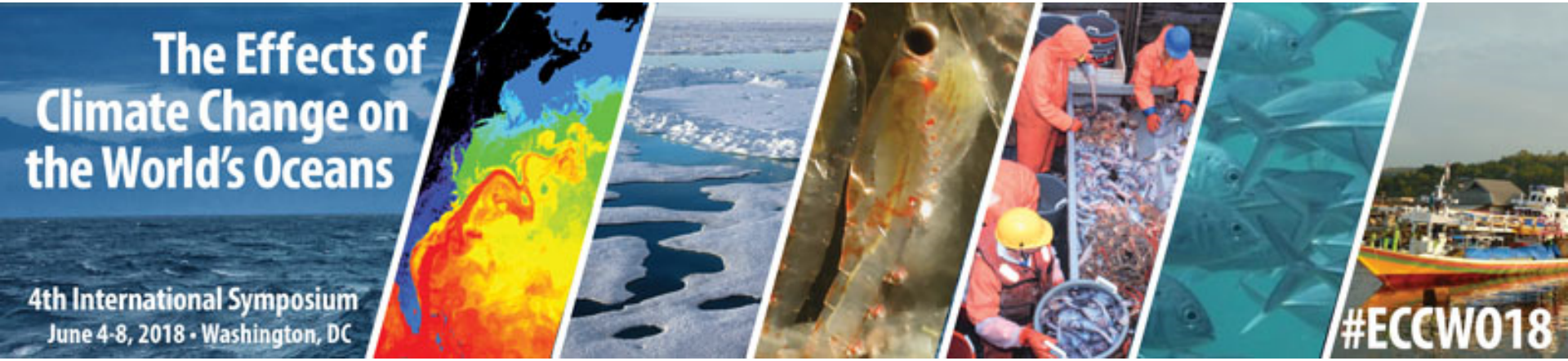
Registration closes Jan 12th (Friday)



Session S5 *Climate Change impacts on high latitude systems on multiple scales in space and time.*
The session will be part of the 4th ECCWO conference 4-6 June 2018 in Washington DC
http://meetings.pices.int/meetings/international/2018/climate-change/program#S1

The Alaska Integrated Ecosystem Assessment Program

Kirstin Holsman* NOAA AFSC
Jamal Moss* NOAA AFSC
Kerim Aydin, Alan Haynie,
Steve Kasperski, Stephani Zador
Phyllis Stabeno
Ivonne Ortiz

Photo: Mark Holsman

What is an Integrated Ecosystem Assessment?

A. It's a set of **best practices** and principles for EBM.

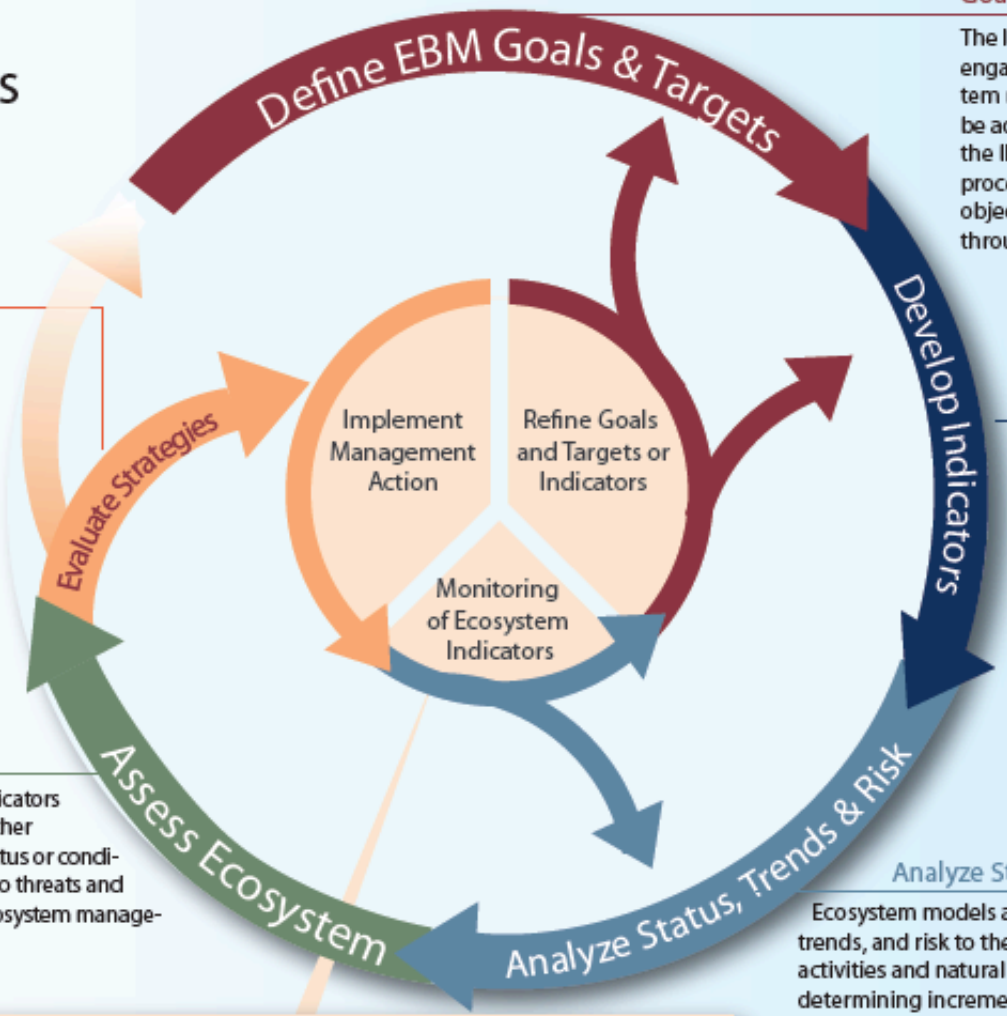
B. It's a **process** for delivering advice to management.

C. It's a **product**: "we have conducted an Integrated Ecosystem Assessment for the Bering Sea."

D. It's a NOAA **program** with a budget and deliverables.

E. All of the above.

The NOAA IEA Process



Define Ecosystem Management Goals & Targets

The IEA process involves manager engagement to identify critical ecosystem management goals and targets to be addressed through and informed by the IEA approach. The rest of the process is driven by these defined objectives. Engagement is continual throughout the entire IEA process.

Develop Ecosystem Indicators

Indicators represent key components in an ecosystem and allow change to be measured. They provide the basis to assess the status and trends in the condition of the ecosystem or of an element within the system. Indicators are essential for all subsequent steps in the IEA approach.

Analyze Status, Trends & Risk

Ecosystem models are used to evaluate the status, trends, and risk to the indicators posed by human activities and natural processes. This step is important in determining incremental improvements or declines in ecosystem indicators in response to changes in drivers and pressures and to predict the potential that an indicator will reach or remain in an undesirable state.

Assess Ecosystem

During this step, individual indicators are considered together to further evaluate the overall current status or condition of the ecosystem relative to threats and risks, historical state, and to ecosystem management goals and targets.

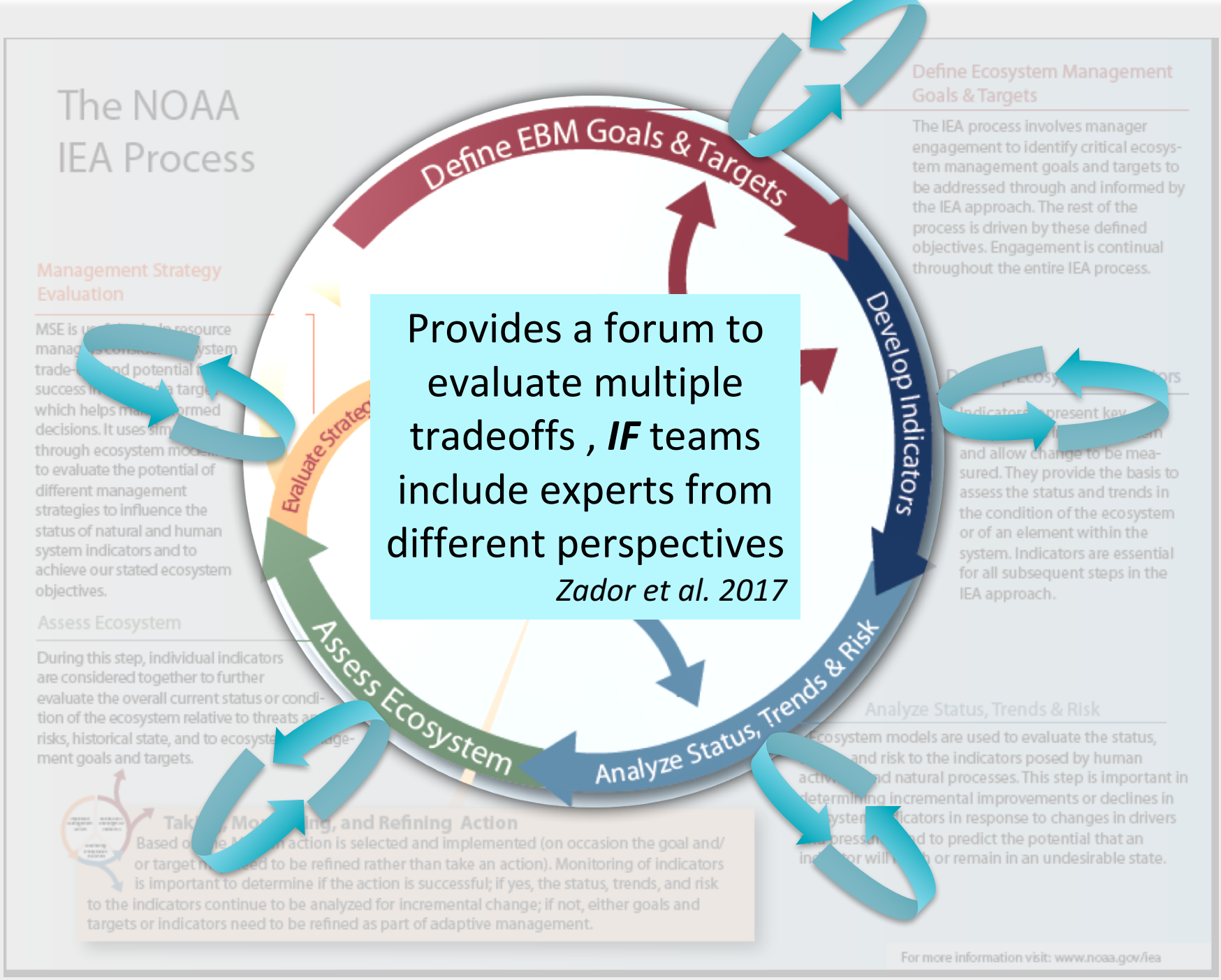
Management Strategy Evaluation

MSE is useful to help resource managers consider the system trade-offs and potential for success in reaching a target which helps make informed decisions. It uses simulation through ecosystem modeling to evaluate the potential of different management strategies to influence the status of natural and human system indicators and to achieve our stated ecosystem objectives.

Taking, Monitoring, and Refining Action

Based on the MSE, an action is selected and implemented (on occasion the goal and/or target may need to be refined rather than take an action). Monitoring of indicators is important to determine if the action is successful; if yes, the status, trends, and risk to the indicators continue to be analyzed for incremental change; if not, either goals and targets or indicators need to be refined as part of adaptive management.

For more information visit: www.noaa.gov/iea



Provides a forum to evaluate multiple tradeoffs , ***IF*** teams include experts from different perspectives

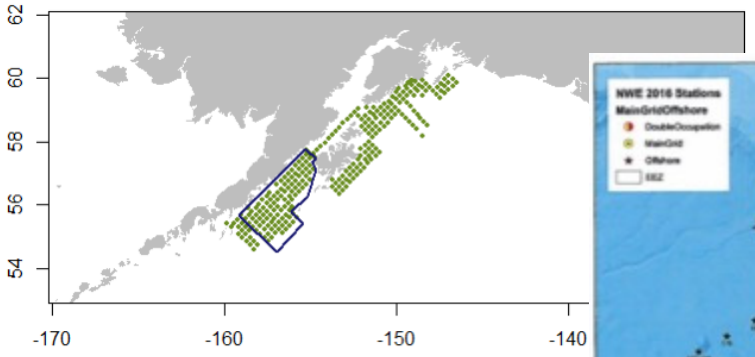
Zador et al. 2017

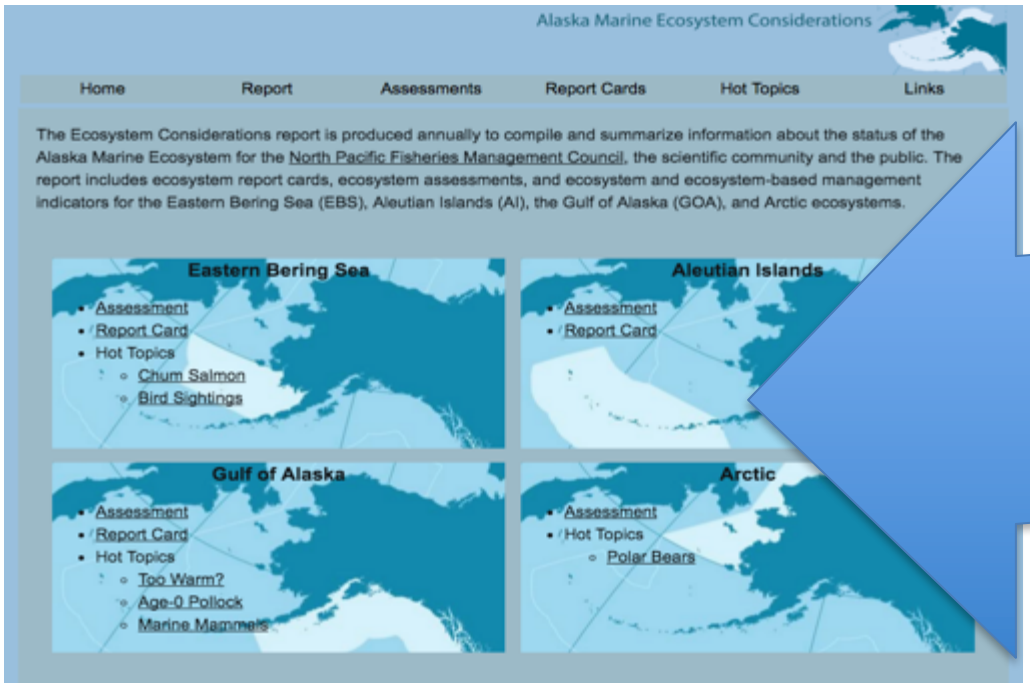
IEA work is PLACE-BASED: 4 LMEs

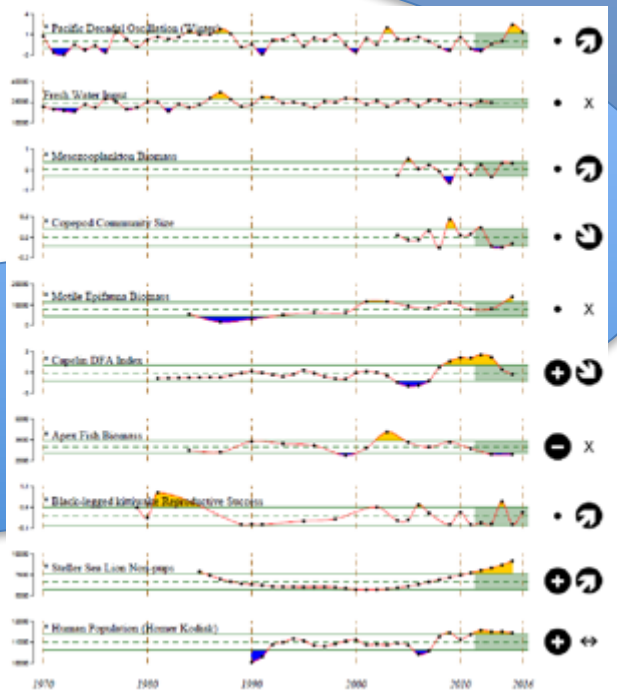
- Tailored to stakeholders
- Can fit management scale
- Model <-> Observation integration

- Some LMEs get less attention.
- Effort is needed to maintain consistency

Increased integration of fieldwork and management advice







IEA Products

- Fisheries Ecosystem Plans (FEPs)
- Conceptual Models
- Ecosystem Models
- Ecosystem Indicators
- Ecosystem Assessment Document
- Risk Assessments
- Management Strategy Evaluations

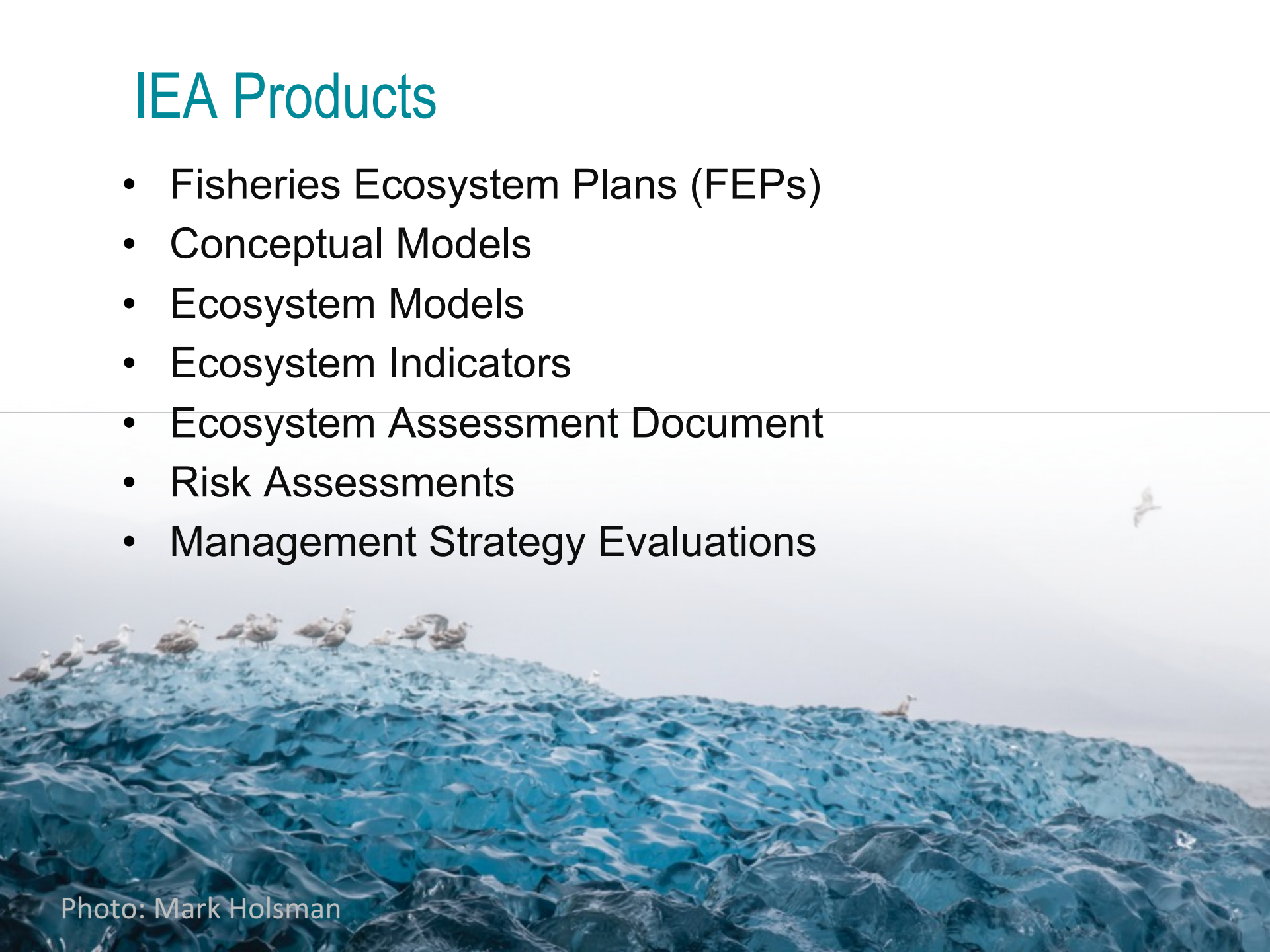


Photo: Mark Holsman

IEA Products

- **Fisheries Ecosystem Plans (FEPs)**
- Conceptual Models
- Ecosystem Models
- Ecosystem Indicators
- Ecosystem Assessment Document
- Risk Assessments
- Management Strategy Evaluations

