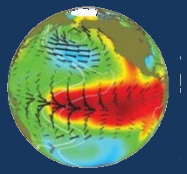
Ecosystem-based management in Alaska: The role of seabirds as indicators of ecosystem change

Seabirds

Forage fish

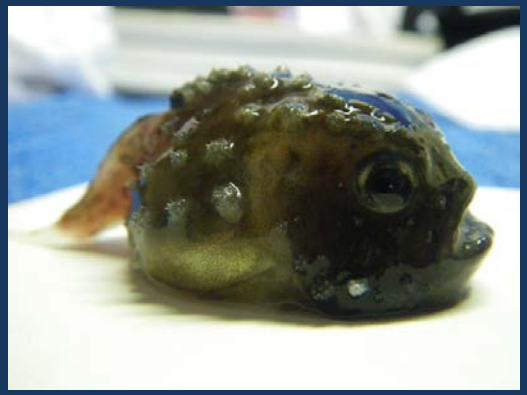
Zooplankton

Climate



Stephani Zador
NOAA Alaska Fishery Sciences Center





Goals

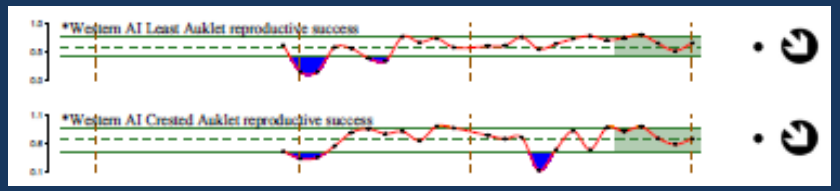
- Ecosystem-based (fishery) management in Alaska
- Ecosystem indicators
- Future directions for ecosystem indicators





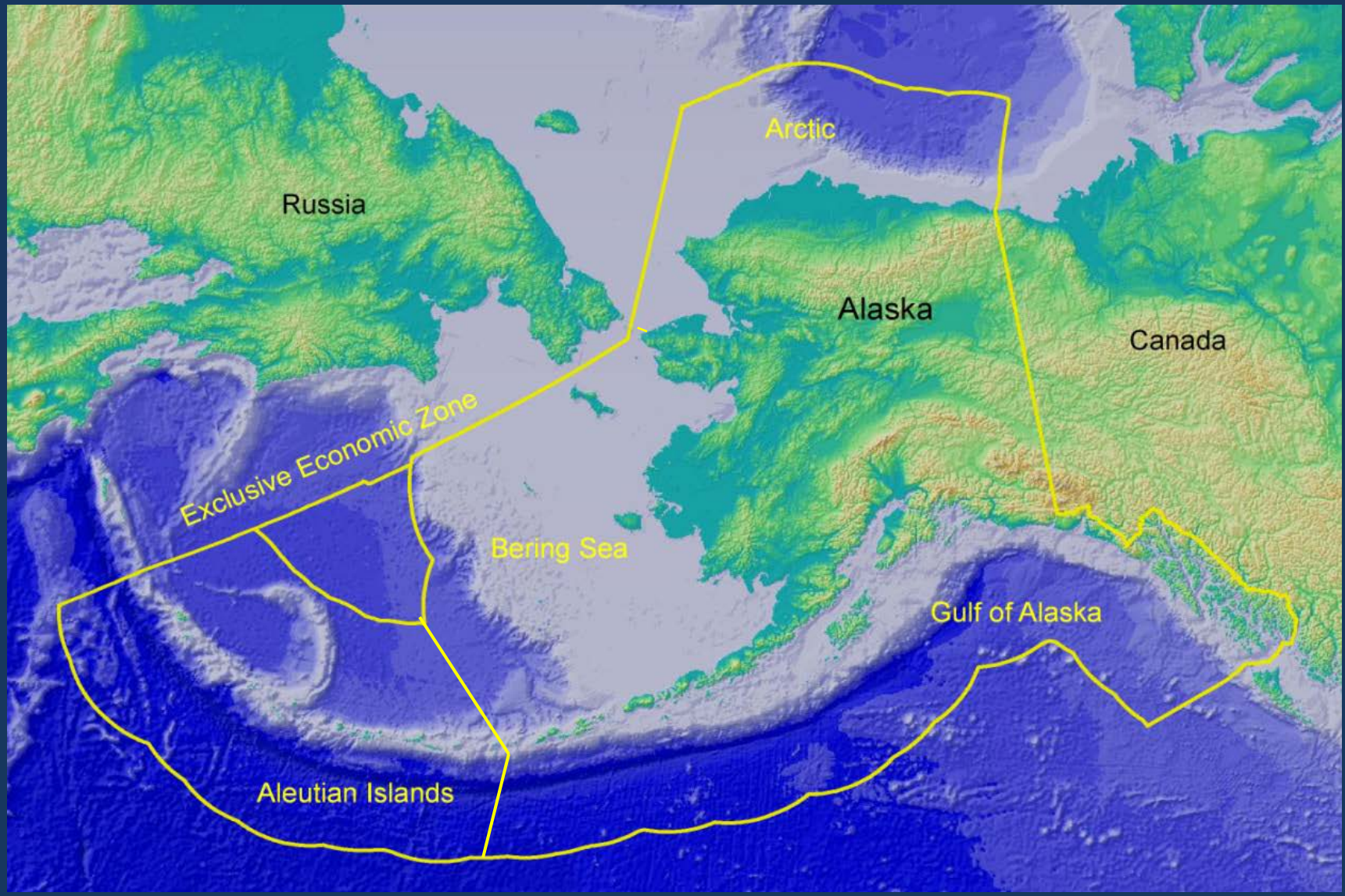
Definitions

- Ecosystem indicators
  - Time-series of data that measures an ecosystem component



- Groundfish
  - Pollock, cod, flatfish, rockfish
  - 2012 value: $ 1.05 billion

Alaska marine ecosystems



Fishery management plan GOALS for Alaska groundfish

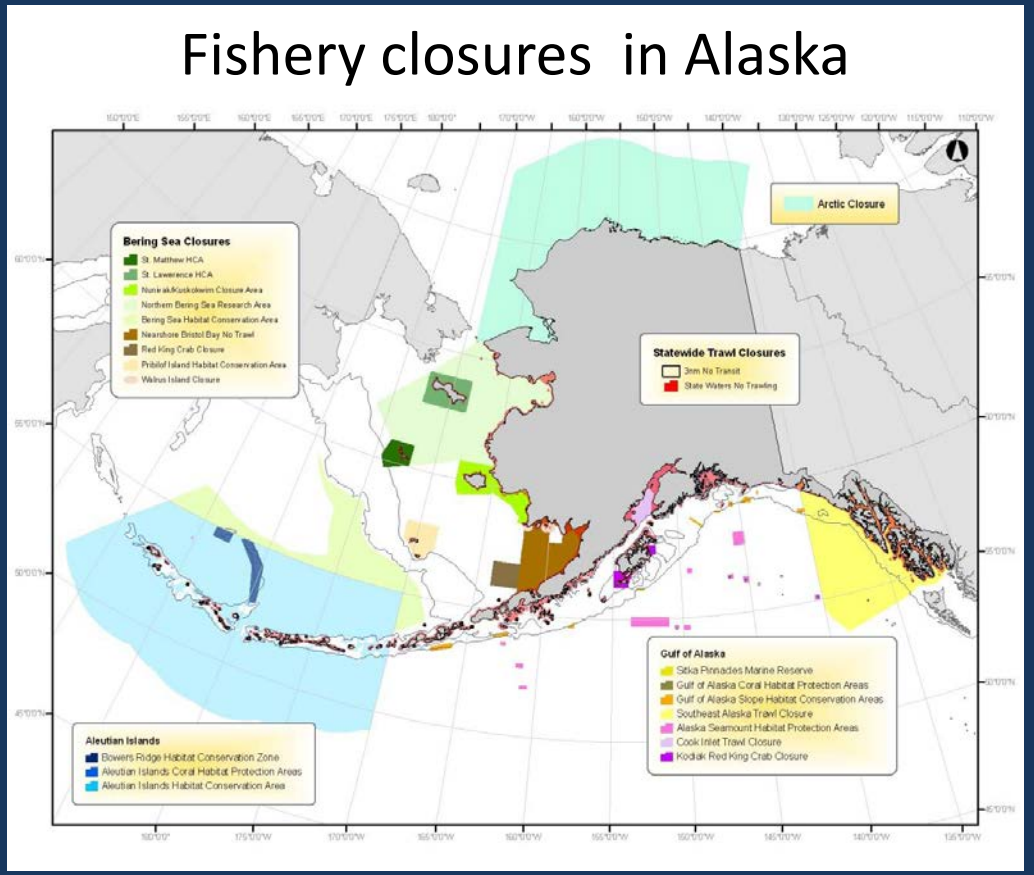
There are many:

1. Prevent overfishing
2. Promote sustainable fisheries & fishing communities
3. Preserve the food web
4. Manage incidental catch & reduce bycatch & waste
5. Avoid impacts to seabirds & marine mammals
6. Reduce and avoid impacts to habitat
7. Promote equitable & efficient use of fishery resources
8. Increase Alaskan native consultation
9. Improve data quality monitoring & assessment

Ecosystem-Based Fishery Management in Alaska

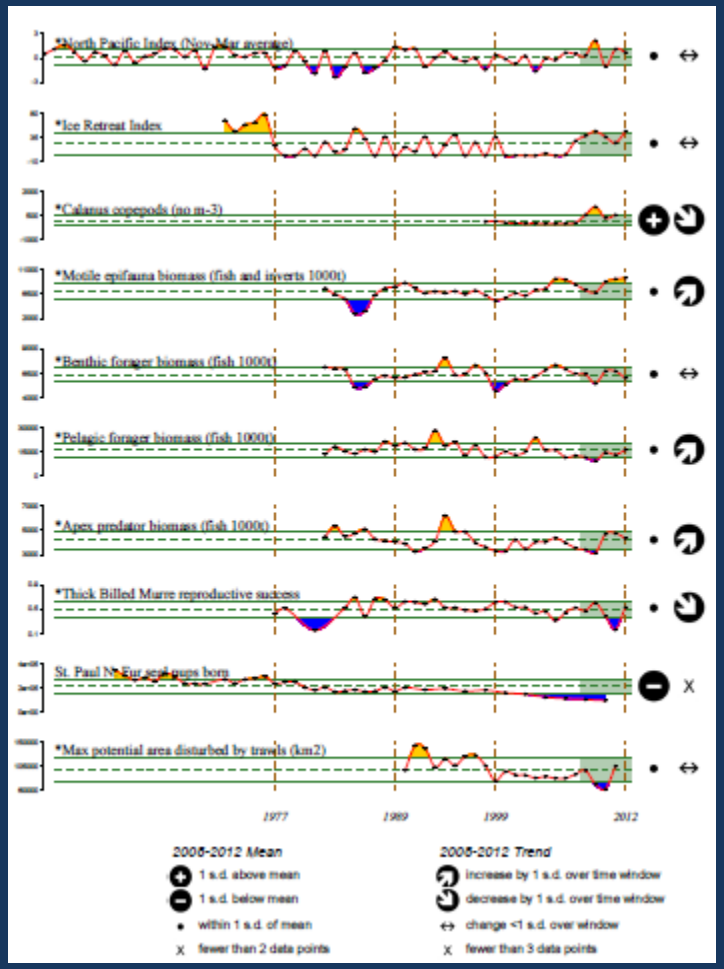
- Current
  - Closures, forage fish ban, gear modification, bycatch reduction, stock assessments, ecosystem assessments, fishery ecosystem plans, 2 MT cap
- Future
  - Integrated ecosystem assessments (IEA), stock assessments, ecosystem models, climate change

Fishery closures in Alaska



Ecosystem Indicators for Fisheries Managers

- NOAA follows 100's of ecosystem indicators that are evaluated annually to inform fisheries managers
- Developed by NOAA and other researchers
- Trends monitored for early signs of ecosystem change that may have management implications
- Ecosystem-based fisheries management



Why a Suite of Indicators?

