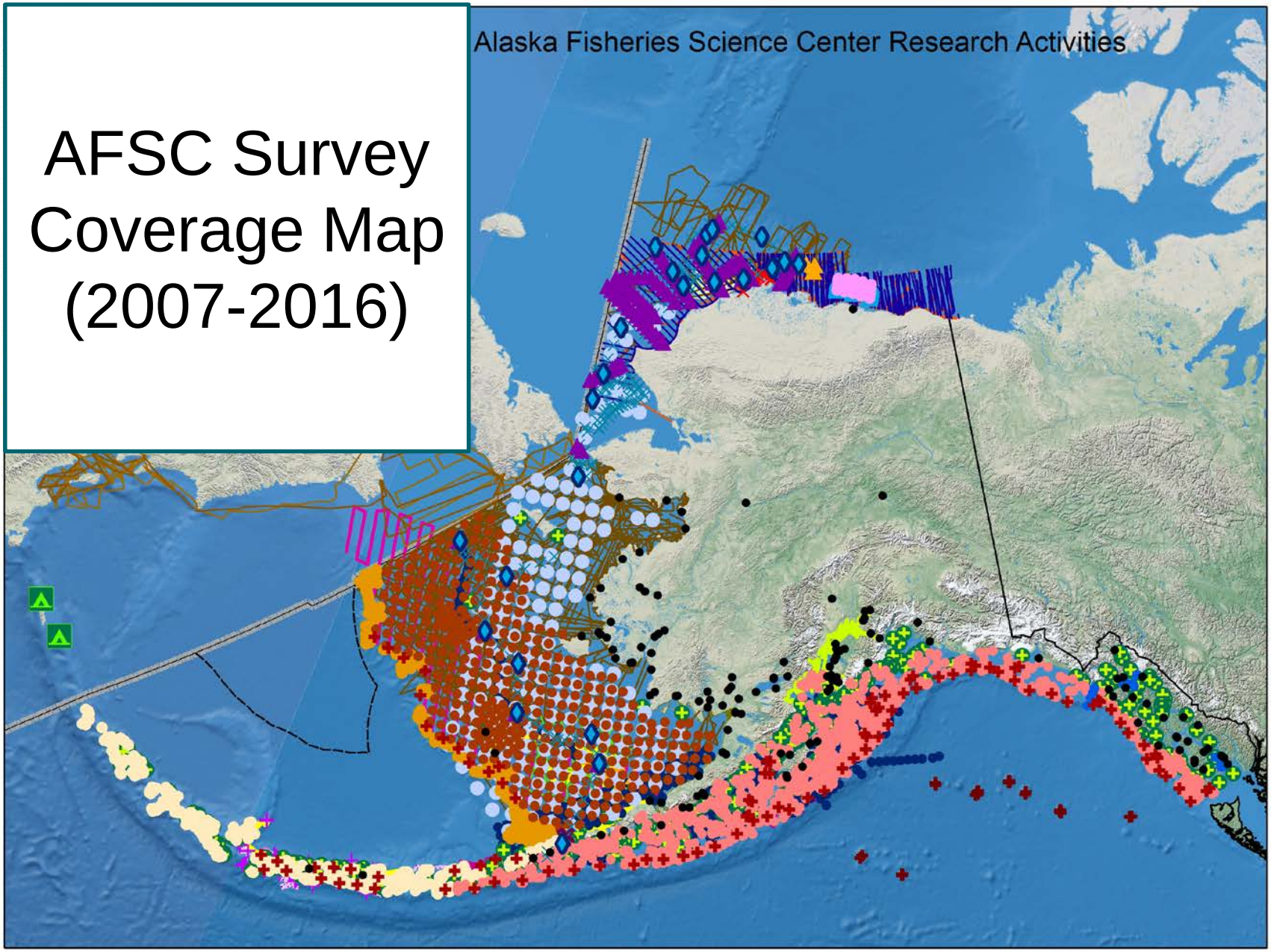
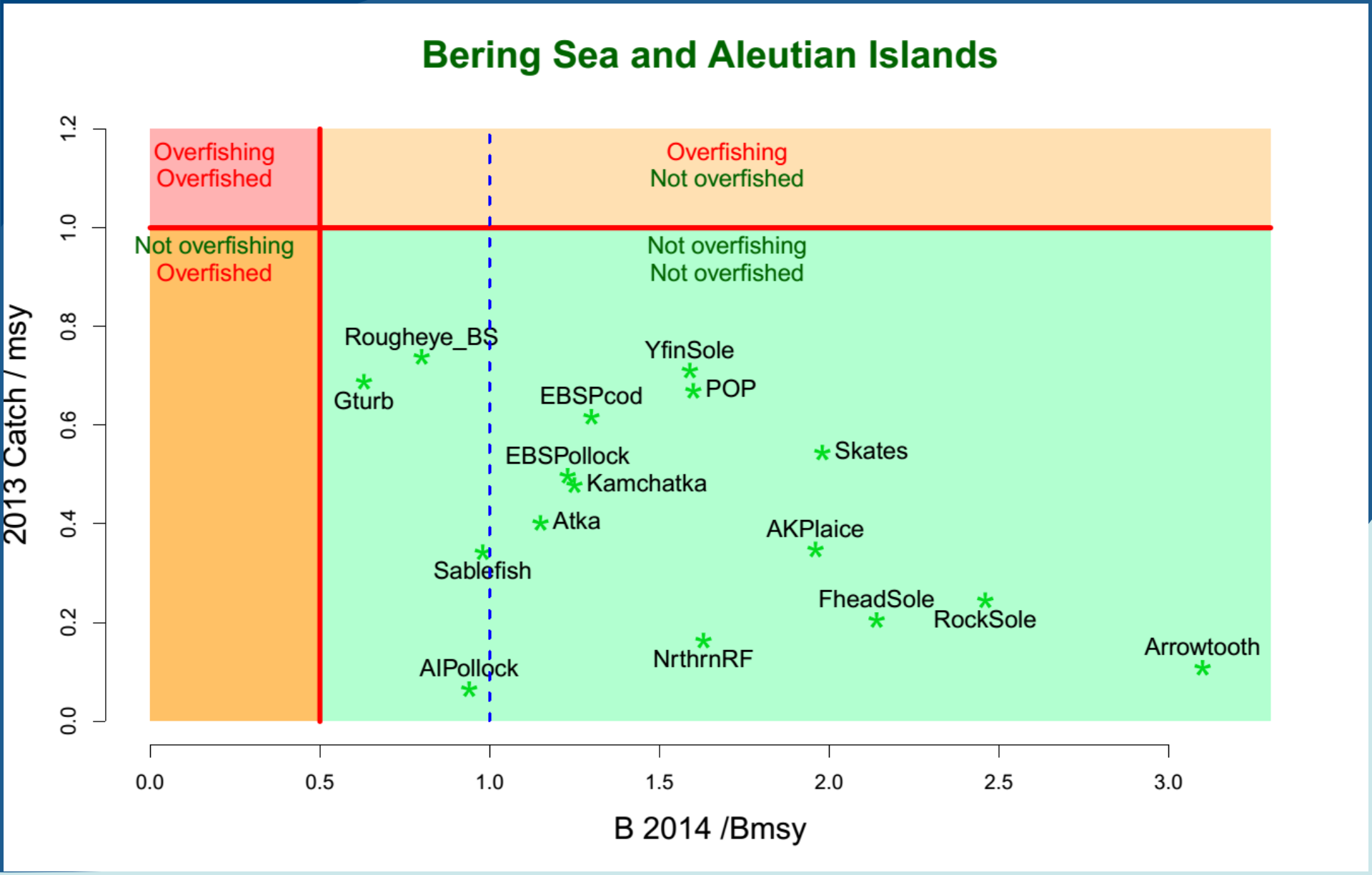
AFSC Survey Coverage Map (2007-2016)