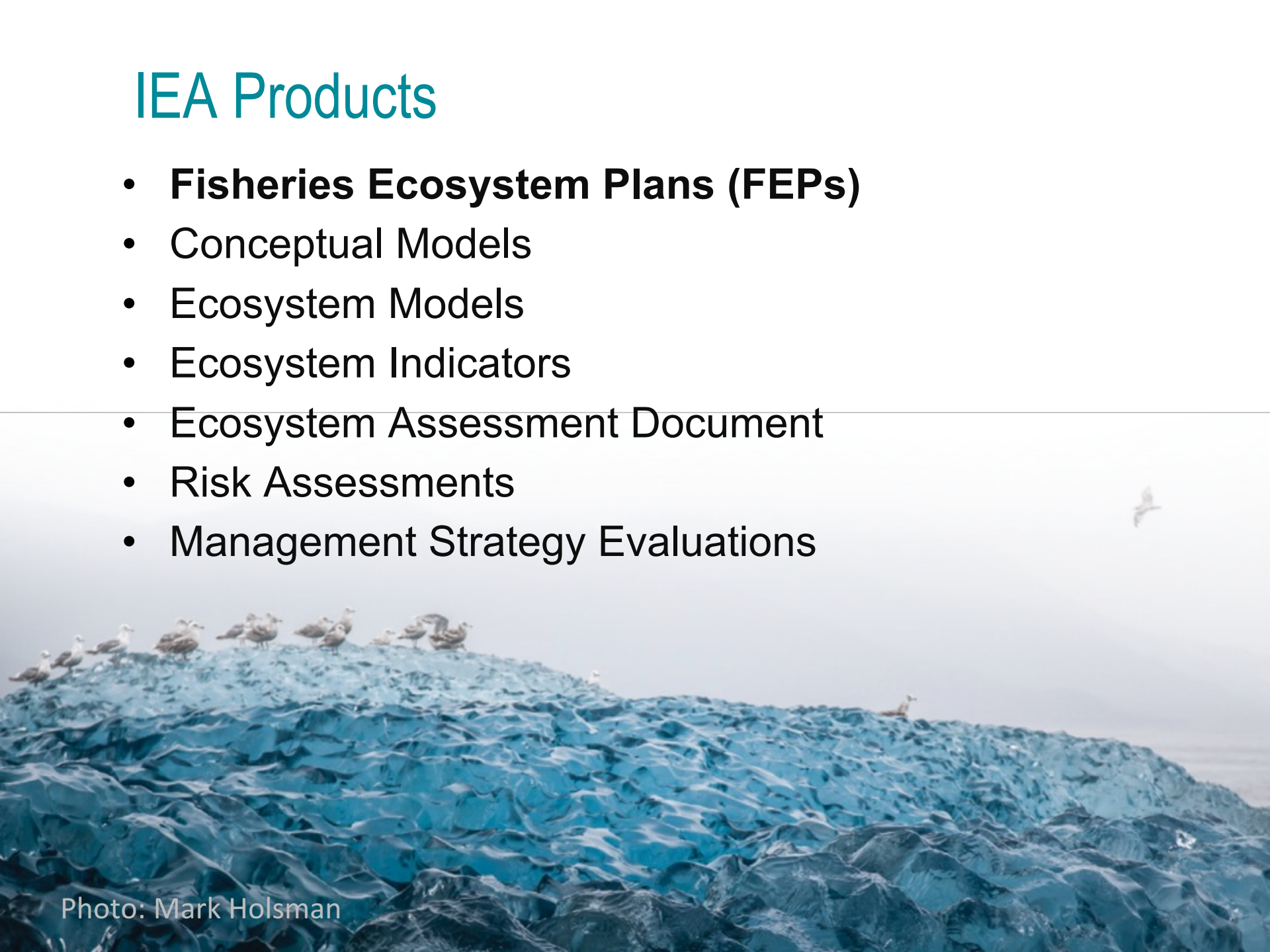
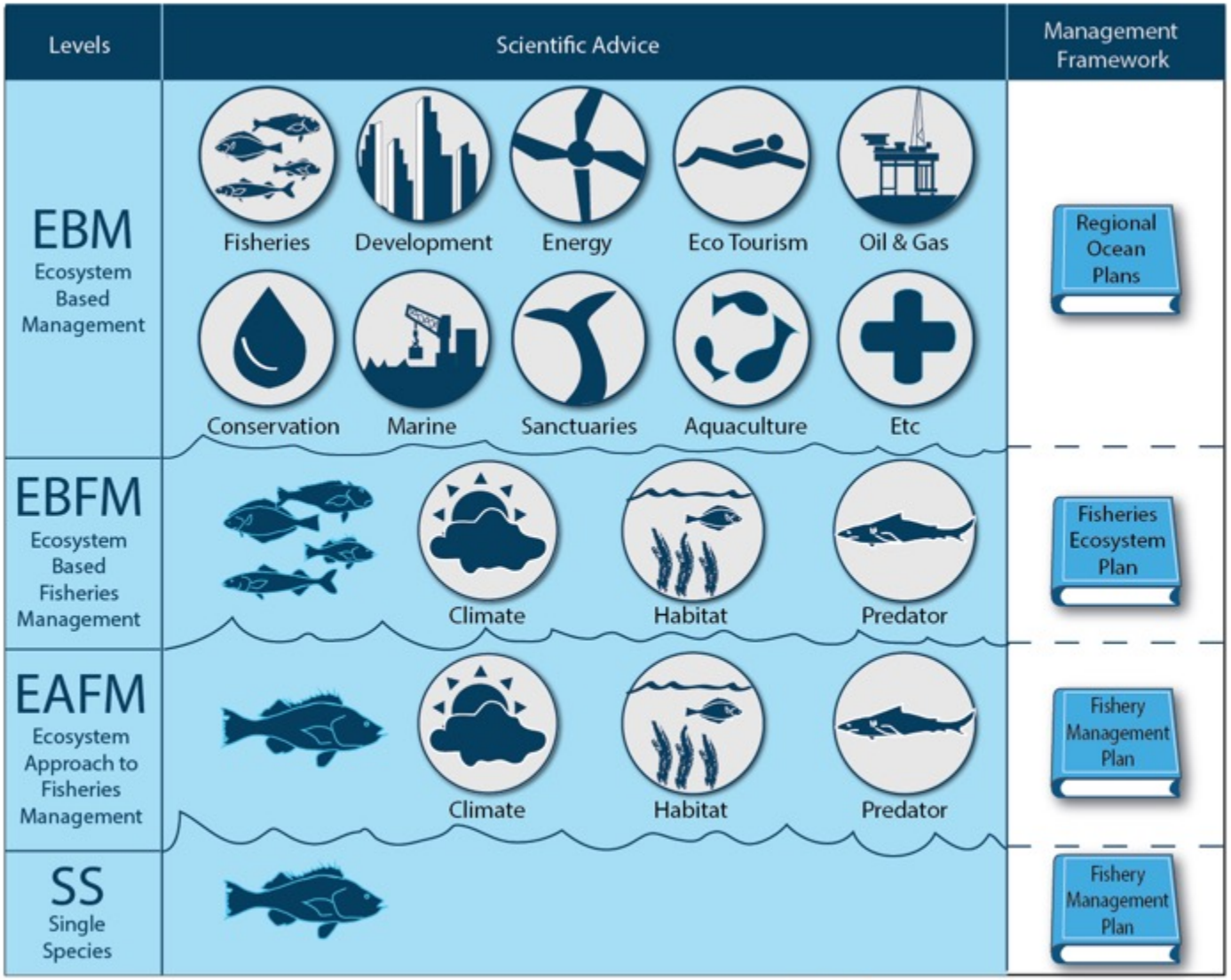


Photo: Mark Holsman



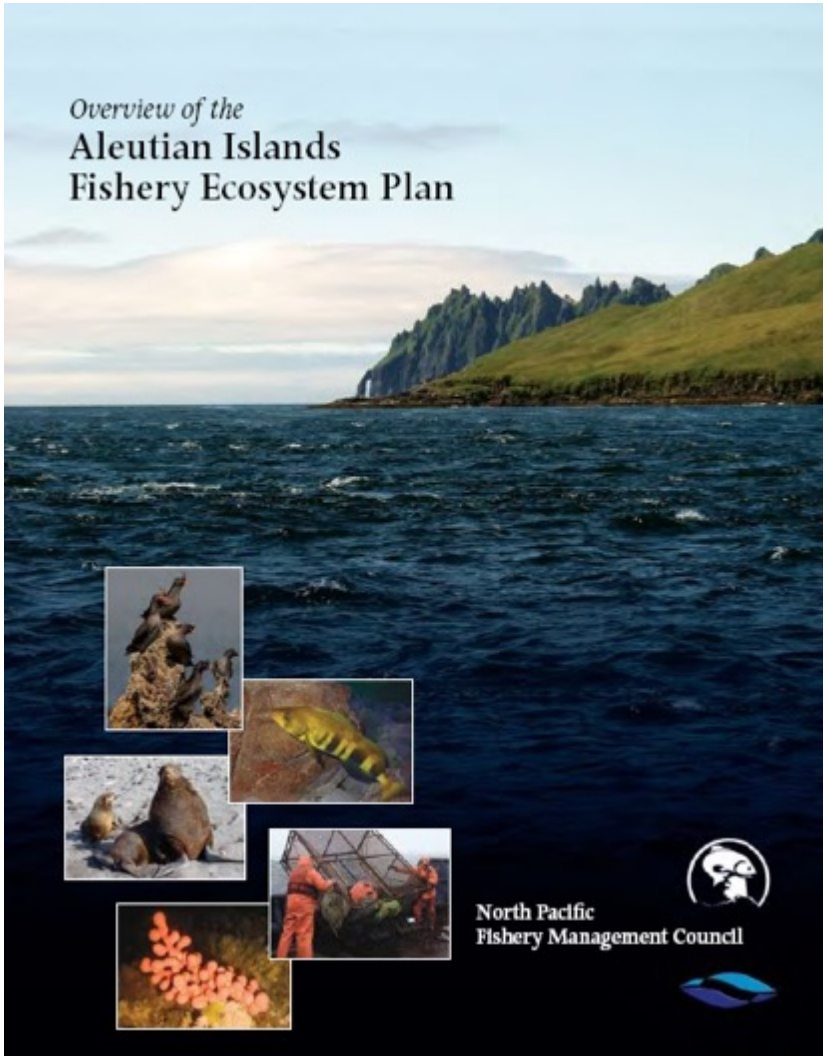
(Image from Dolan et al. 2016)

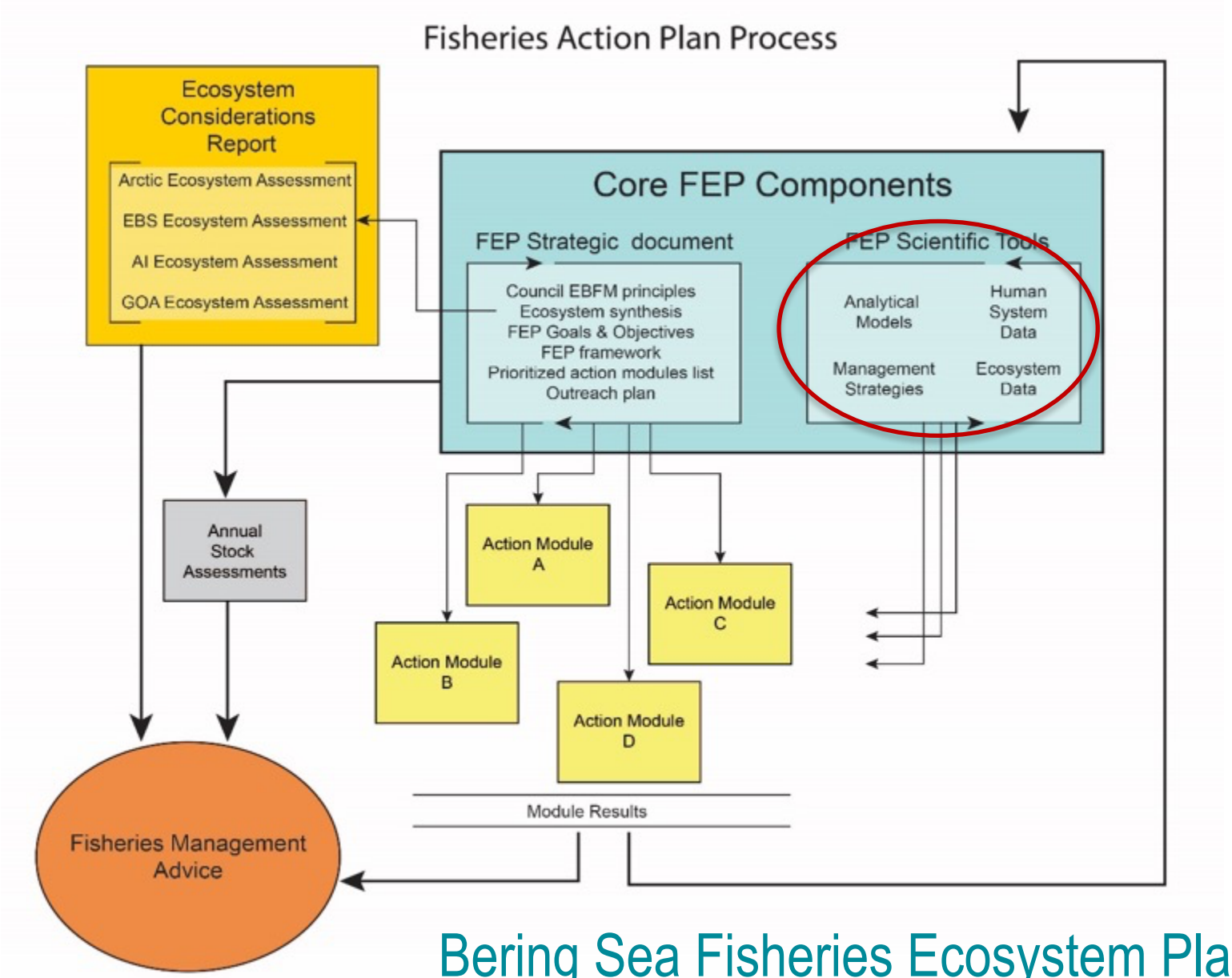
NOAA FISHERIES

Fisheries Ecosystem Plans

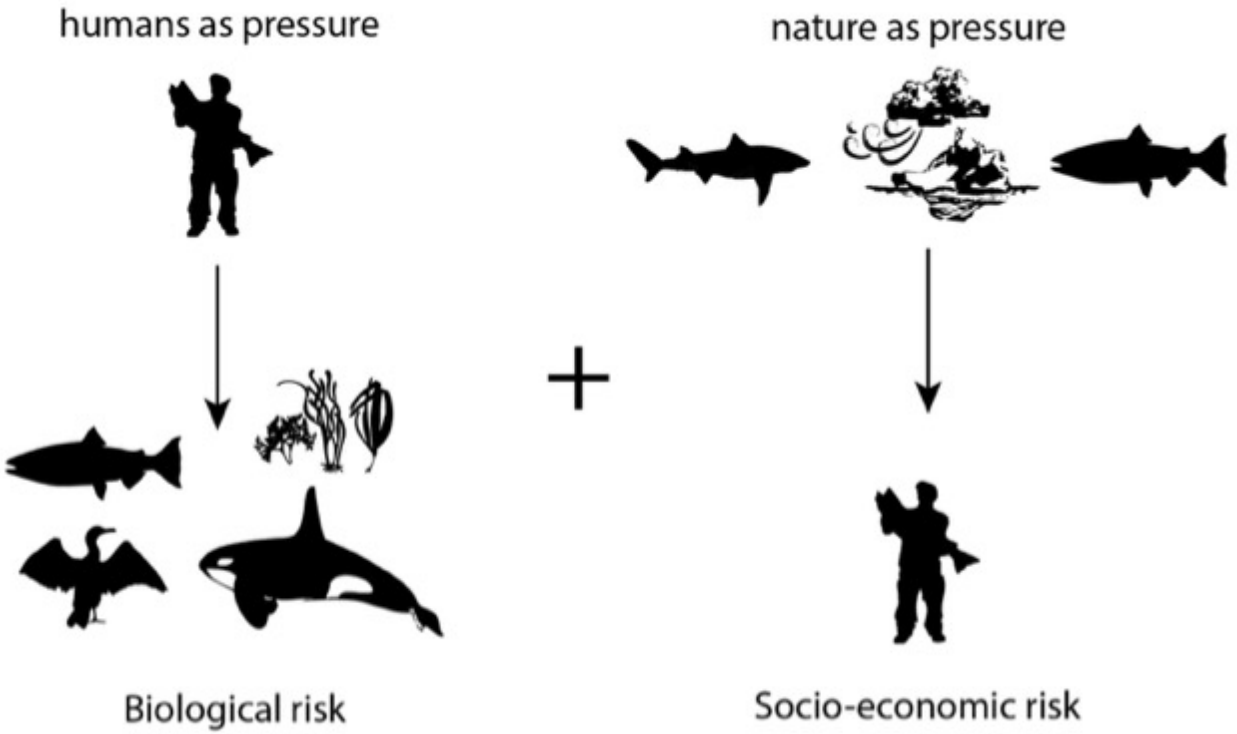
Initial plans “general scoping and framing”, not living documents.

Upcoming: Bering Sea FEP, a “living” document or plan.

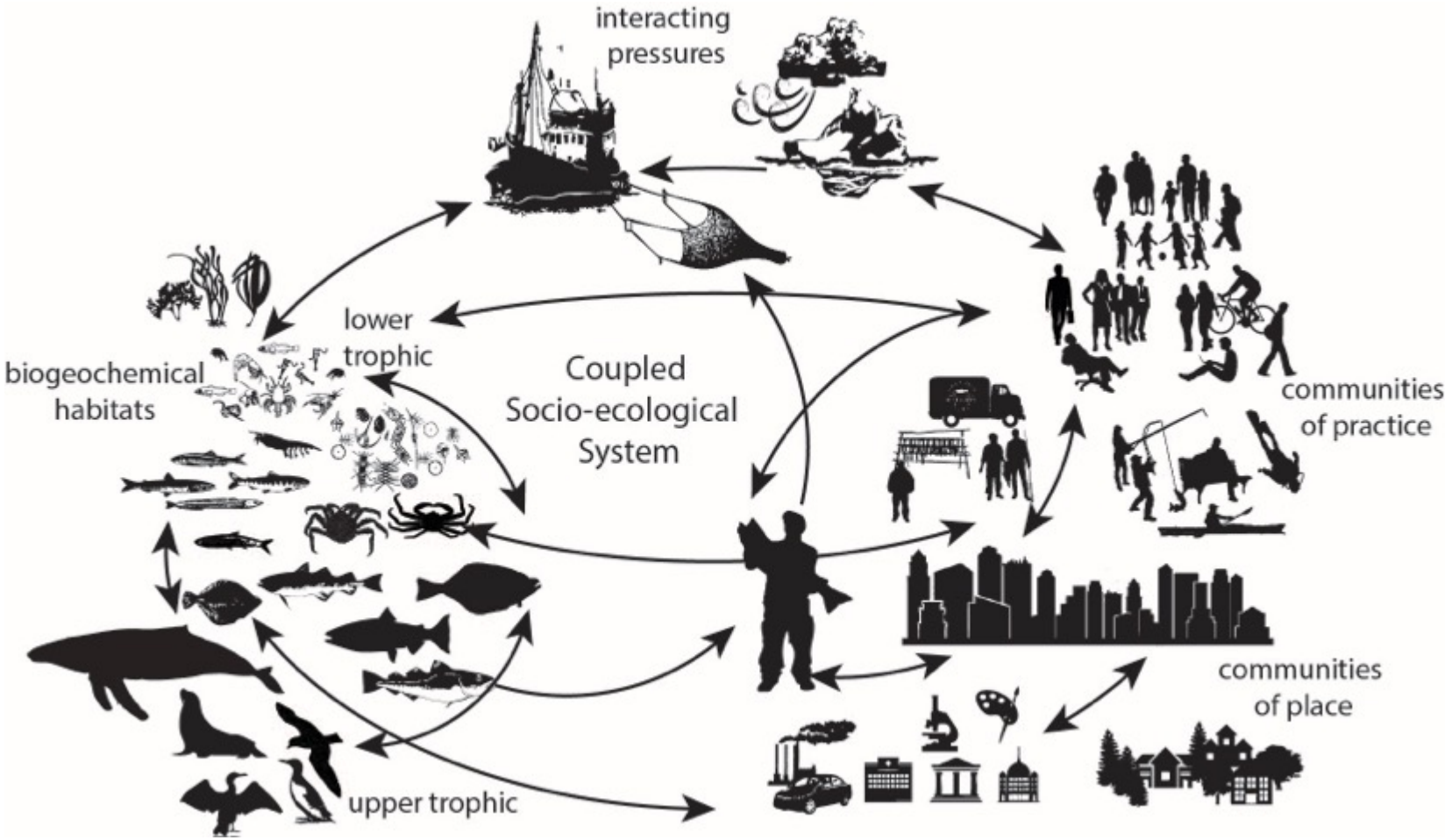




Bering Sea Fisheries Ecosystem Plan



Holsman et al. 2017

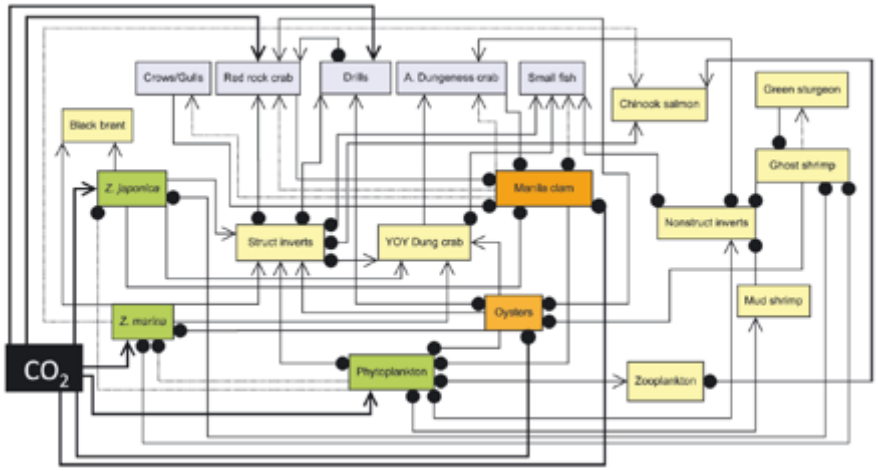


Holsman et al. 2017

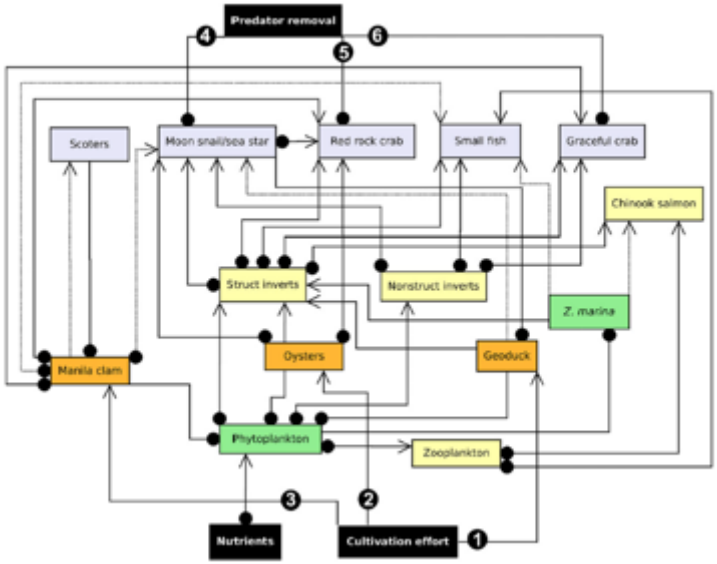
Qualitative modeling with quantitative flair