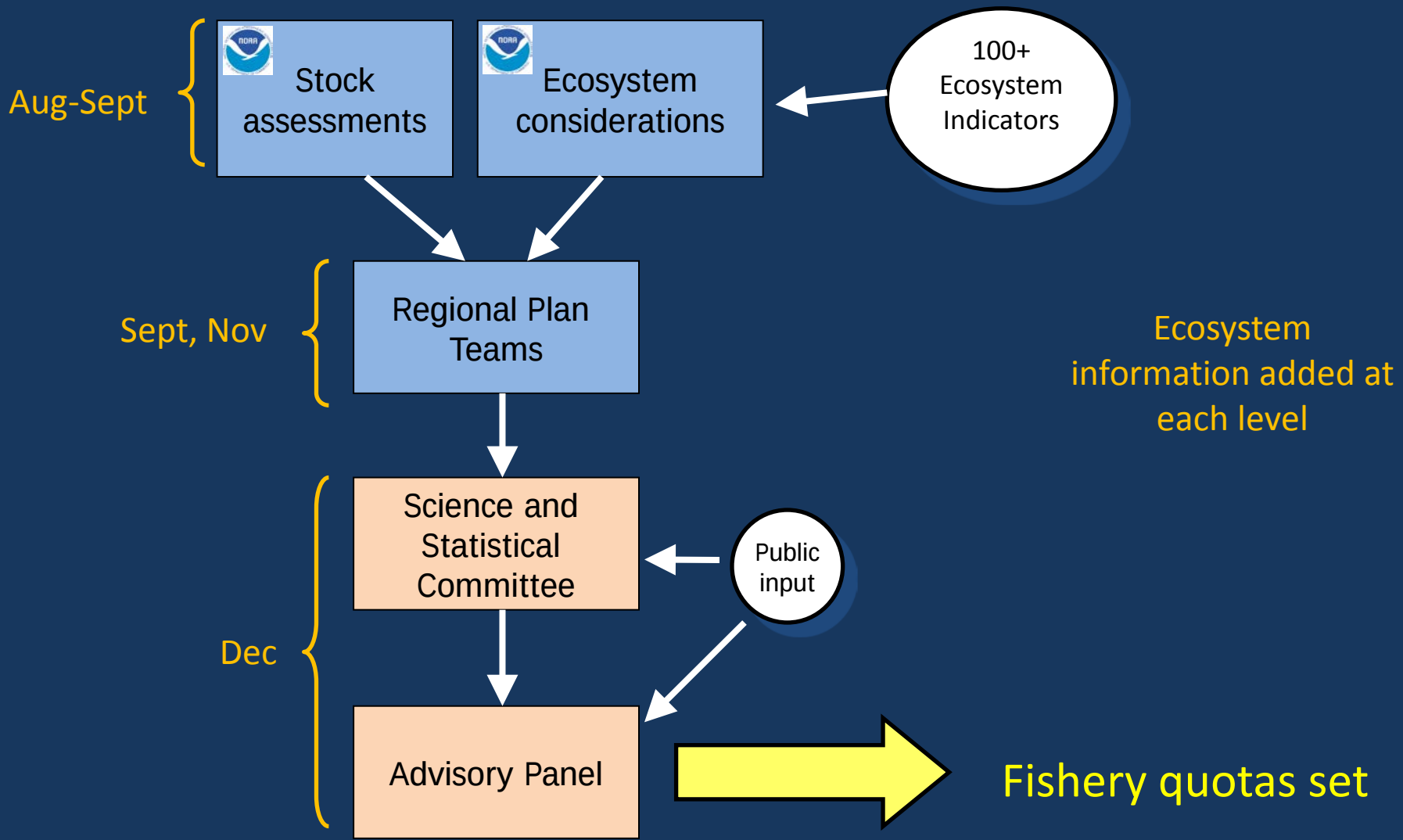
Synthesis – more than the sum of its parts

1. Provide stronger links between ecosystem research and management
2. Spur new understanding of connections between ecosystem components

What makes a good indicator?

- What do the indicators indicate??
  - Functional responses
  - Species interactions
- Need to be useful
  - Requires understanding the management system
  - Frequent dialogue, adaptive

The annual Council process



How ecosystem knowledge is used in setting fishery quota – an example

From Council minutes, December 2006:

- "The [eastern Bering Sea walleye pollock] stock remains above the MSY level, having declined ... at a rate of about 19% per year....

Result from stock assessment

- Other issues raised ... suggest a need for further caution.
  - a northward shift ... with some portion of the population into Russian waters.

Assessment + ecosystem indicators

  - a large decline in zooplankton, which is important in providing forage for juvenile pollock.

Ecosystem indicators

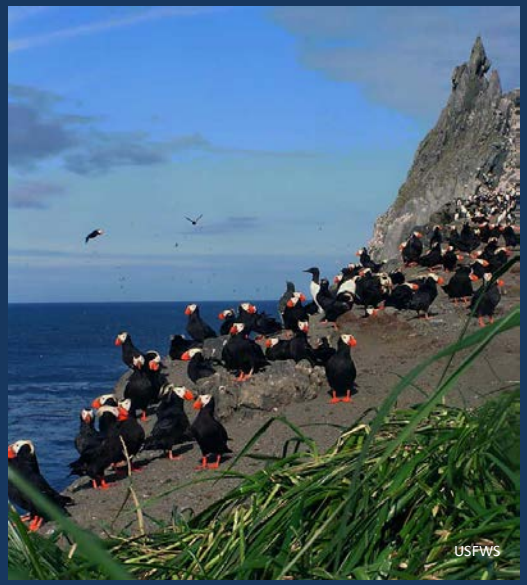
  - increasing predation by arrowtooth flounder on juvenile pollock.

A multispecies model

Consequently, … a reduction in … catch … is justified."

Seabirds as indicators

Direct and Indirect



Biological Oceanography, Vol. 5, pp. 261–271, 1987
Printed in the UK.

Seabirds as Indicators of Marine Food Supplies

D. K. CAIRNS*
Newfoundland Institute for Cold Ocean Science
and
Psychology Department
Memorial University of Newfoundland

Vol. 352: 199–204, 2007
doi: 10.3354/meps07070
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published December 20

OPEN ACCESS

THEME SECTION

Seabirds as indicators of marine ecosystems

Idea: John F. Piatt, William J. Sydeman
Coordination: William J. Sydeman, John F. Piatt, Howard I. Browman

Fisheries Research 95 (2009) 6–13
Contents lists available at ScienceDirect
Fisheries Research
journal homepage: www.elsevier.com/locate/fishres
ELSEVIER

Review

A review of the use of seabirds as indicators in fisheries and ecosystem management

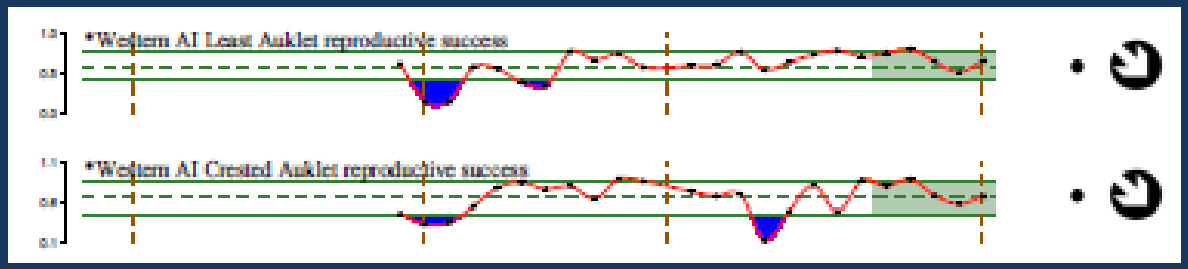
L.D. Einoder[a,b,+]
[a] School of Earth and Environmental Sciences, Adelaide University, South Australia 5000, Australia
[b] South Australian Research and Development Institute (Aquatic Sciences), P.O. Box 120, Henley Beach, South Australia 5022, Australia

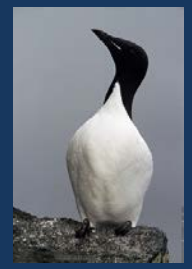
Seabirds as indicators of the marine environment

Matt Parsons, Ian Mitchell, Adam Butler, Norman Ratcliffe, Morten Frederiksen, Simon Foster, and James B. Reid

How seabirds fit into Alaska fisheries management

- Seabirds are becoming increasingly important indicators:
  - of fisheries interactions (bycatch)
  - of the ecosystem (colony-based)





Indicators: from qualitative to quantitative

- 4 case studies:
  - Qualitative synthesis
    1. Red flags in the Gulf of Alaska
  - Indicator selection
    2. Report cards for the Aleutians and the eastern Bering Sea
  - Developing multivariate indicators
    3. Combined Pribilof seabird indicators
    4. Ecosystem reference point for the eastern Bering Sea

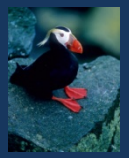
Case Study #1

Qualitative Indicator Synthesis: Red Flags

Qualitative Indicator Synthesis: Red Flags

Ecosystem indicators that cumulatively suggest anomalous conditions occurred in 2011

Red Flag #1: Seabirds



Widespread Reproductive Failure

N

Middleton:
Fail: Tufted puffin
Ok: Black-legged kittiwake
Ok: Rhinoceros auklet

Barrens:
Fail:
Black-legged kittiwake

St. Lazaria:
Ok: Common murre
Ok: Thick-billed murre

Chowiet:
Fail: Black-legged kittiwake
Fail: Tufted puffin
Fail: Parakeet auklet
Poor: Common murre
Poor: Thick-billed murre

