Science, Service, Stewardship

Tools and Methods for FEP development

Kerim Aydin, Stephani Zador, Ivonne Ortiz, and Kirstin Holsman

Alaska Fisheries Science Center and

University of Washington

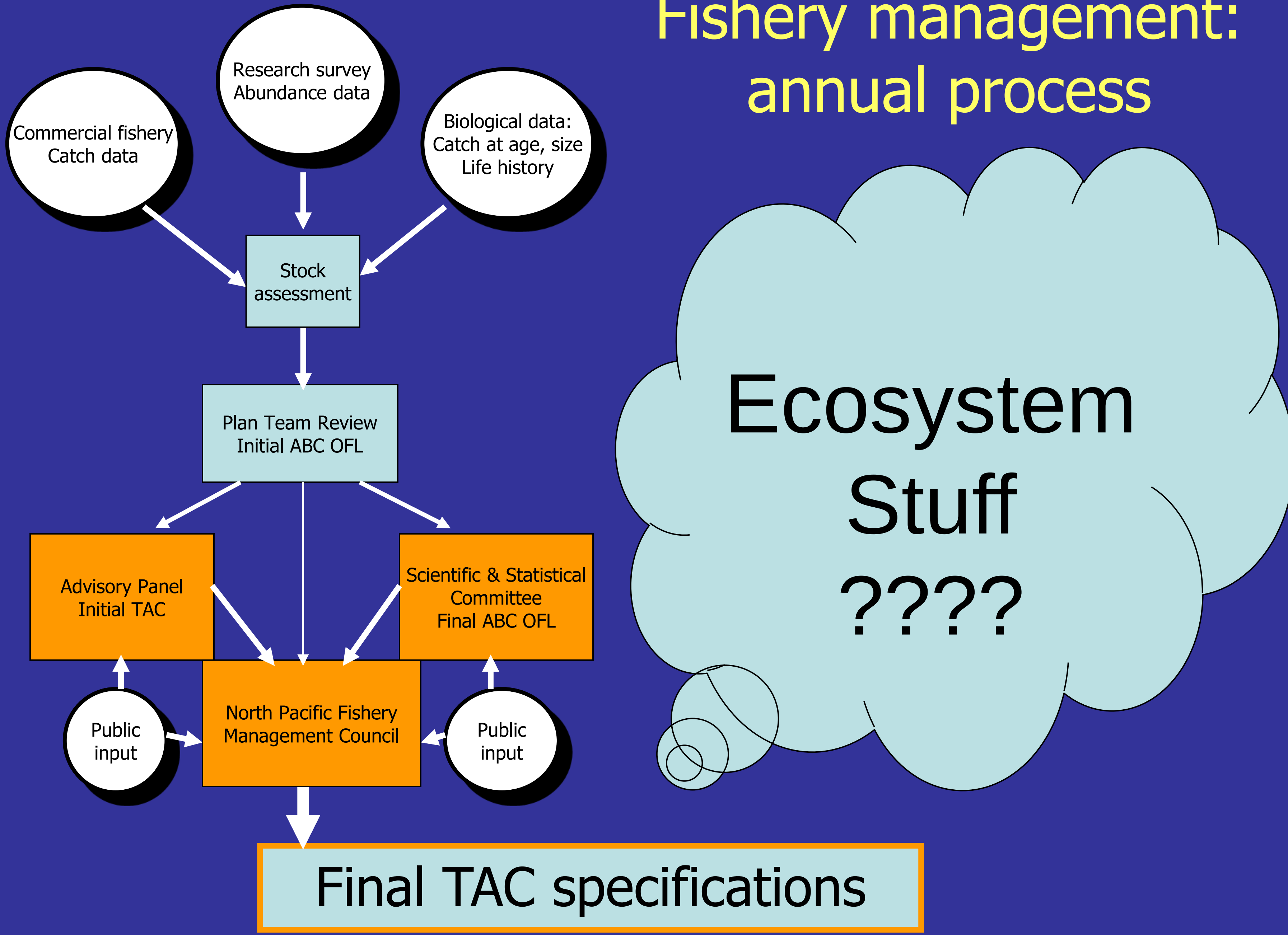
NOAA FISHERIES SERVICE

NOAA FISHERIES SERVICE

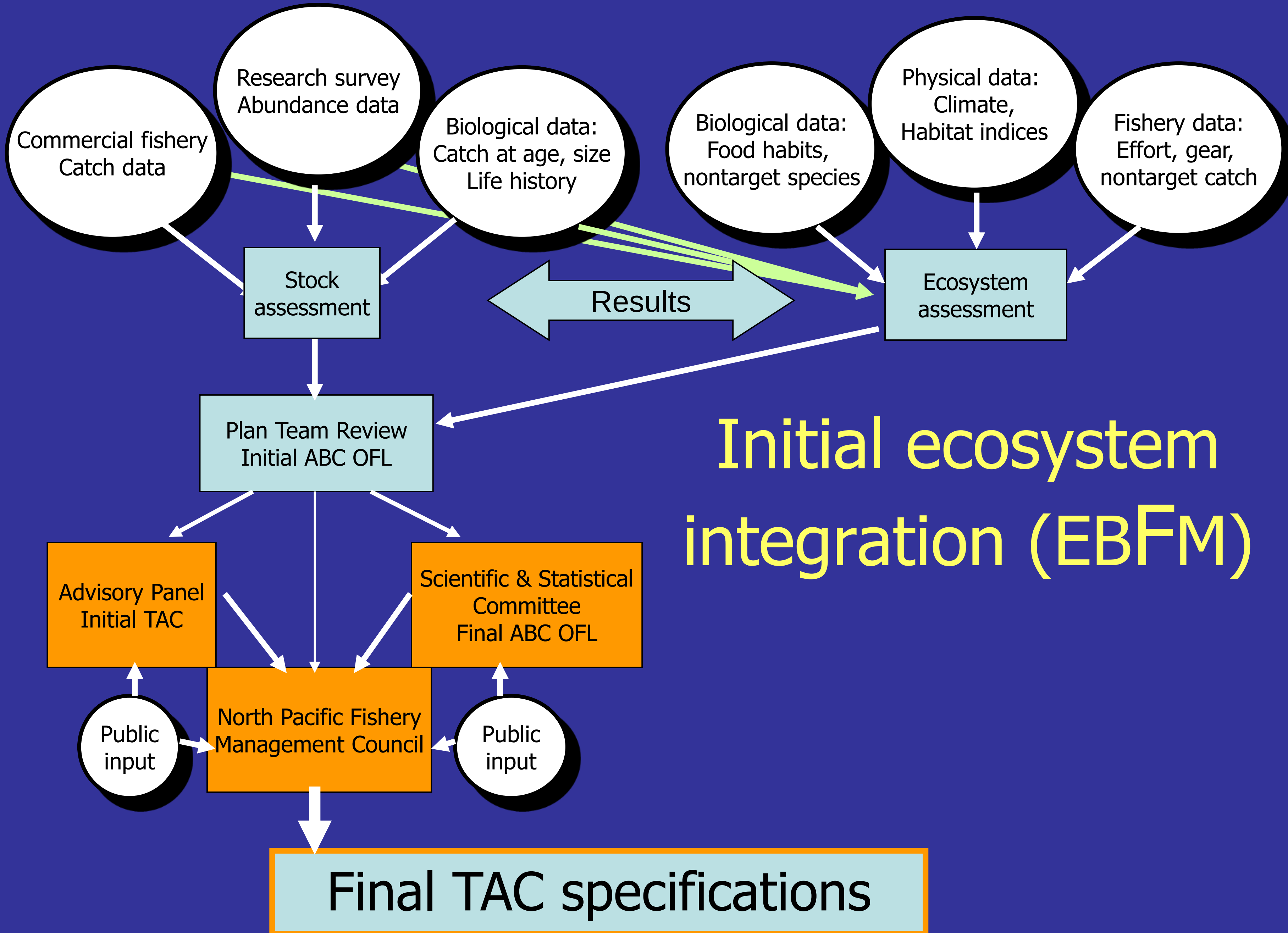
Schedule 8:45 – 12:00

- *Introduction (Kerim)*
- *Scoping (Kerim)*
- *Developing indicators (Stephani)*
- *Evaluating status and thresholds (Kerim)*
- *Spatial Modeling (Ivonne)*
- *Risk assessment & MSEs (Kirstin)*

Fishery management: annual process



Initial ecosystem integration (EBFM)



NOAA FISHERIES SERVICE

Acronyms

- *The NOAA Integrated Ecosystem Assessment (IEA) Program is an* ***ongoing science program*** *to develop and use EBM tools, and deliver results to management.*

- *The* ***IEA Process*** *is one method of formalizing steps recommended in EBFM and EFB literature.*

- *An* ***FEP*** *is (in part) a specific implementation plan built with strong stakeholder input.*
    - A cohesive document that sets guidelines for capacity building and implementation of EBM within the Council/management, AND in view of marine uses from other sectors. It is a tool both to be used within the Council/ management organizations and to be used by the Council when facing/addressing non-fisheries sectors.

Methods versus tools

- *"Methods" such as Risk Assessment or Management Strategy Evaluation.*
- *"Tools" such as FEAST or single-species assessments.*
- *"Scenarios" (or "alternatives") are developed by stakeholder process (e.g. FEP team).*

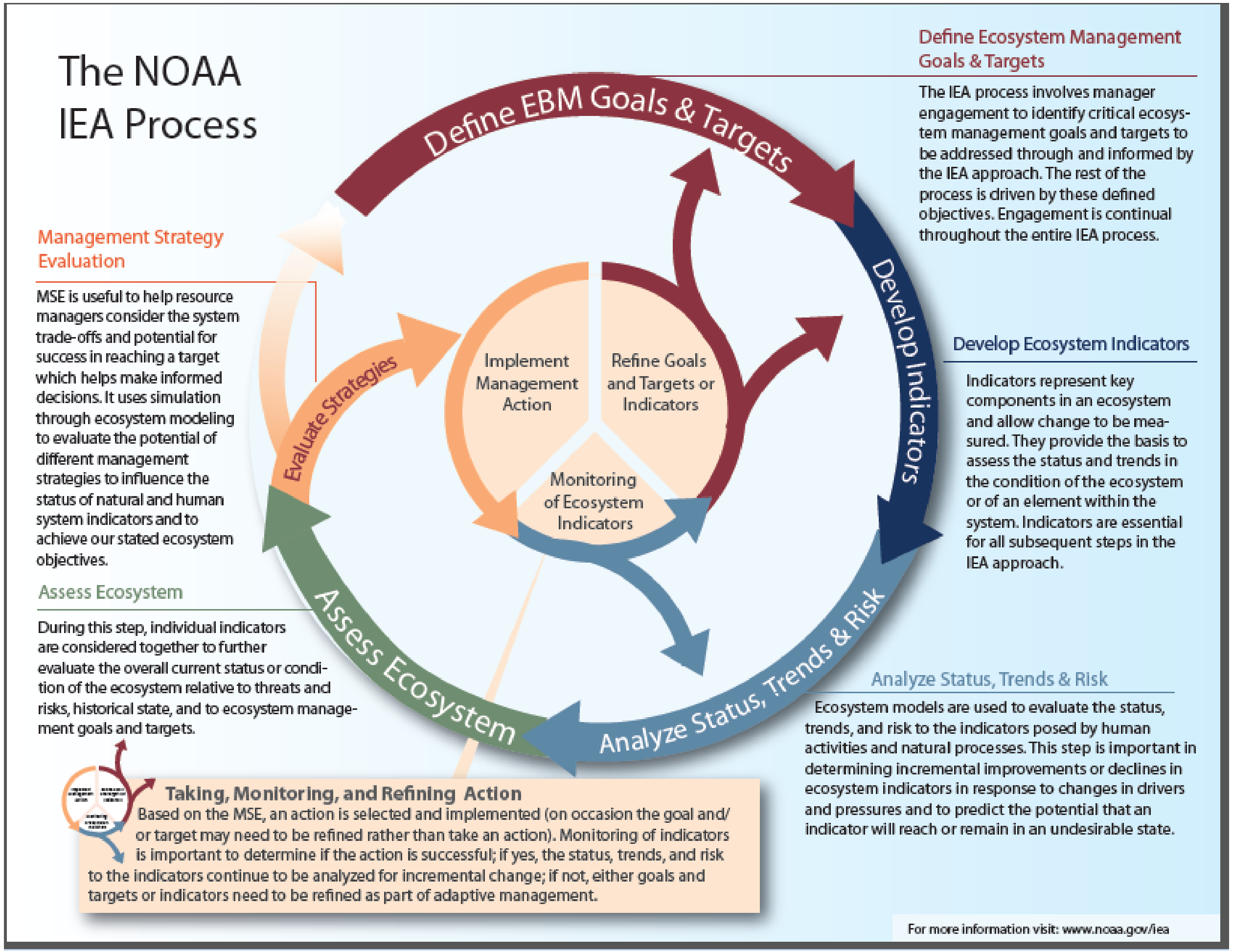
NOAA
FISHERIES
SERVICE

Methods

Define goals and targets:

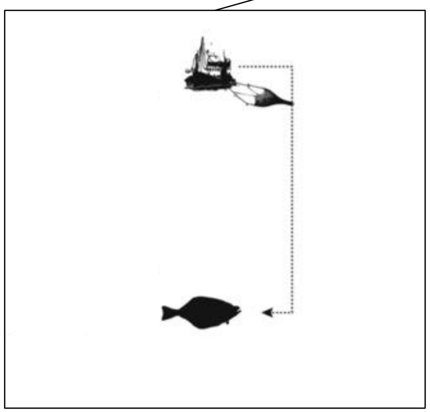
For some aspects, FEP may define goals and targets.