- Focus: shellfish aquaculture in two data-variable food webs
- Drivers: OA, new culture practices, invasive species, eutrophication, predators
- Jon used a method called **Qualitative Network Modeling (QNM)** for analyses

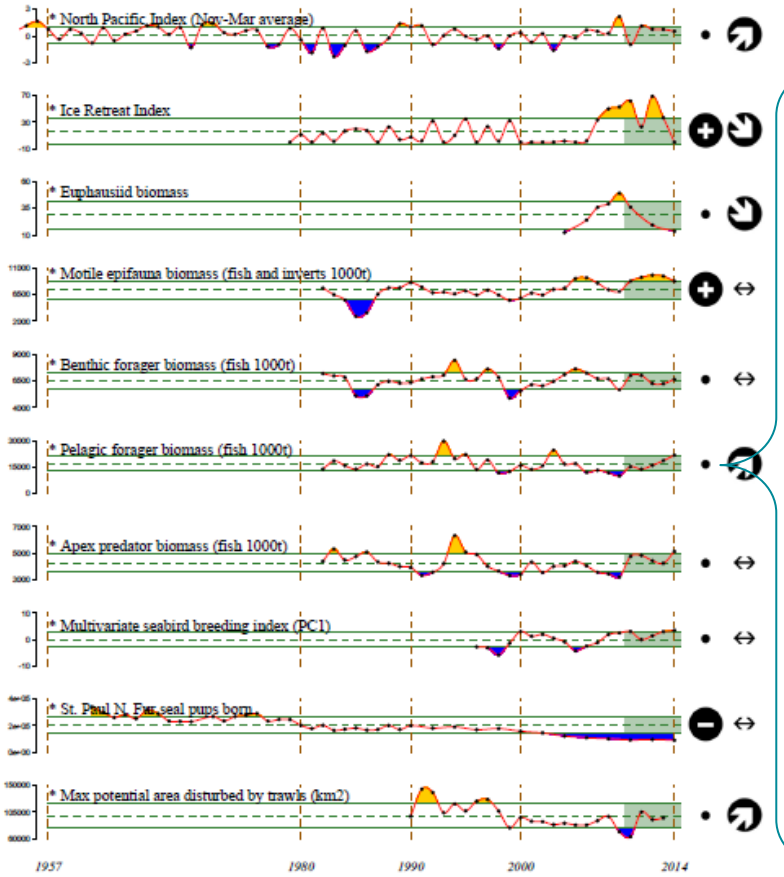
Willapa Bay
(Reum et al. 2015, MEPS)

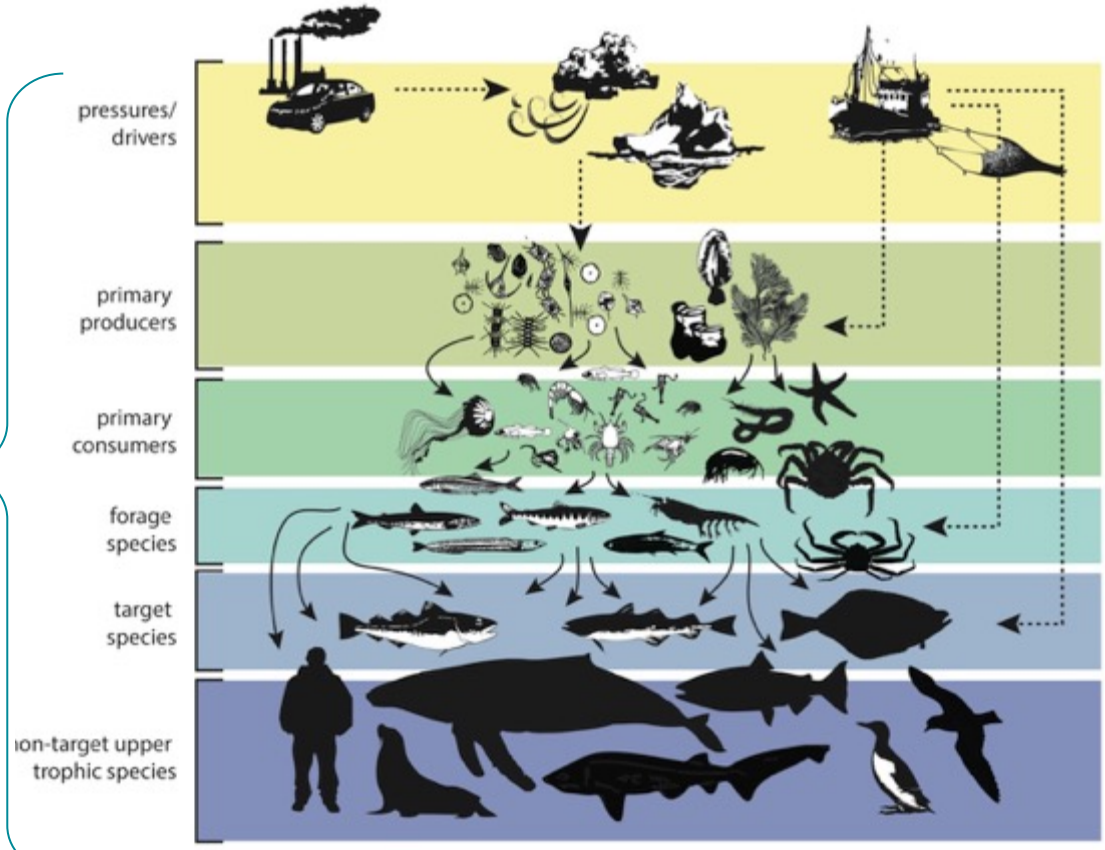


South Puget Sound
(Reum et al. 2015, ICES J Mar Sci)



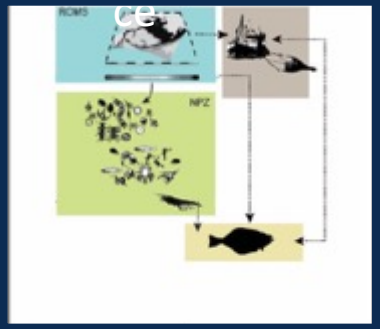
Report Cards for different conceptual model components

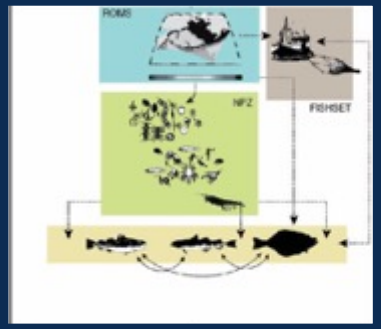


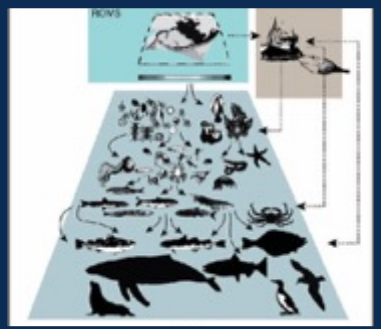


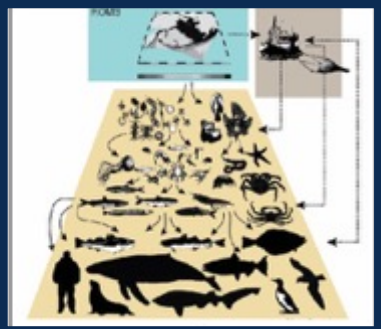
Indicators for each trophic level

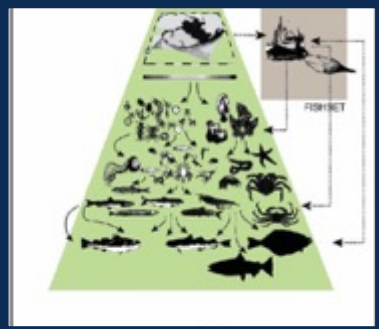
CE-SSM | CE-MSM | CE-EwE | CE-MIZER | FEAST









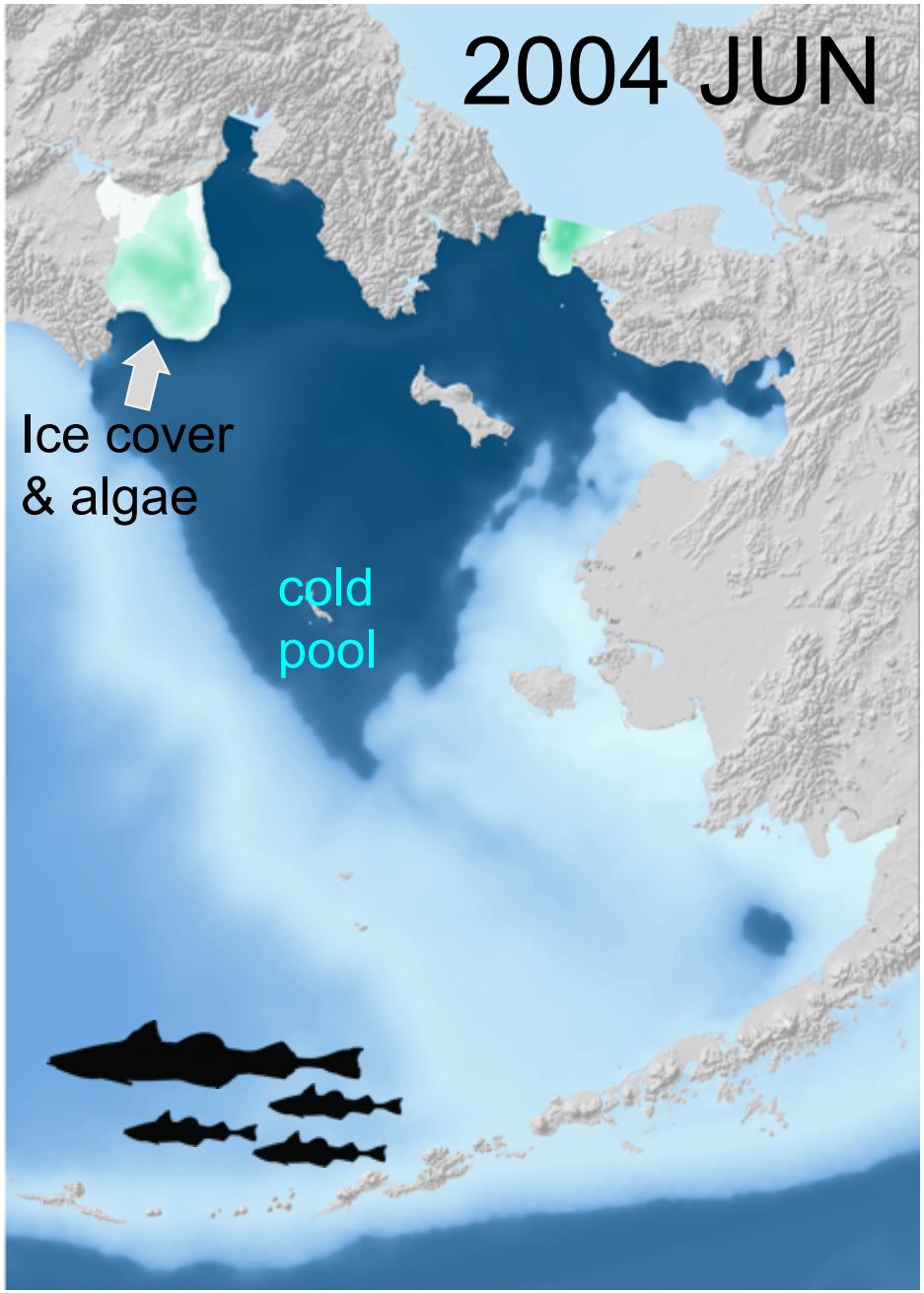


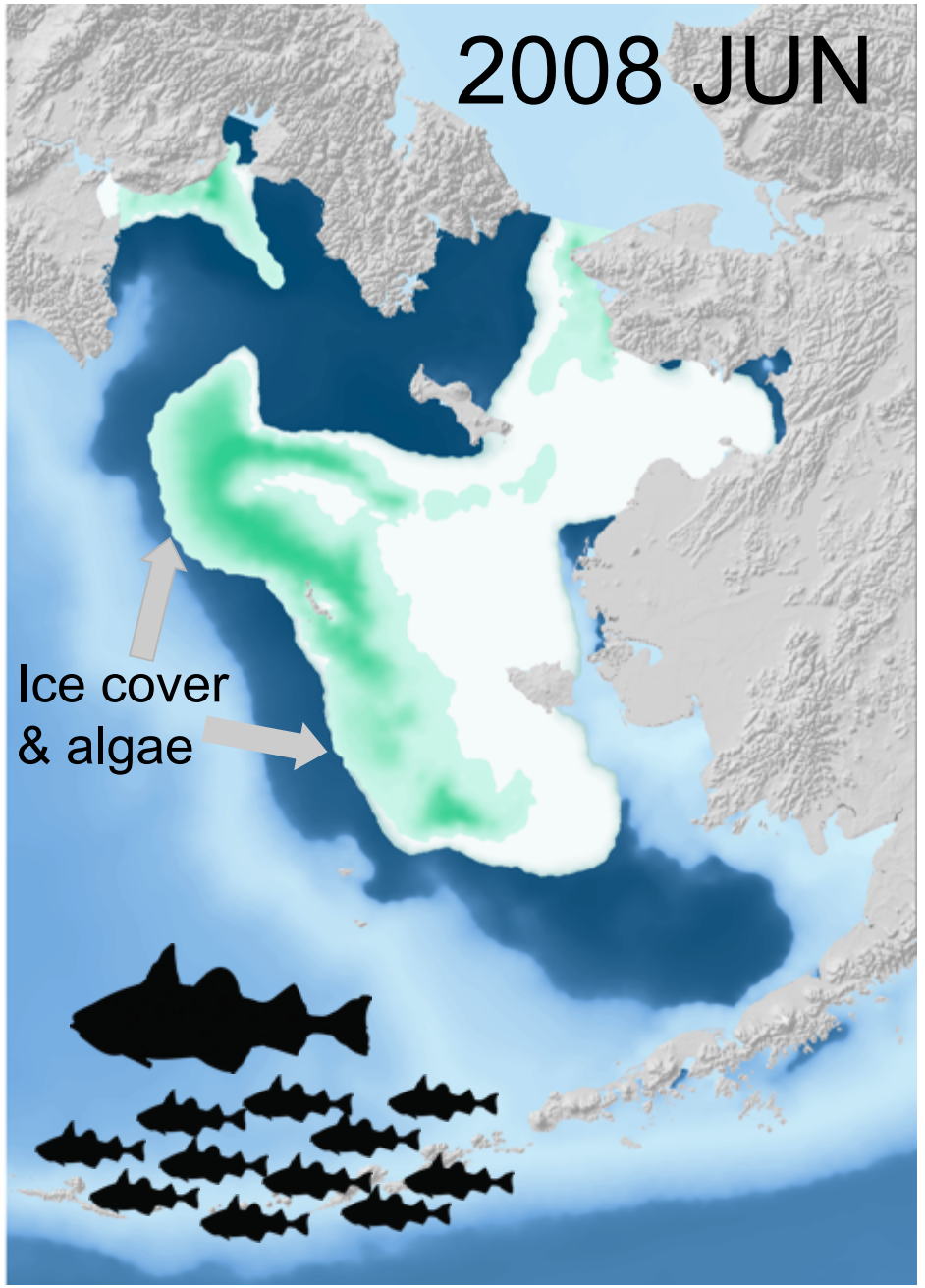
Fast
Statistical
Implicit ecosystem “noise”