Aiktak:
Fail: Common murre
Fail: Thick-billed murre
Ok: Tufted puffin

Gulf of Alaska

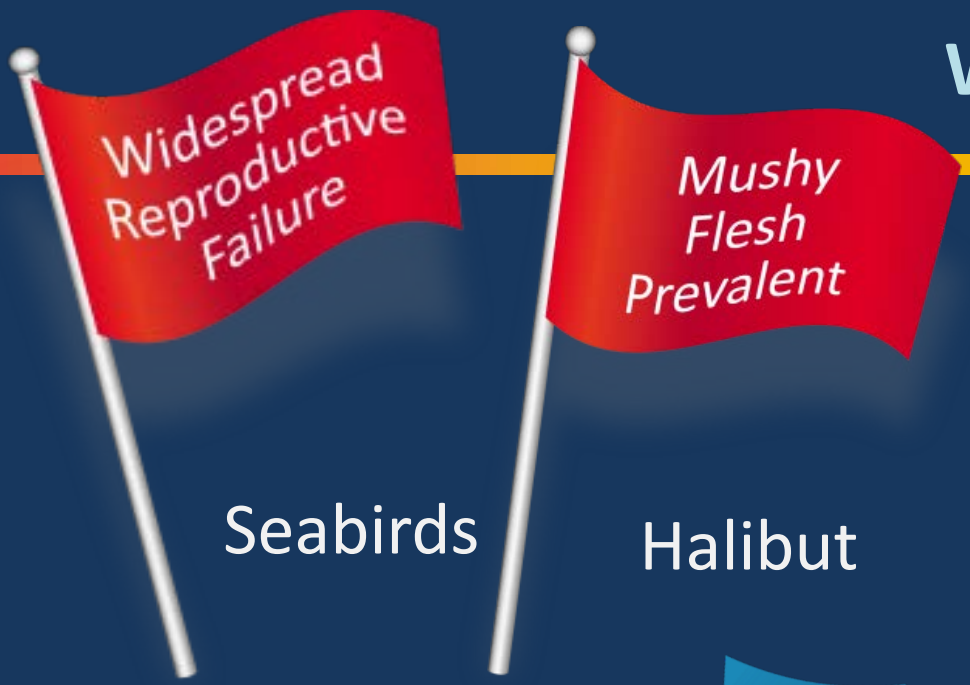
Red Flag #2: Halibut

Mushy Flesh Prevalent

Reoccurrence of "Mushy" Halibut Syndrome

- First detected in GOA in 1998
- Also seen 2005 and 2012
- Hypothesized nutritional deficiency
- Stomachs contain crab rather than forage fish

What Do They Indicate?

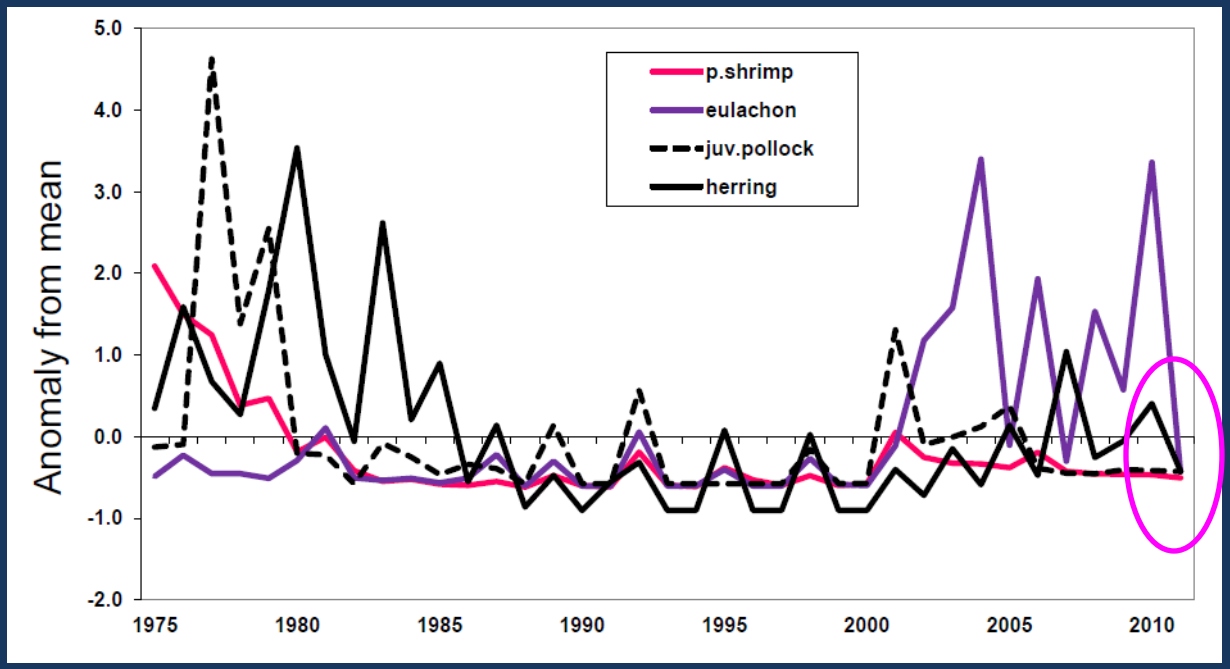


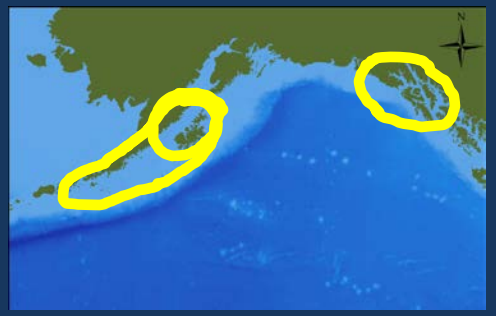
- Both are attributed to poor foraging conditions

Forage Fish?

Forage Fish

Below average forage fish catch rates in small mesh surveys (Urban et al. 2012)





- Winter age-1 pollock (2011 year class) survey estimates low
- Juvenile pink salmon catch rates 2nd lowest in 15 years (Orsi et al. 2012)

Seabirds

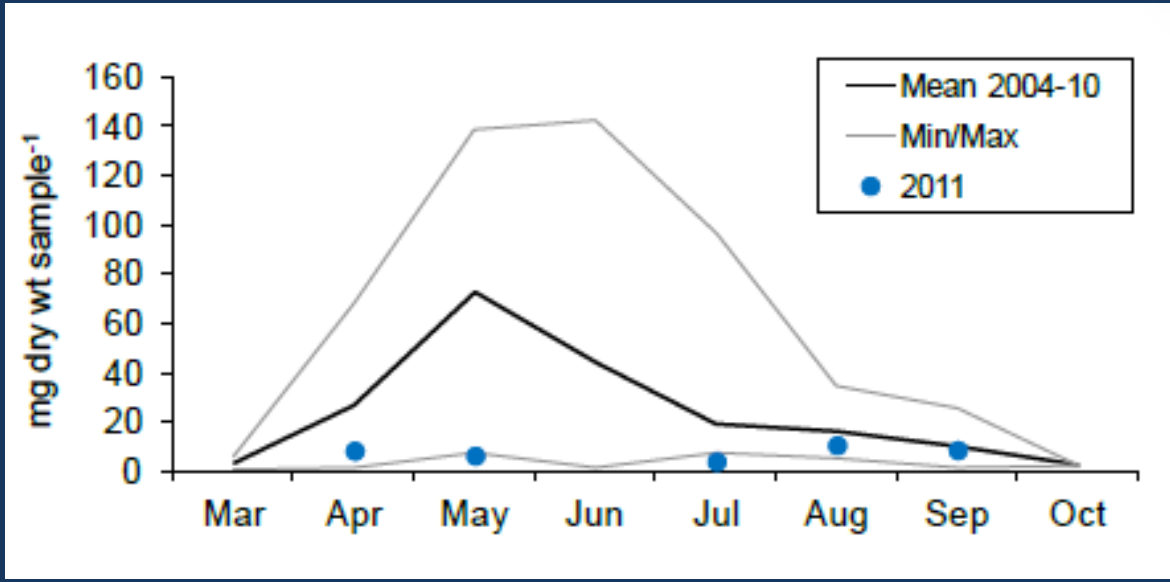
Halibut

Forage fish

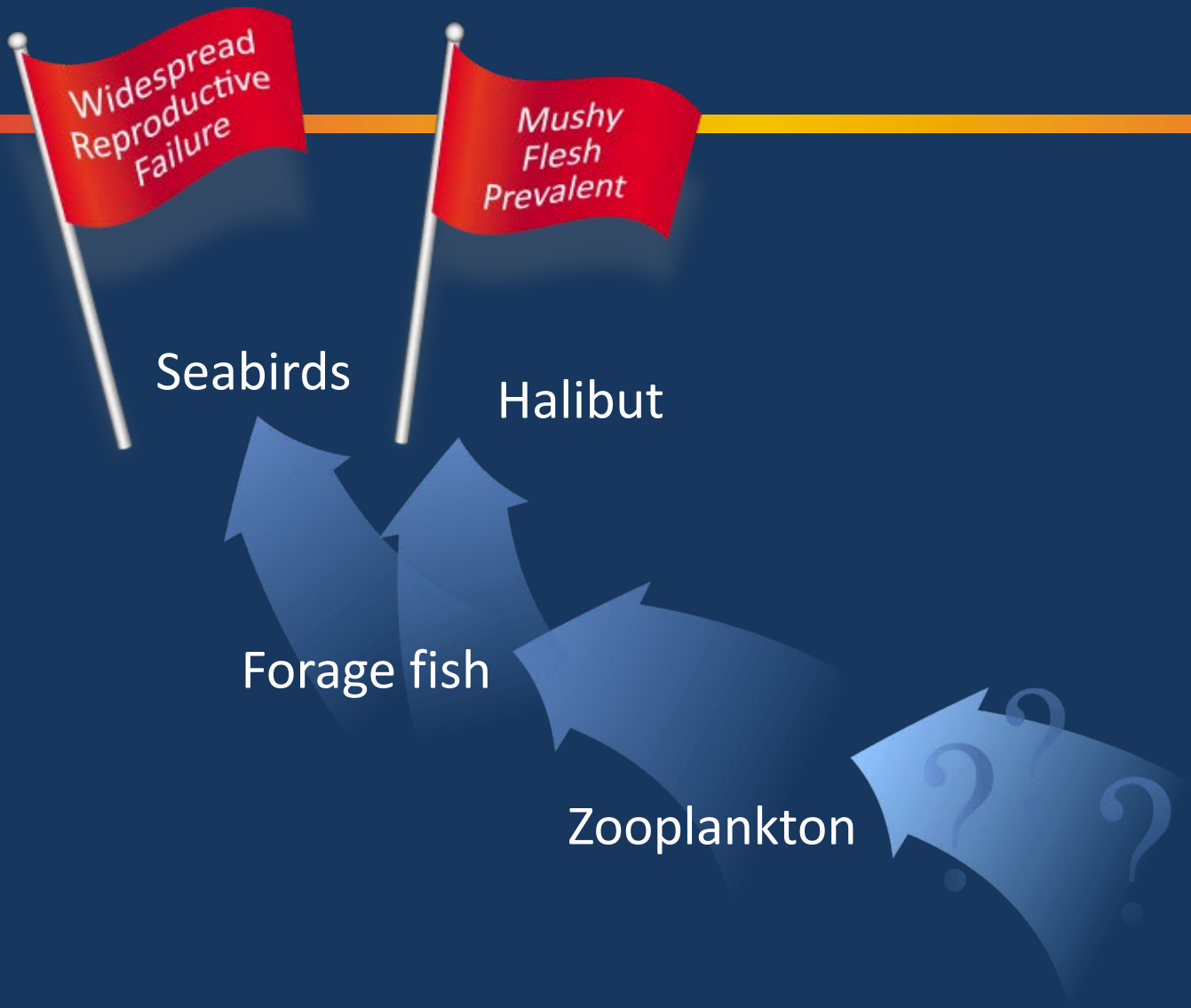
Zooplankton?