For some aspects, define how to define goals and targets.

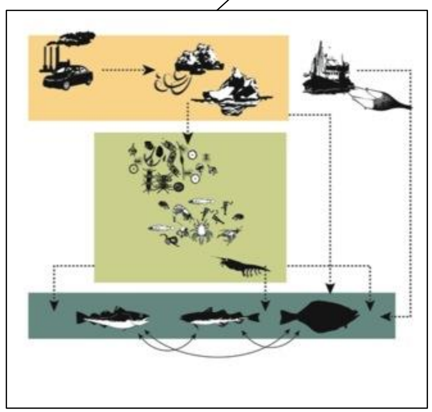


Tools

Bering Sea Models

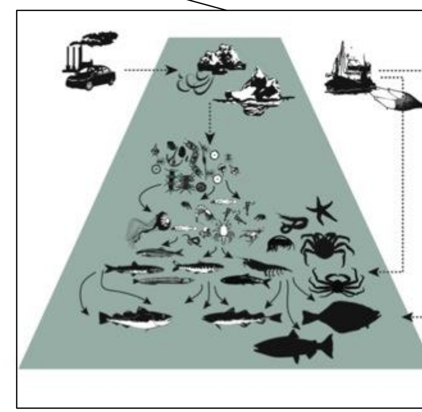


Single Species



CEATTLE

ECOPATH



FEAST

Spatial

Additive Pressures

Multiple Interacting (non-linear) Pressures

Non-linear Species Interactions; Non-linear Cumulative Effects

Estimation of Error/ multiple random iterations

NOAA
FISHERIES
SERVICE

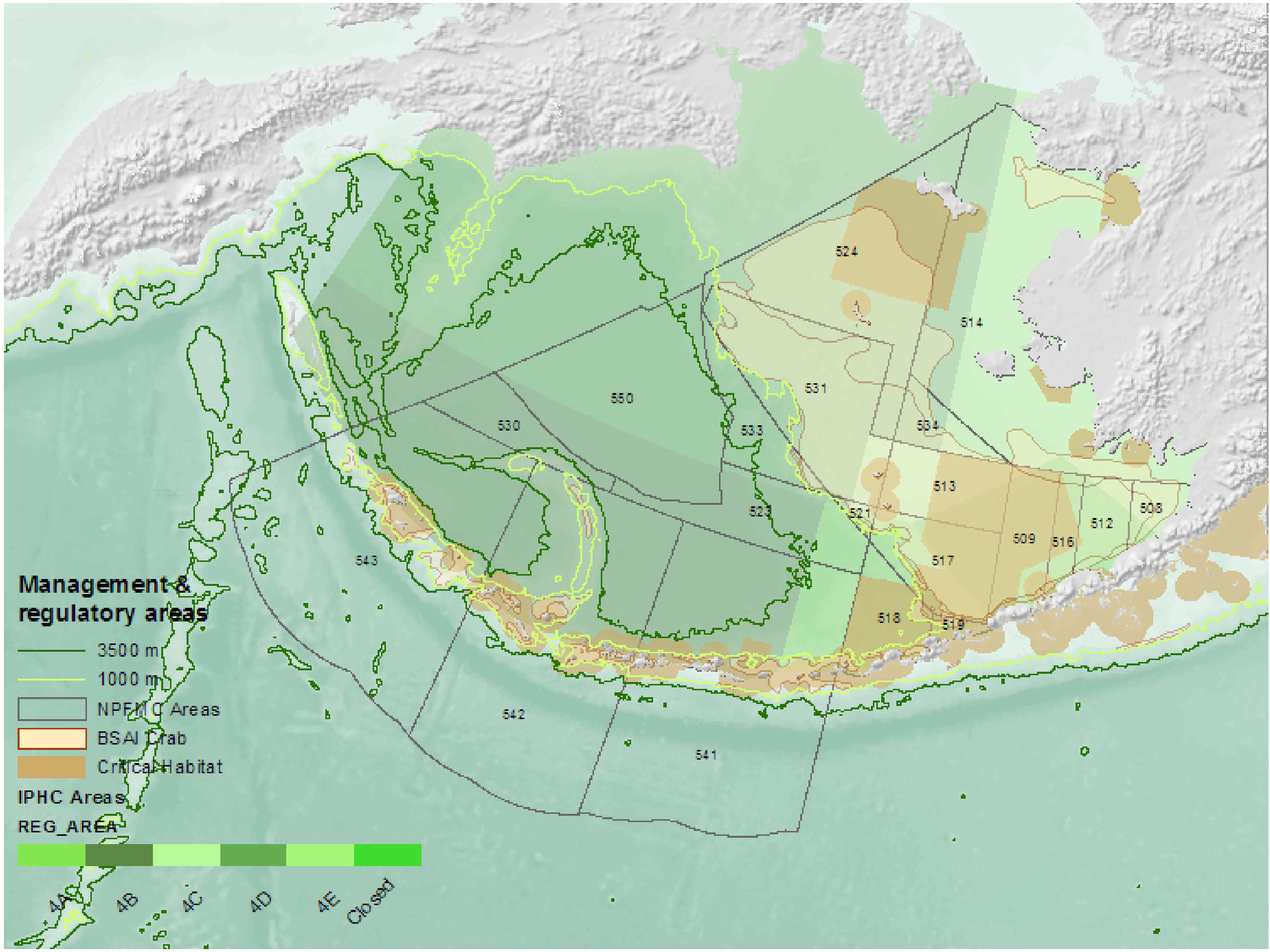
Scoping

NOAA FISHERIES SERVICE

Geographical extent:

Primary management & regulatory areas

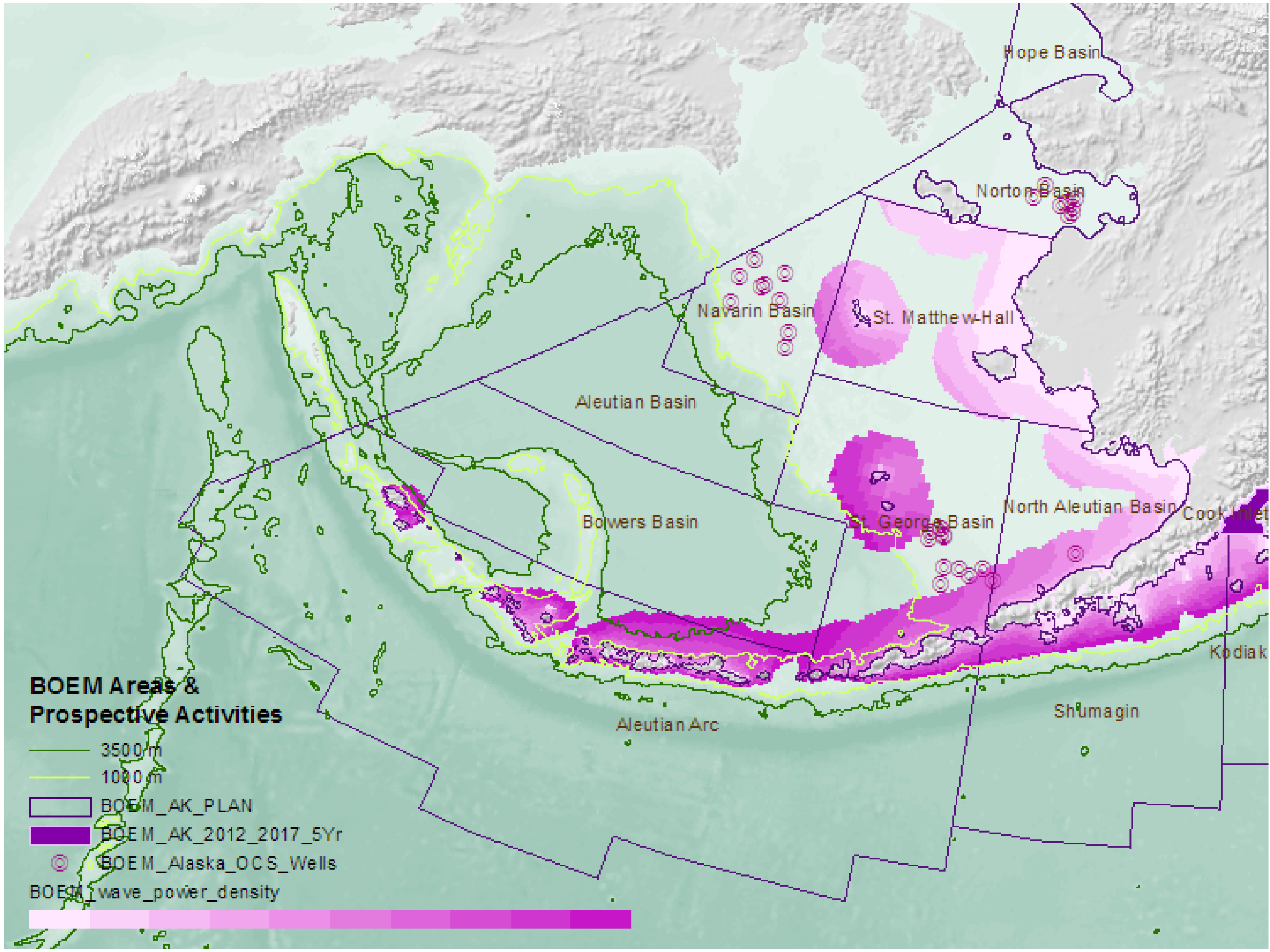
Note: BS versus BSAI?



NOAA FISHERIES SERVICE

Geographical extent:

Other Sectors: BOEM areas and prospective activities



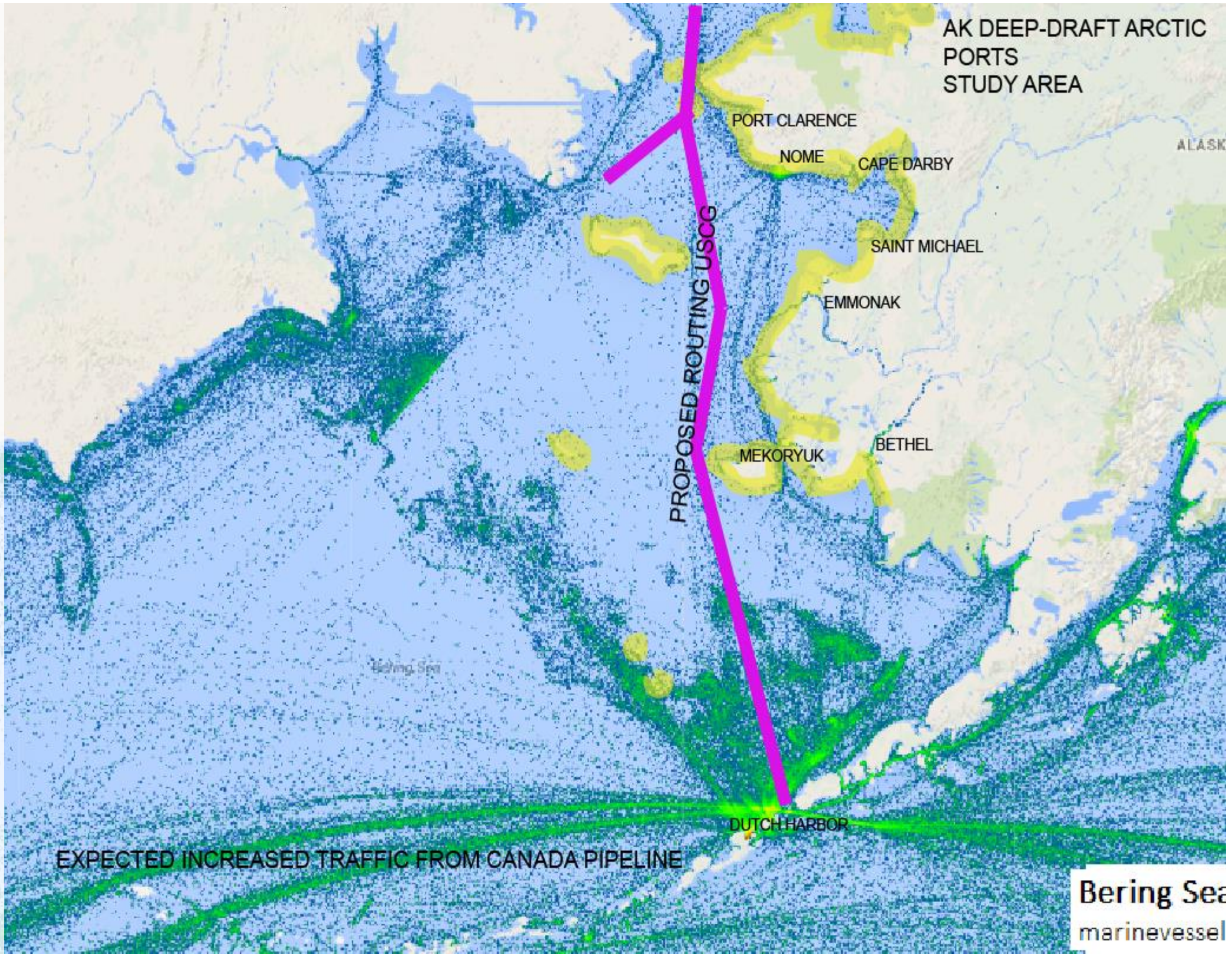
NOAA FISHERIES SERVICE

Vessel traffic

Ports: AK Dept Transportation & Public Facilities + US Army Corps of Engineers

Proposed Routing: US Coast Guard

Particularly Sensitive Areas: Bering Strait & Unimak Pass (recommendation to) International Maritime Organization