Slow, high resolution
Mechanistic
Explicit ecosystem interactions

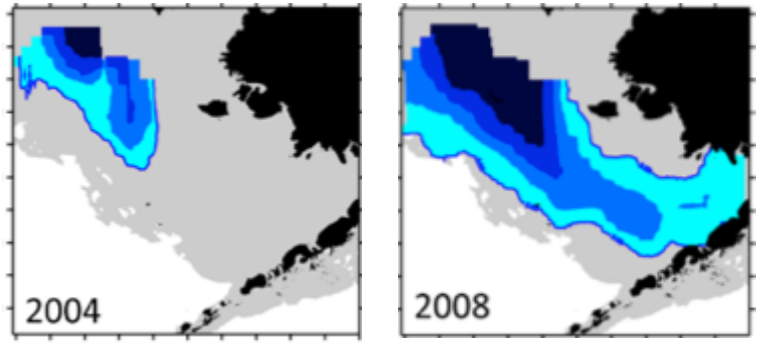
Alaska IEA modeling suite

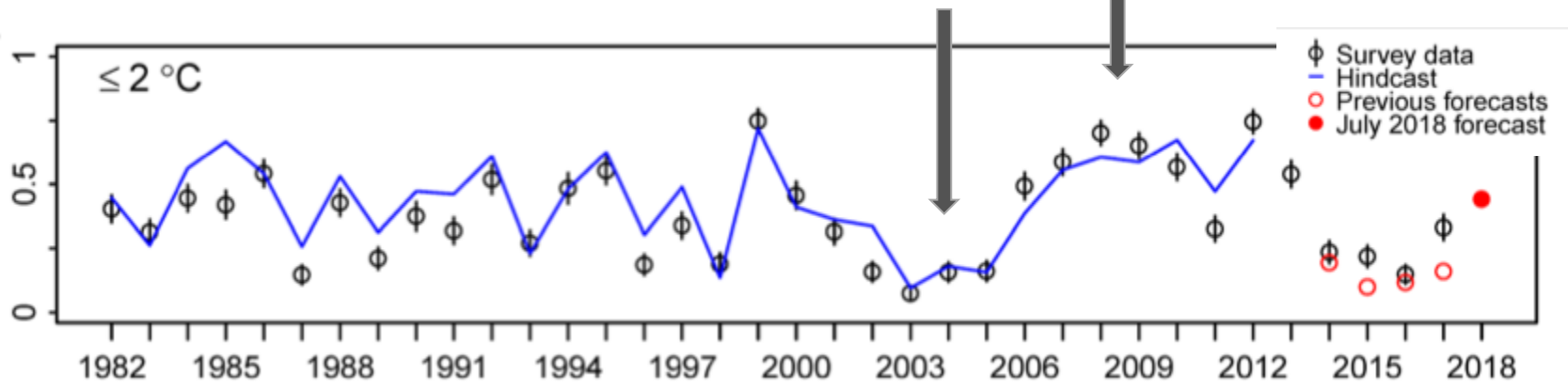
NOAA FISHERIES


2004 JUN
Ice cover
& algae
cold
pool


2008 JUN
Ice cover
& algae

9-month (seasonal) forecast - cold pool

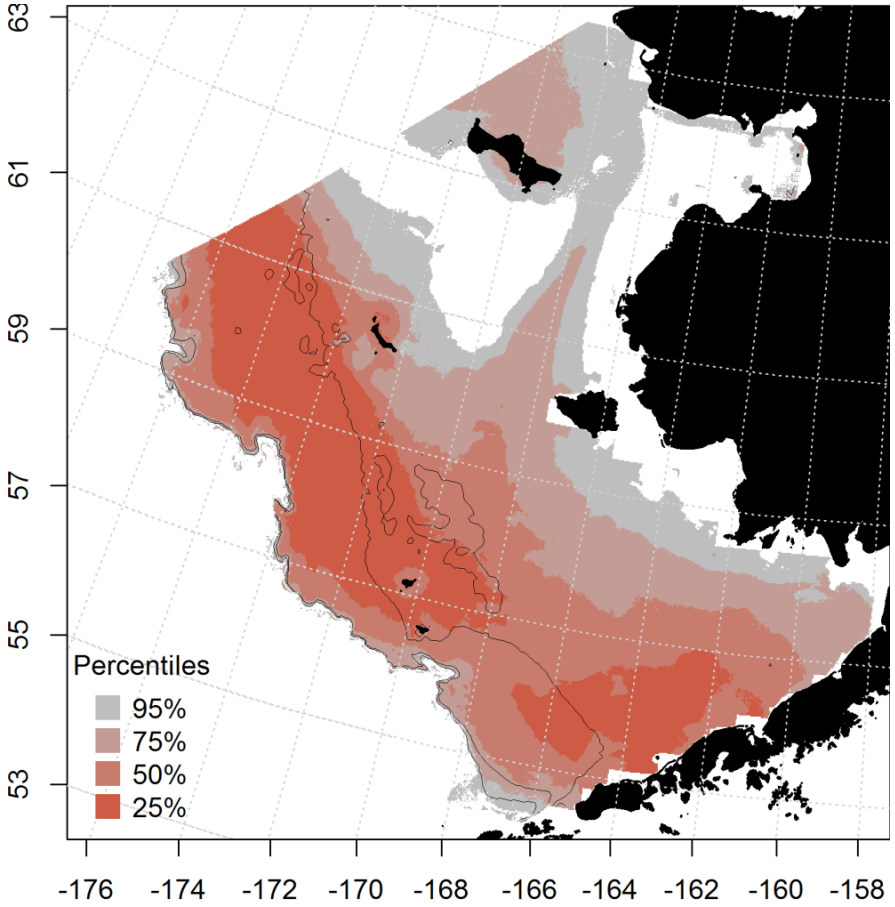




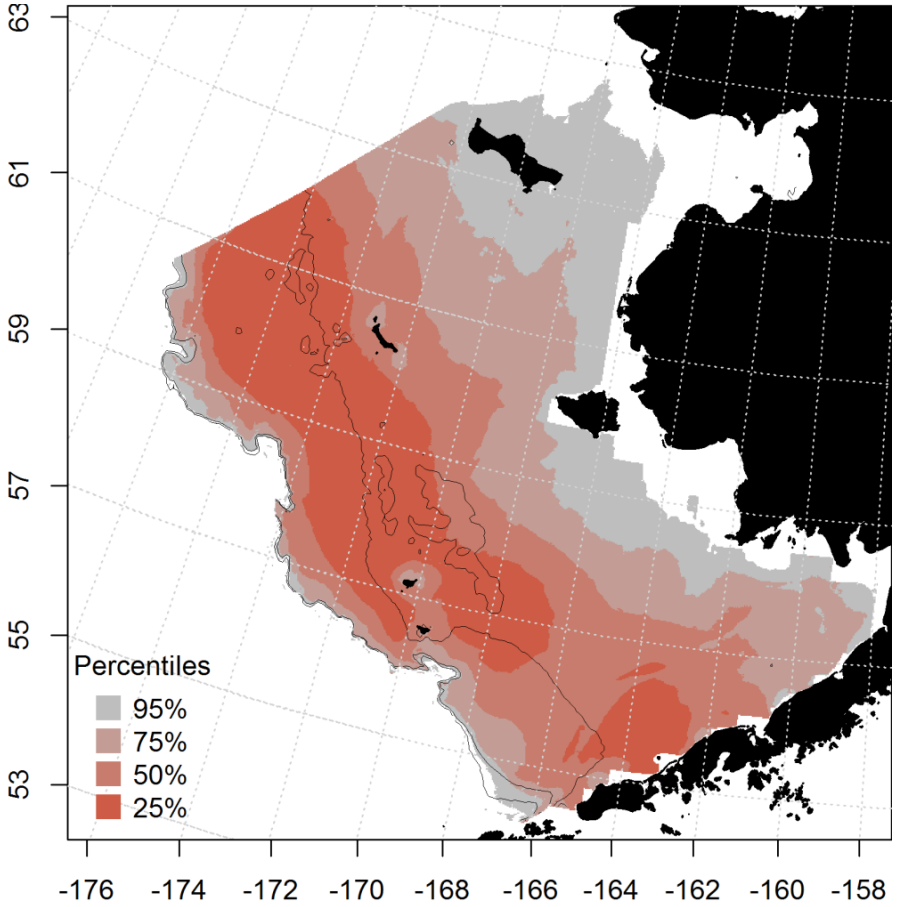
- Included in annual ecosystem chapter (November prediction for following summer)
- Strong traction/interest in fishing community
- Forecast led to increased oceanographic field presence in 2015 (unprecedented warmth forecast)
- Validation funded under NOAA MAPP Program

Shifts in Essential Fish Habitat

Rooper, Ortiz, Laman, Hermann, Wilborn



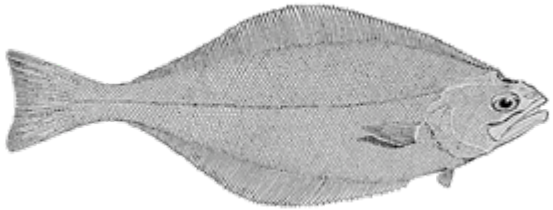
Current EFH walleye pollock



EFH 2030-40 CMIP3 ensemble

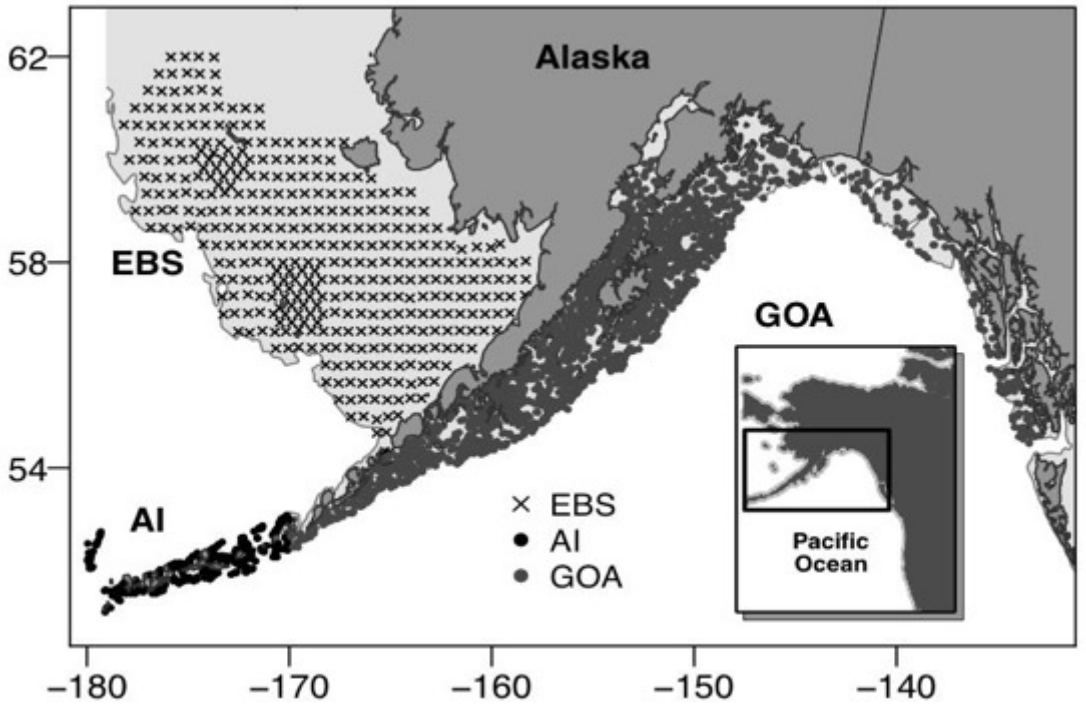
CEATTLE (Multi-species stock assessment model)

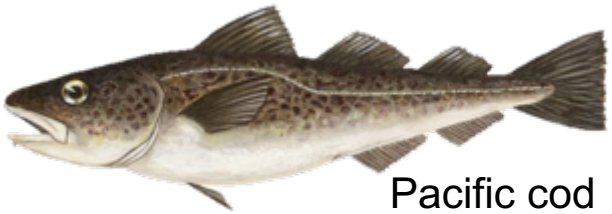
Walleye pollock
(*Gadus chalcogrammus*)



Arrowtooth flounder
(*Atheresthes stomias)*

Eastern Bering Sea, Alaska, USA



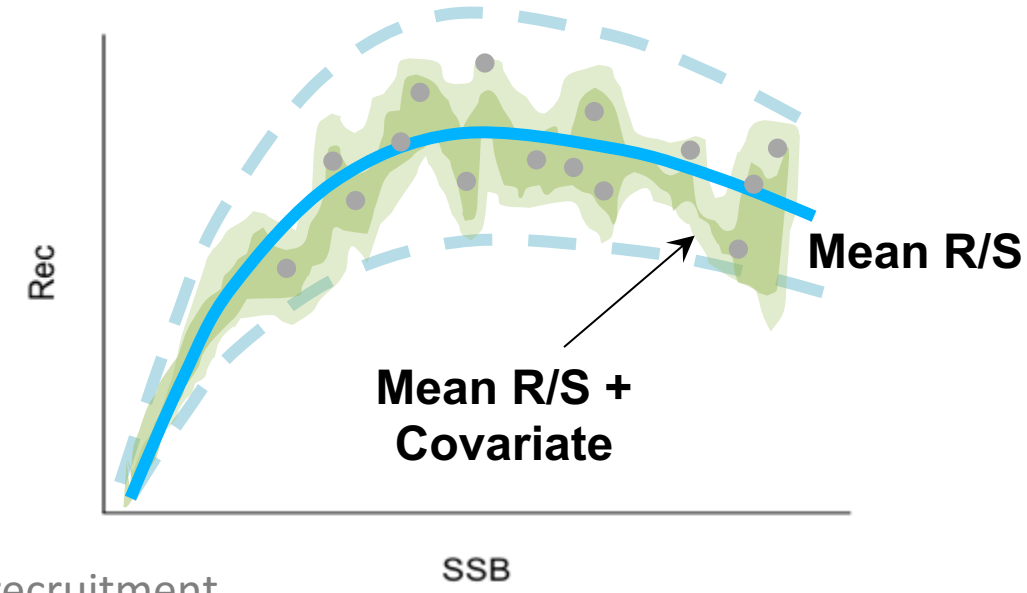


Pacific cod
(*Gadus macrocephalus*)

W@Age~*f*(Temperature)
Pred/prey~*f*(Temperature)

Holsman, Ianelli and Aydin

CEATTLE Recruitment – ROMS/NPZ forced forecasts



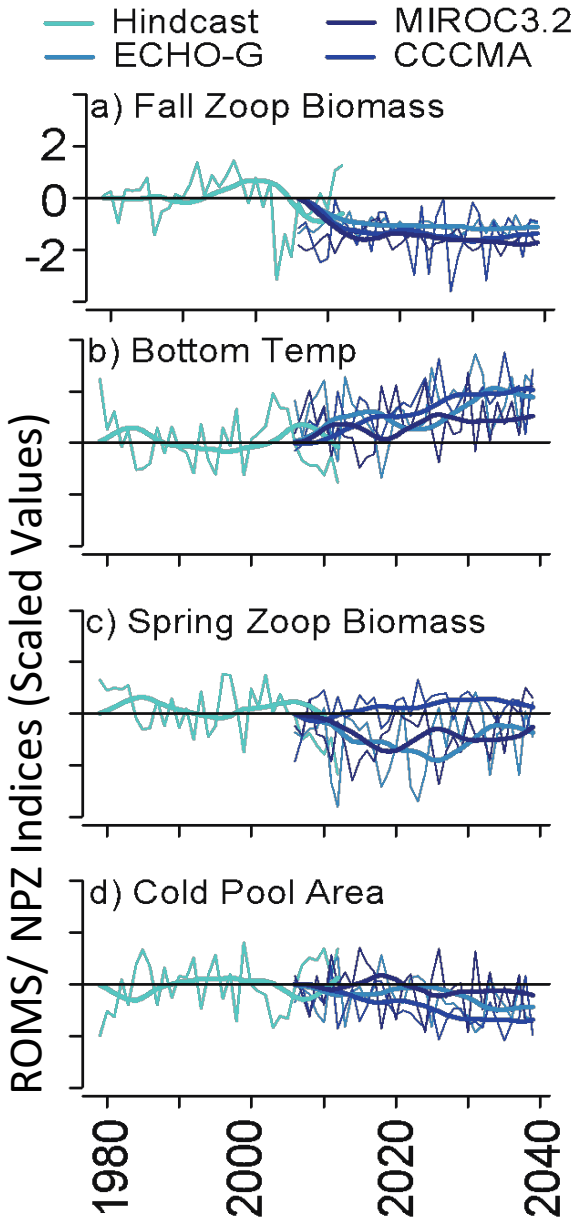
recruitment

$$log(R_t) = log(\alpha \cdot B_{t-1}) - \beta_1 \cdot B_{t-1} + \sum \beta_k \cdot X_{k,t} + \varepsilon,$$

productivity

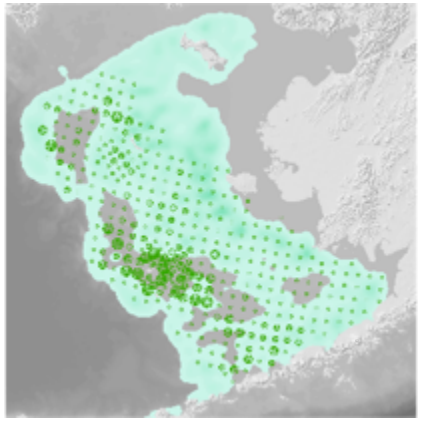
carrying capacity

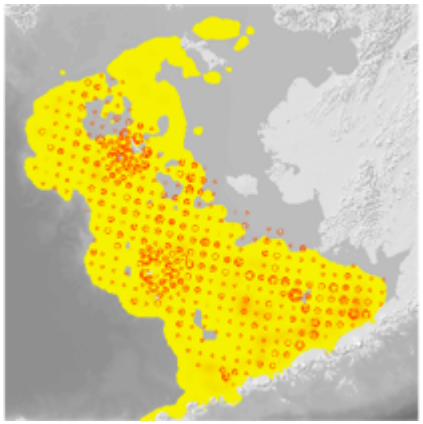
environmental effects on carrying capacity

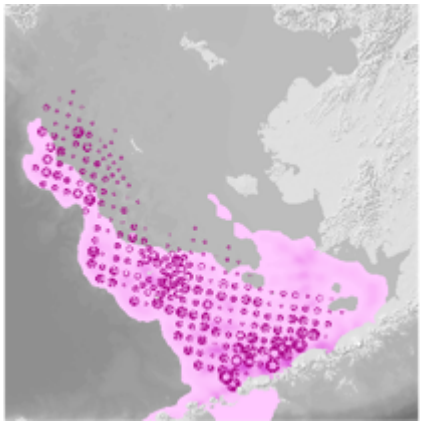


FEAST (Forage Euphausiid Abundance in Space and Time) model

(Ortiz, Kearney, Hermann, Aydin)

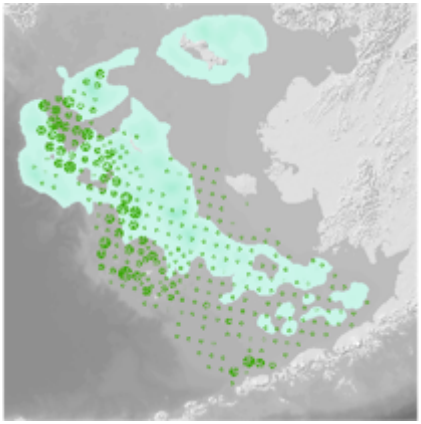


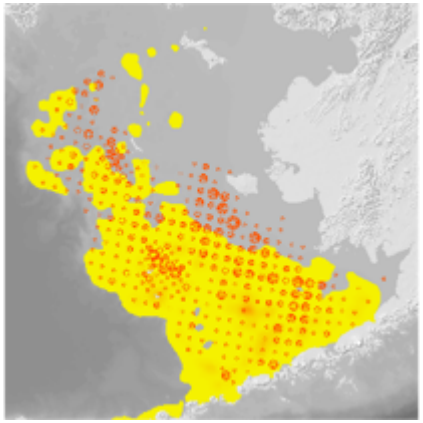




2004

Pollock Cod Arrowtooth

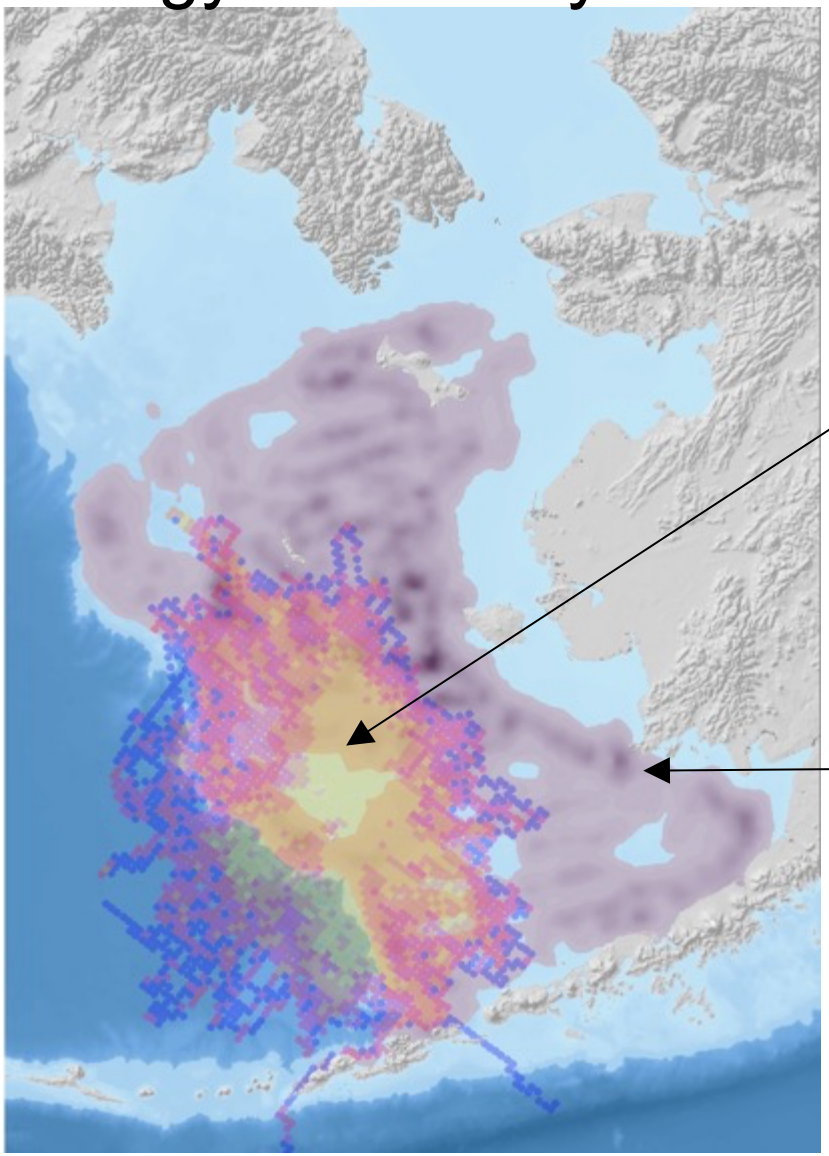




2008

Circles are bottom-trawl data; shading is FEAST modeled distribution

Matching Northern Fur Seal energy demand to pollock energy availability

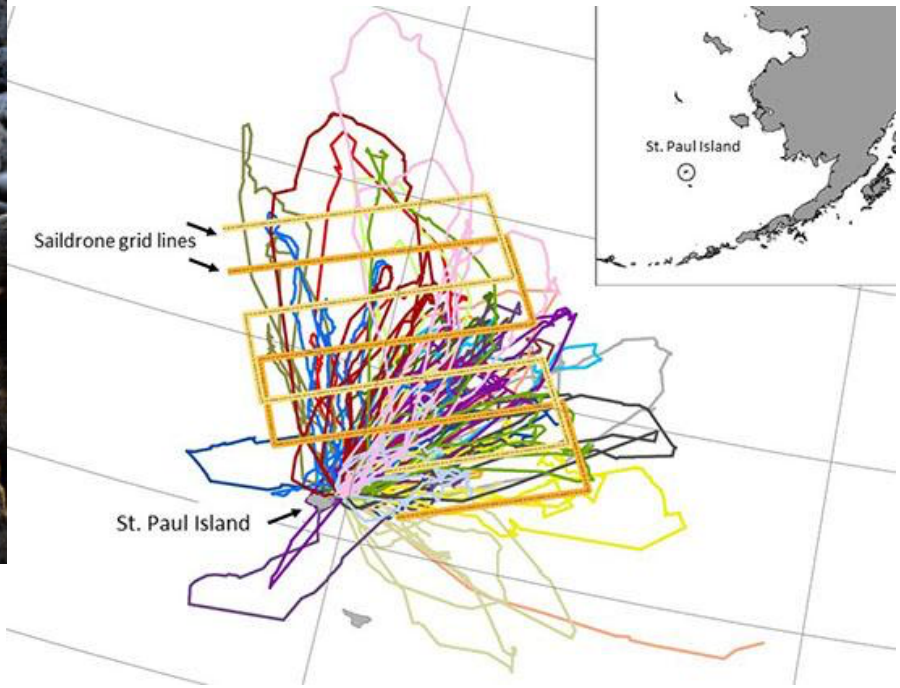


Pooled NFS trips show areas of maximum energy expenditure/ demand (pink, blues shows decreasing energy)