Zooplankton

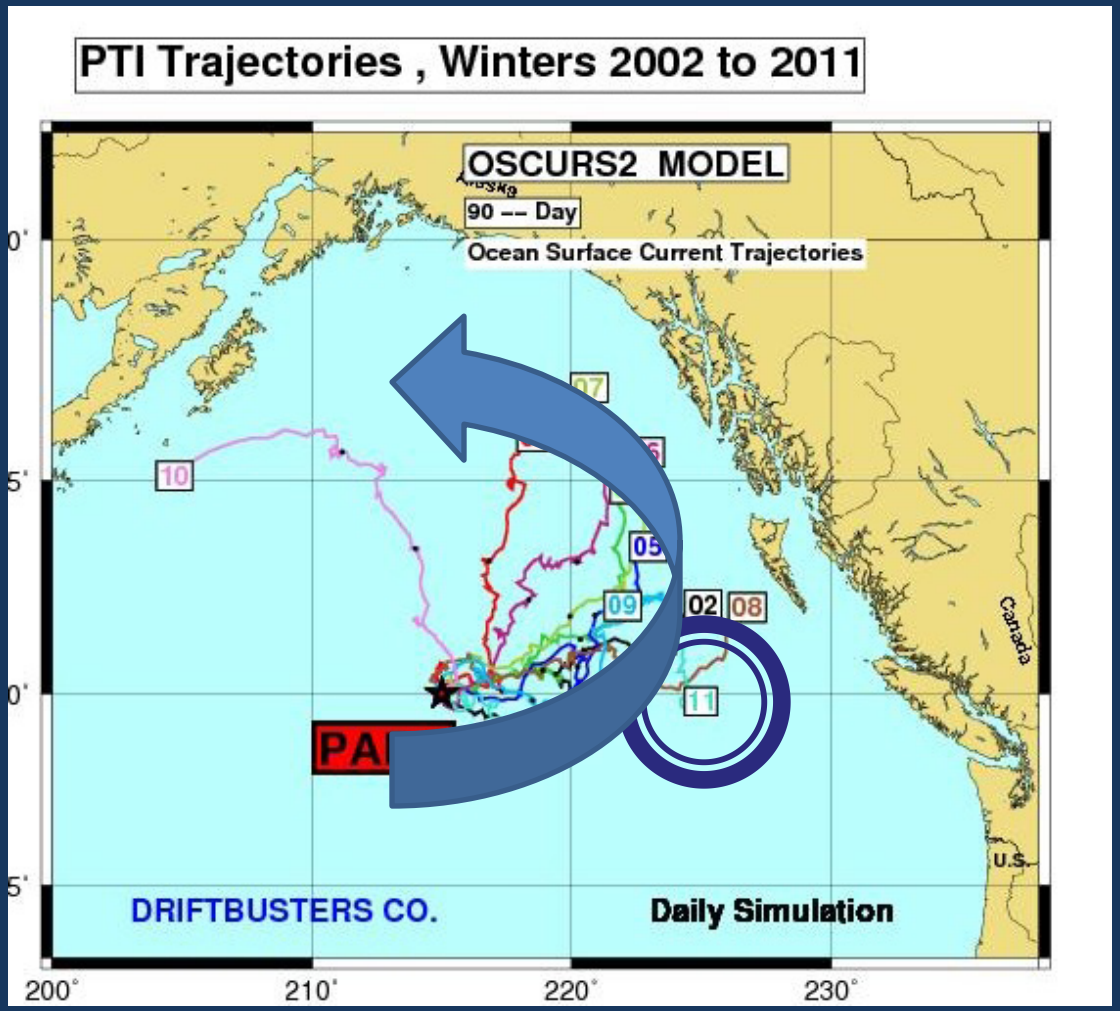
Very low zooplankton biomass sampled by Continuous Plankton Recorders (Batten 2012)



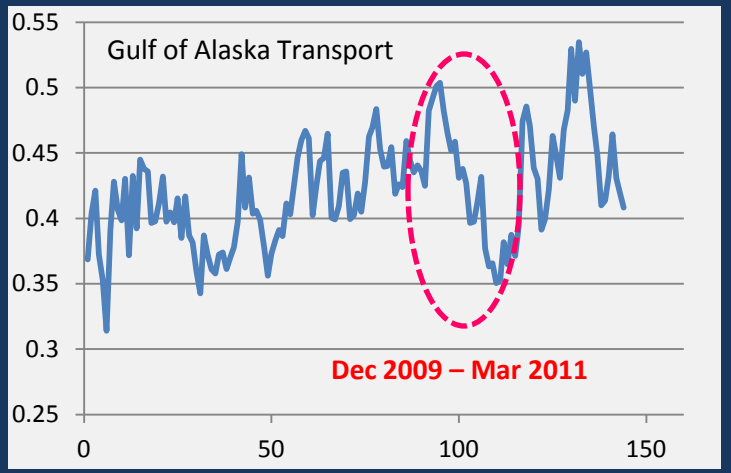
- Also, **high abundance of salps** in eastern GOA


Widespread Reproductive Failure
Mushy Flesh Prevalent
Seabirds
Halibut
Forage fish
Zooplankton
Climate?

Climate

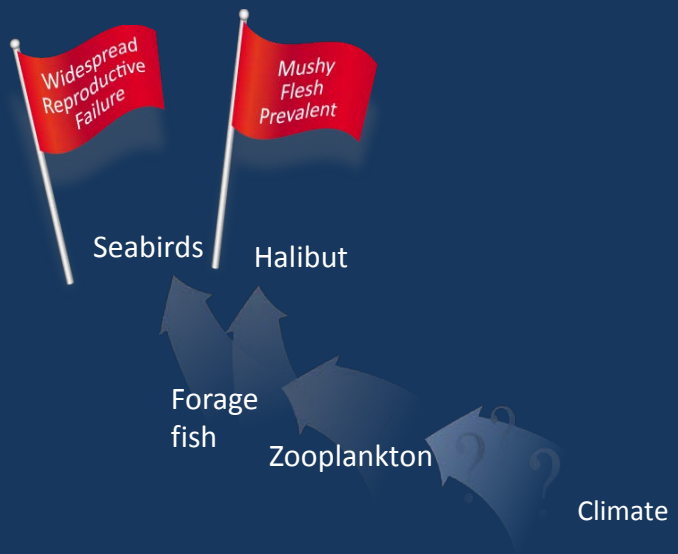


- PAPA Trajectory Index unusually east and southernmost since 1993 (Stockhausen and Ingraham 2012)
- Decline in poleward branch of the Alaska Current (Bond 2012, Freeland)



Qualitative Indicator Synthesis: Conclusions and Prediction

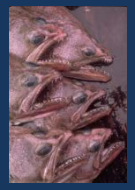
- **Synthesis** of indicators' status across multiple trophic levels **can reveal broad-scale changes**
- **Upper trophic organisms can provide near-real time cues** of environmental state.
- **Changes in bottom-up forcing factors** may have negatively influenced productivity during 2011.
- Thus, **2011 may be a poor year class for forage fish and forage-fish eating predators**.
  - Prediction holding true for pollock



How do we turn myriad indicators into something more useful for managers?

Case Study #2

Indicator Selection: Developing Report Cards



Indicator Selection: Developing Report Cards

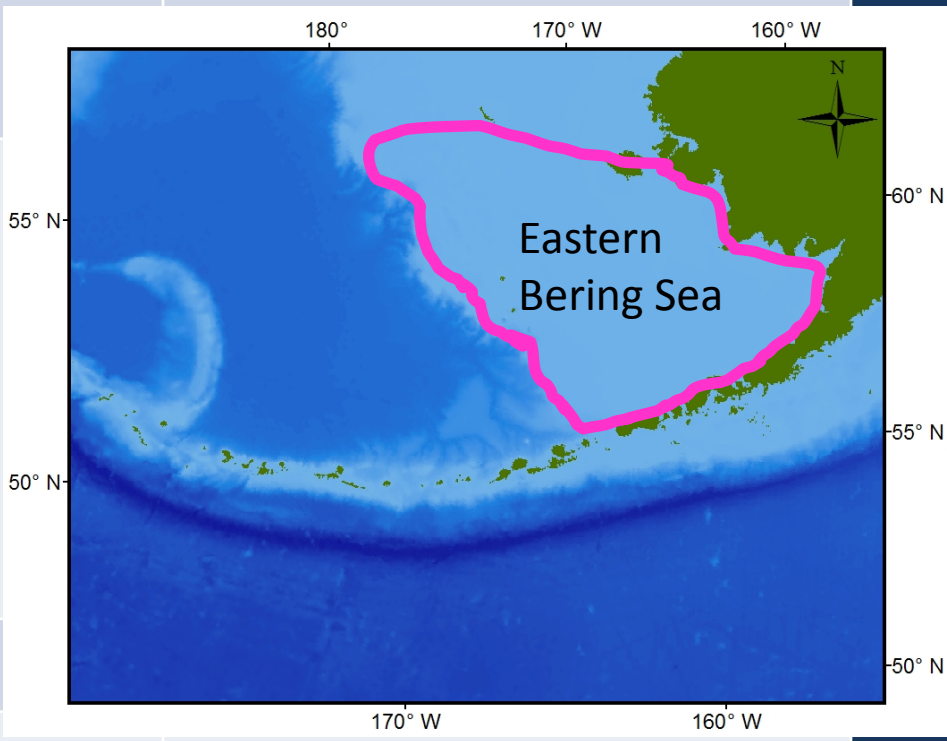
Goal: to create short Ecosystem summaries