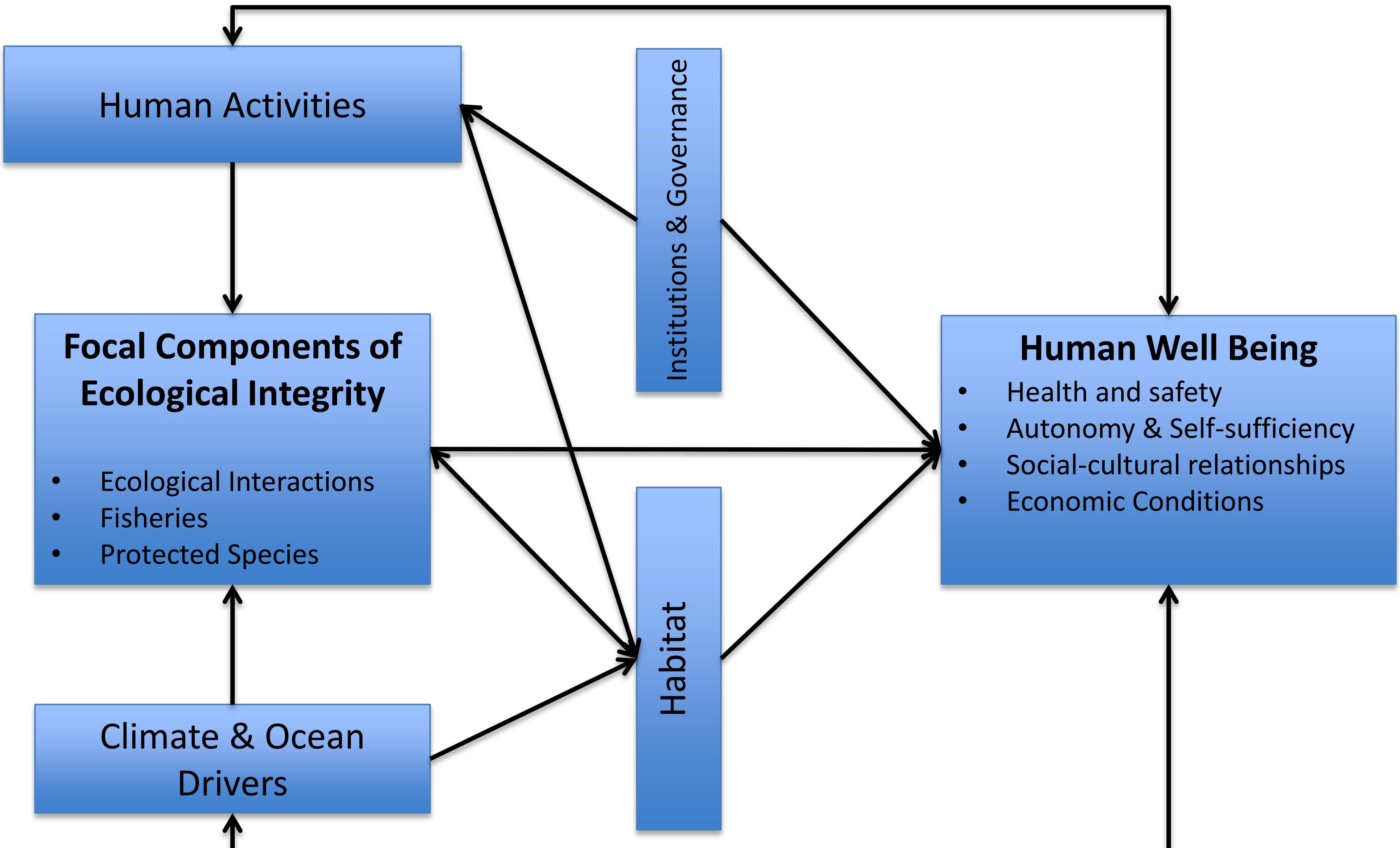
Conceptual Models: Goals

Goals of conceptual model development:

- Unifying framework
  - Single construct that crosses disciplines
  - Clarifies system boundaries
  - Reveals gaps
- Communication Tool
  - Within group
  - To other scientists
  - To the public
- Linking
  - Indicators should consistently map back to elements of model
  - Integrates concepts across ecological component

Conceptual model Example 1.1

Overview: Socio-Ecological System



Conceptual models: Example 1.2

CALIFORNIA CURRENT INTEGRATED ECOSYSTEM ASSESSMENT

Conceptual models: Example 2.1

Ecological Components

1. **[Ecological Interactions]:**

   What are the strongest food web interactions

2. **[Environmental Drivers]:**

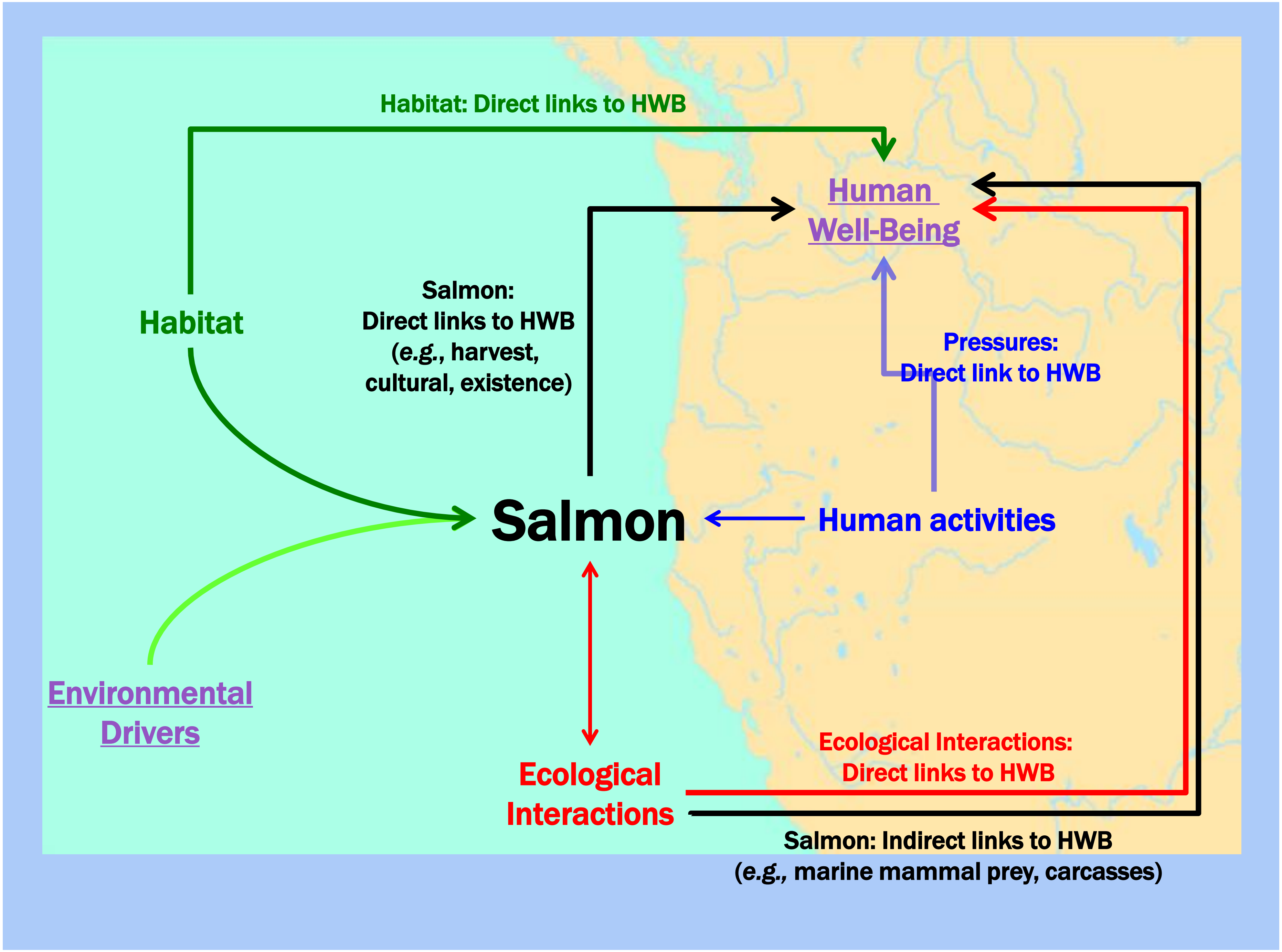
   What are the acknowledged drivers of abundance and community composition?

3. **[Human Activities]:**

   What are the strongest known human interactions or human risks posed to this group?