Bering Sea and Aleutian Islands Groundfish



Fishery Toolbox Timeline

Logistic eqn

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

1838

Single-species models:

1954

Computers 1975

Statistical models fitted to data

May, Clark, Hilborn, Walters

MSY

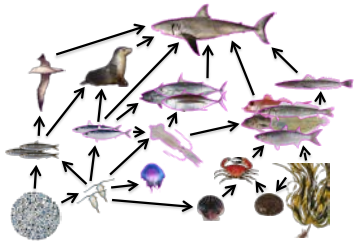
Bioeconomic models

MEY

Ecosystem Approach to Fisheries

Rio 1992

1995



Ecosystem Models MMSY & MSE

Climate Change

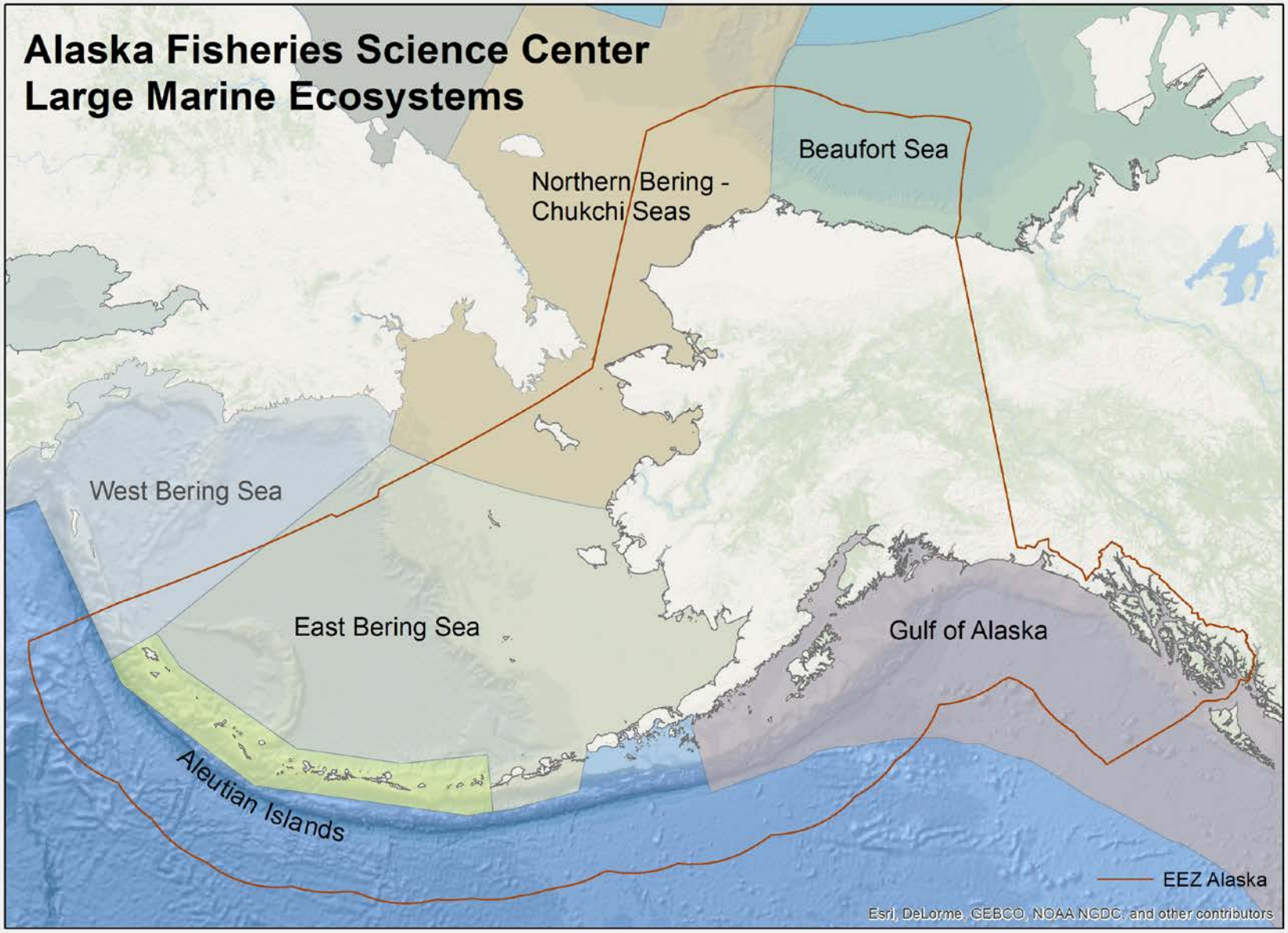
IPCC 2007

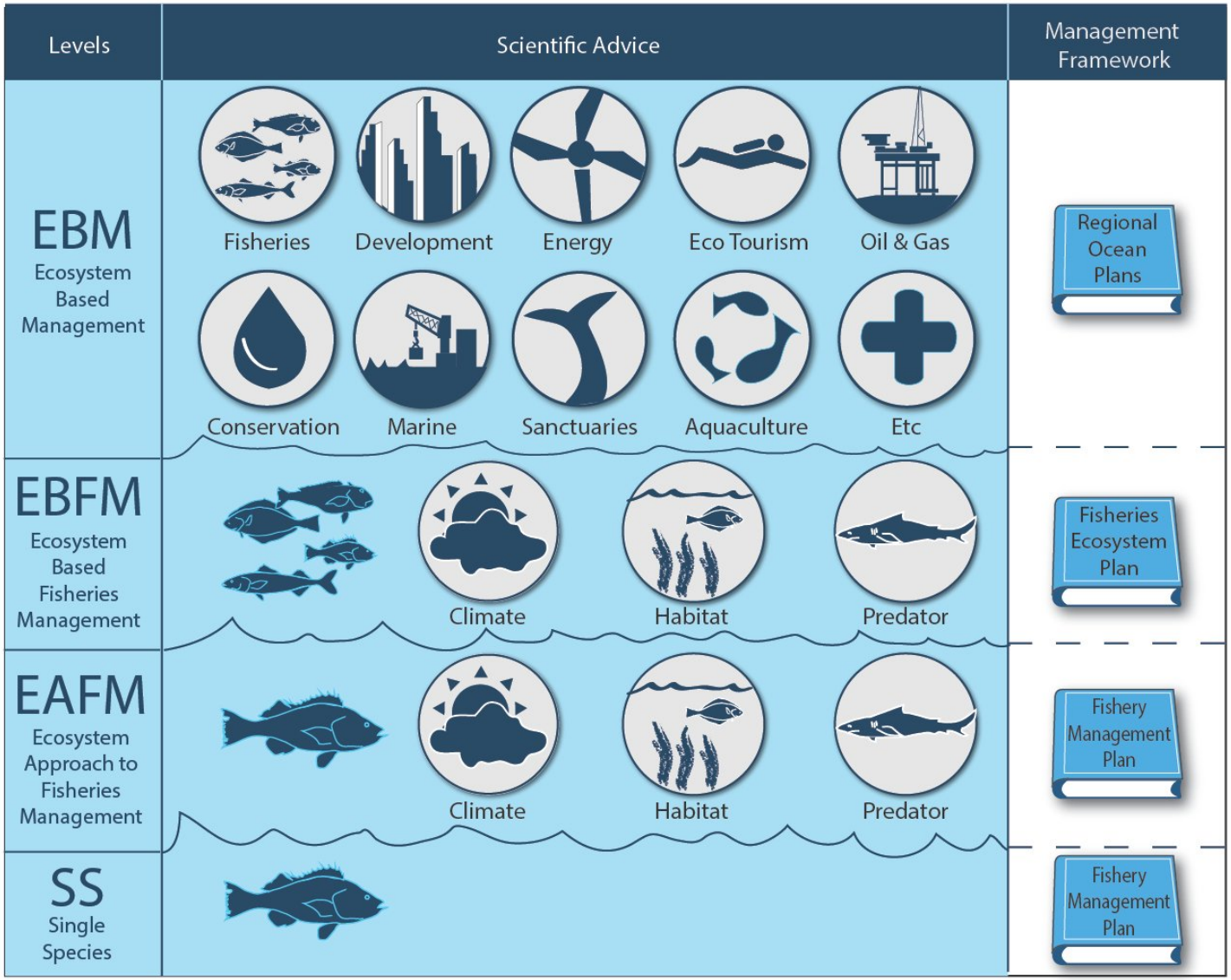
Models that link climate forcing with stock assessment models