"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

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

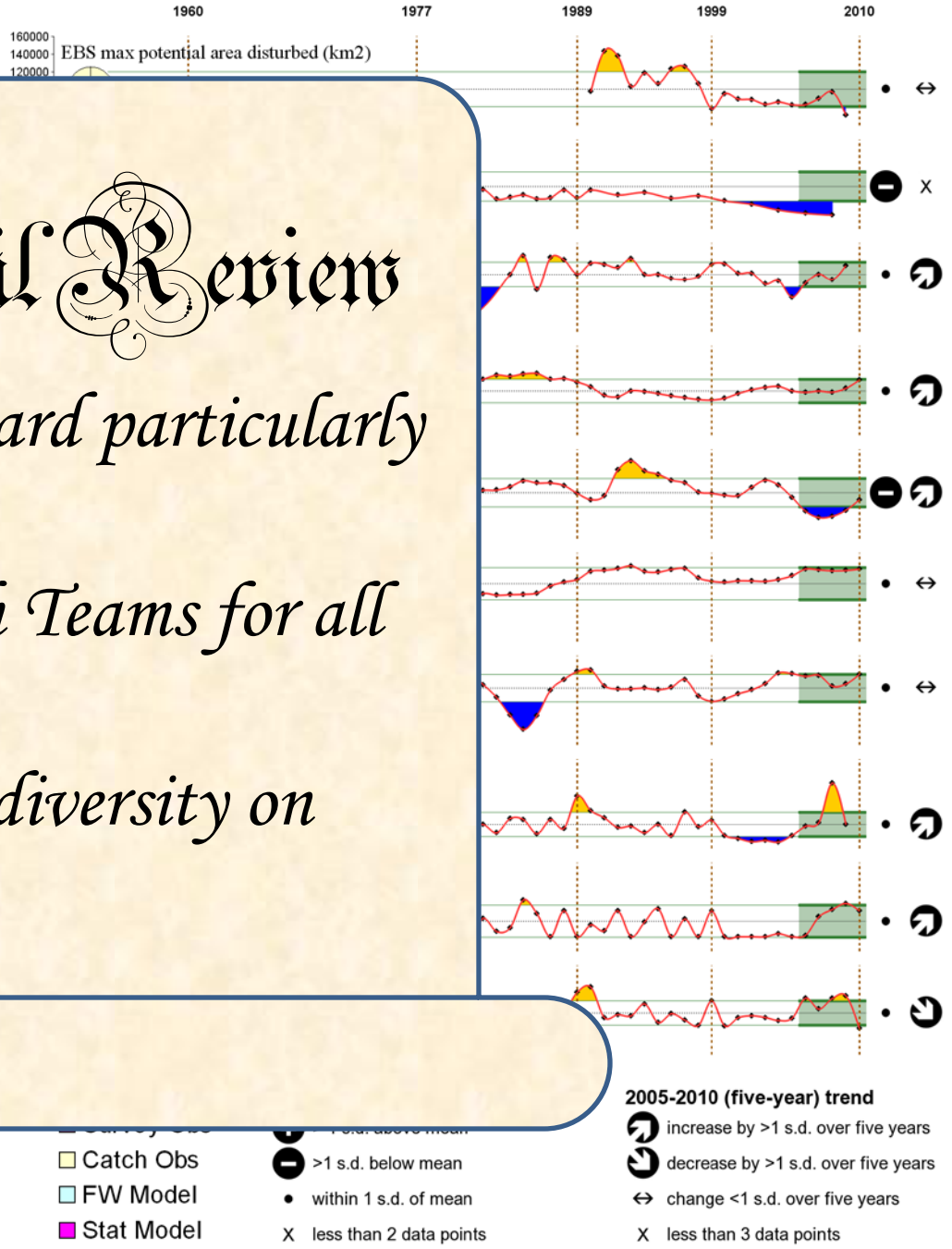
EASTERN BERING SEA

- 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

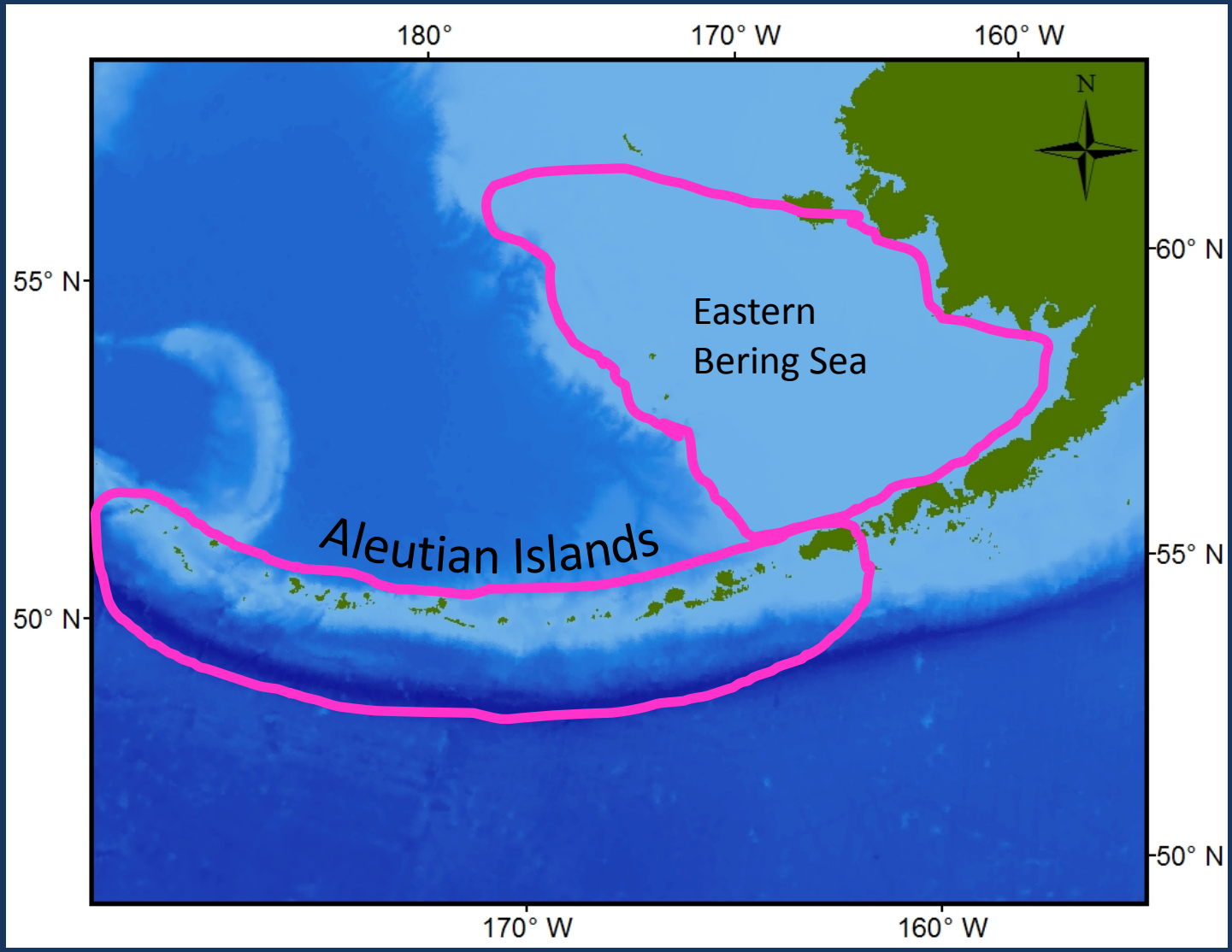
Indicators
Climate
Zooplankton
Forage fish
Fish biomass
Marine Mammals
Seabirds
Humans

Council Review

1. *Report Card particularly useful*
2. *Establish Teams for all regions*
3. *Increase diversity on Teams*