Underlying modeled pollock energy density distribution by age from FEAST provides energy availability

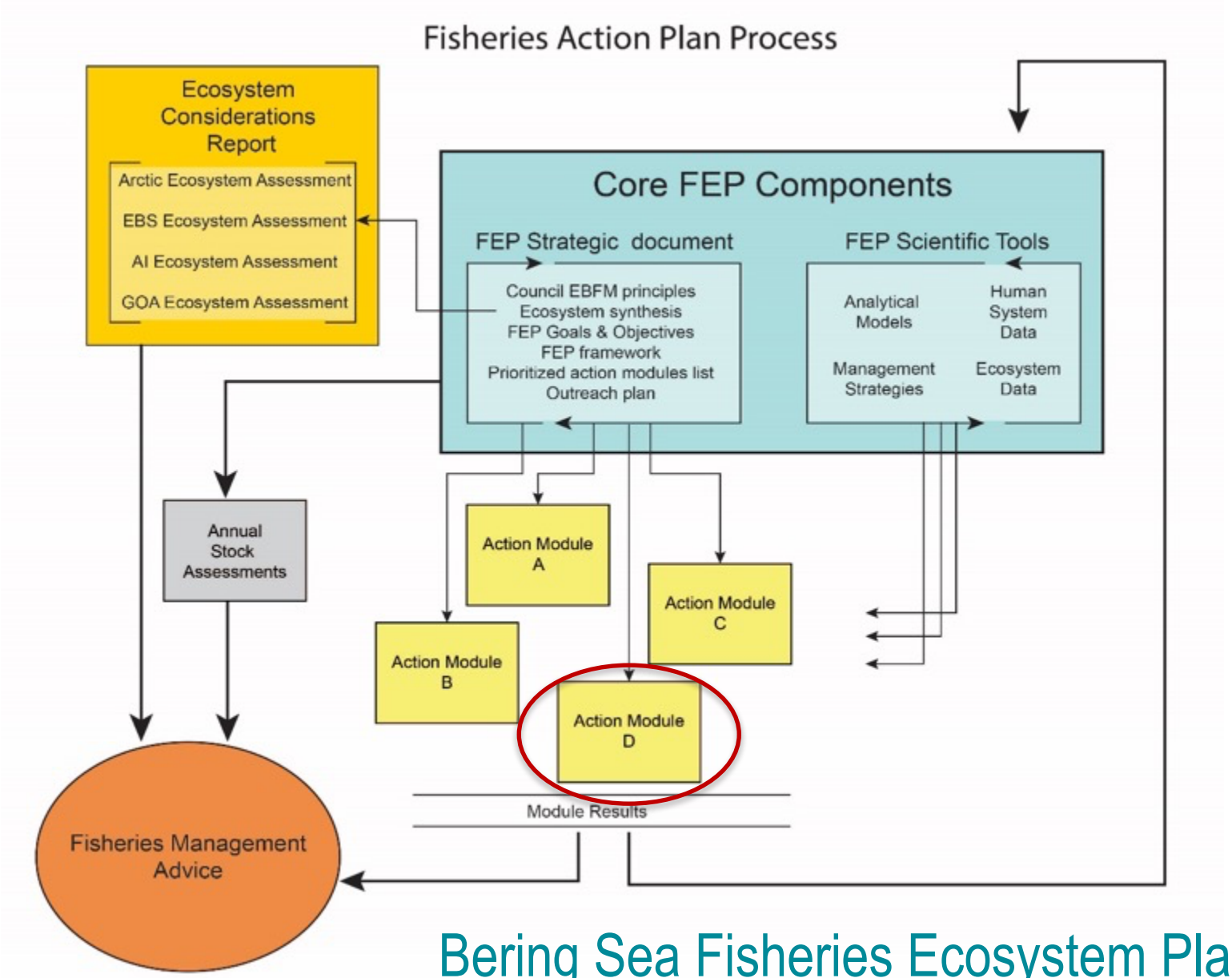
(Sterling, Ortiz)

https://www.afsc.noaa.gov/Science_blog/FurSeal_2017_main.htm



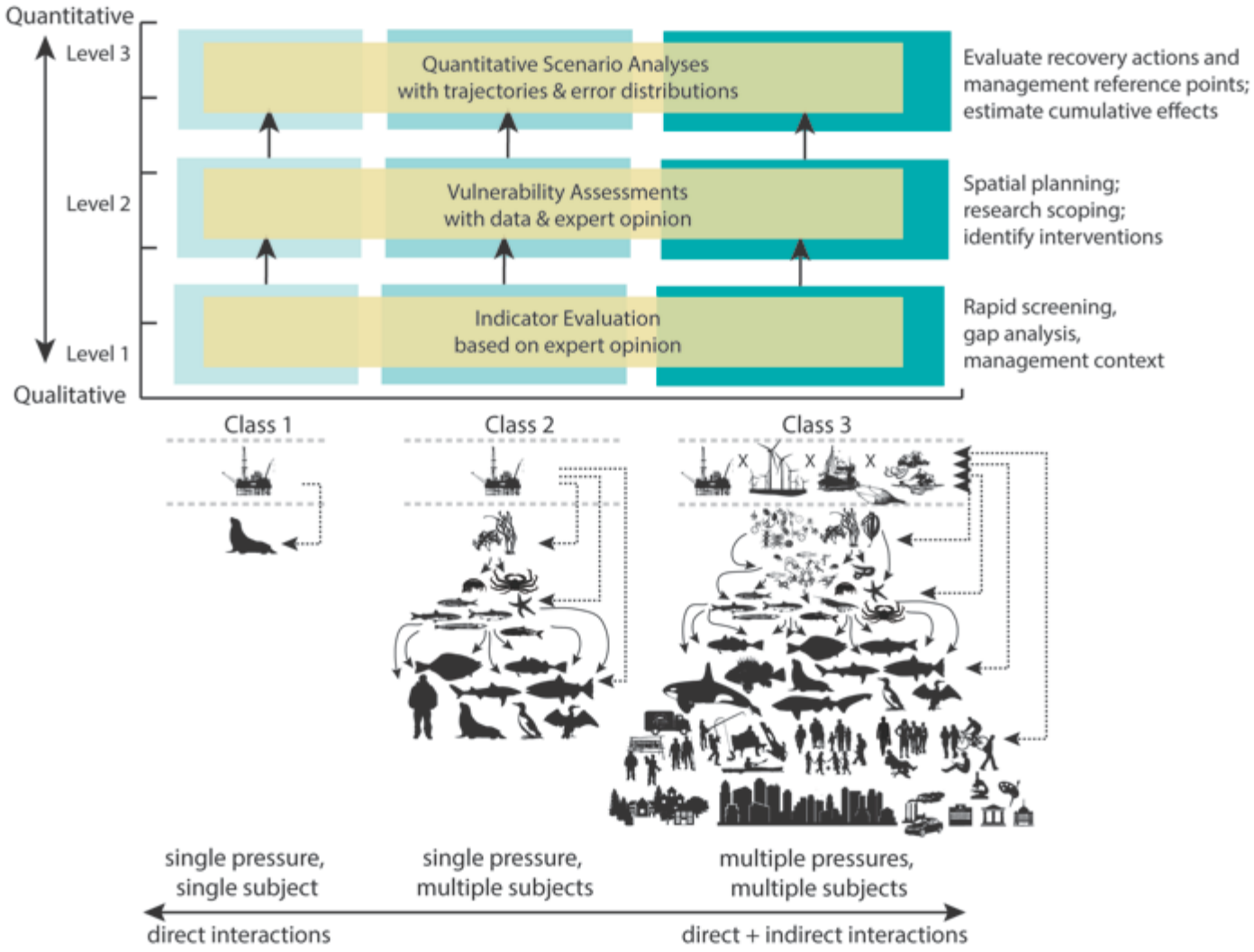
(Mordy, Kuhn, De Robertis, Sterling)

LEO Network: www.leonetwork.org

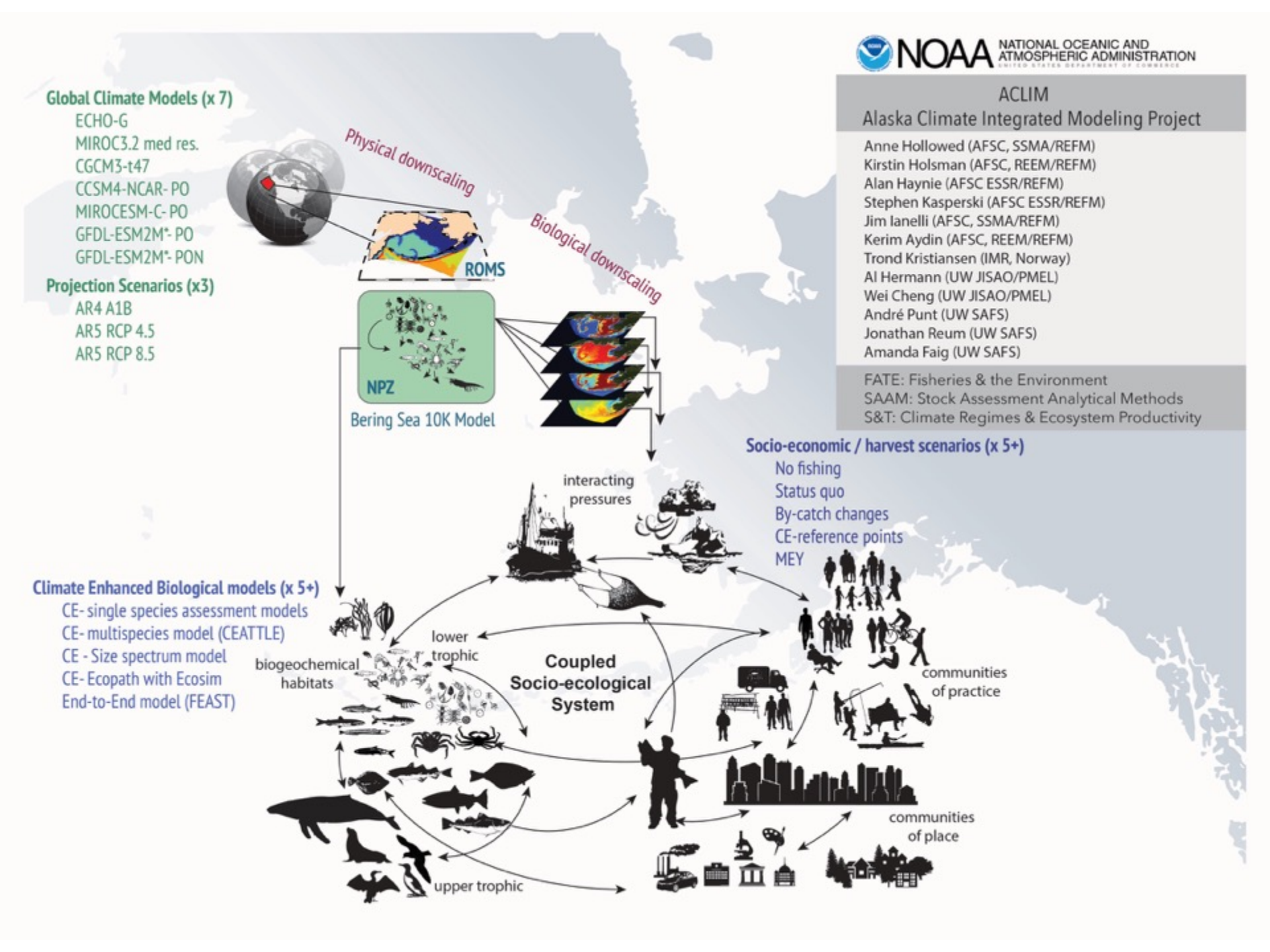


Bering Sea Fisheries Ecosystem Plan

Ecosystem Risk Assessment

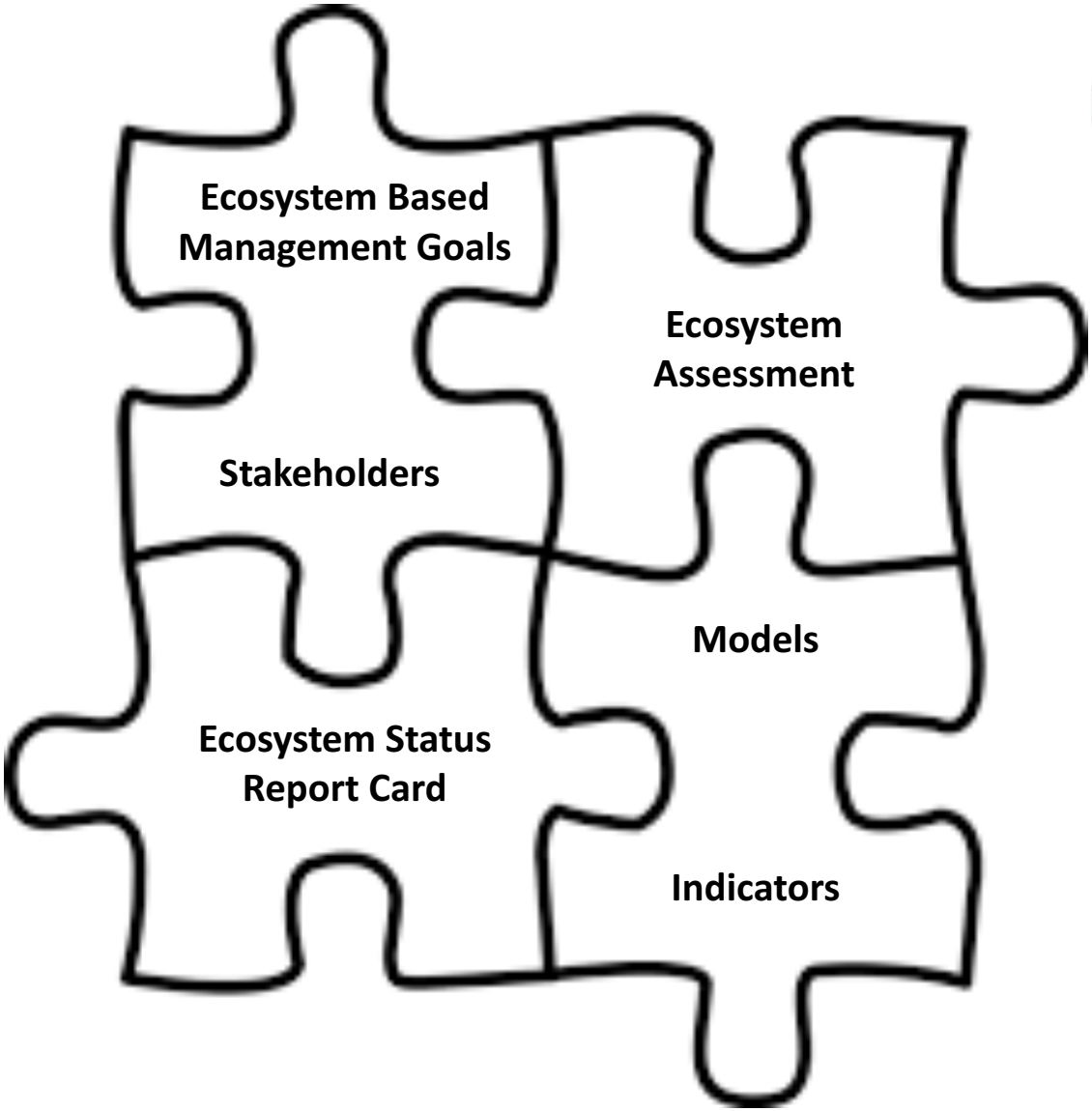


Holsman et al. 2017


NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ACLIM
Alaska Climate Integrated Modeling Project
Anne Hollowed (AFSC, SSMA/REFM)
Kirstin Holsman (AFSC, REEM/REFM)
Alan Haynie (AFSC ESSR/REFM)
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)
Jonathan Reum (UW SAFS)
Amanda Faig (UW SAFS)
FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity
Global Climate Models (x 7)
ECHO-G
MIROC3.2 med res.
CGCM3-t47
CCSM4-NCAR- PO
MIROCESM-C- PO
GFDL-ESM2M*- PO
GFDL-ESM2M*- PON
Projection Scenarios (x3)
AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5
Physical downscaling
ROMS
Biological downscaling
NPZ
Bering Sea 10K Model
Socio-economic / harvest scenarios (x 5+)
No fishing
Status quo
By-catch changes
CE-reference points
MEY
interacting pressures
Climate Enhanced Biological models (x 5+)
CE- single species assessment models
CE- multispecies model (CEATTLE)
CE - Size spectrum model
CE- Ecopath with Ecosim
End-to-End model (FEAST)
lower trophic
biogeochemical habitats
Coupled Socio-ecological System
communities of practice
communities of place
upper trophic

- Knowledge and understanding are always evolving, so build the IEA to allow for that evolution
- If an IEA reflects a narrow viewpoint, or a discrete set of priorities it will become obsolete
- It is extremely important to create formal collaborations that intentionally span perspectives and backgrounds
- IEA can then provide the consistent place for ecosystem knowledge to be discussed and shared

Putting the Pieces Together: Initial Steps Establishing an IEA for the Gulf of Alaska



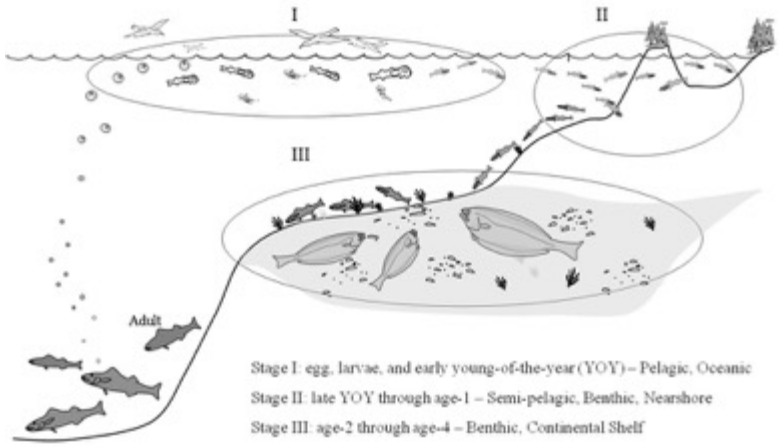
Timing is Right

- **Gulf of Alaska Integrated Ecosystem Research Program**
  - **interdisciplinary study of the GOA**
- **Gulf of Alaska (climate) Regional Action Plan**
  - **document on climate affect on GOA Ecosystem production**
- **Fisheries Management Council Actively Implementing**
  - **EBFM**