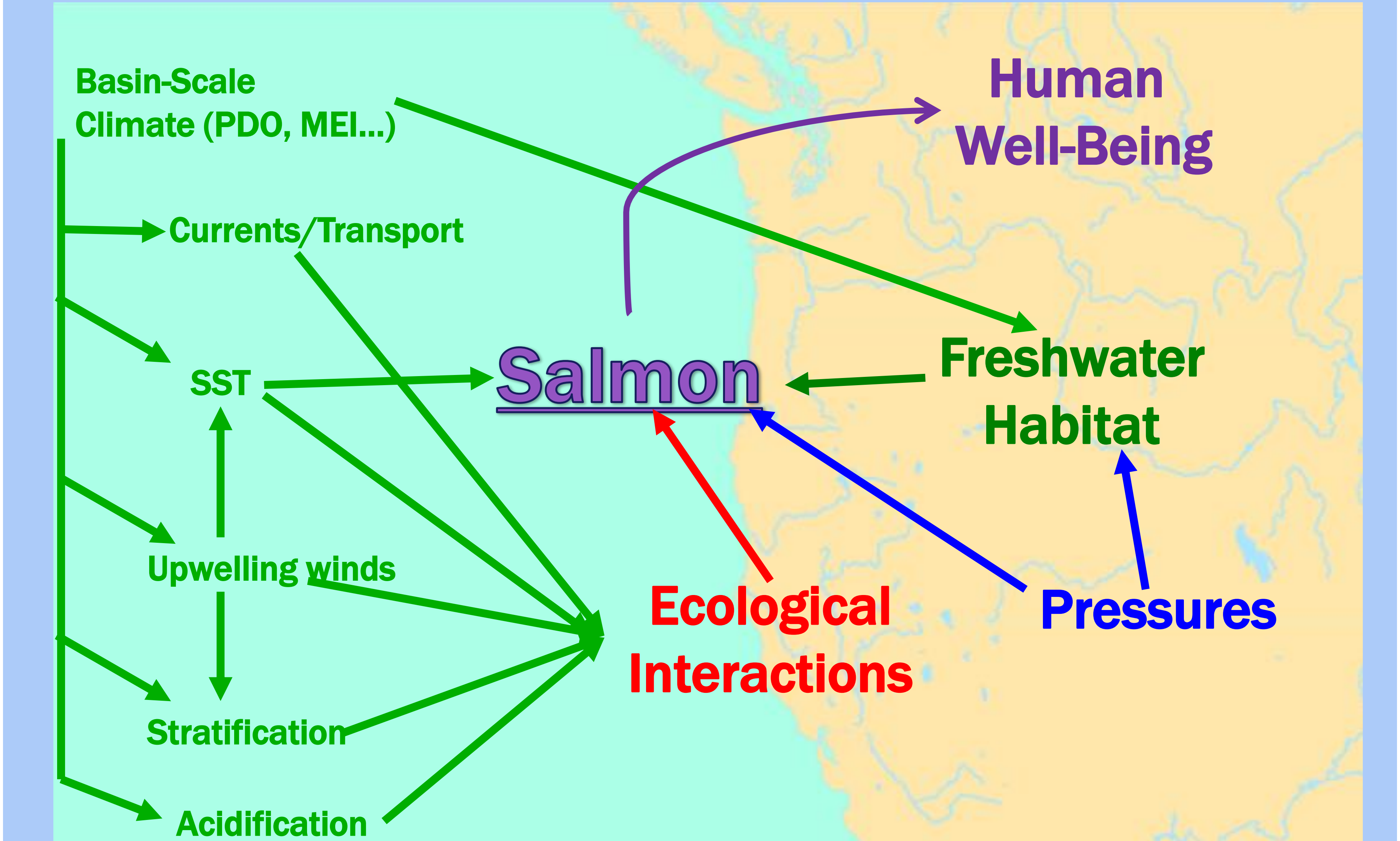
4. **[Human Wellbeing]:**

   Human dimension; context



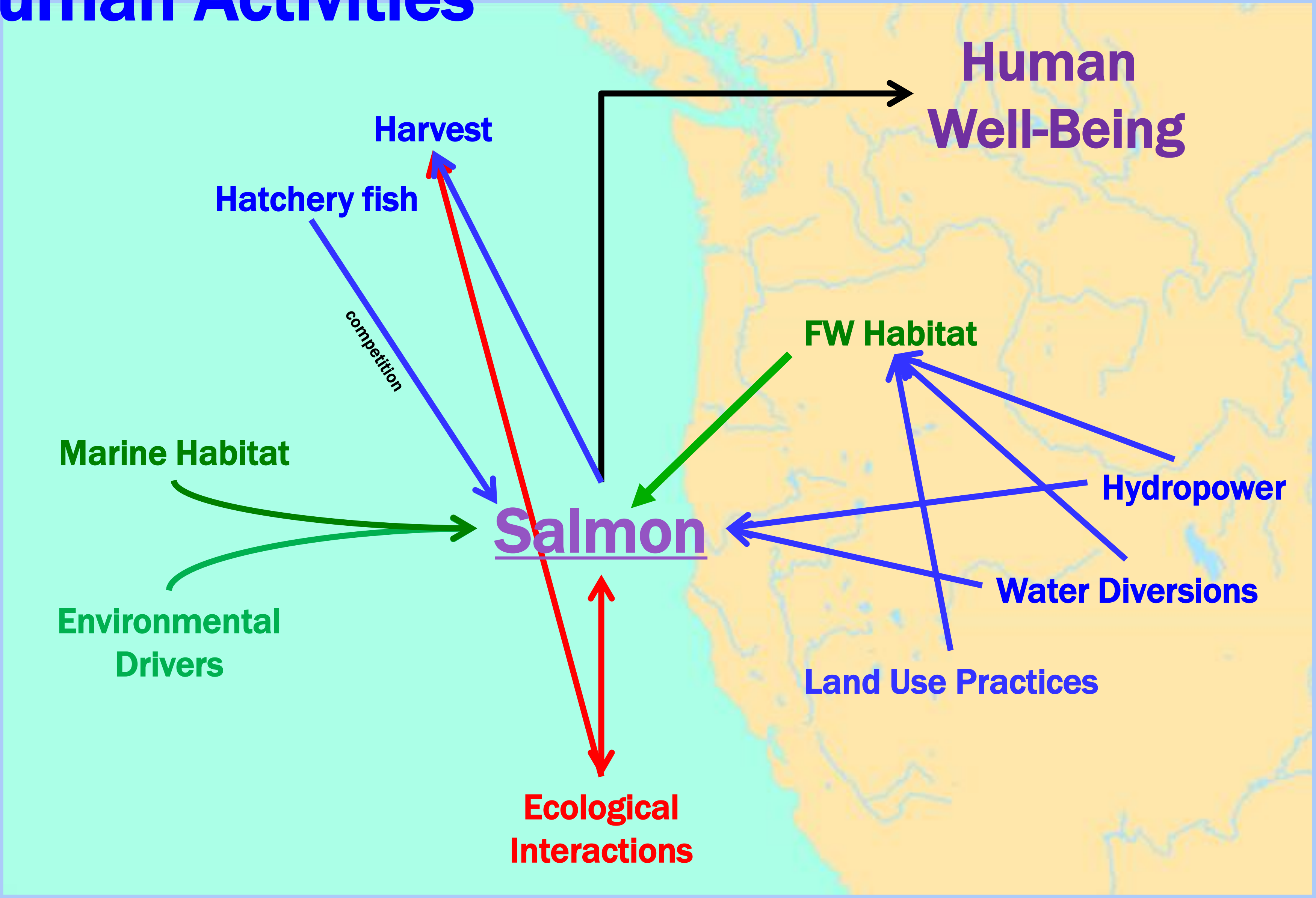
Habitat: Direct links to HWB
Human Well-Being
Habitat
Salmon:
Direct links to HWB
(e.g., harvest,
cultural, existence)
Pressures:
Direct link to HWB
Salmon
Human activities
Environmental Drivers
Ecological Interactions:
Direct links to HWB
Ecological Interactions
Salmon: Indirect links to HWB
(e.g., marine mammal prey, carcasses)

Environmental drivers

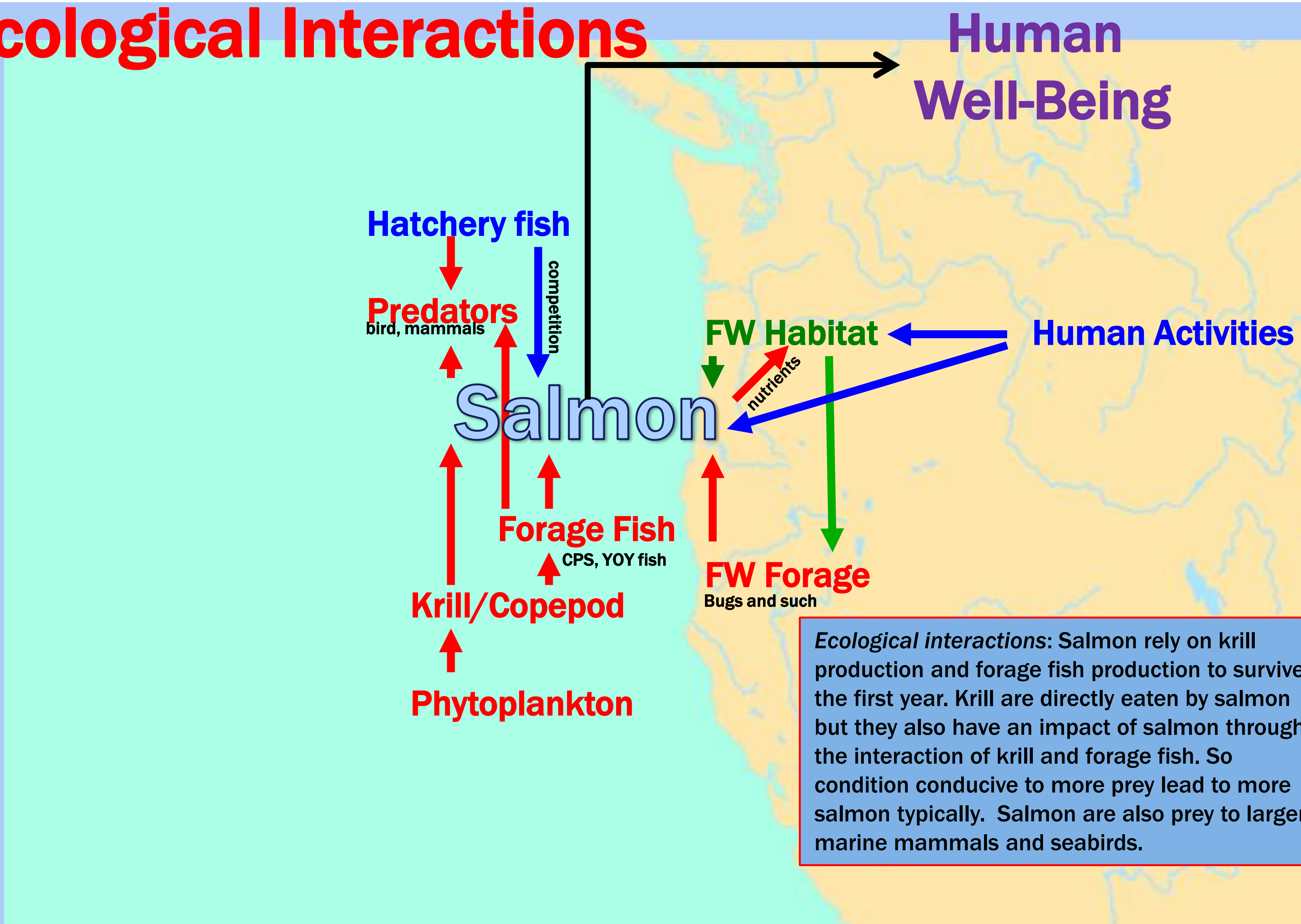


Environmental drivers: Ocean drivers are largely dependent on basin-scale forcing such as PDO state. Specifically, PDO, MEI and such represent the forces that ultimately result in local production. There is also a need to consider regional drivers such as local upwelling and wind dynamics and they translate to water column characteristics and forage dynamics. Freshwater habitat and the factors related to it relate to the production of salmon entering the ocean.