Upload humans in models

Integrated socio-ecological models

Derived from Éva Plagányi (2016 ICES Plenary; see https://www.youtube.com/watch?v=yDeLh6IprYo)


Alaska Fisheries Science Center
Large Marine Ecosystems
Beaufort Sea
Northern Bering -
Chukchi Seas
West Bering Sea
East Bering Sea
Gulf of Alaska
Aleutian Islands
EEZ Alaska
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors


Levels
Scientific Advice
Management Framework
EBM
Ecosystem Based Management
Fisheries
Development
Energy
Eco Tourism
Oil & Gas
Conservation
Marine
Sanctuaries
Aquaculture
Etc
Regional Ocean Plans
EBFM
Ecosystem Based Fisheries Management
Climate
Habitat
Predator
Fisheries Ecosystem Plan
EAFM
Ecosystem Approach to Fisheries Management
Climate
Habitat
Predator
Fishery Management Plan
SS
Single Species
Fishery Management Plan

Definition: Fishery Ecosystem Plan (FEP)

- The Councils can develop FEPs as a mechanism for incorporating ecosystem principles, goals, and policies into their current fishery management structure.

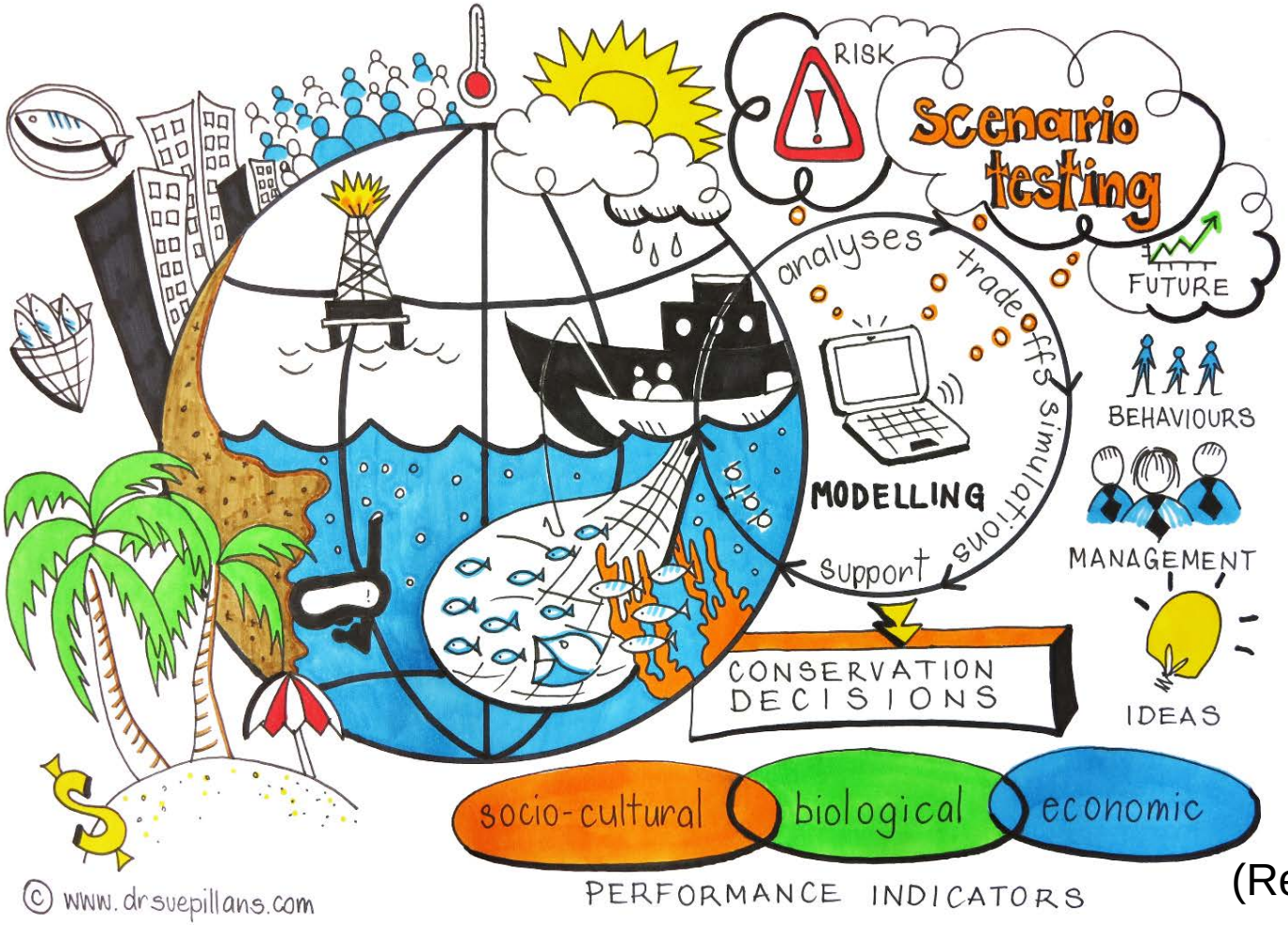
- The objectives of fishery ecosystem plans are to:

1. Provide a clear description and understanding of the fundamental physical, biological, and human context of ecosystems within which fisheries are managed.