#1. Conceptual Model

Biological & Physical Variables

Species-specific Responses

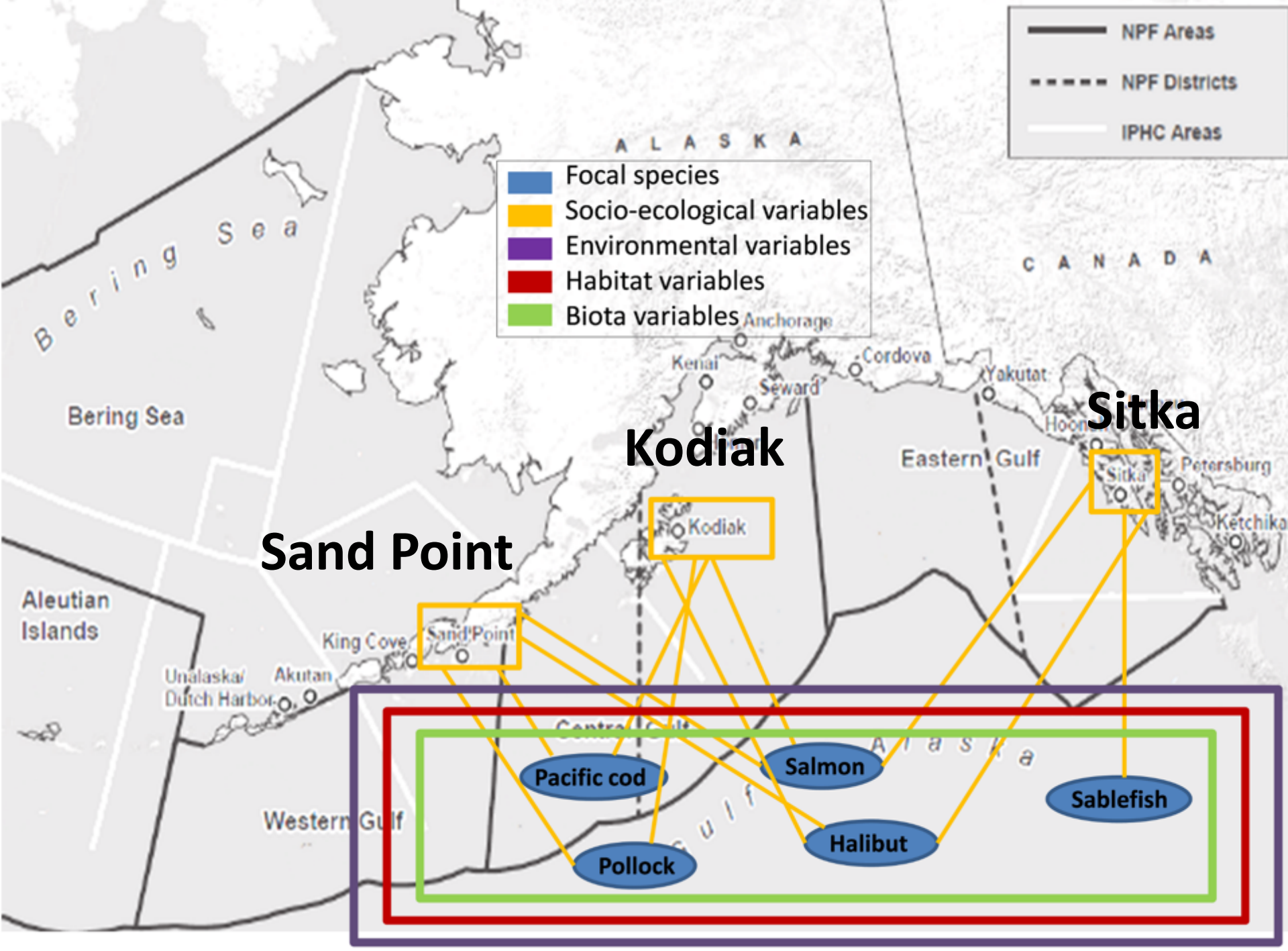


Community Health & Resilience

Qualitative Network Models

Summarizing information (example):

FROM: key variable	TO: Pollock	Pacific Cod	Halibut	Sablefish	Salmon	Link direction	Link description
ENSO			*			Positive	Enhanced onshelf transport results in greater larval abundance
Aleutian low					*	Positive	Aleutian Low pressure area affects water column stabilities. Increased food availability
Winds	*					Positive	Enhanced alongshore wind is associated with greater larval abundance
Transport/runoff		*				Positive	River runoff contribute to eddies formation, increased nutrient flux, and production
Temperature				*		Negative	Colder winter sea surface temperature is associated with positive recruitment


NPF Areas
NPF Districts
IPHC Areas
Focal species
Socio-ecological variables
Environmental variables
Habitat variables
Biota variables
ALASKA
CANADA
Bering Sea
Bering Sea
Anchorage
Kenai
Seward
Cordova
Yakutat
Hoonah
Petersburg
Ketchikan
Kodiak
Sitka
Sand Point
Kodiak
Sitka
Eastern Gulf
Aleutian Islands
King Cove
Sand Point
Unalaska/ Dutch Harbor
Akutan
Western Gulf
Central Gulf
Alaska
Gulf
Pacific cod
Salmon
Sablefish
Halibut
Pollock

#2. Placed-based IEA in Sitka

NSRAA

ALASKA DEPARTMENT OF FISH AND GAME

Sitka Tribe of Alaska

SITKA SOUND SCIENCE CENTER

Allen Marine

#3. Engage Other Stakeholders & Develop Products

Coastal Communities

North Pacific Fishery Management Council

Parting Thoughts

Know your stakeholders

Each region & IEA is going to be different

IEAs are a way of doing business

End Slides

SEAK IEA (Sitka Sound - Cross Sound)

Partners:

- ALFA, SSSC, Sitka Tribes, Sitka Conservation Society
- SE Trollers Assoc., NSRAA, ADF&G, UAS, Allen Marine (potentially)

Interests:

- Understanding of how inside waters and seasonal patters affect groundfish
- Understand plankton, forage fish, and marine mammal interactions in Sitka Sound
- Ocean habitat quality for salmon
- Common frame work for understanding why/how axillary information is used in opening and closing fisheries
- Ocean acidification

Products:

- Troll logbook database program (reinstate)
- Basic predator/prey/ecosystem model of Sitka Sound
- Leading indicator for harmful algal blooms
- Management tools

Timeline of ecosystem-based fisheries management science

1980s: Proactive ecosystem measures in Alaska

Ecosystem models, 2M MT cap, forage fish ban

1990s: What is ecosystem-based management?

Academic panel reports (nationwide), development of Alaska Ecosystem Status Report (*"Ecosystem Considerations"*)

2000s: Product and tool development

Models, analysis tools, extended observations, conceptual models

2010s: Development of formalized programs

National and Local Roadmaps, Integrated Ecosystem Assessments

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Alaska CLIMate Project

Anne Hollowed (AFSC, SSMA/REFM)
Kirstin Holsman (AFSC, REEM/REFM)
Alan Haynie (AFSC ESSR/REFM)
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

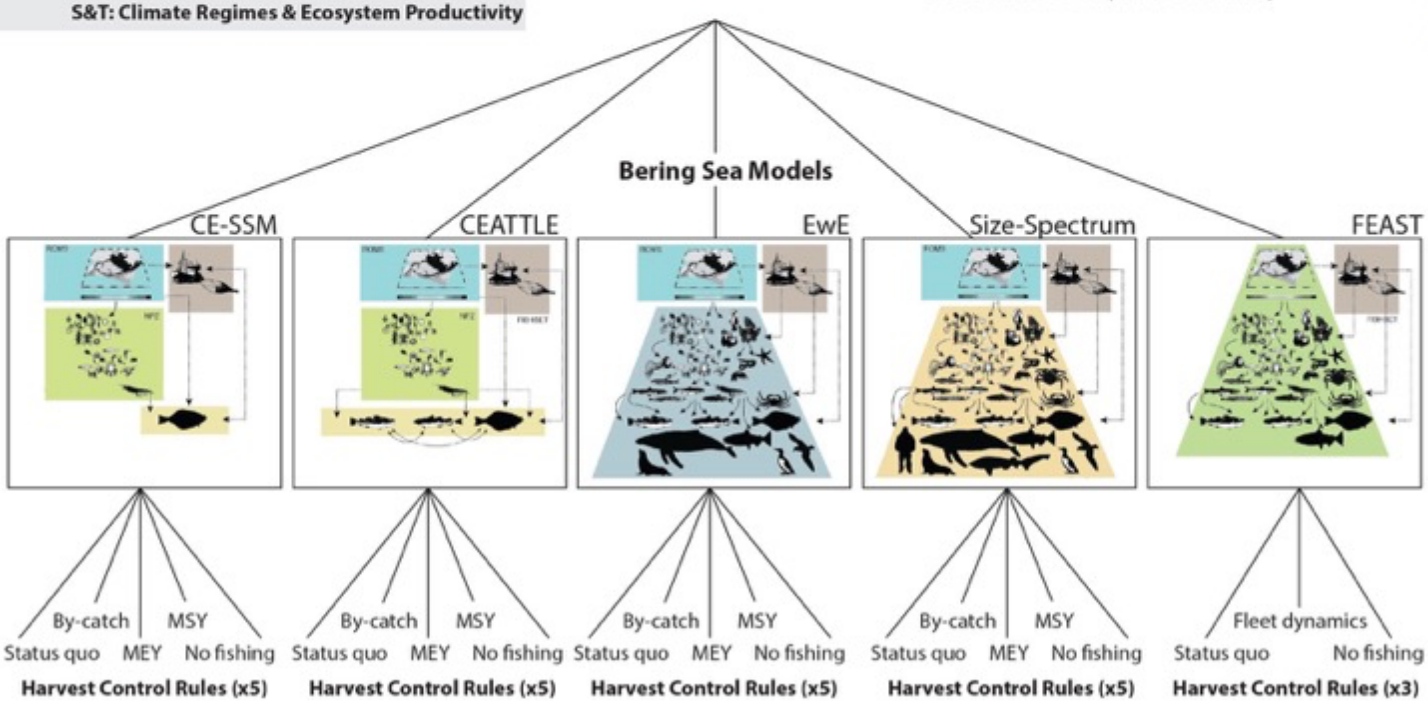
IPCC Scenarios (x3)

AR4 A1B
AR5 RCP6.0
AR5 RCP8.5

Global Climate Models (x 11)

ECHO-G (AR4 A1B)
MIROC3.2 med res. (AR4 A1B)
CGCM3-t47 (AR4 A1B)
CCSM4-NCAR- PO (AR5 RCP 6.0 & 8.5)
MIROCESM-C- PO (AR5 RCP 6.0 & 8.5)
GFDL-ESM2M*- PO (AR5 RCP 6.0 & 8.5)
GFDL-ESM2M*- PON (AR5 RCP 6.0 & 8.5)

Bering Sea Models



multiple non-linear pressures

multiple non-linear interacting pressures

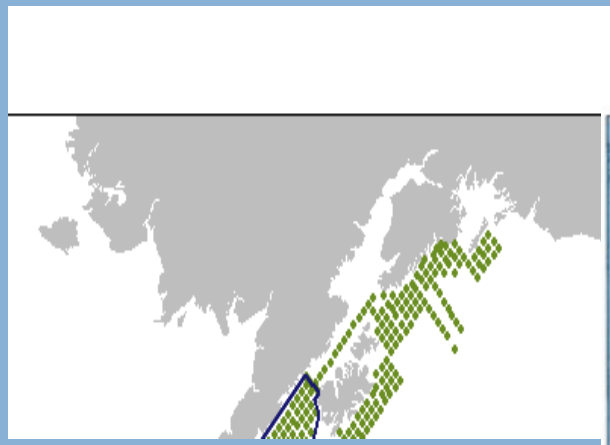
Future Climate Scenarios

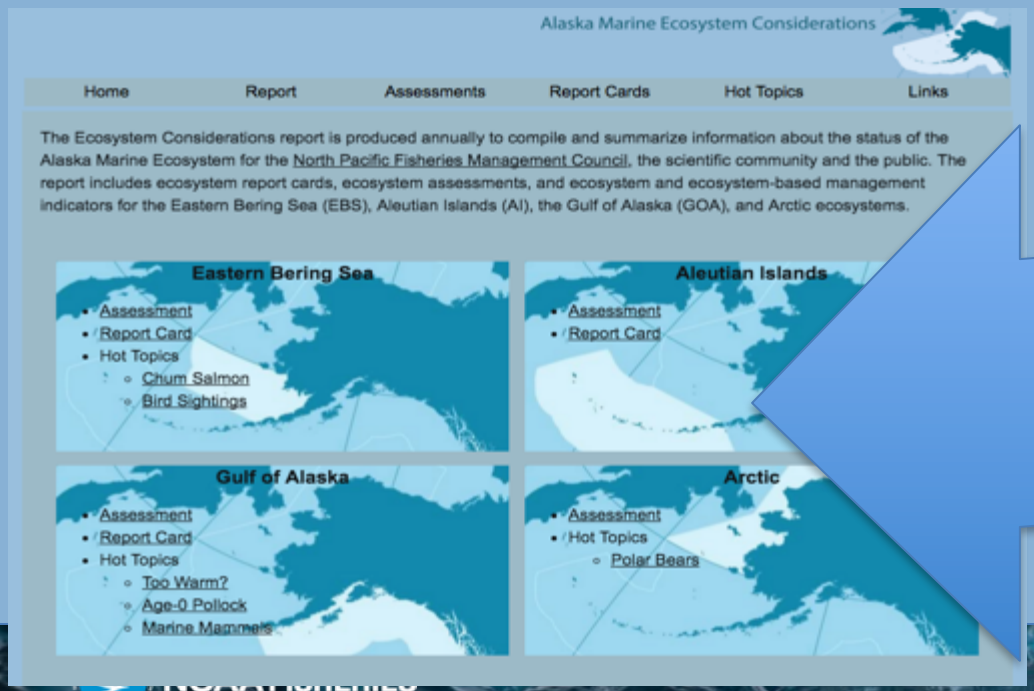
Climate-enhanced Biological Models

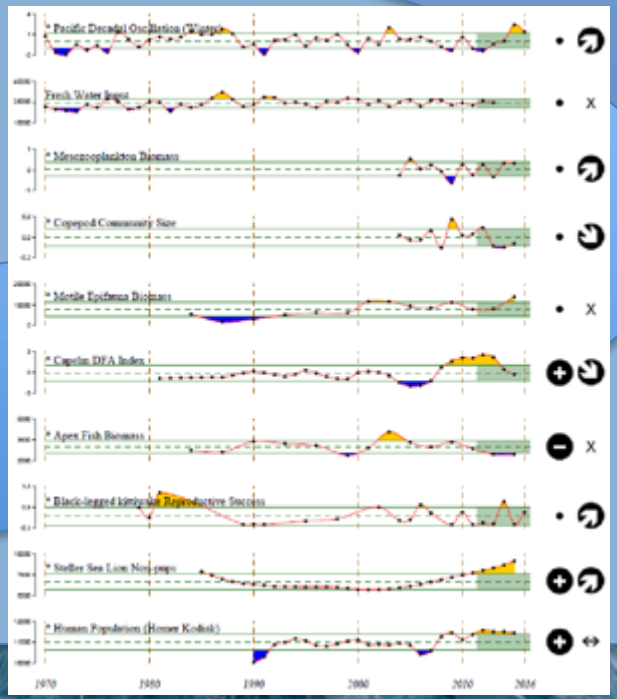
Fishing Scenarios

https://www.afsc.noaa.gov/REFM/REEM/ACLIM.htm

Increased integration of fieldwork and management advice





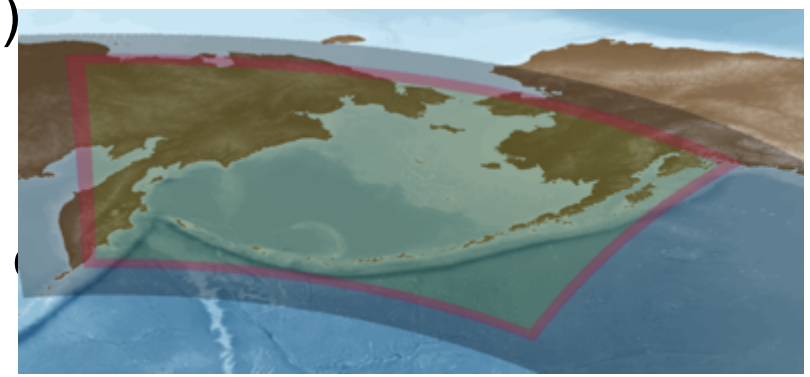


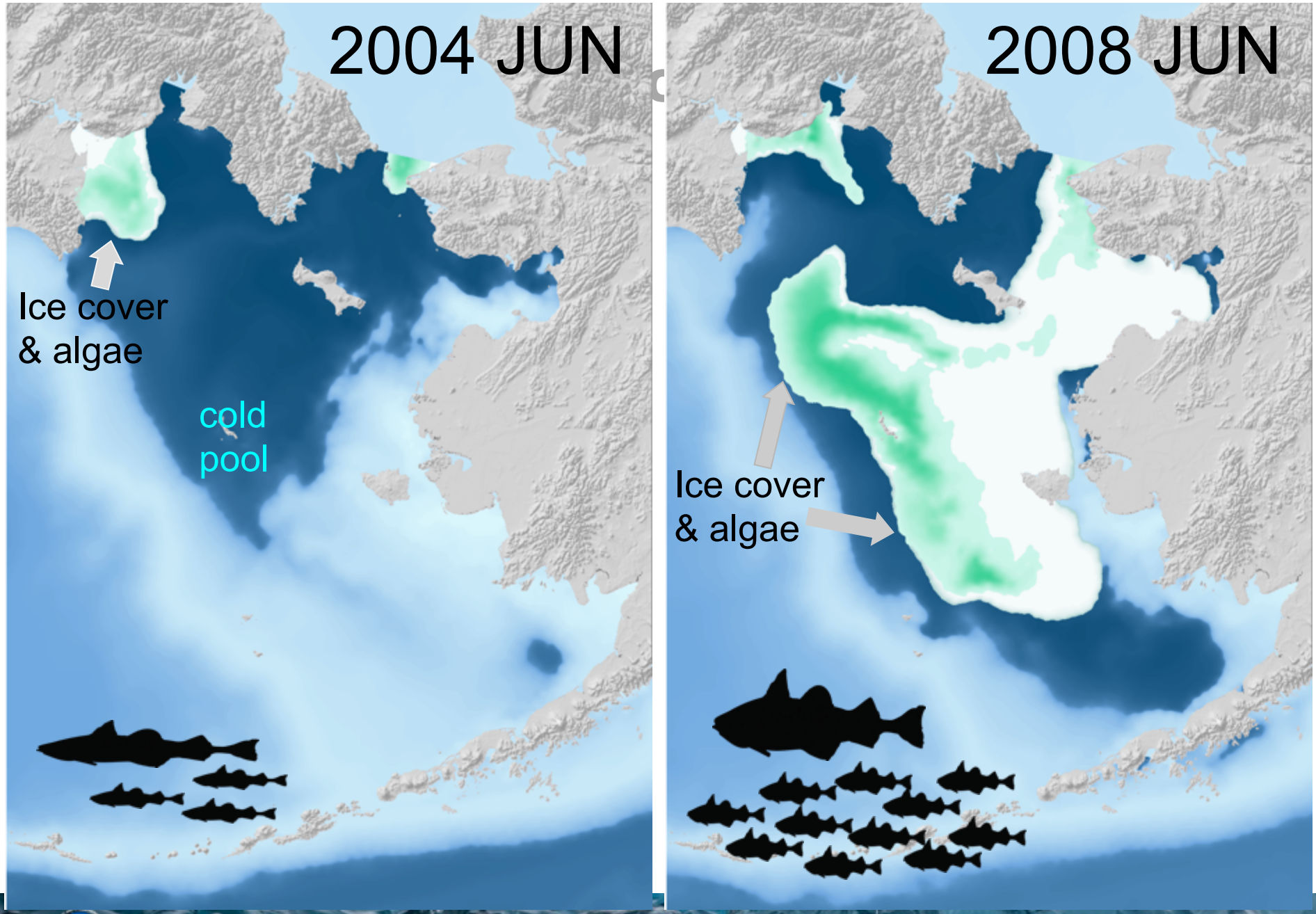
Bering ROMS/NPZ

(Regional Oceanographic model with nutrients and plankton dynamics)