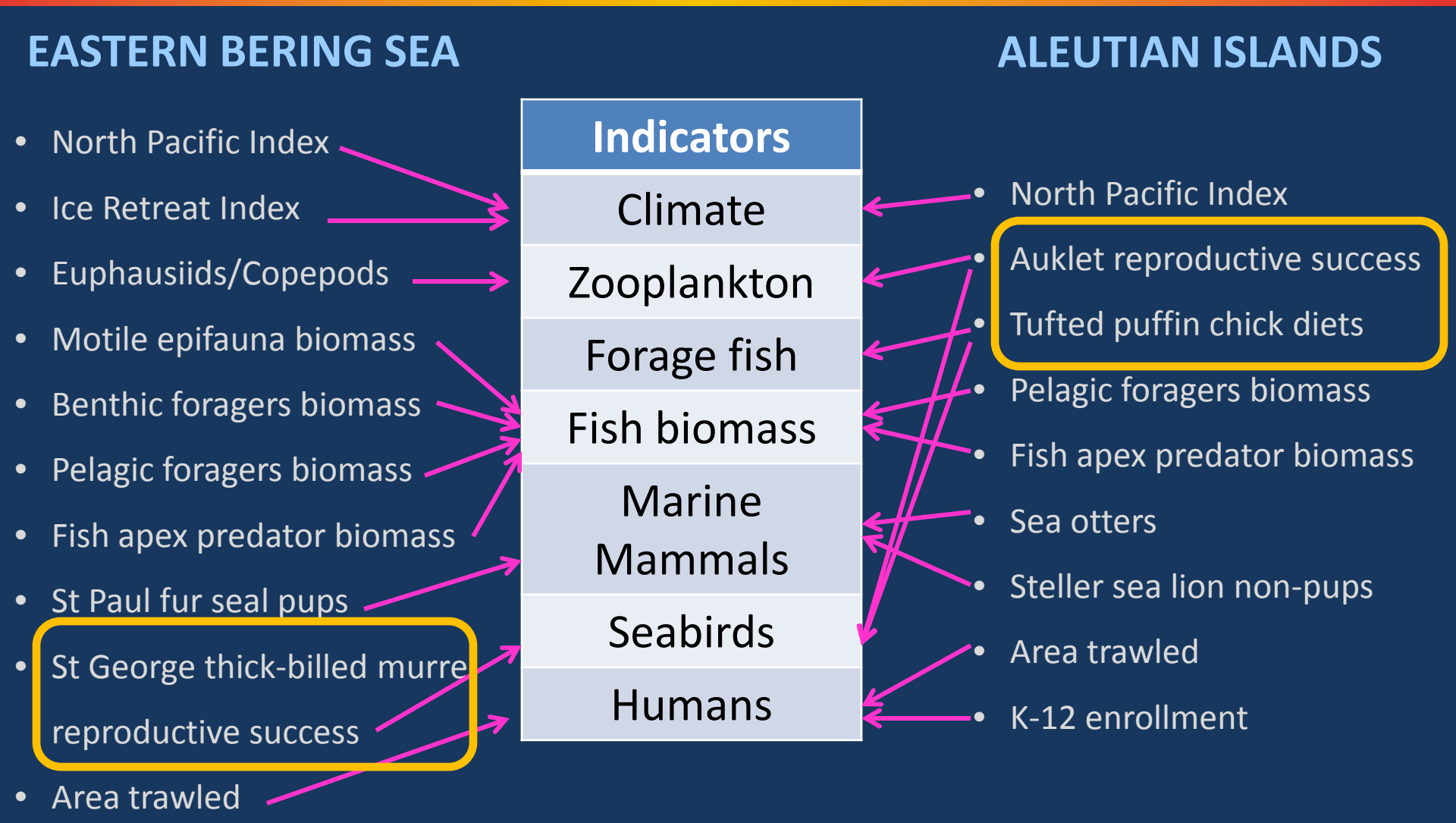
Aleutian Islands



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

"Top" Indicators for Ecosystem Assessments Now Include Seabirds

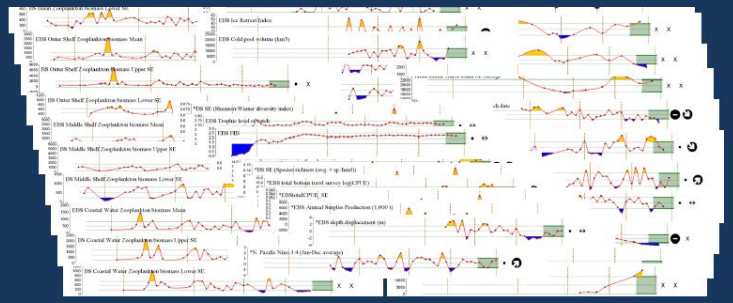


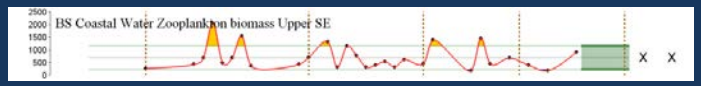
Indicator Selection: Conclusions

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

Multivariate indicators: quantitative method to reduce datasets

- Previously, selecting and interpreting indicators ‘as is’
- How to create useful indicators?
  - I. **Reducing multiple time series** – creating combined seabird indicators
  - II. **Reducing an ecosystem to one indicator** – creating an ecosystem reference point





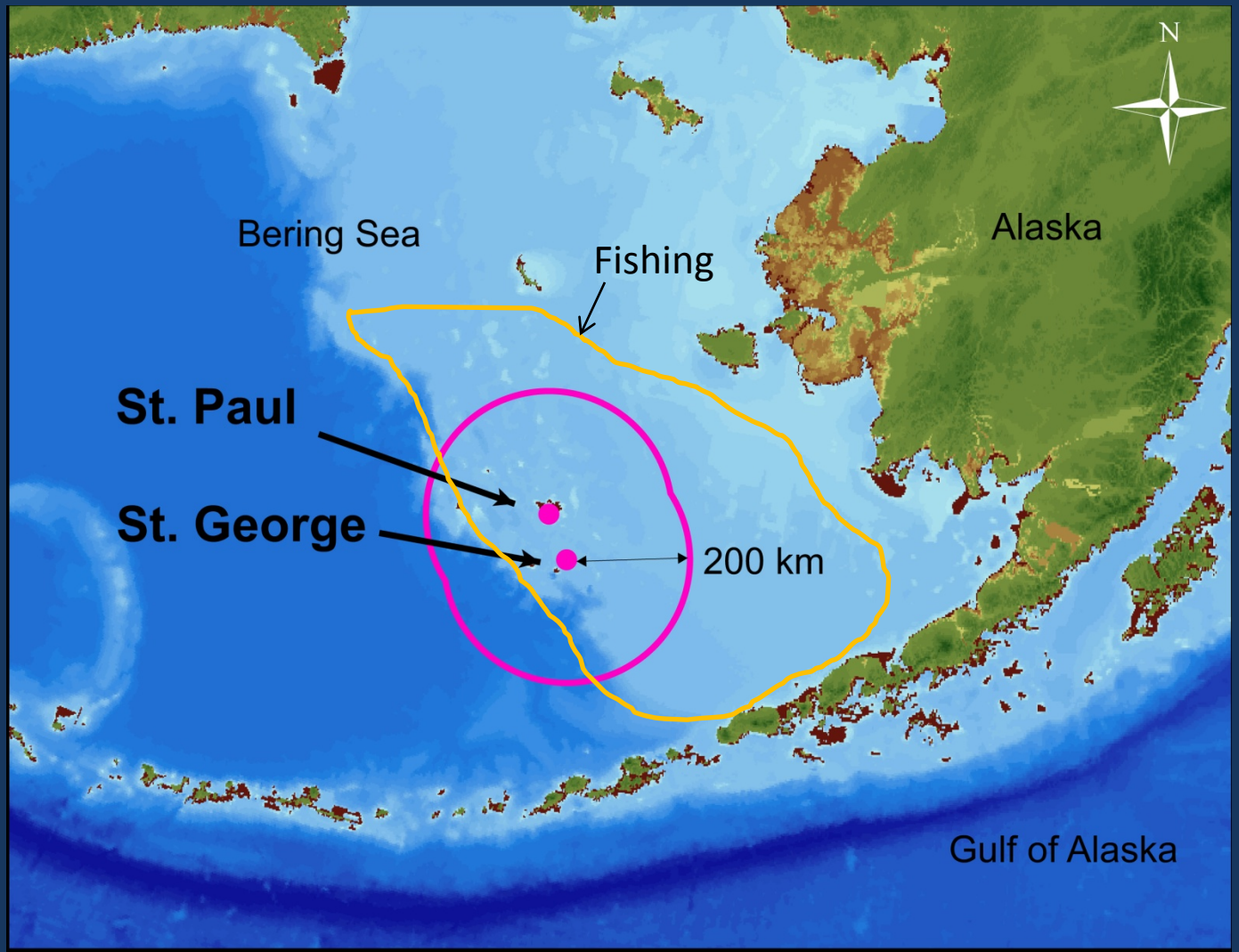
?

Case Study #3

Reducing multiple time series: creating combined seabird indicators

Reducing multiple time series: creating combined seabird indicators

- The Pribilof Islands, eastern Bering Sea



Study Species

- **Same species breed on each island**
  - Black-legged kittiwakes (BLKI)
  - Red-legged kittiwakes (RLKI)

  } **Surface-feeders**

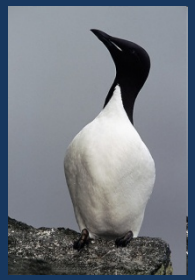
  - Thick-billed murres (TBMU)
  - Common murres (COMU)

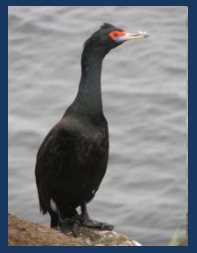
  } **Divers**

  - Red-faced cormorants (RFCO)

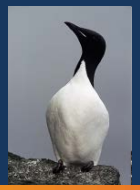
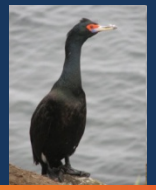
  Near-shore foragers







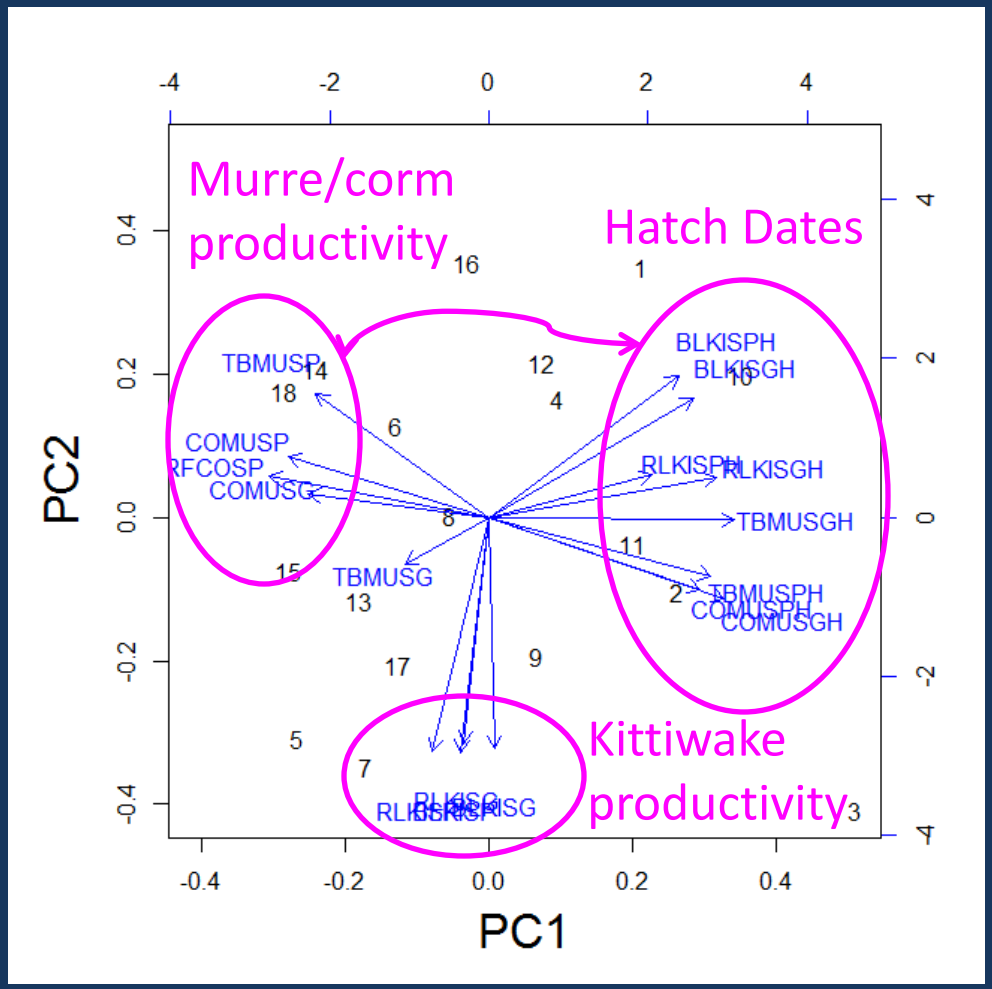
Methods


- **17 productivity and phenology datasets**
  - **1996-2013**
- **Reducing multiple time series: Principal Components Analysis (PCA)**
- **What do the indicators indicate? Time series analysis**
  - **Leading PC scores against local environmental variables**
  - **Cross correlations with lags ≤3 yr**

Results: Two strong and distinct trends

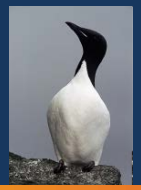
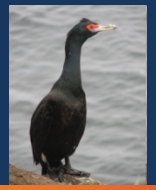
- **Explanatory value: PC1 = 42.7% and PC2 = 23.5%**