Human Activities

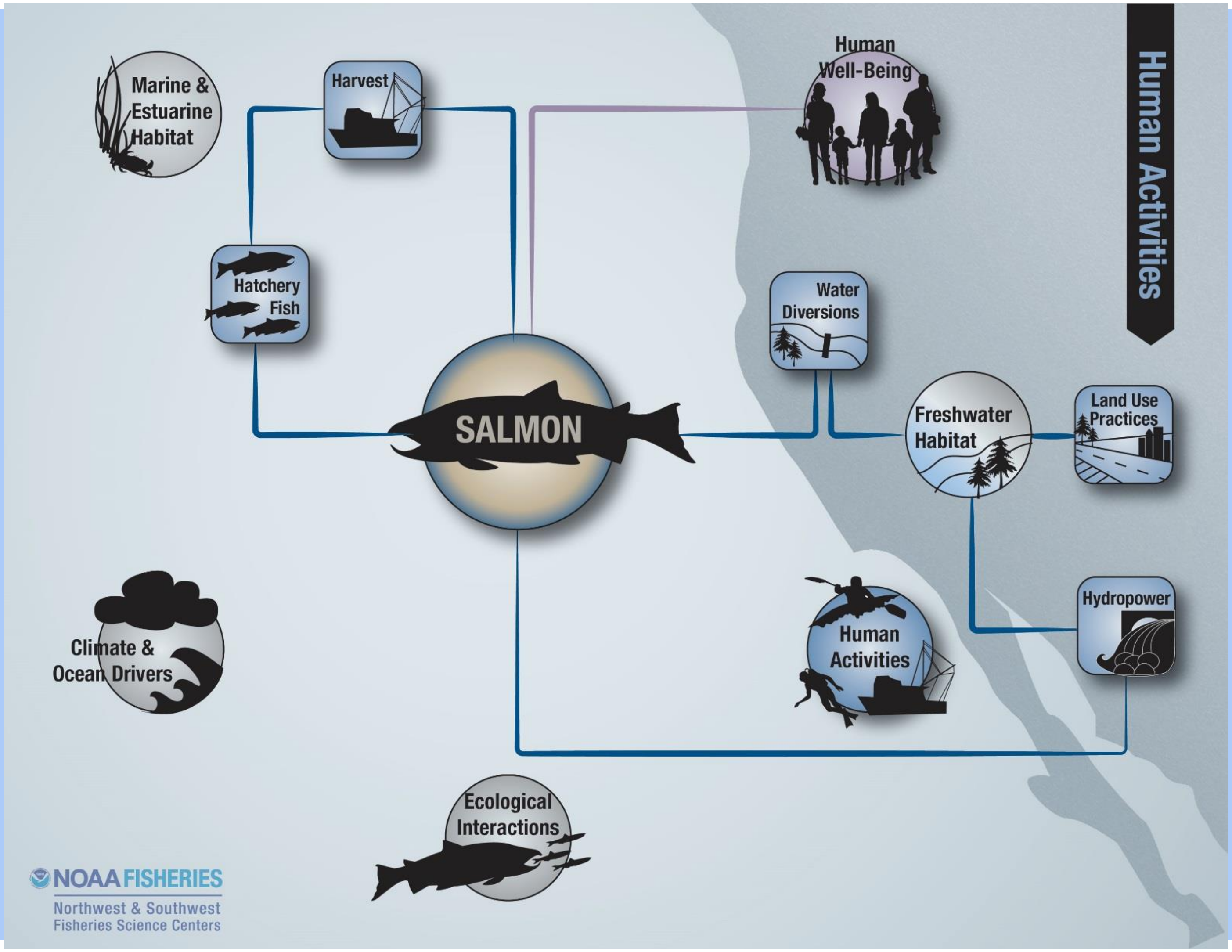


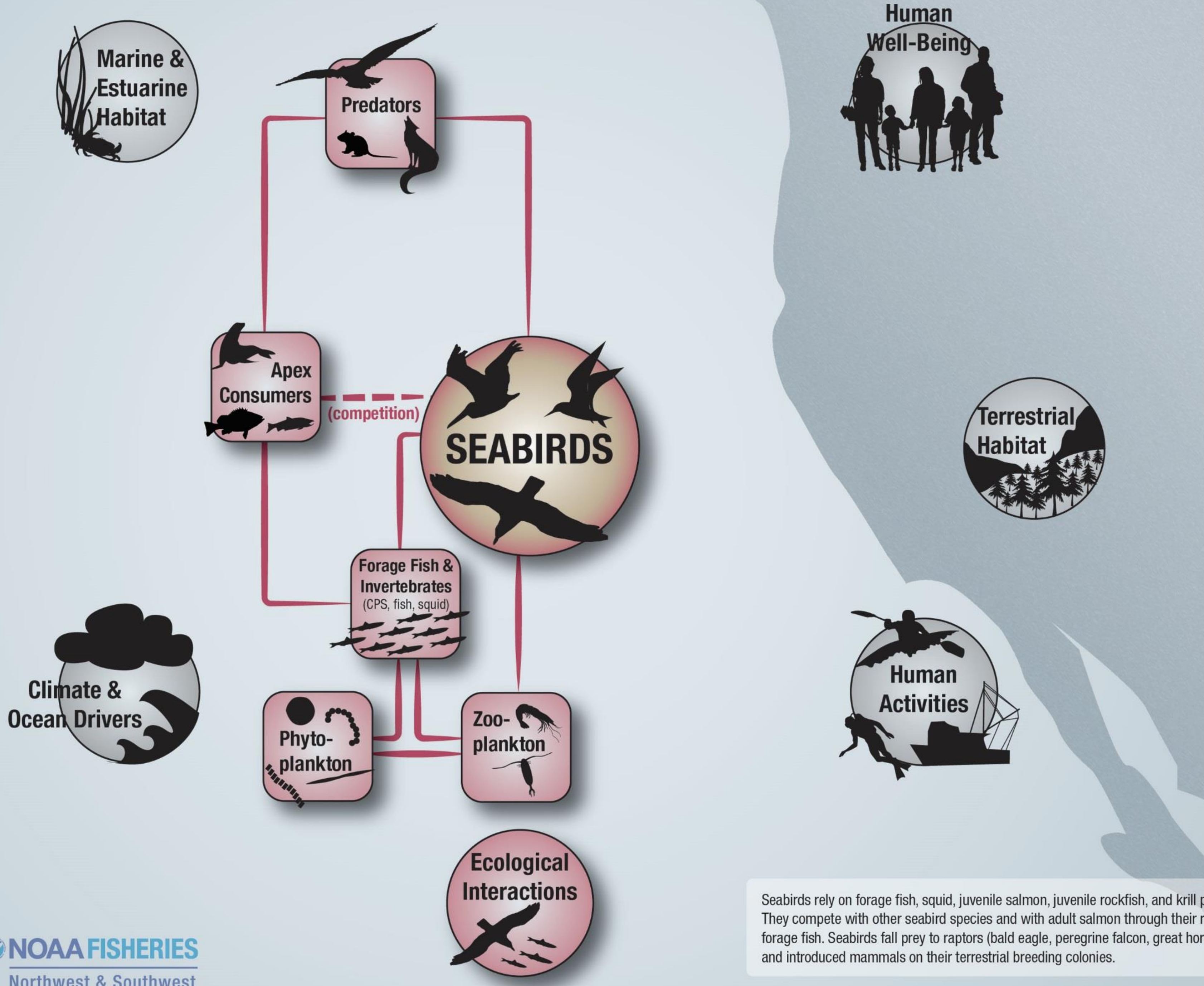
Ecological Interactions



Ecological interactions: Salmon rely on krill production and forage fish production to survive the first year. Krill are directly eaten by salmon but they also have an impact of salmon through the interaction of krill and forage fish. So condition conducive to more prey lead to more salmon typically. Salmon are also prey to larger marine mammals and seabirds.

CONCEPTUAL MODEL EXAMPLE 2.2 SALMON





Seabirds rely on forage fish, squid, juvenile salmon, juvenile rockfish, and krill production. They compete with other seabird species and with adult salmon through their reliance on forage fish. Seabirds fall prey to raptors (bald eagle, peregrine falcon, great horned owl) and introduced mammals on their terrestrial breeding colonies.

CCIEA
CALIFORNIA CURRENT INTEGRATED ECOSYSTEM ASSESSMENT

Conceptual Models

Strengths

- Simple, elegant, engaging; good communication tool
- Readily adaptable
- Help us identify gaps, inconsistencies, biases
- Organize suites of indicators or predictors
- Good reminders from time to time


CCIEA PHASE III REPORT 2013: ECOSYSTEM COMPONENTS, FISHERIES – COASTAL PELAGICS AND FORAGE

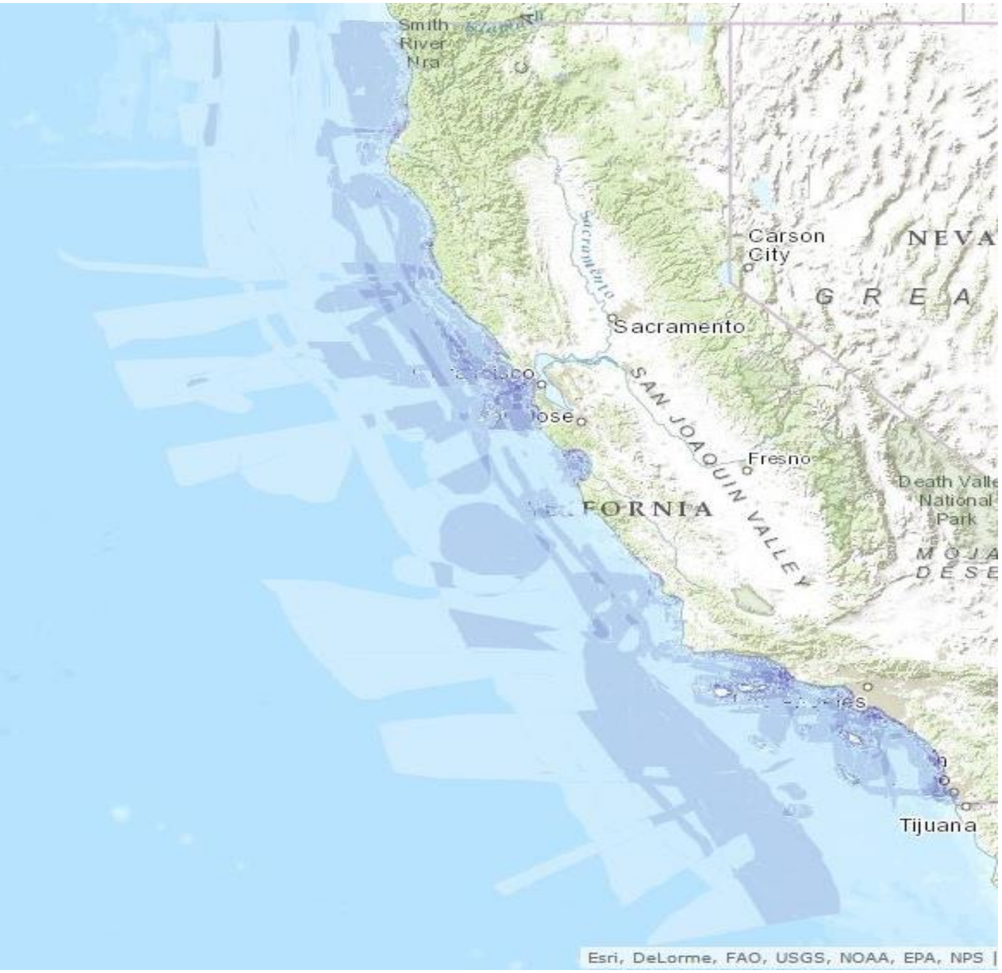
COASTAL PELAGIC AND FORAGE FISHES

Brian K. Wells[1], Richard D. Brodeur[2], John C. Field[1], Ed Weber[1], Andrew R. Thompson[1], Sam McClatchie[1], Paul R. Crone[1], Kevin T. Hill[1], Caren Barceló[3]

1. NOAA Fisheries, Southwest Fisheries Science Center
2. NOAA Fisheries, Northwest Fisheries Science Center
3. Oregon State University, College of Earth, Ocean and Atmospheric Science, 104 CEOAS Administration Building, Corvallis, Oregon 97331

- **Major development theme/product of an FEP?**

NOAA FISHERIES SERVICE



AK differences from other regions:

High number of native Alaskan communities

Very limited Coastal development

Limited marine uses other than fishing (vs CA: oil, mining, alternative energy, military)

No Coastal Management

Management scope (salmon, crab)

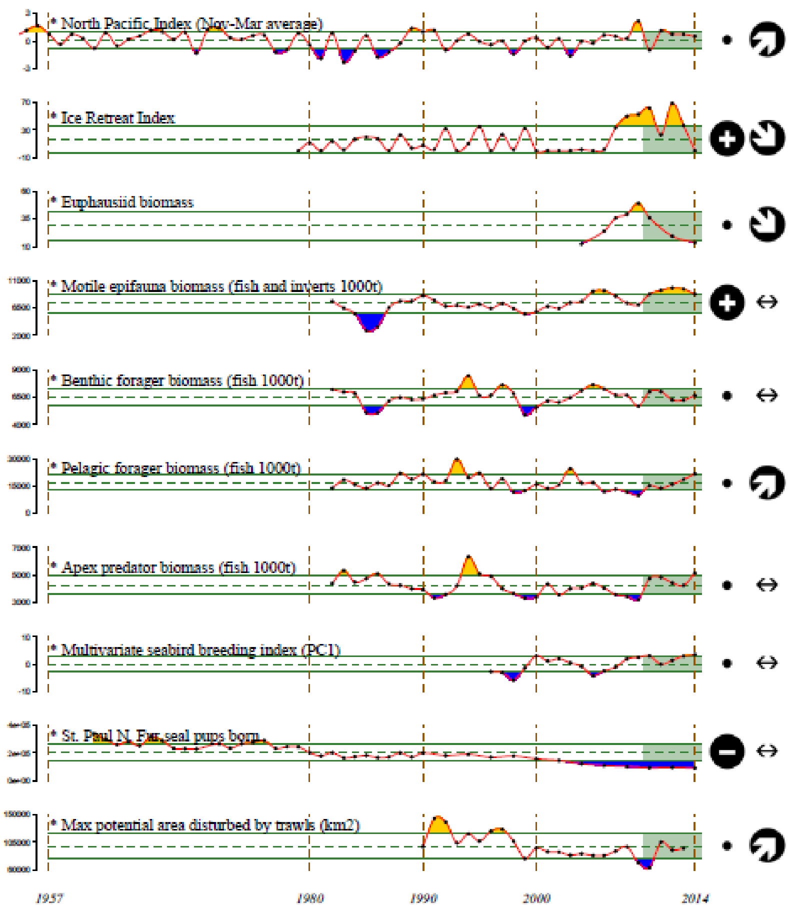
NOAA FISHERIES SERVICE

Develop Indicators

Developing Indicators: Report Cards

Eastern Bering Sea 2014 Report Card

- The North Pacific atmosphere-ocean system during 2013-2014 featured **the development of strongly positive SST anomalies south of Alaska**. This warming was caused by unusually quiet weather conditions during the winter of 2013-14 in association with a weak Aleutian low (positive NPI), and abnormally high SLP off the coast of the Pacific Northwest.
- The **eastern Bering Sea experienced warmer air temperatures and less sea ice** that were related to the broader North Pacific conditions. Dates of sea ice retreat, summer surface and bottom temperatures, and the extent of the cold pool were **similar to those of the warm years of 2003-2005**.
- The summer **acoustically-determined time series of euphausiids continues to decrease** from its peak in 2009. This suggests that prey availability for planktivorous fish, seabirds, and mammals was low in 2014.
- **Survey biomass of motile epifauna** has been **above its long-term mean** since 2010, although the trend has stabilized. However, the trend of the last 30 years shows a **decrease in crustaceans** (especially commercial crabs) and a **long-term increase in echinoderms**, including brittle stars, sea stars, and sea urchins. It is not know the extent to which this reflects changes in survey methodology rather than actual trends.
- **Survey biomass of benthic foragers has remained stable** since 1982, with interannual variability driven by short-term fluctuations in yellowfin and rock sole abundance.
- **Survey biomass of pelagic foragers has increased steadily** since 2009 and is currently above its 30-year mean. While this is primarily driven by the **increase in walleye pollock** from its historical low in the survey in 2009, it is also a result of **increases in capelin from 2009-2013**, perhaps due to cold conditions prevalent in recent years.
- **Fish apex predator survey biomass is currently above its 30-year mean**, although the increasing trend seen in recent years has leveled off. **The increase since 2009** back towards the mean is driven primarily by the increase in Pacific cod from low levels in the early 2000s. **Arrowtooth flounder**, while still above its long-term mean, **has declined nearly 50% in the survey from early 2000s** highs, although this may be due to a distributional shift in response to colder water over the last few years, rather than a population decline.
- **The multivariate seabird breeding index is above the long term mean**, indicating that seabirds bred earlier and more successfully in 2014. This suggests that **foraging conditions were favorable for piscivorous seabirds**.
- **Northern fur seal pup production for St. Paul Island remained low** in 2014, with fewer pups produced than the last survey in 2012.