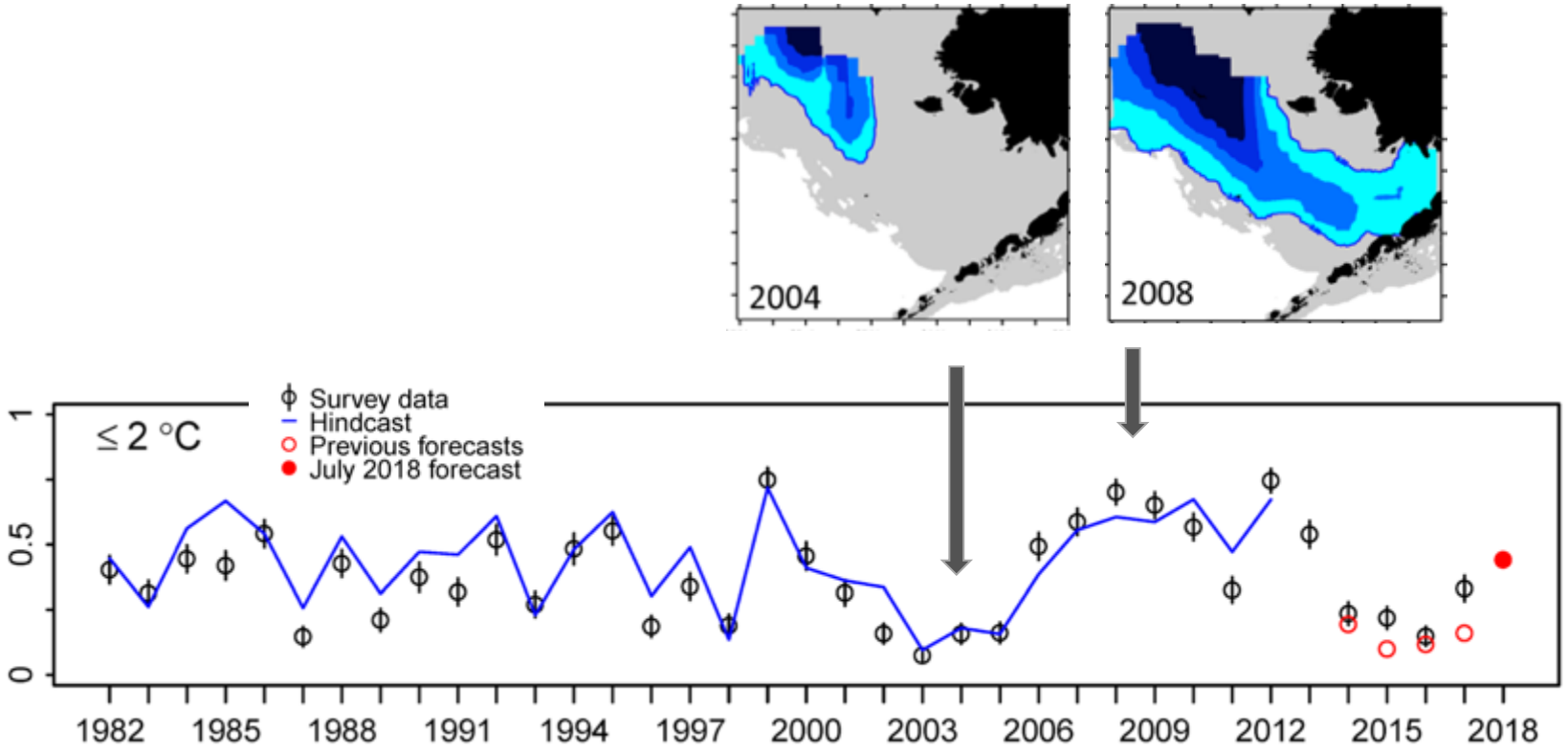
- Developed with NSF/North Pacific Research Board
- Ongoing IEA partnership (AFSC/PMEL)
- Significant advances in ice modeling, ice plankton

- Products
  - 40-year hindcast (1971-2012)
  - Nowcasts (annual)
  - 9-month forecast (annual)
  - Forecasts to 2100 with IPCC
  - Rapid Climate Assessment
  - EFH maps




2004 JUN
Ice cover
& algae
cold
pool
2008 JUN
Ice cover
& algae

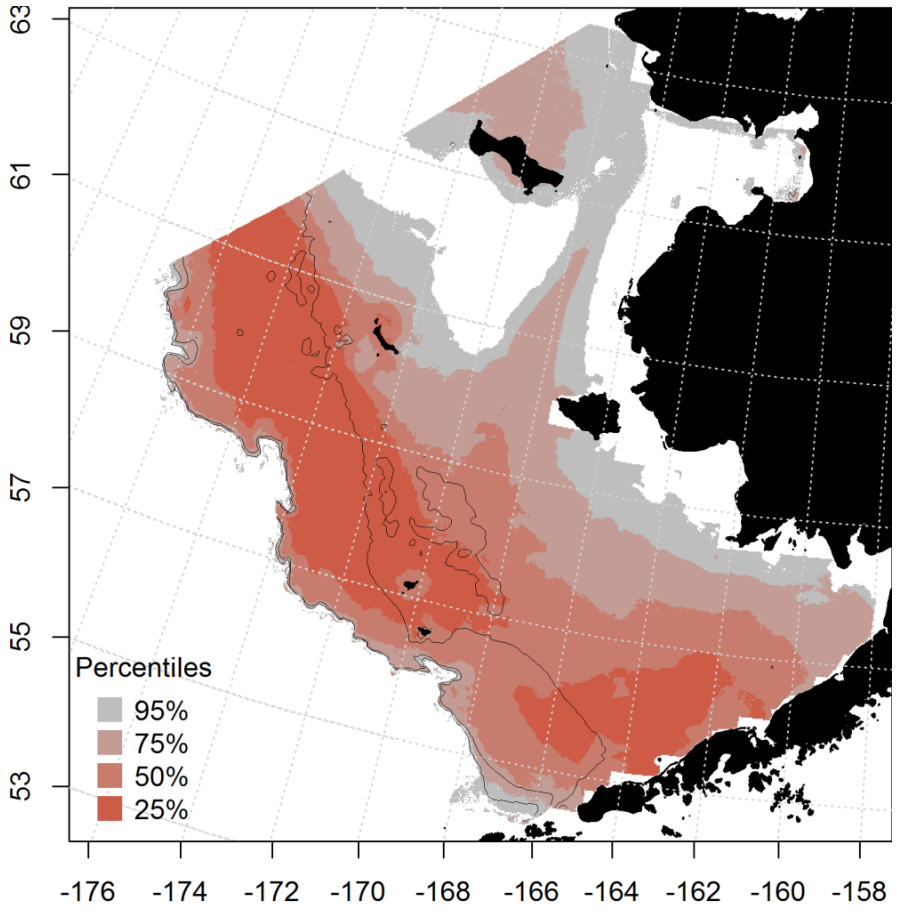
9-month (seasonal) forecast - cold pool

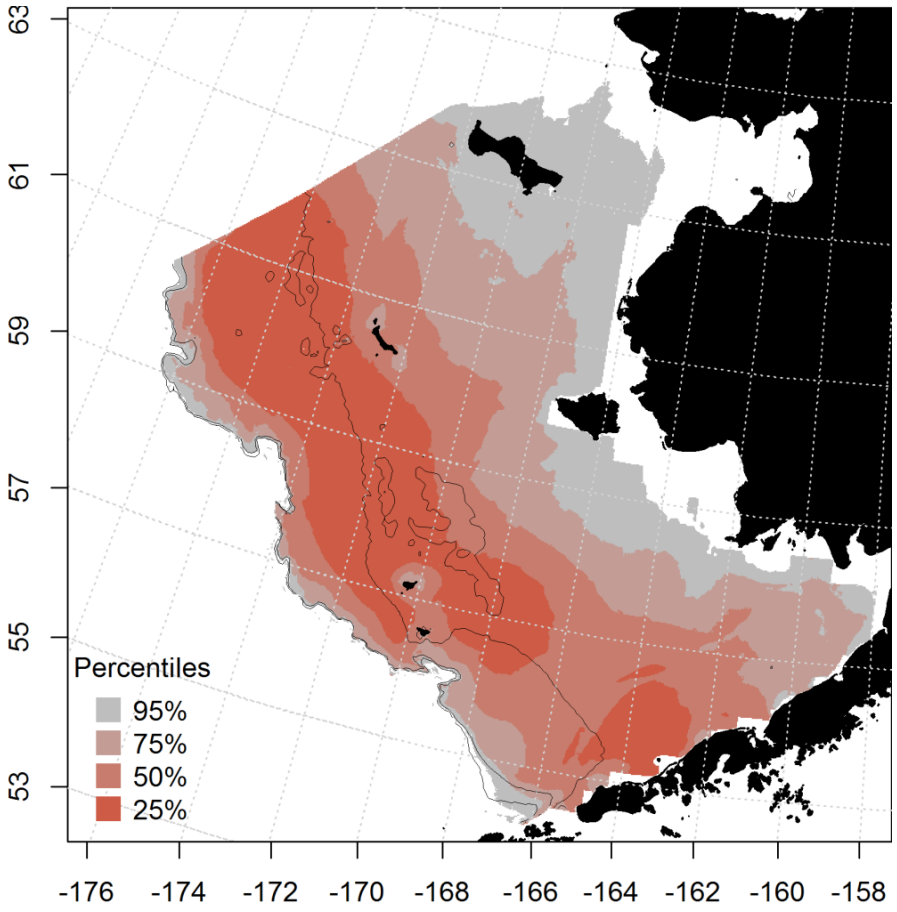


- Included in annual ecosystem chapter (November prediction for following summer)
- Strong traction/interest in fishing community
- Forecast led to increased oceanographic field presence in 2015 (unprecedented warmth forecast)
- Validation funded under NOAA MAPP Program

Shifts in Essential Fish Habitat

Rooper, Ortiz, Laman, Hermann, Wilborn





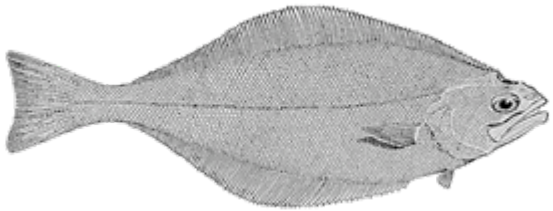
Current EFH walleye pollock

EFH 2030-40 CMIP3 ensemble

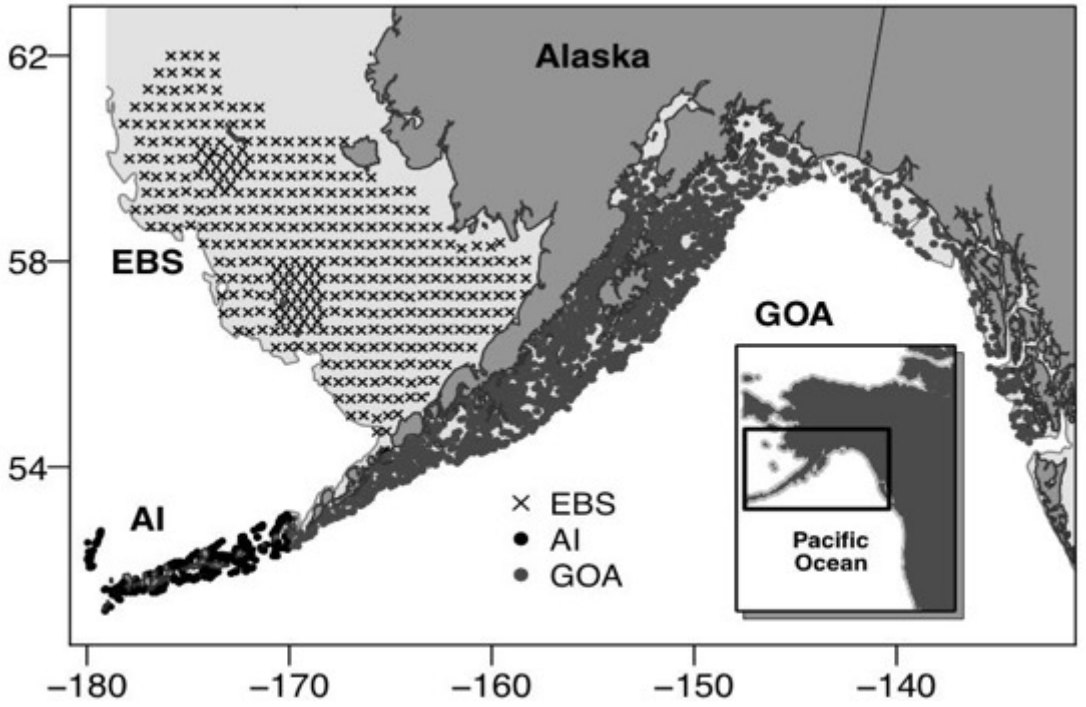
CEATTLE (Multi-species stock assessment model)

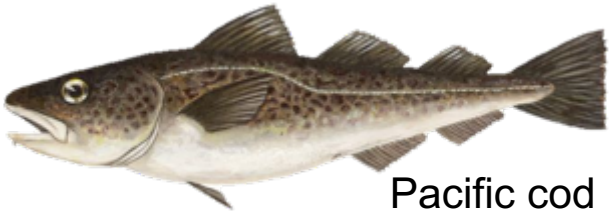
Eastern Bering Sea, Alaska, USA

Walleye pollock
(*Gadus chalcogrammus*)



Arrowtooth flounder
(*Atheresthes stomias)*

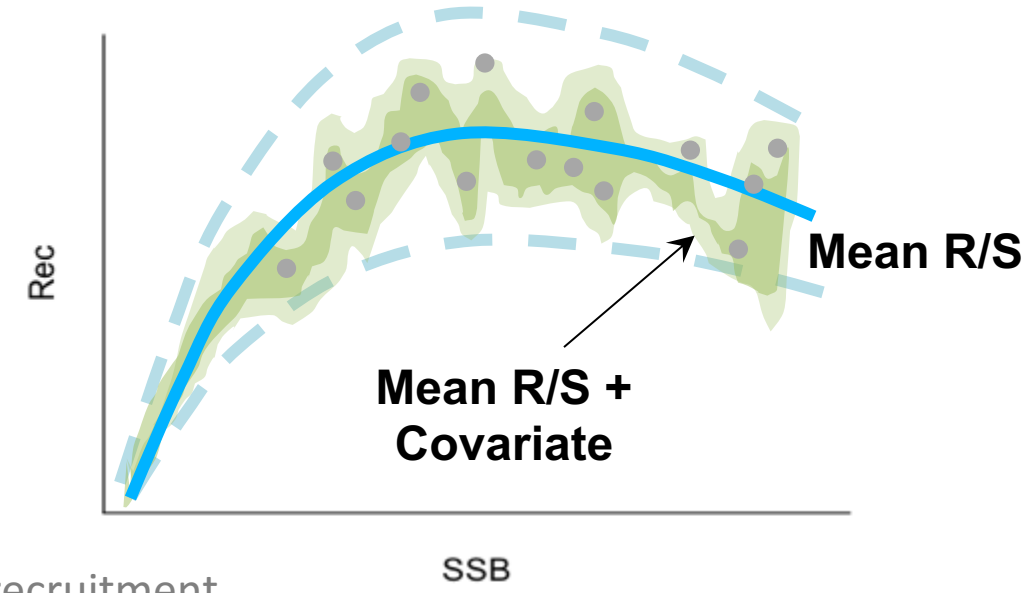




Pacific cod
(*Gadus macrocephalus*)

W@Age~*f*(Temperature)
Pred/prey~*f*(Temperature)

CEATTLE Recruitment – ROMS/NPZ forced forecasts



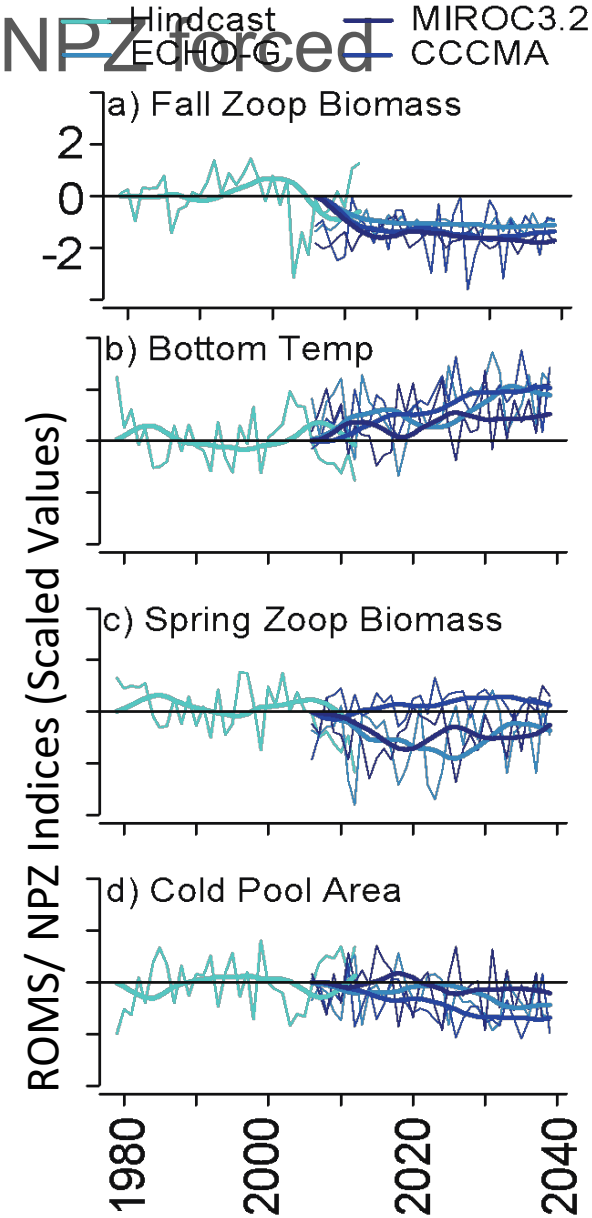
recruitment

$$log(R_t) = log(\alpha \cdot B_{t-1}) - \beta_1 \cdot B_{t-1} + \sum \beta_k \cdot X_{k,t} + \varepsilon,$$

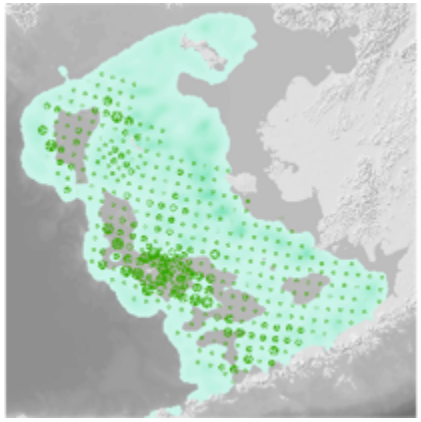
productivity

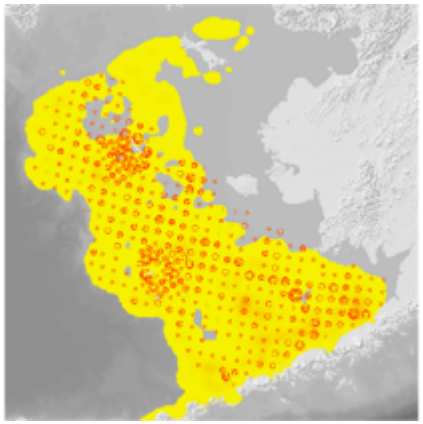
carrying capacity

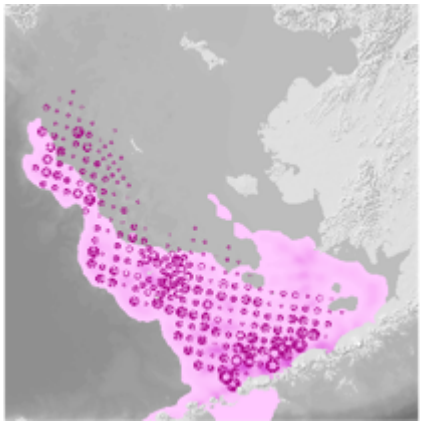
environmental effects on carrying capacity



(Ortiz, Kearney, Hermann, Aydin)