2. Direct how that information should be used in the context of fishery management plans.

3. Set policies that guide development and implementation of fishery management options.

The complex interdependencies that characterise the modern Anthropocene



FEP

ROP

(Regional Ocean Plan)

Plagányi, É.E. and E.A. Fulton. In press. The future of modelling to support conservation decisions in the Anthropocene Ocean. In: Levin, P.S. & M.R. Poe. Conservation for the Anthropocene Ocean: Interdisciplinary science in support of nature and people. Elsevier

Definition: Anthropocene

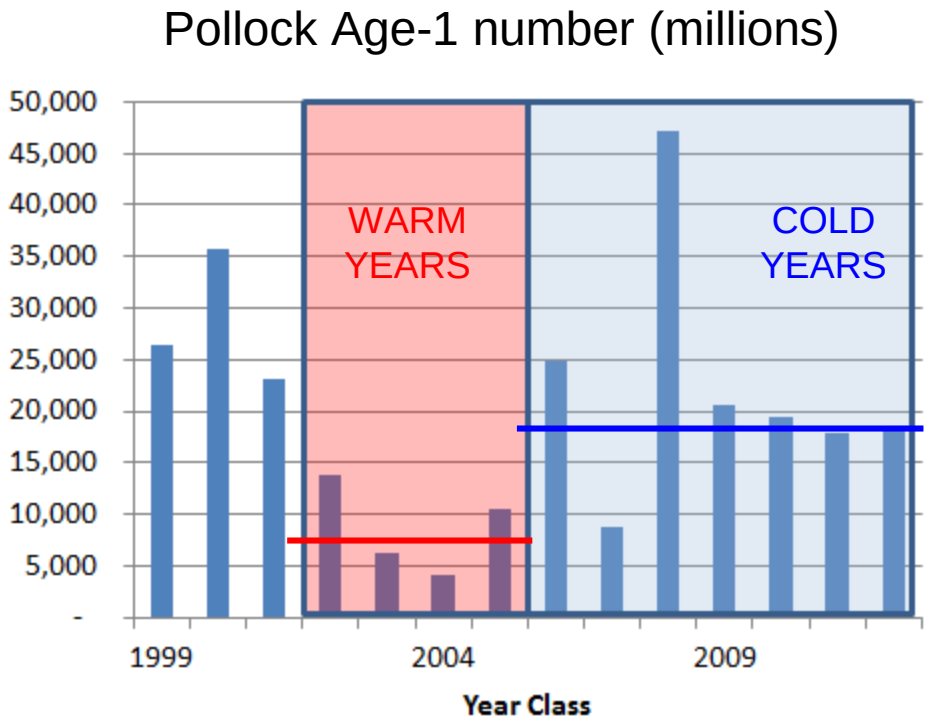
- a proposed epoch that begins when human activities started to have a significant global impact on Earth's geology and ecosystems.

- The Anthropocene has no agreed start date, but some scientists propose that, based on atmospheric evidence, it may be considered to start with the Industrial Revolution (late eighteenth century).

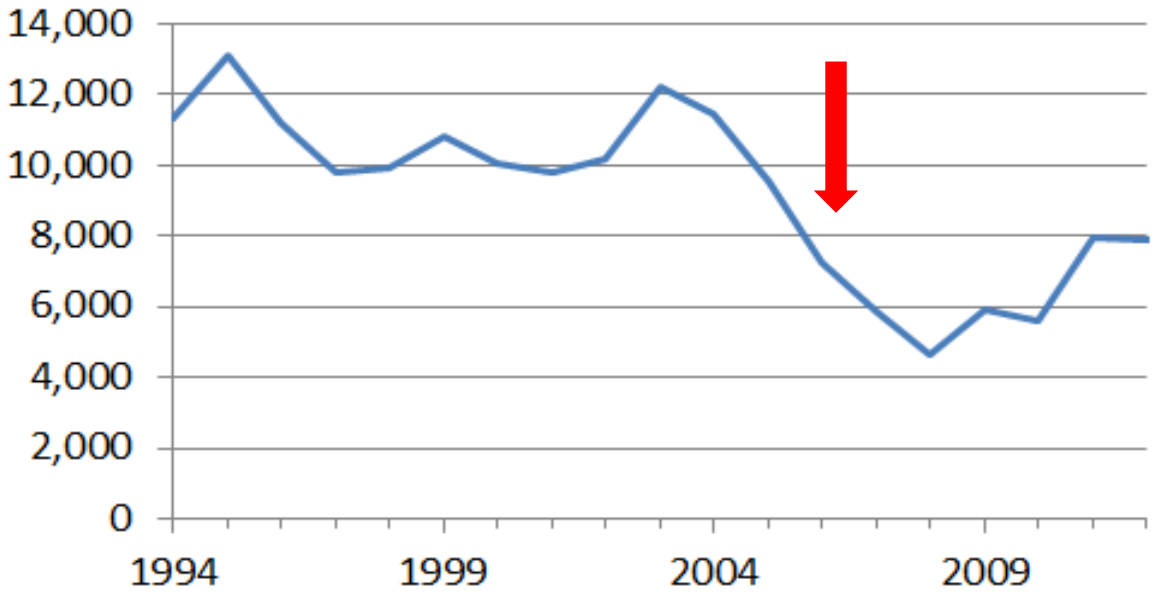
NMFS Climate Science Strategy (CSS)

- Science Centers acquire and distribute the scientific information necessary to sustain fisheries and their ecosystems for the benefit of the nation.
- To continue to fulfill the mission in the face of climate change, the Science Centers seek to acquire and develop information needed to understand, prepare for, and respond to climate change impacts on commercial fisheries.

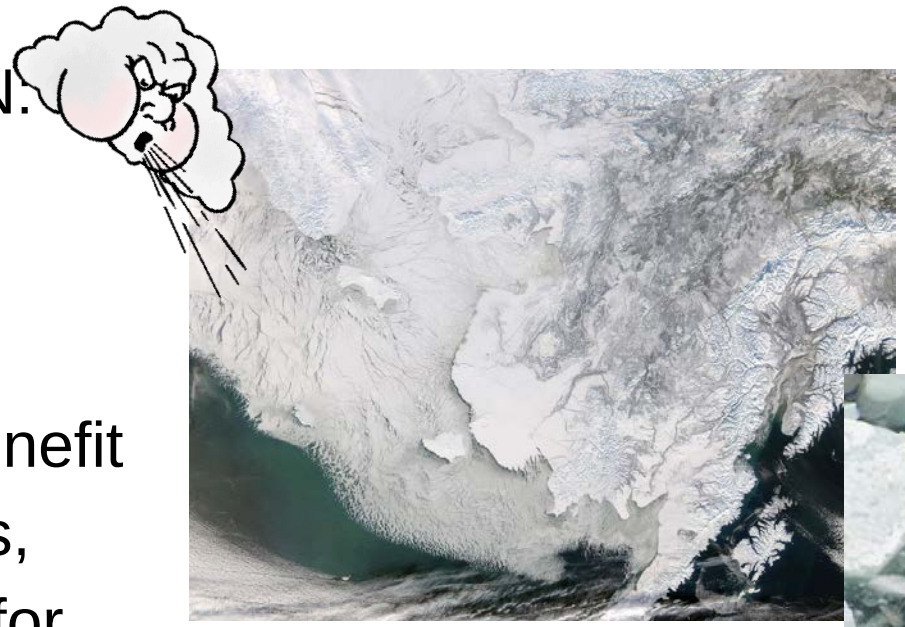
Ecosystem information explained why walleye pollock abundance dramatically fell in the early 2000's, leading to a 40% drop in the quota for the largest single fishery in the US, and then rebounded.



Age-3+ Biomass (thousands t)



EXPLANATION: Due to bloom timing, large crustacean zooplankton benefit from icy winters, providing prey for age-0 pollock to enter their first winter fat. With increased overwinter survival, recruitment is enhanced.



In warm years, prey have less lipid, age- 0 pollock enter winter in poor condition, recruitment down.