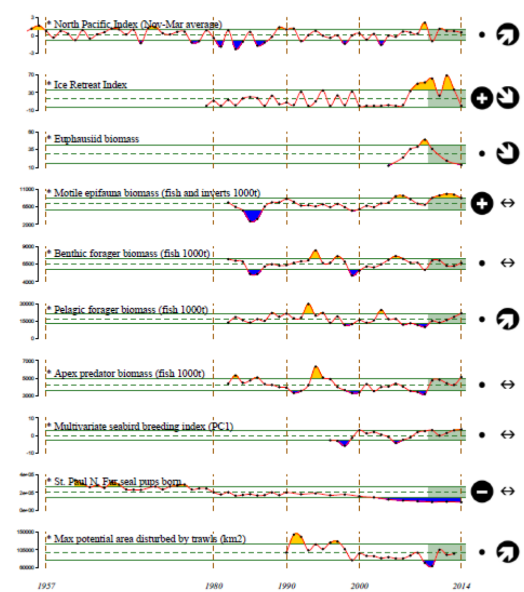
Current Report Cards: EBS and AI

"Team-based Synthesis Approach"

- Created Ecosystem Assessment Synthesis teams: regional scientific experts, fisheries managers, others
- Met 1-2 times
- Chose structuring themes to guide indicator selection
- Developed list of 8-10 indicators:
  - "vital signs"
  - updatable

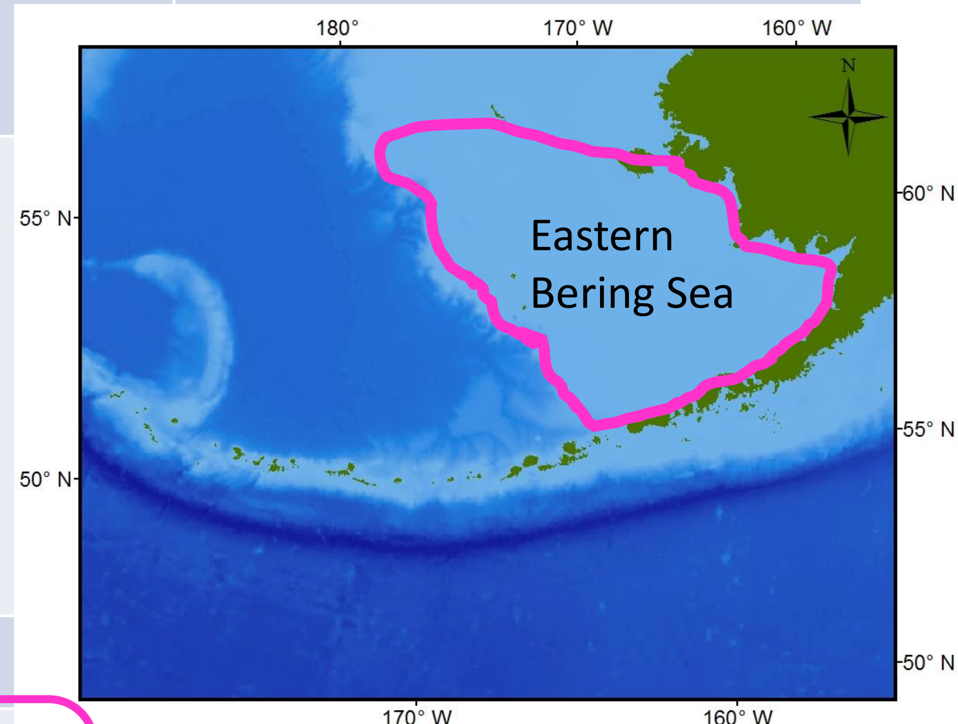
Eastern Bering Sea 2014 Report Card

- The North Pacific atmosphere-ocean system during 2013-2014 featured **the development of strongly positive SST anomalies south of Alaska**. This warming was caused by unusually quiet weather conditions during the winter of 2013-14 in association with a weak Aleutian low (positive NPI), and abnormally high SLP off the coast of the Pacific Northwest.
- The **eastern Bering Sea experienced warmer air temperatures and less sea ice** that were related to the broader North Pacific conditions. Dates of sea ice retreat, summer surface and bottom temperatures, and the extent of the cold pool were **similar to those of the warm years of 2003-2005**.
- The summer **acoustically-determined time series of euphausiids continues to decrease** from its peak in 2009. This suggests that prey availability for planktivorous fish, seabirds, and mammals was low in 2014.
- **Survey biomass of motile epifauna** has been **above its long-term mean** since 2010, although the trend has stabilized. However, the trend of the last 30 years shows a **decrease in crustaceans** (especially commercial crabs) and a **long-term increase in echinoderms**, including brittle stars, sea stars, and sea urchins. It is not know the extent to which this reflects changes in survey methodology rather than actual trends.
- **Survey biomass of benthic foragers has remained stable** since 1982, with interannual variability driven by short-term fluctuations in yellowfin and rock sole abundance.
- **Survey biomass of pelagic foragers has increased steadily** since 2009 and is currently above its 30-year mean. While this is primarily driven by the **increase in walleye pollock** from its historical low in the survey in 2009, it is also a result of **increases in capelin from 2009-2013**, perhaps due to cold conditions prevalent in recent years.
- **Fish apex predator survey biomass is currently above its 30-year mean**, although the increasing trend seen in recent years has leveled off. **The increase since 2009** back towards the mean is driven primarily by the increase in Pacific cod from low levels in the early 2000s. **Arrowtooth flounder**, while still above its long-term mean, **has declined nearly 50% in the survey from early 2000s** highs, although this may be due to a distributional shift in response to colder water over the last few years, rather than a population decline.
- **The multivariate seabird breeding index is above the long term mean**, indicating that seabirds bred earlier and more successfully in 2014. This suggests that **foraging conditions were favorable for piscivorous seabirds**.
- **Northern fur seal pup production for St. Paul Island remained low** in 2014, with fewer pups produced than the last survey in 2012.



Ecosystem comparison

	Eastern Bering Sea	Aleutian Islands
Habitat	Broad, flat, muddy shelf. Valuable fisheries. Fish-related research.	
Team members: NOAA Academia Management Commercial Other Fed Non Profit Research sponsor	 17 2 1 (3)	
Structuring theme	Production	
Indicator focus	Broad, community-level, indicators of ecosystem-wide productivity, and those most informative for managers	



Results

Indicators
Climate
Zooplankton
Forage fish
Fish biomass
Marine Mammals
Seabirds
Humans

Results

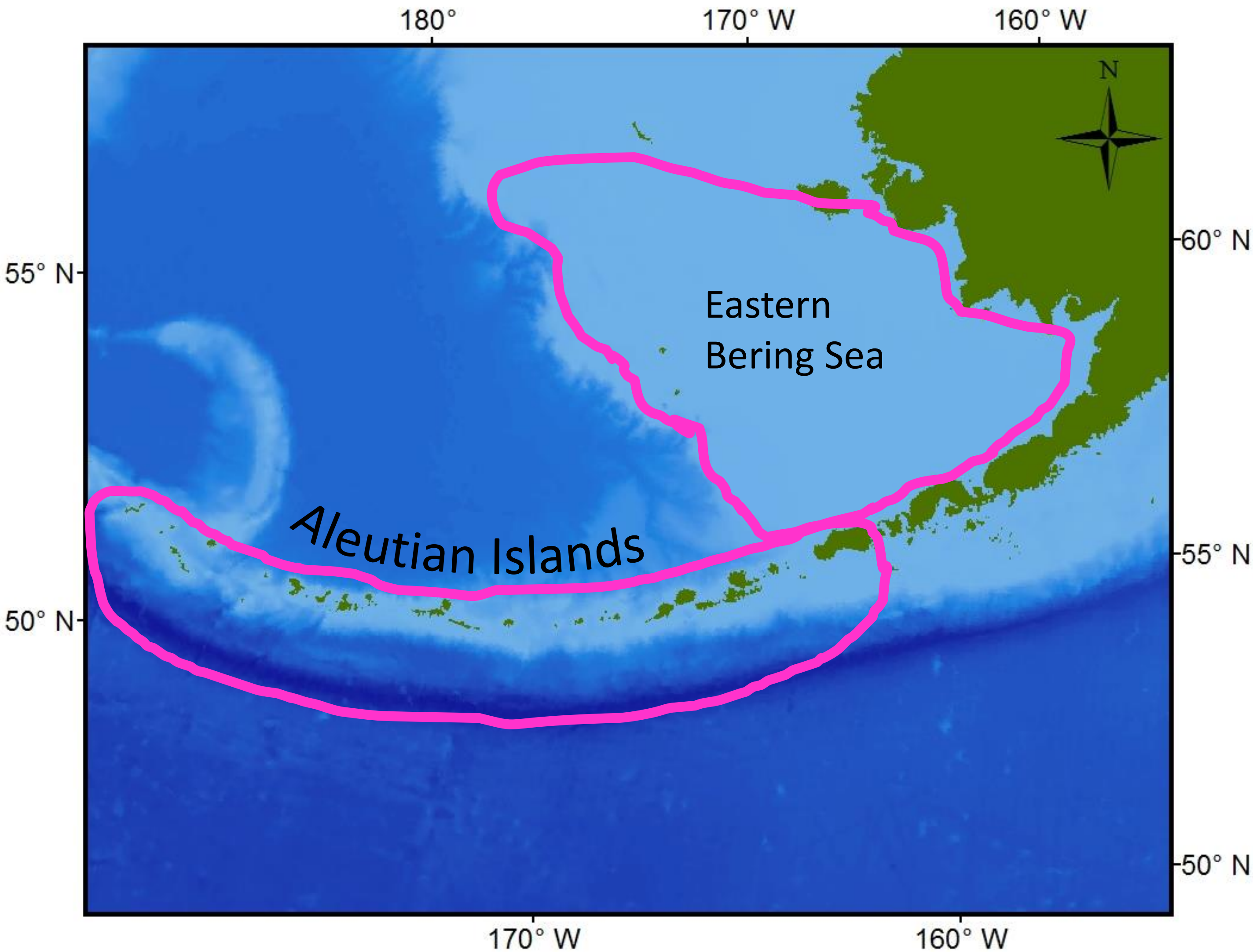
EASTERN BERING SEA

- North Pacific Index
- Ice Retreat Index
- Euphausiids/Copepods
- Motile epifauna biomass
- Benthic foragers biomass
- Pelagic foragers biomass
- Fish apex predator biomass
- St Paul fur seal pups
- ~~St George thick-billed murre reproductive success~~
- Area trawled

Indicators
Climate
Zooplankton
Forage fish
Fish biomass
Marine Mammals
Seabirds
Humans

Multivariate seabird index

Aleutian Islands



Ecosystem comparison

	Eastern Bering Sea	Aleutian Islands
Habitat	Broad, flat, muddy shelf. Valuable fisheries -> Lots of fish-related research.	Extensive rocky island chain, deep trenches, oceanic basins. Smaller-scale fisheries (and research)
Team members: NOAA Academia Management Commercial Other Fed Non Profit Research sponsor	 17 2 1 (3)	 10 4 1 1 2 1 1
Structuring theme	Production	Variability
Indicator focus	Broad, community-level, indicators of ecosystem-wide productivity, and those most informative for managers	Characterize global attributes with local behavior

Some similarities, some differences

EASTERN BERING SEA

- North Pacific Index
- Ice Retreat Index
- Euphausiids/Copepods
- Motile epifauna biomass
- Benthic foragers biomass
- Pelagic foragers biomass
- Fish apex predator biomass
- St Paul fur seal pups
- St George thick-billed murre reproductive success
- Area trawled

Indicators
Climate
Zooplankton
Forage fish
Fish biomass
Marine Mammals
Seabirds
Humans

ALEUTIAN ISLANDS

- North Pacific Index
- Auklet reproductive success
- Tufted puffin chick diets
- Pelagic foragers biomass
- Fish apex predator biomass
- Sea otters
- Steller sea lion non-pups
- Area trawled
- K-12 enrollment

Indicator Selection: Conclusions

1. Indicator selection influenced by:
    - Physical and biological nature of ecosystem
    - Extent of regional scientific knowledge
    - Expertise and interests of Team members
2. Assessment development should be iterative process with frequent review by managers

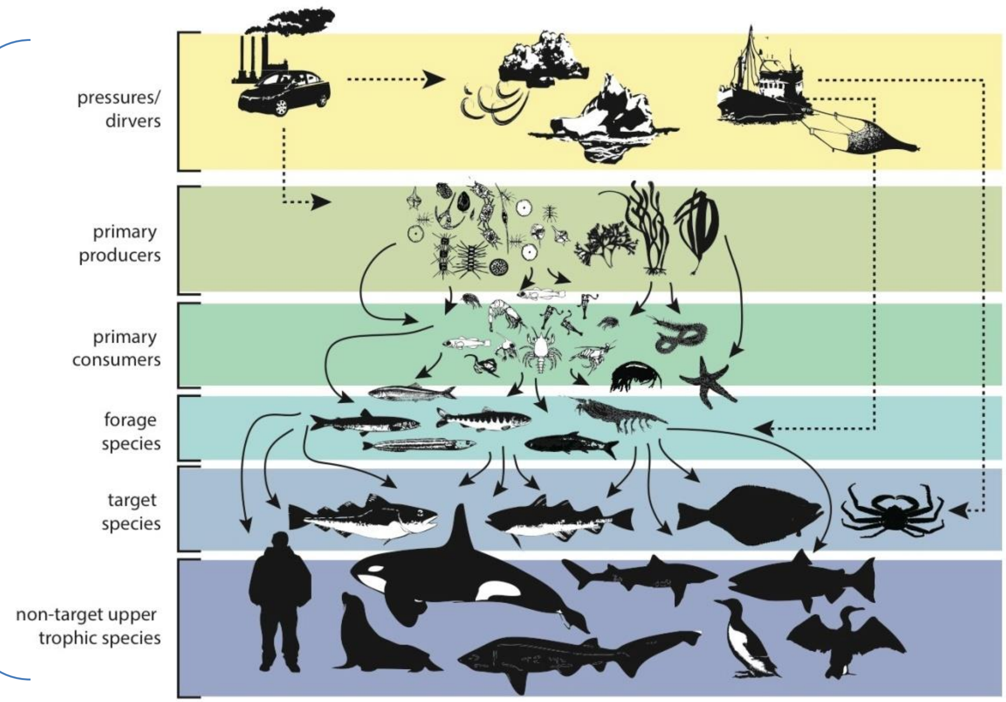
Original plan: Revisit and revise assessments periodically (~ 3-5 yrs) – time to revisit the EBS!