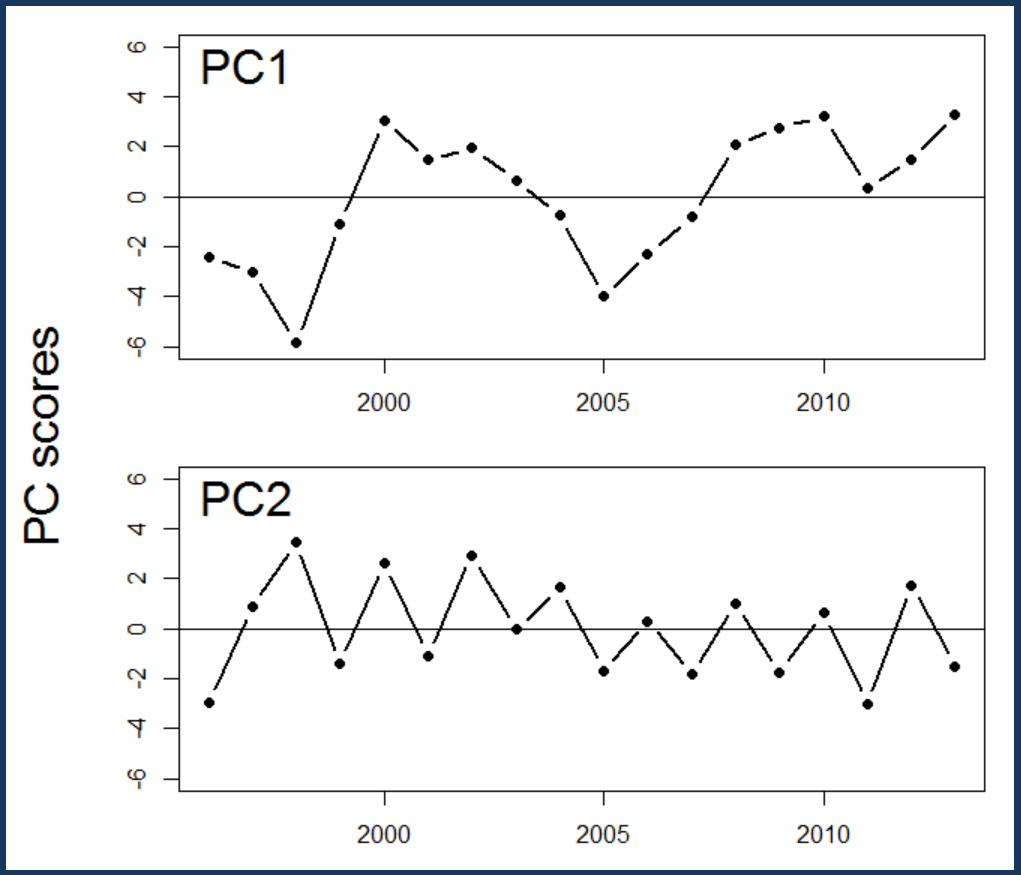


PC1 - “The phenology and divers productivity index”

PC2 - “The kittiwake productivity index”

The New Indicators: Temporal trends

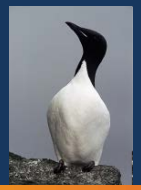
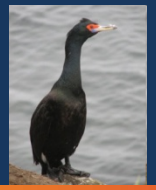



Higher murre and cormorant productivity. Earlier seabird hatch dates

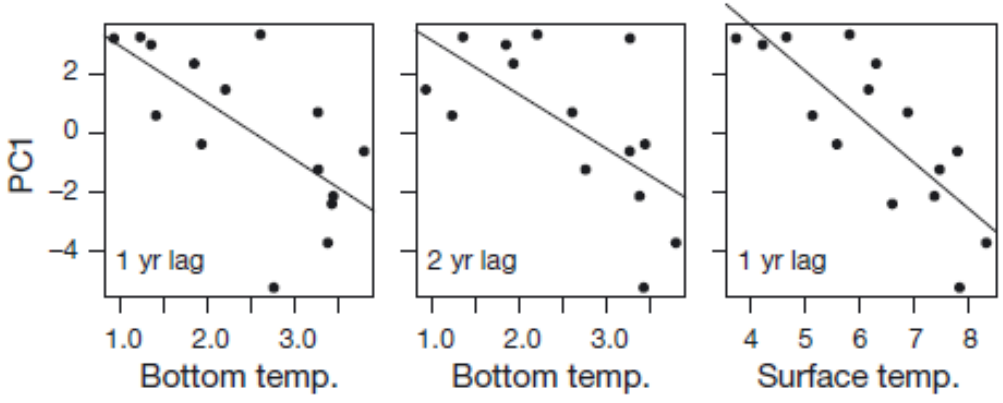
Higher kittiwake productivity

- Reduces 17 time series to 2!
- Together explain 66.2% of variance

What do these 2 seabird trends indicate?

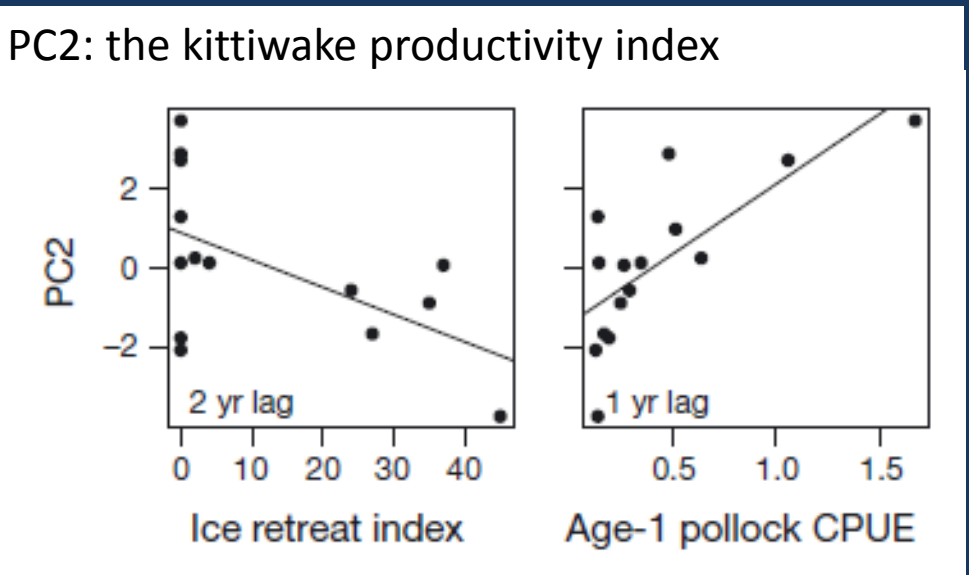




PC1: the phenology and divers productivity index



The warmer in year x, the later and less productive in year x+1, x+2

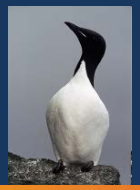
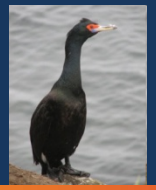
PC2: the kittiwake productivity index



The more age-1 pollock in survey, the higher kittiwake productivity the following year

Zador et al., 2013 MEPS

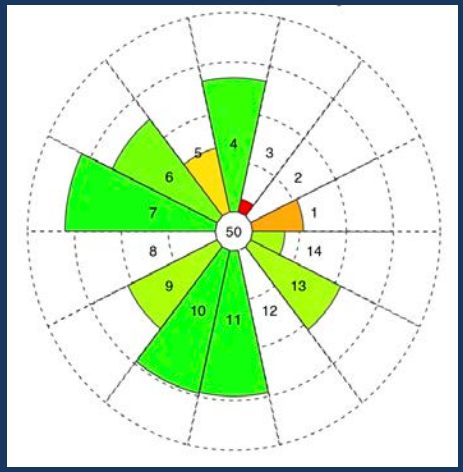
Combined seabird indicators: Conclusions

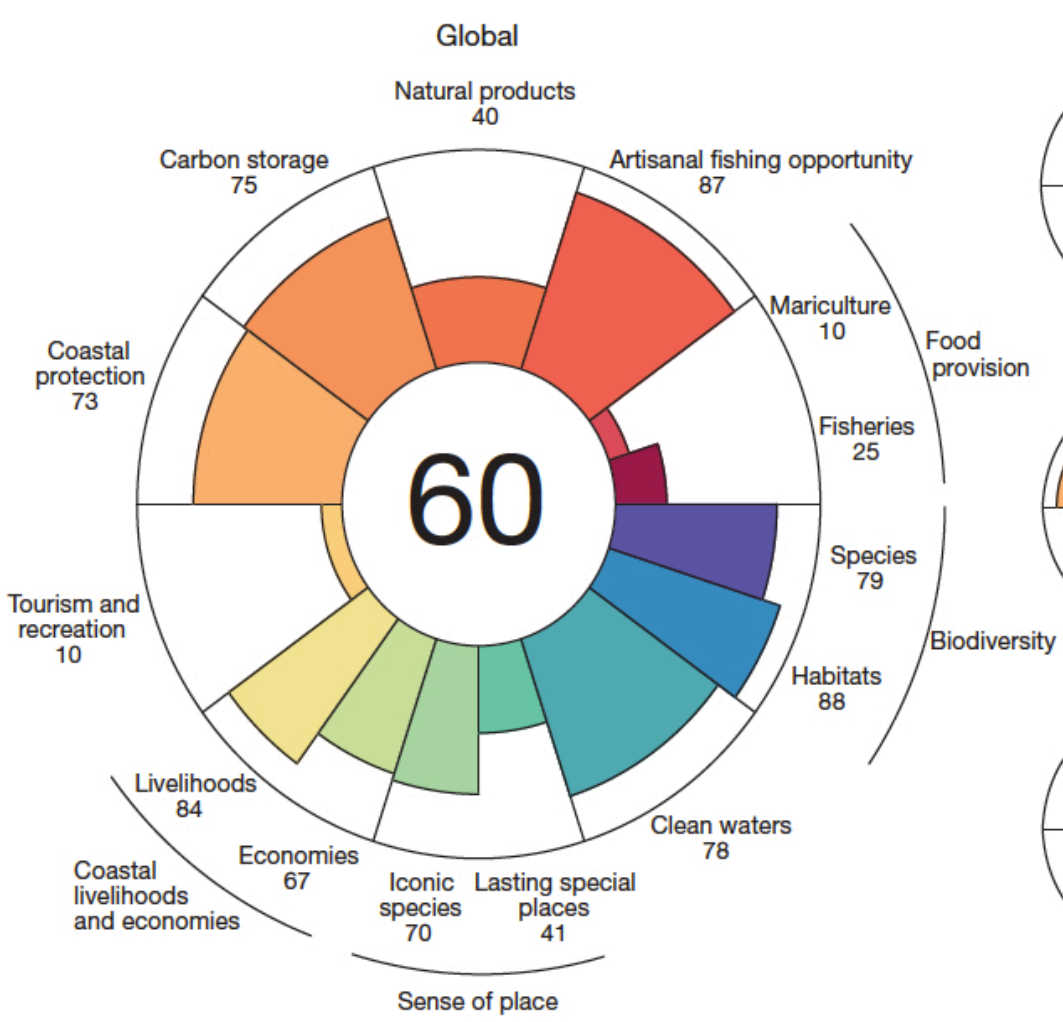

- Multivariate indices simplify multiple seabird reproductive trends.
- Time series analysis reveals lagged effects of ecosystem