NMFS CSS: Regional Action Plan for each of the 11 LMEs

Goal: Improve efforts to identify and adapt fisheries to climate change

By:

- Identify winners and losers
- Adjust management advice based on Management Strategy Evaluations (MSE), as necessary
- Identify and monitor thresholds in ecosystem parameters signaling need to adjust management strategies

www.afsc.noaa.gov/news/Regional_action_plan_Bering_Sea.htm

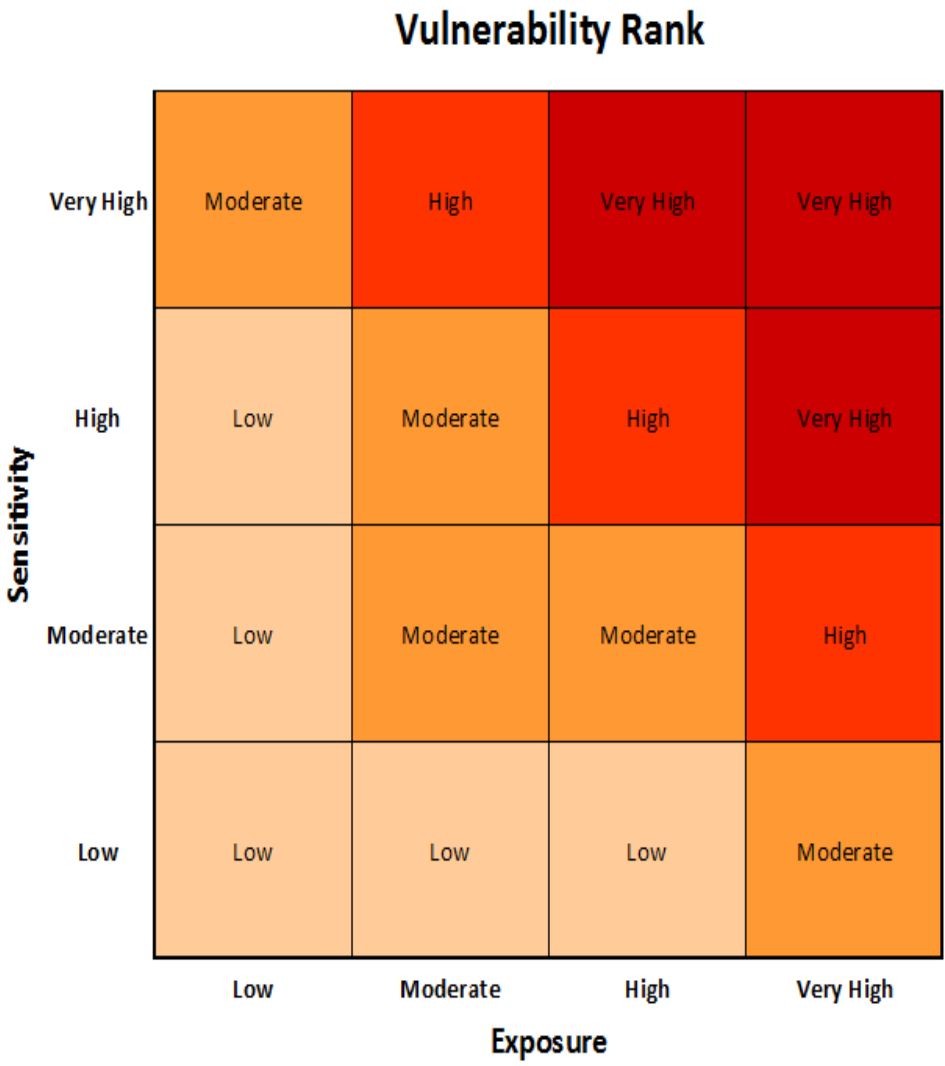
Climate vulnerability assessment:

--- will **qualitatively assess** species vulnerabilities to climate change,

--- currently underway,

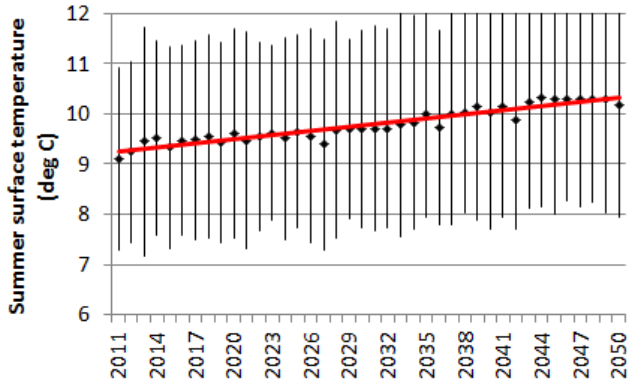
--- uses expert elicitation methods to quantify a species' exposure and sensitivity to expected climate change.

Key – assign ***Exposure*** and ***Sensitivity*** rating



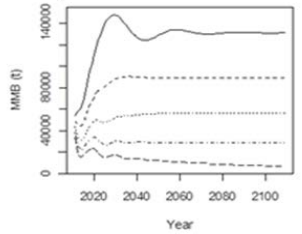
Spencer, Hollowed, Nelson, Sigler, In prep.. *Climate Vulnerability Assessment for the southeastern Bering Sea.*.

Climate informed stock assessment and management

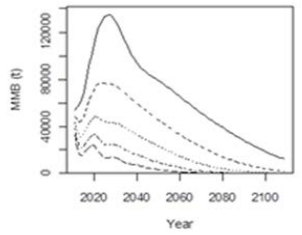


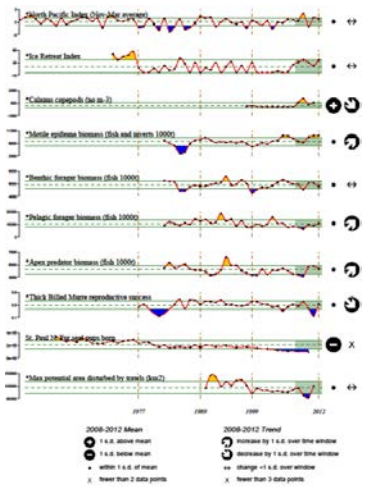
Modeling

stock dynamics without OA



stock dynamics **with** OA





Ecosystem monitoring (surveys)

Process studies

Alaska Climate Project: ACLIM

Approach:

- examine current fishery management approaches: which are robust to future climate driven changes

- evaluate performance of additional "climate-ready approaches

- generate predictions of future fishable biomass and recommended harvest rates under climate change and harvest scenarios

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Alaska CLIMate Project

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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)

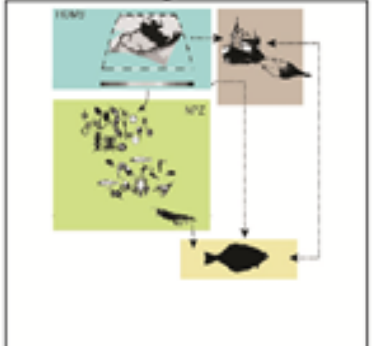
AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5

Global Climate Models (x 11)

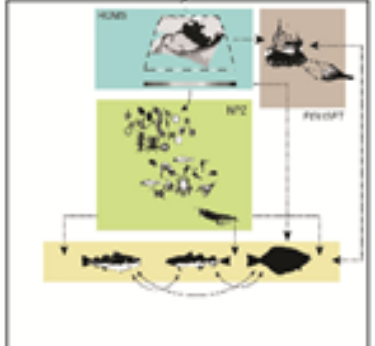
ECHO-G (AR4 A1B)
MIROC3.2 med res. (AR4 A1B)
CGCM3-t47 (AR4 A1B)
CCSM4-NCAR- PO (AR5 RCP 4.5 & 8.5)
MIROCESM-C- PO (AR5 RCP 4.5 & 8.5)
GFDL-ESM2M*- PO (AR5 RCP 4.5 & 8.5)
GFDL-ESM2M*- PON (AR5 RCP 4.5 & 8.5)