Next steps

- Progress towards the inclusion of ecosystem data directly into stock assessments and resulting management recommendations

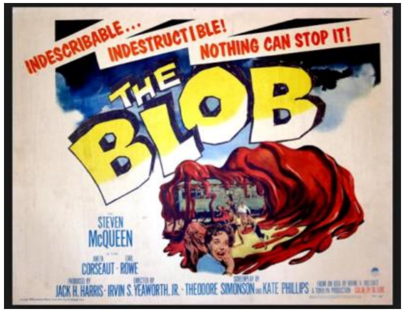
Report Cards for different conceptual model components

Indicators to be selected for each pathway and trophic level



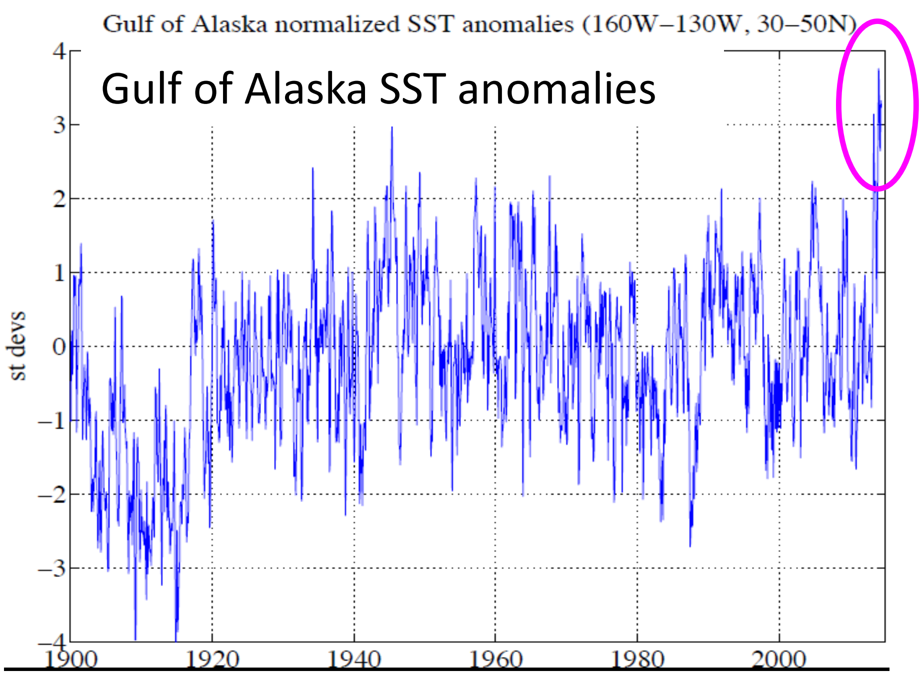
Models for evaluating indicators?

- Qualitative
    - Synthesis



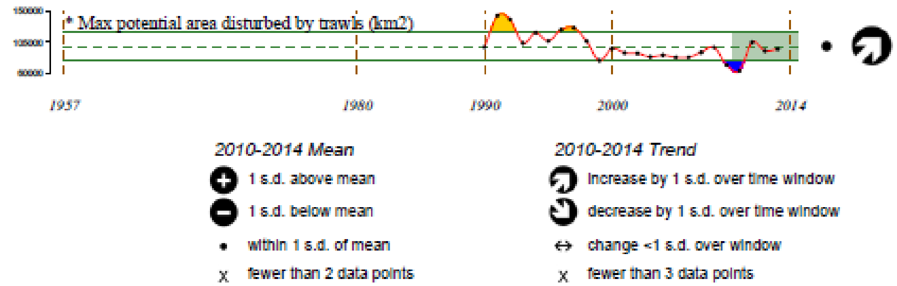
As we build modeling and predictive capacity, we will still need qualitative synthesis to:

- capture events outside the bounds of current models
- detect impacts of the unexpected



Models for evaluating indicators?

- Qualitative
  - Synthesis
- Qualitative/Quantitative
  - Recent 5 year mean relative to long-term mean
  - Recent 5 year trend
- Quantitative
  - Thresholds



Vol. 521: 1–17, 2015
doi: 10.3354/meps11165

MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser

Published February 17

FREE ACCESS

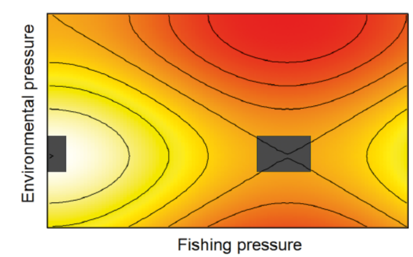
FEATURE ARTICLE

Critical points in ecosystem responses to fishing and environmental pressures

Scott I. Large[1,3,*], Gavin Fay[1,4], Kevin D. Friedland[2], Jason S. Link[1]

[1]NOAA-Fisheries, 166 Water Street, Woods Hole, MA 02543, USA
[2]NOAA, National Marine Fisheries Service, 28 Tarzwell Drive, Narragansett, RI 02882, USA
[3]*Present address:* International Council for the Exploration of the Sea (ICES), Copenhagen V 1553, Denmark
[4]*Present address:* School for Marine Science and Technology, University of Massachusetts Dartmouth, Fairhaven, MA 02719, USA

ABSTRACT: Ecosystem dynamics are often influenced by both environmental and anthropogenic pressures. Increased demand for living marine resources has resulted in global declines of targeted species, which are often managed under a single-species paradigm that does not fully incorporate ecosystem considerations such as ecological interactions or environmental factors. Ecosystem-based fisheries management (EBFM) is a more holistic approach that concurrently addresses human, ecological, and environmental factors influencing living marine resources and evaluates these considerations collectively on a system level. For EBFM, reference points associated with management action need to be quantified. Methods have been developed to assign decision criteria to ecological indicators' response to human-use pressures, yet few efforts have established decision crite-



Critical points (gray polygons) quantified on a surface of ecosystem response dependent upon fishing and environmental pressures.

Image: S. I. Large

NOAA
FISHERIES
SERVICE

Evaluate Status and Thresholds

CCIEA PHASE III REPORT 2013 – COASTAL PELAGICS AND FORAGE, APPENDIX C-1

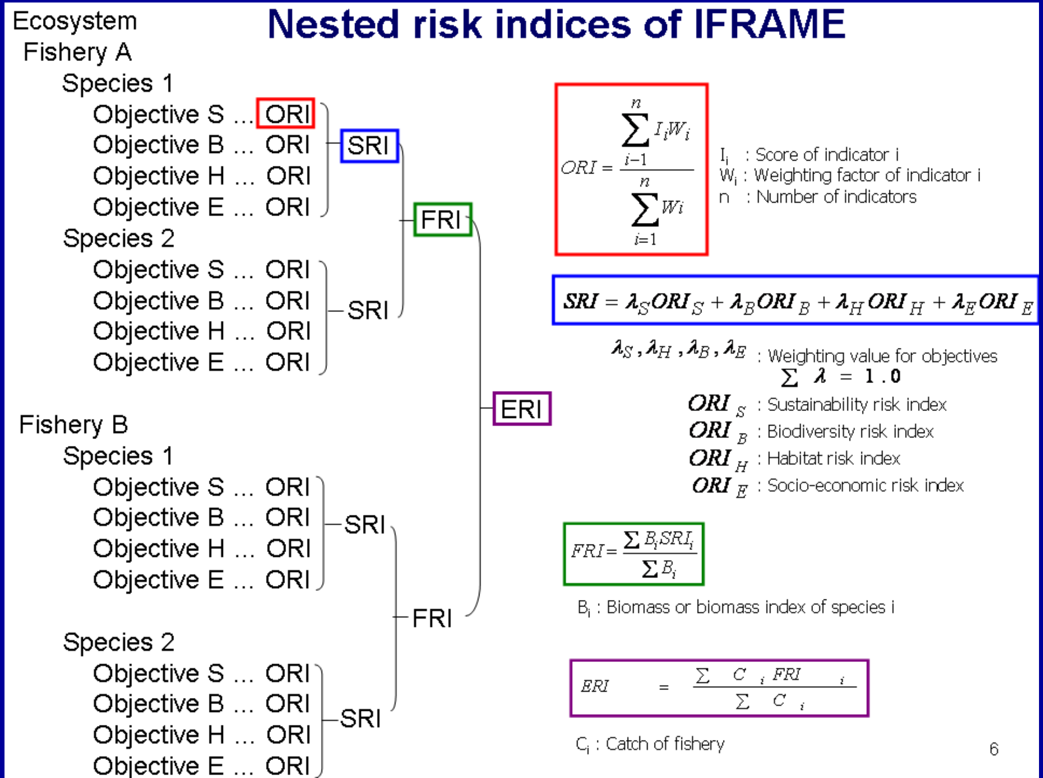
APPENDIX C-1. EVALUATION OF INDICATORS FOR COASTAL PELAGIC AND FORAGE SPECIES USING THE BONNEVILLE POWER ADMINISTRATION DATA SET

Jameal F. Samhouri[1], Gregory D. Williams[1], Richard Brodeur[1], and Caren Barcelo[2]

1. NOAA FISHERIES, NORTHWEST FISHERIES SCIENCE CENTER
2. OREGON STATE UNIVERSITY, COLLEGE OF EARTH, OCEAN AND ATMOSPHERIC SCIENCE, 104 CEOAS ADMINISTRATION BUILDING, CORVALLIS, OREGON 97331

Goal: formal ecosystem thresholds

- Example: 2 million MT cap on total removals from the Bering Sea.
- Future development (e.g. through the Fisheries and the Environment (FATE) program):

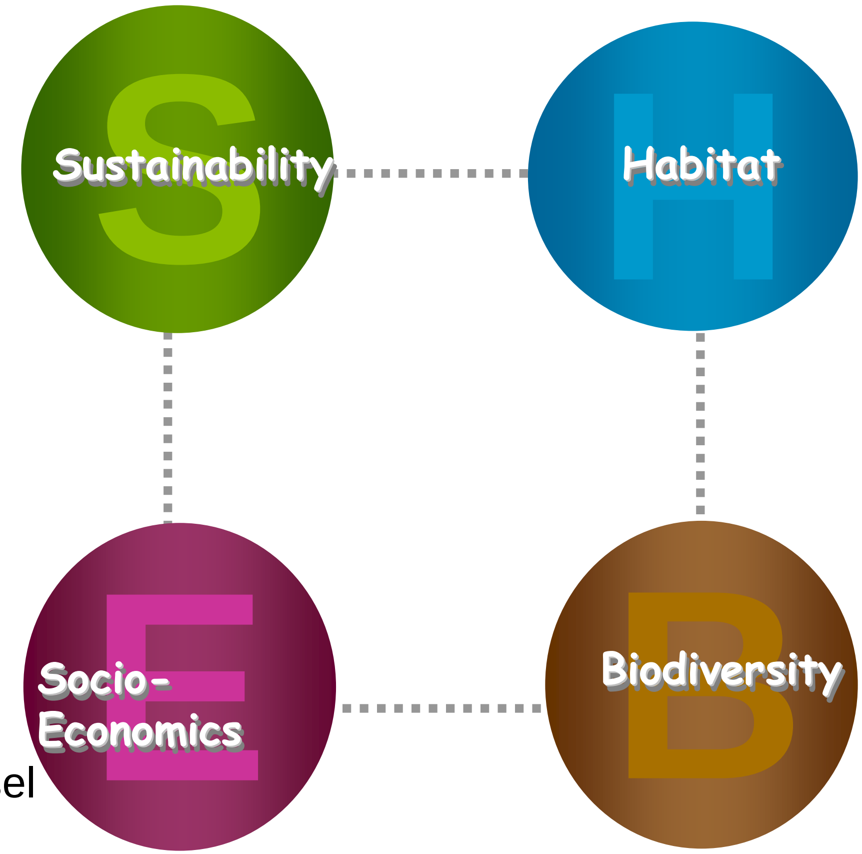


EBS trawl impacts modified from

Integrated Fisheries Risk Assessment for Method for Ecosystems (Zhang et al. 2009)