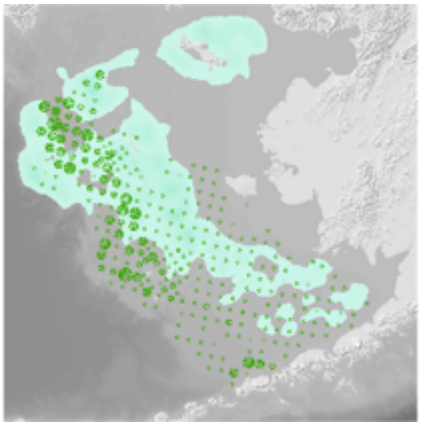


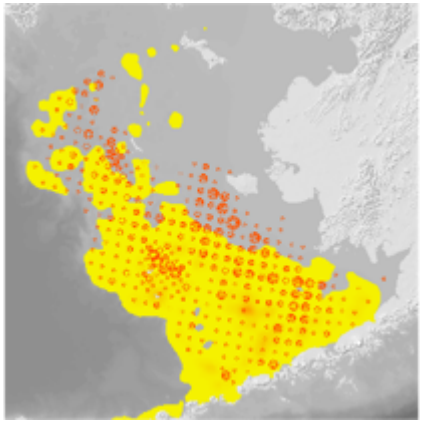
2004

Pollock

Cod

Arrowtooth

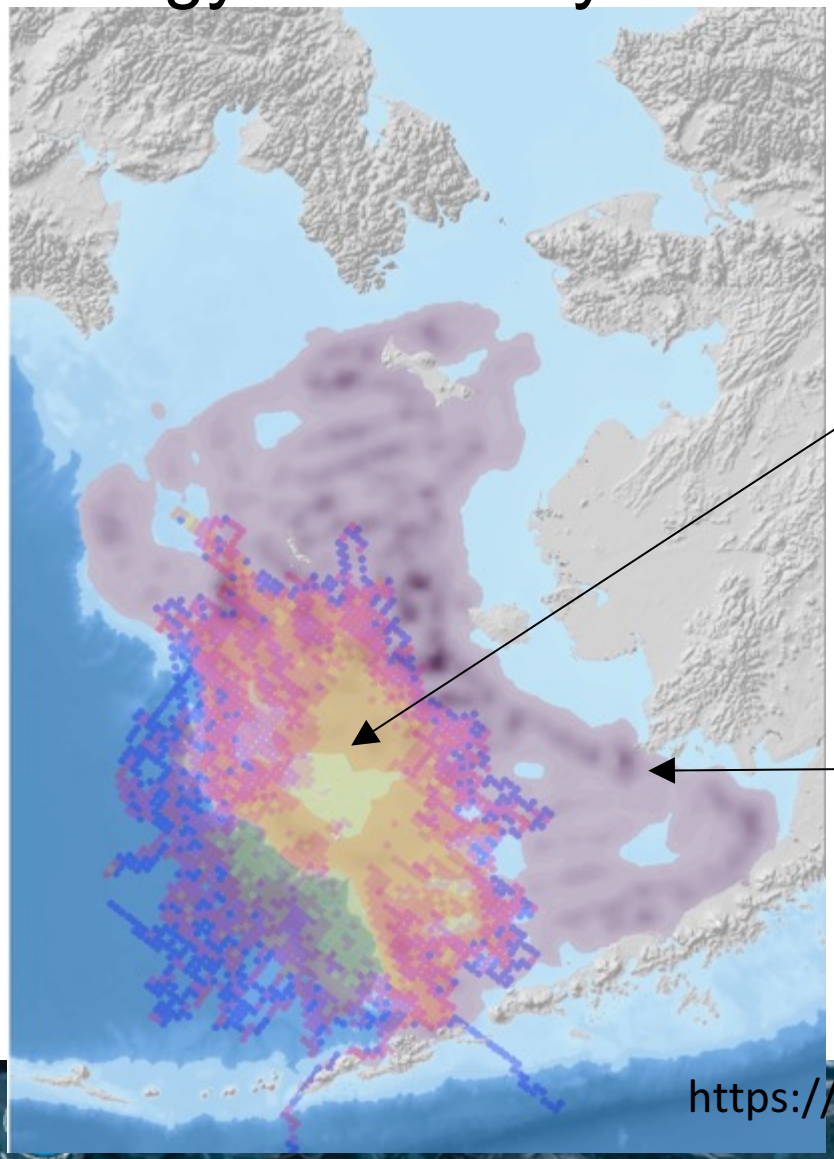




2008

Circles are bottom-trawl data; shading is FEAST modeled distribution

Matching Northern Fur Seal energy demand to pollock energy availability

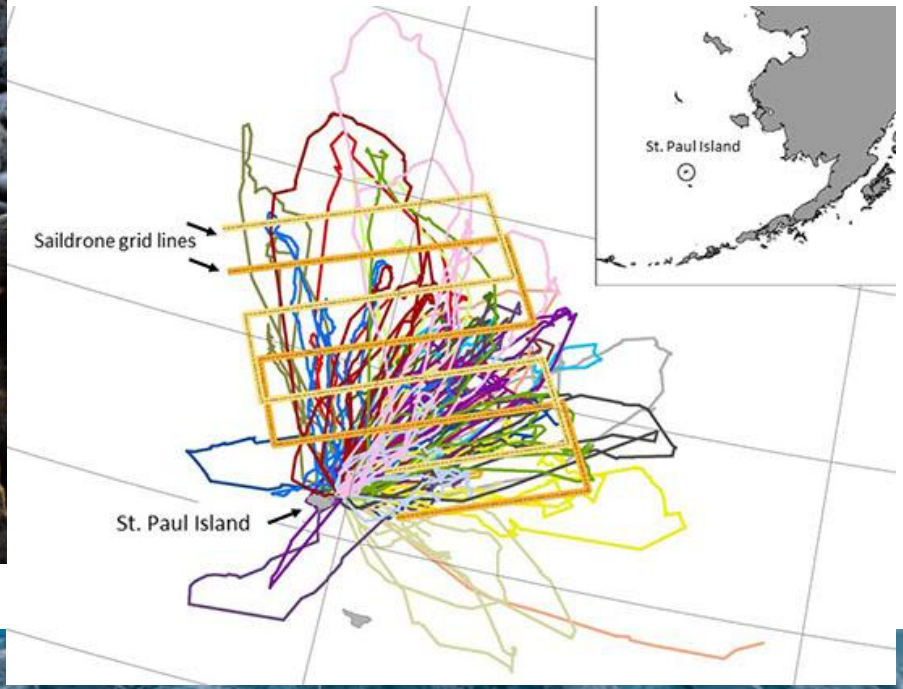


Pooled NFS trips show areas of maximum energy expenditure/ demand (pink, blues shows decreasing energy)

Underlying modeled pollock energy density distribution by age from FEAST provides energy availability

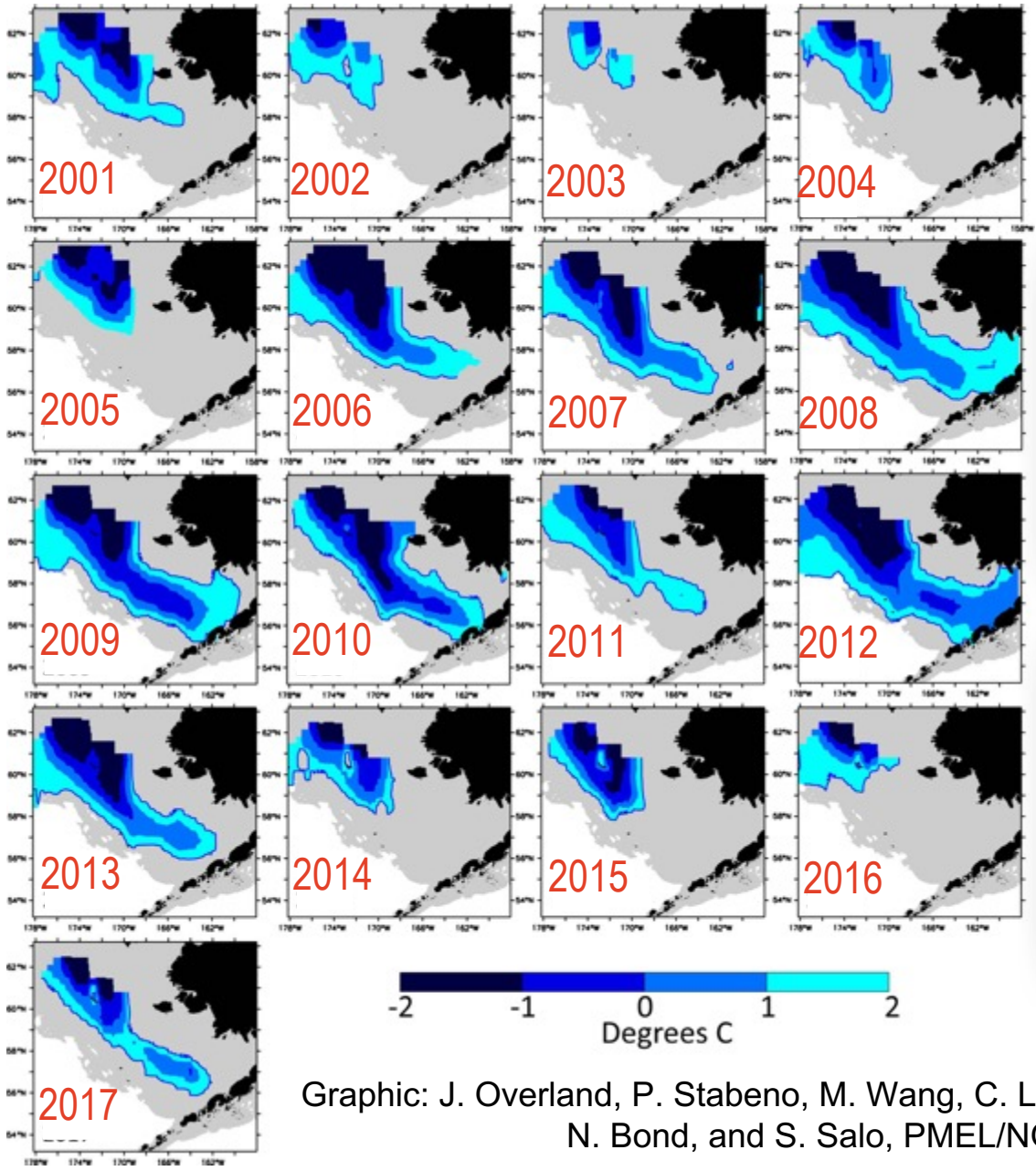
(Sterling, Ortiz)

https://www.afsc.noaa.gov/Science_blog/FurSeal_2017main.htm

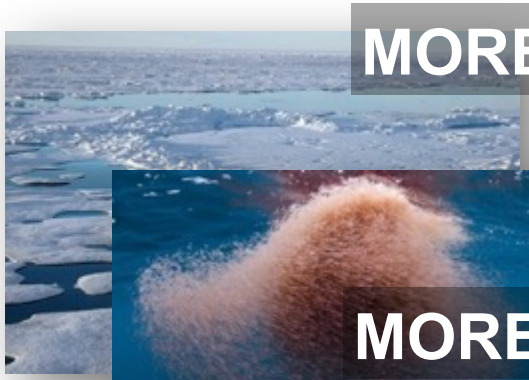


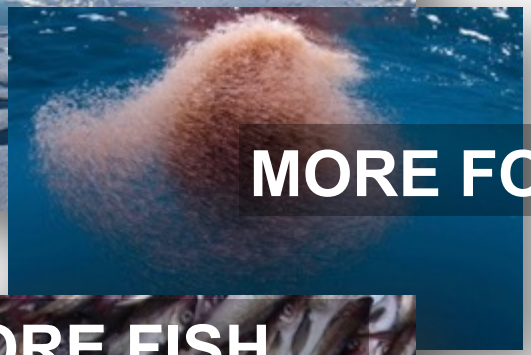
(Mordy, Kuhn, De Robertis, Sterling)

Bering Sea "Cold Pool" 2001-2017

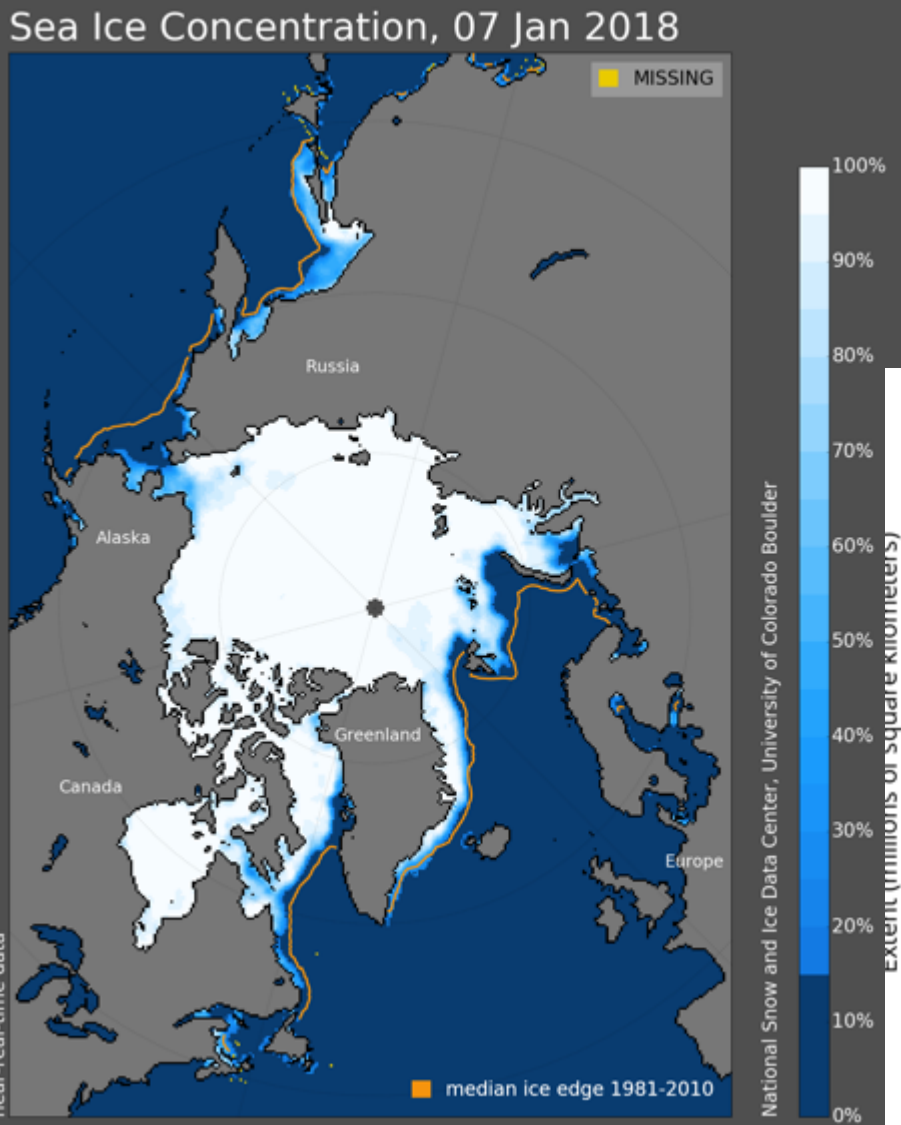


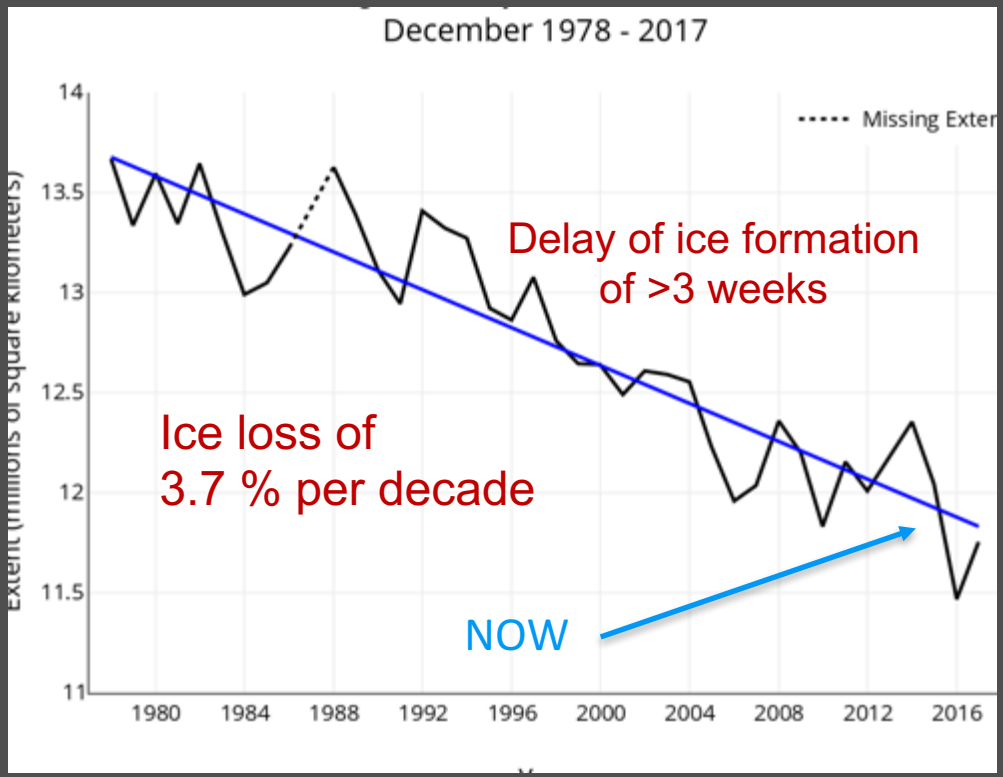
Graphic: J. Overland, P. Stabeno, M. Wang, C. Ladd, N. Bond, and S. Salo, PMEL/NOAA





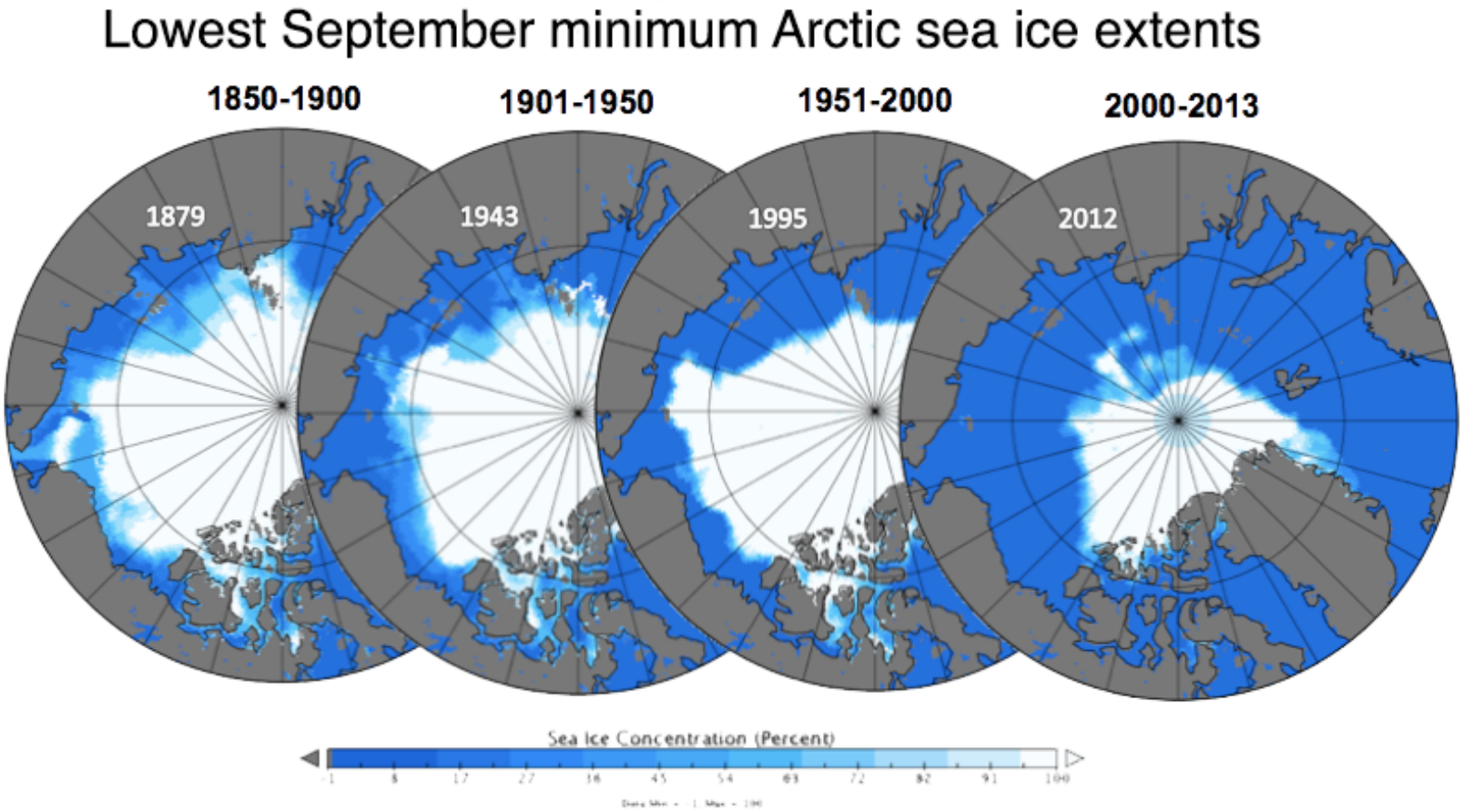
National Sea Ice Data Center





http://nsidc.org/arcticseaicenews/

http://nsidc.org/arcticseaicenews/



What does Ecosystem-based management look like to you?

- What sorts of data and knowledge are included? (e.g., survey based data, Local or Traditional Ecological Knowledge, Citizen or cooperatively collected data)
- Who is (or should be) involved?
- How do you collectively consider different sources of knowledge and data?
- What are the connections and in-roads to management decisions?
- How has the ecosystem approach evolved over time in your experience?

What is the advantage of an Ecosystem Approach to managing marine systems?

- What is the value added of an ecosystem approach?
- What does management look like if it doesn't include ecosystem –perspective and information?
- What are some successful examples where ecosystem science helped?

What are the challenges of an Ecosystem Approach to management?

- Are there times when ecosystem information is difficult to interpret? and why?
- How do you resolve differences in data collection and information?
- What are the biases and challenges that are unique to ecosystem-based management?
- What are some examples of when an ecosystem approach didn't work, and why?