Bering Sea Models

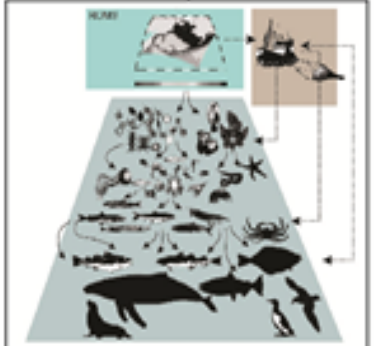
CE-SSM



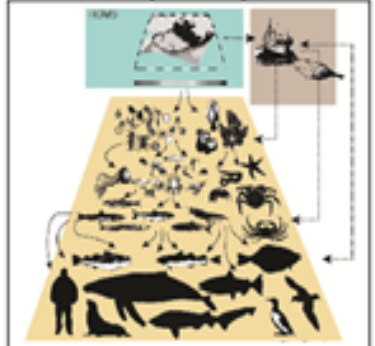
CEATTLE



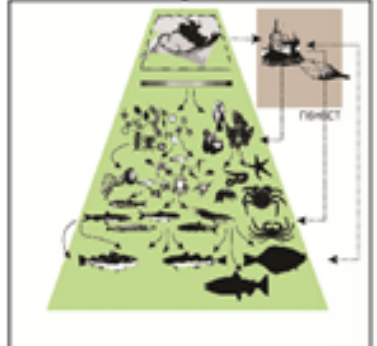
EwE

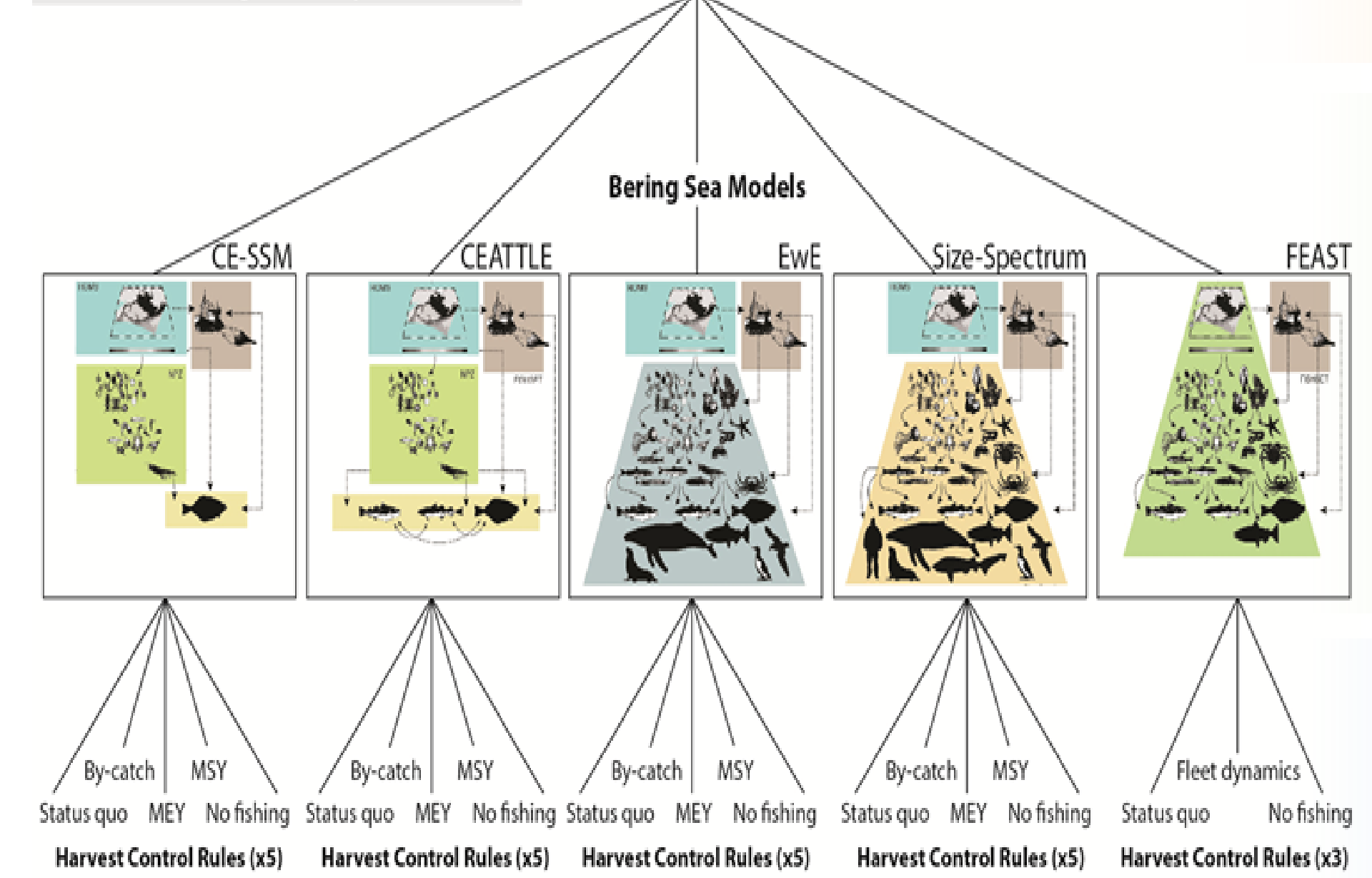


Size-Spectrum

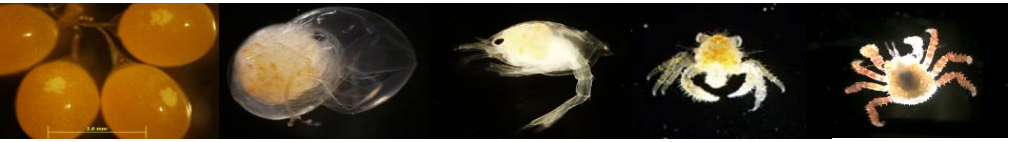


FEAST



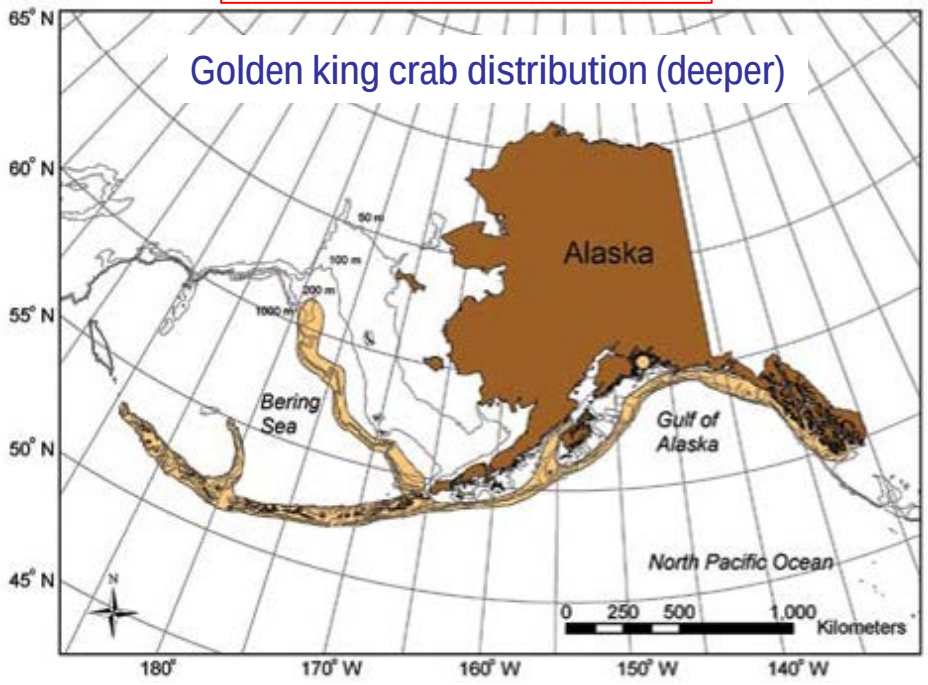

Bering Sea Models
CE-SSM
CEATTLE
EwE
Size-Spectrum
FEAST
By-catch
MSY
Status quo
MEY
No fishing
Harvest Control Rules (x5)
By-catch
MSY
Status quo
MEY
No fishing
Harvest Control Rules (x5)
By-catch
MSY
Status quo
MEY
No fishing
Harvest Control Rules (x5)
By-catch
MSY
Status quo
MEY
No fishing
Harvest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