- Biomass
- Fishing intensity

Habitat size



- Habitat damage
- Discarded wastes
- Habitat protection

- Employment
- Average wage
- Profit-per-vessel

- Discards
- Trophic level
- Diversity
- Integrity of functional group

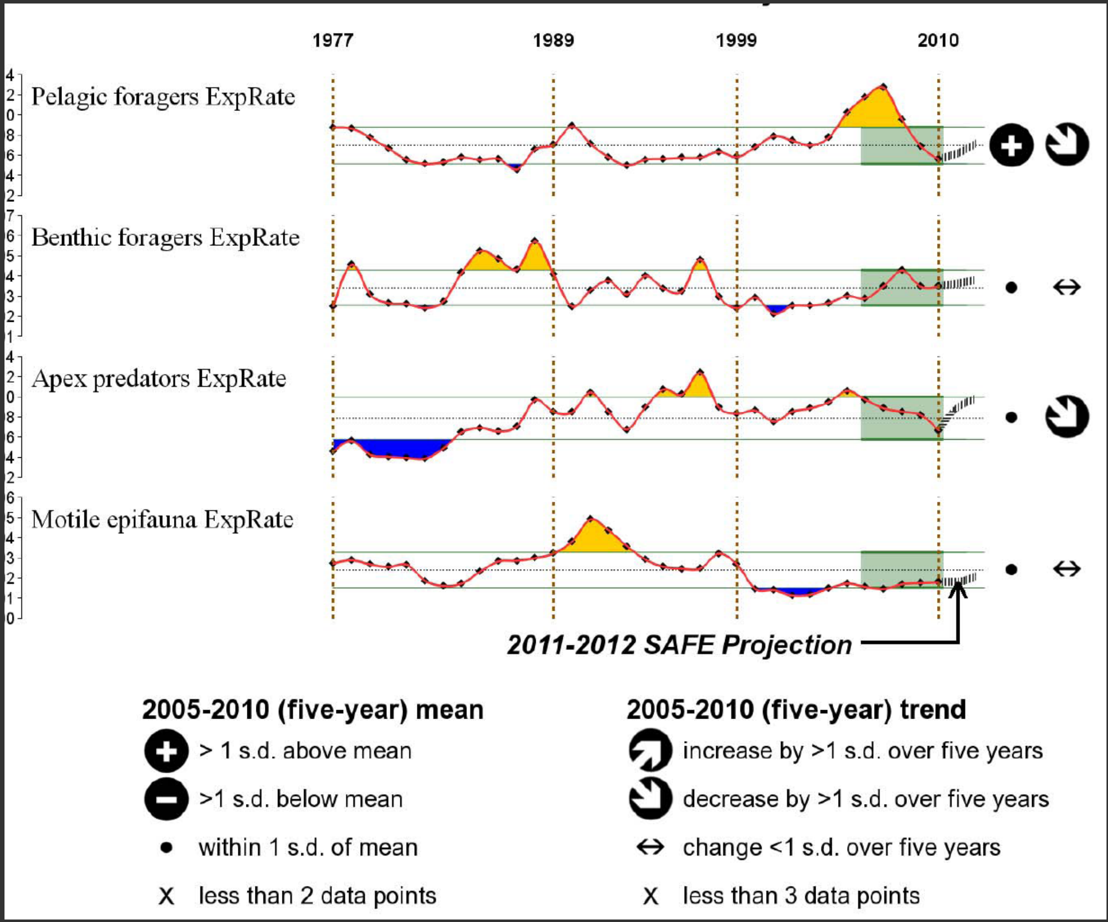
Guild Catch and Exploitation Rates

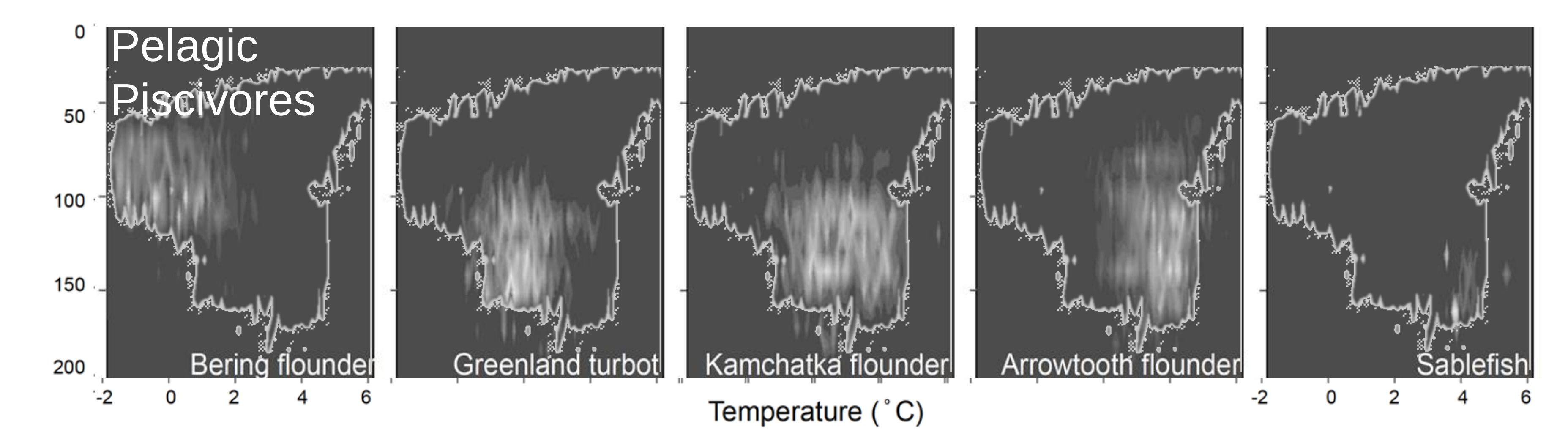
Pelagic foragers aggregate biomass

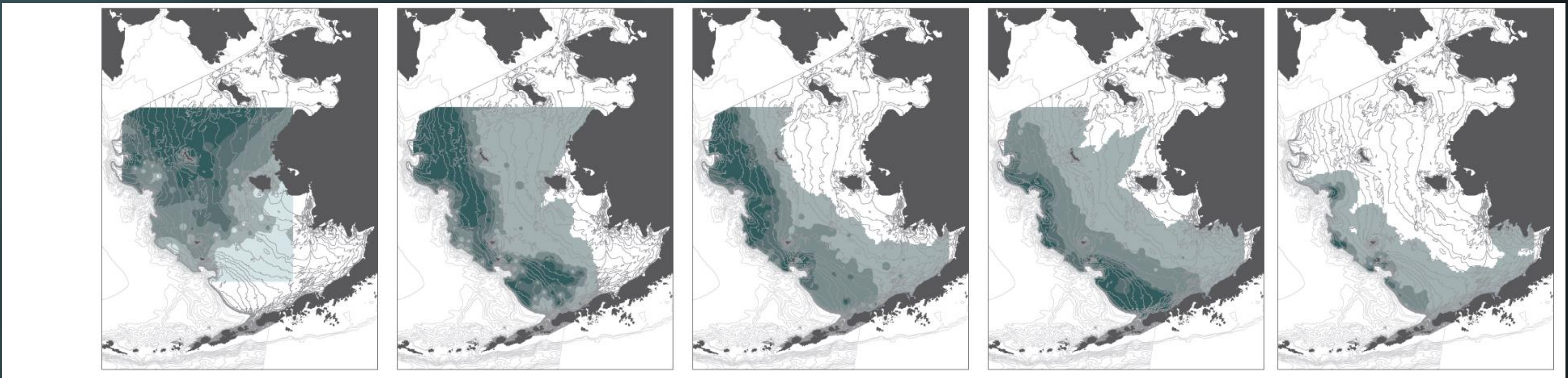
Benthic foragers aggregate biomass

Fish apex predators aggregate biomass

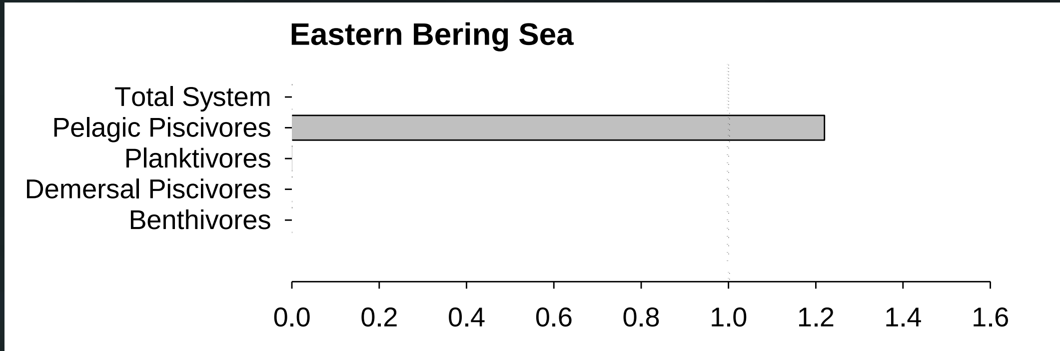
Motile epifauna aggregate biomass





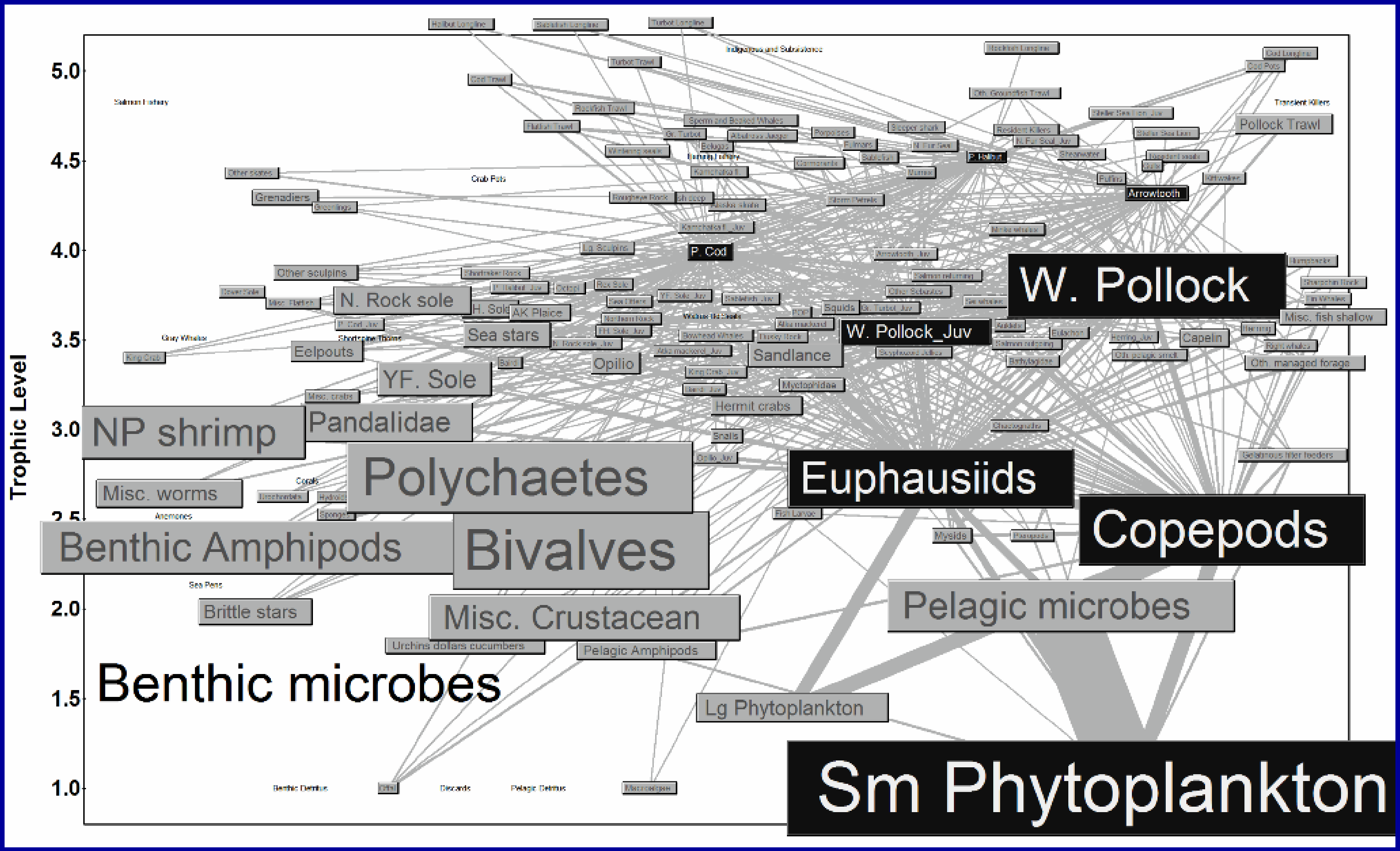


Similar distributions across the guild, but partitioning within that space



Goal: formal ecosystem thresholds

- 2 million MT cap on total removals from the Bering Sea.



- Tool: Ecopath food web/ network models

Goal: formal ecosystem thresholds

- Example: 2 million MT cap on total removals from the BSAI.

- Scenarios and alternatives:
  - "Simple" (2MMT, fixed)
  - "Complex" (varies bases on productivitiy).
  - Guild limits: Forage fish, apex predators, etc.
  - System of indicators (IFRAME).

NOAA FISHERIES SERVICE

Spatial Models

NOAA
FISHERIES
SERVICE

Risk Assessment and MSE