Ocean Acidification Effects on Alaska Crabs

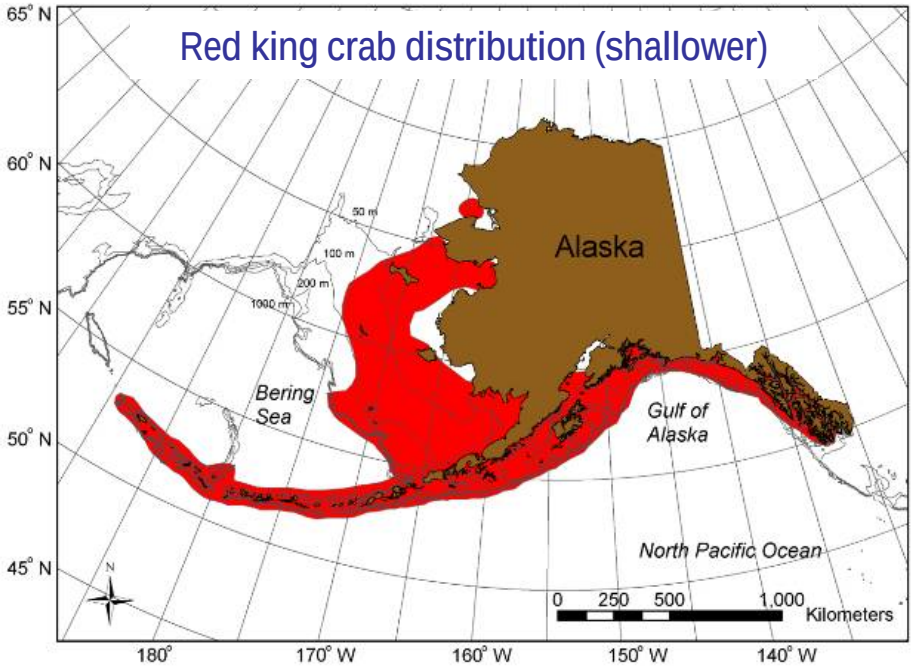


EXPERIMENTS DIRECTED TOWARD UNDERSTANDING THIS DIFFERENCE AND FORECASTING ABUNDANCE

Inhabits **undersaturated** depths

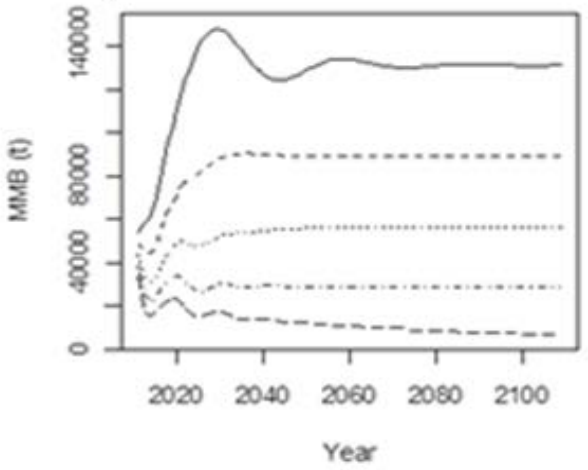


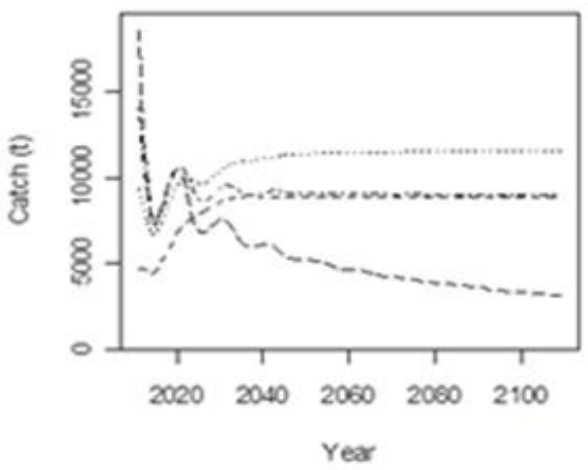
Inhabits largely **saturated** depths



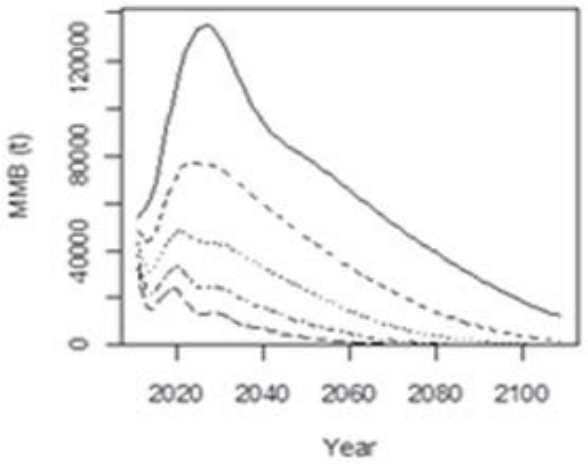
MSE results from model runs:

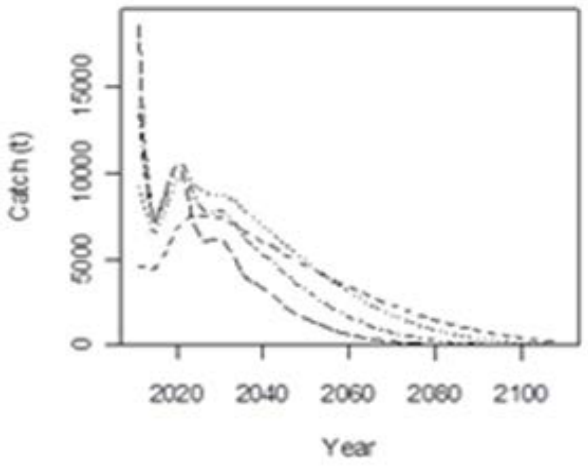
stock dynamics without OA





stock dynamics **with** OA



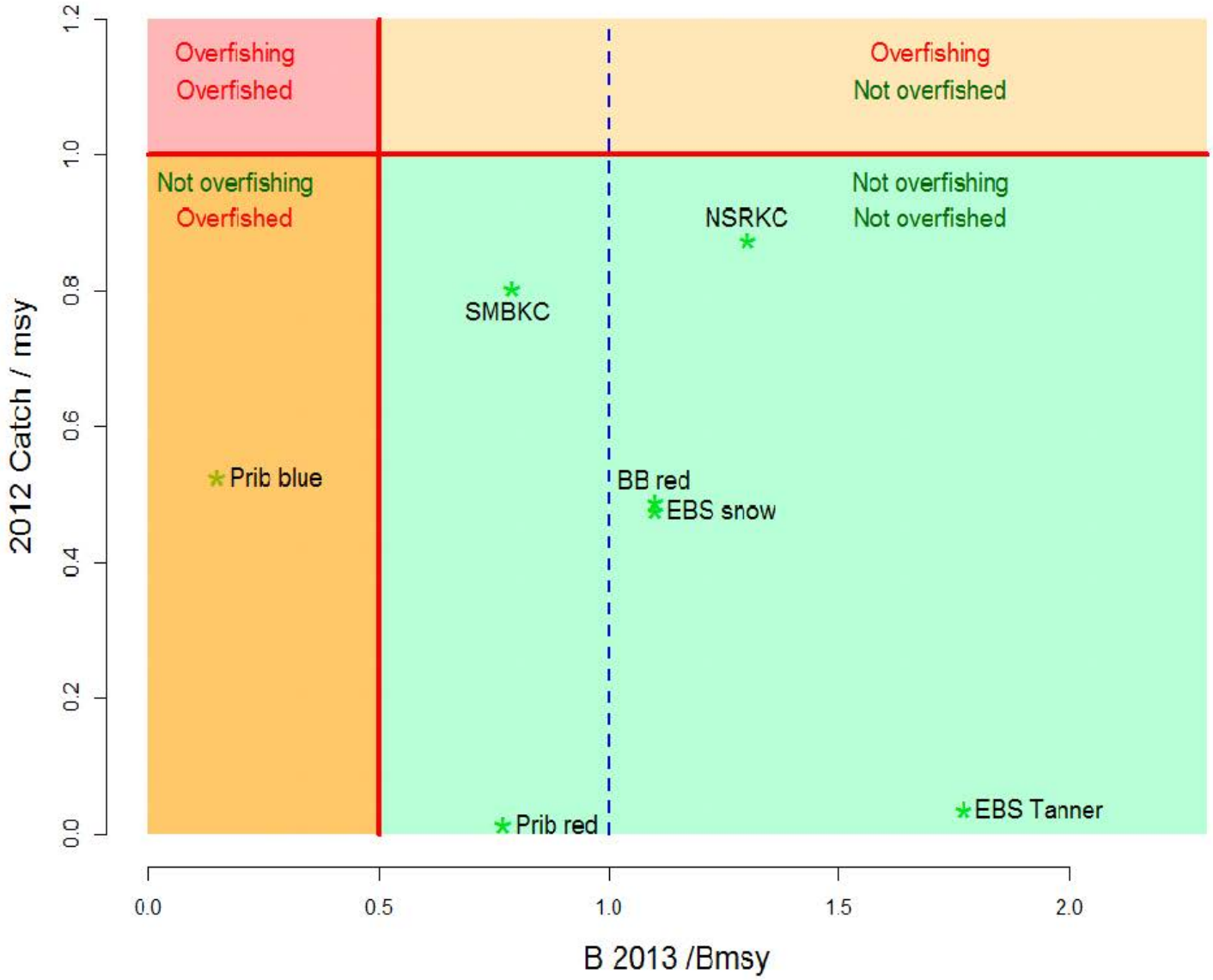


Conclusions:

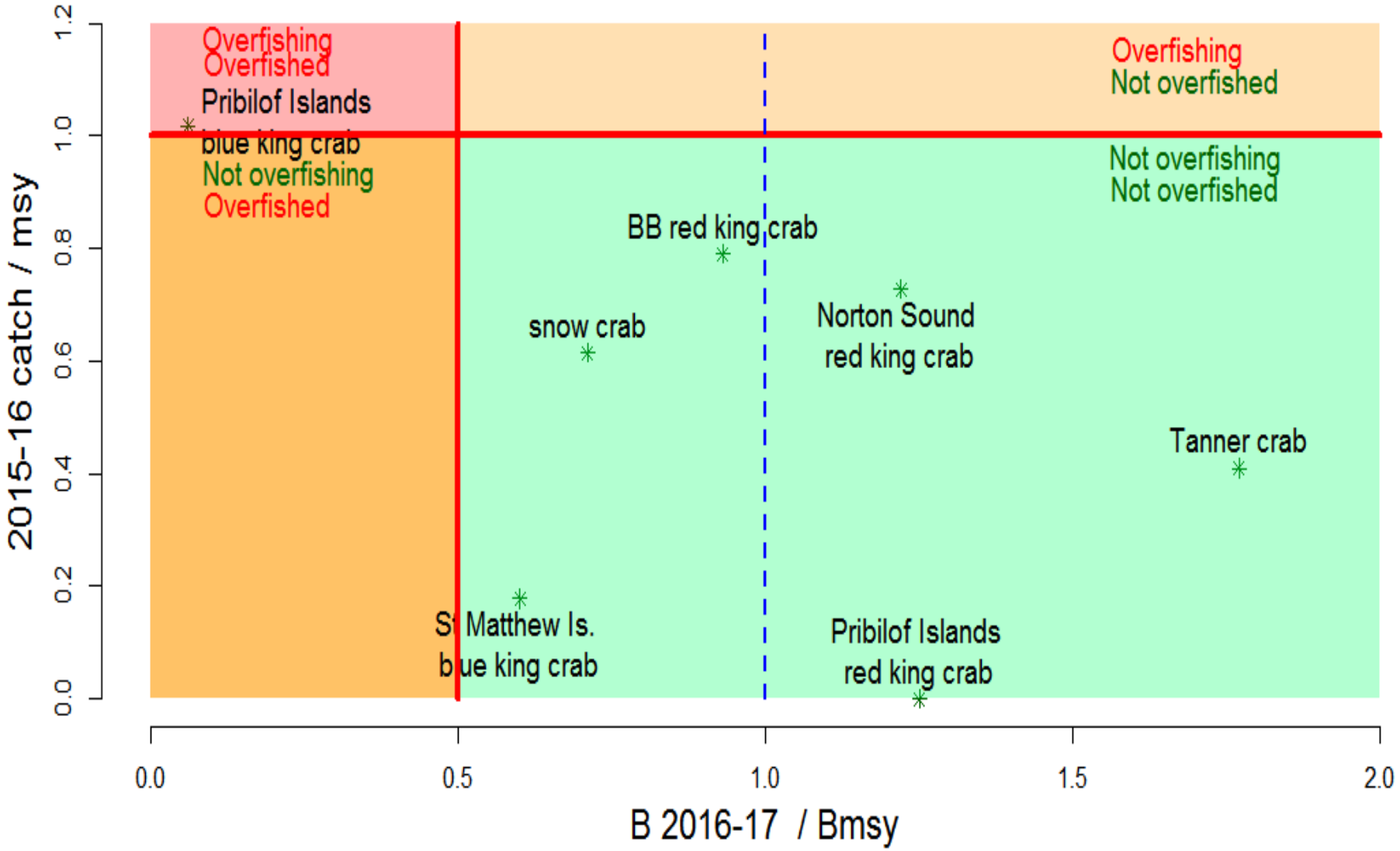
We are no longer simply observers and users of natural systems, but integrated components of the system

- Fishery management in US LMEs has ever increasing complexity due to the number of resource users, conflicting mandates, and climate change
- Effective management will require relying on more information and a better understanding of process e.g.
  - Accounting for ecosystem interactions
  - Climate change
  - Socio-cultural and governance considerations

Bering Sea Crab



EBS crab stocks



Gulf of Alaska Groundfish