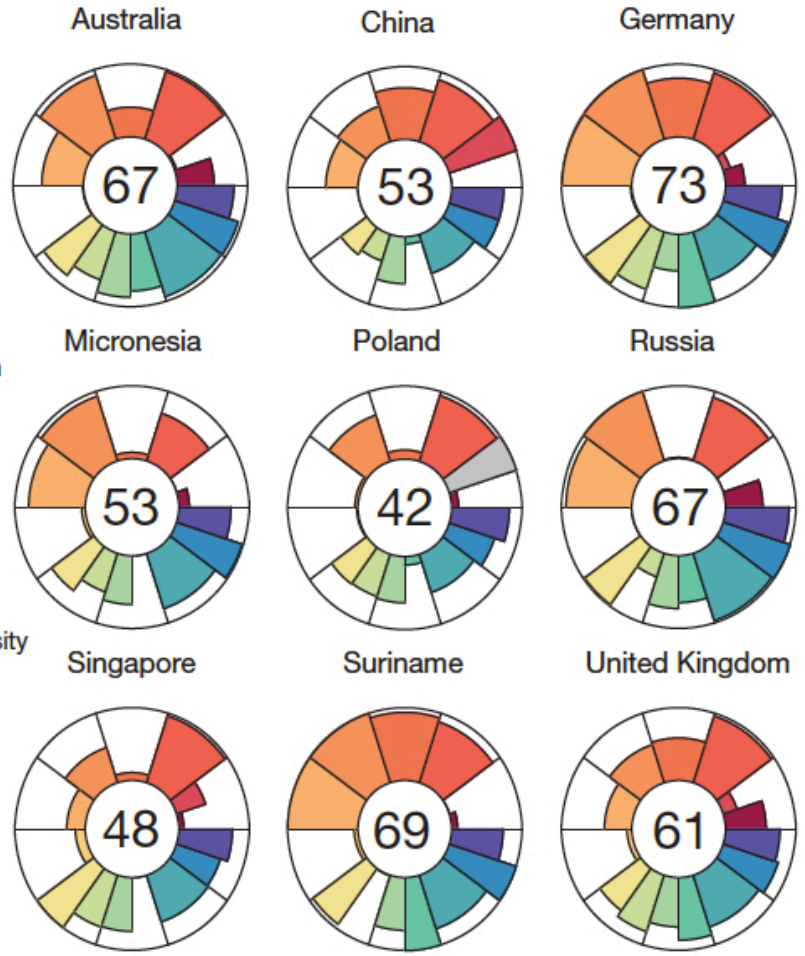
Case Study #4

Reducing an ecosystem to one indicator: creating an ecosystem reference point



Ocean Health Index





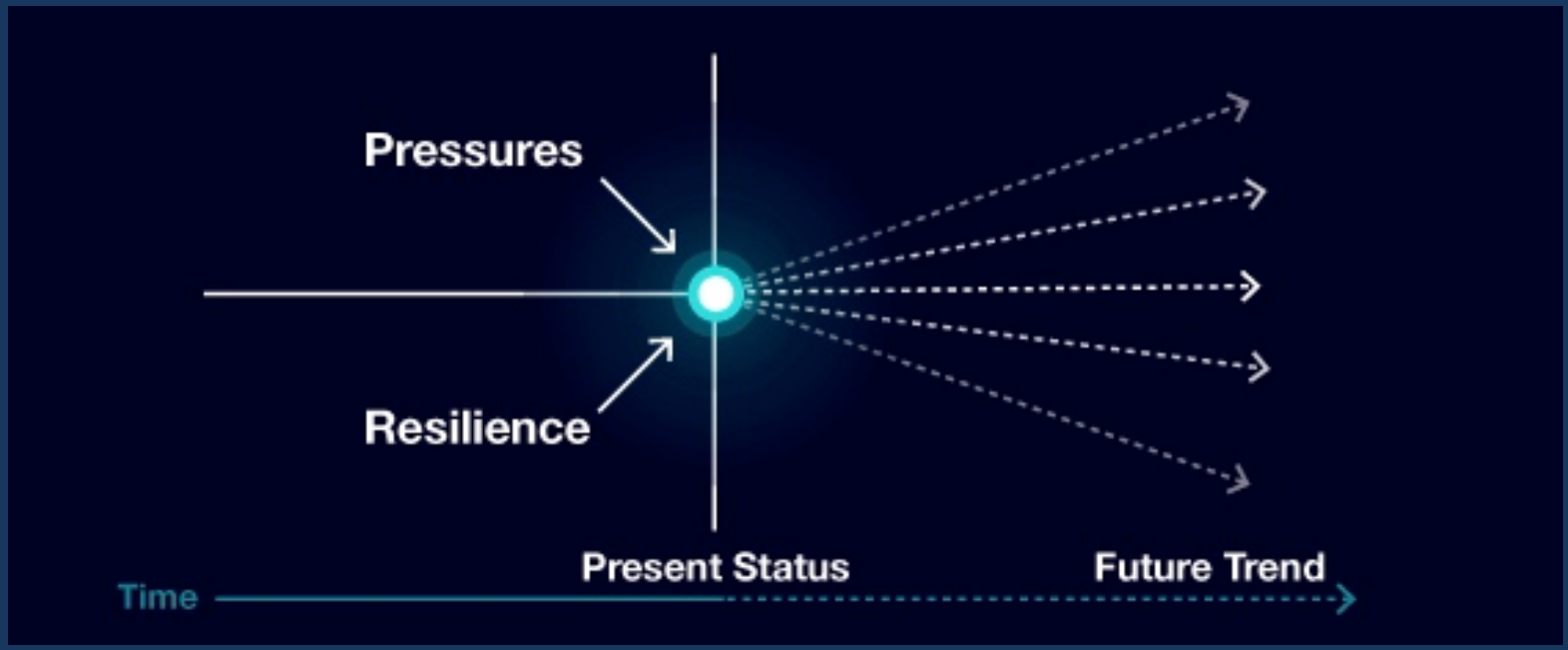
Ocean Health Index

www.oceanhealthindex.org/

OHI = sum (Goal Score* Weight)

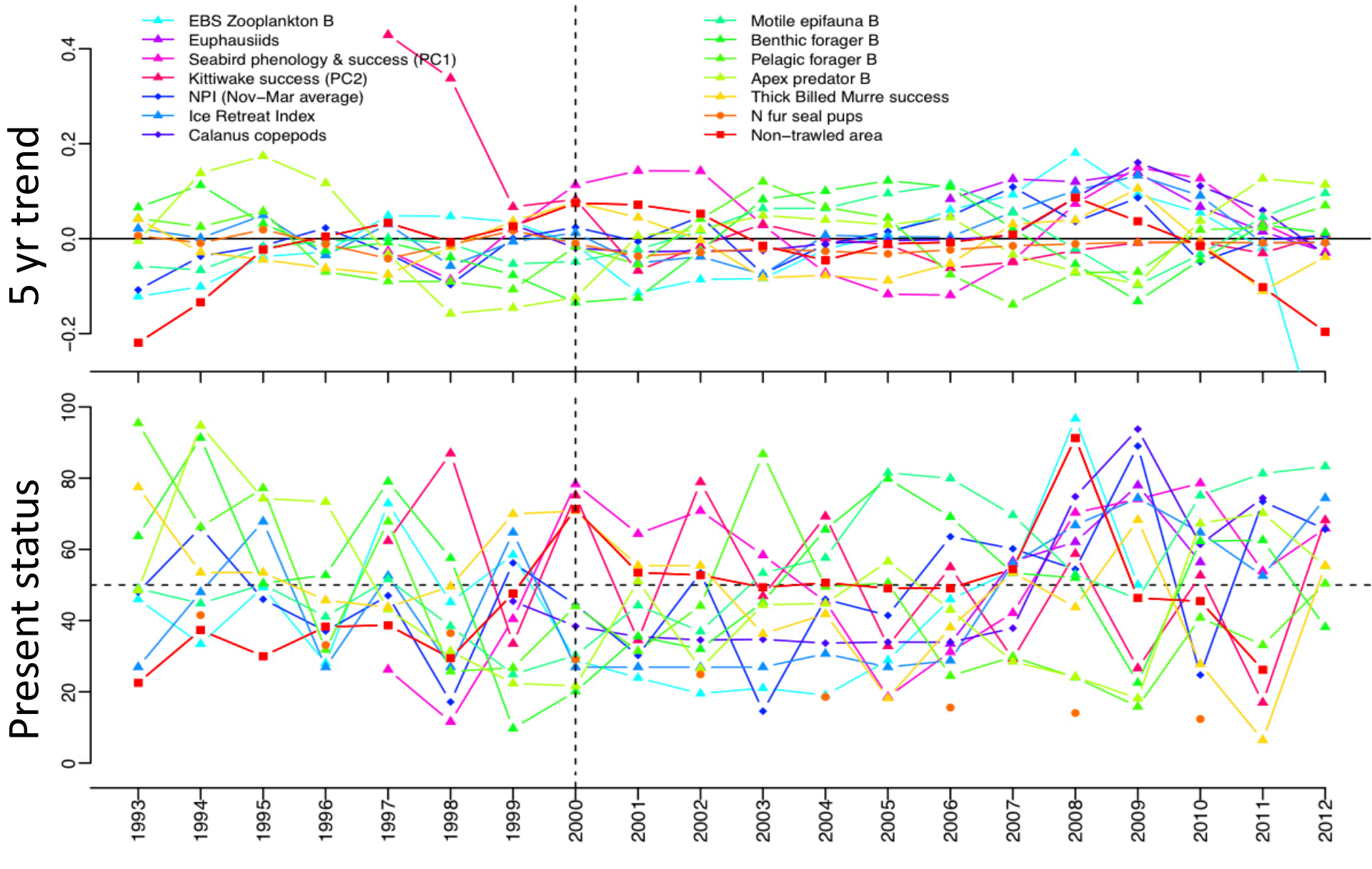
Goal Score = (Present Status + Likely Future Status) / 2

Likely Future Status= 1+ 2/3 * Trend + 1/3*(Resilience - Pressure)



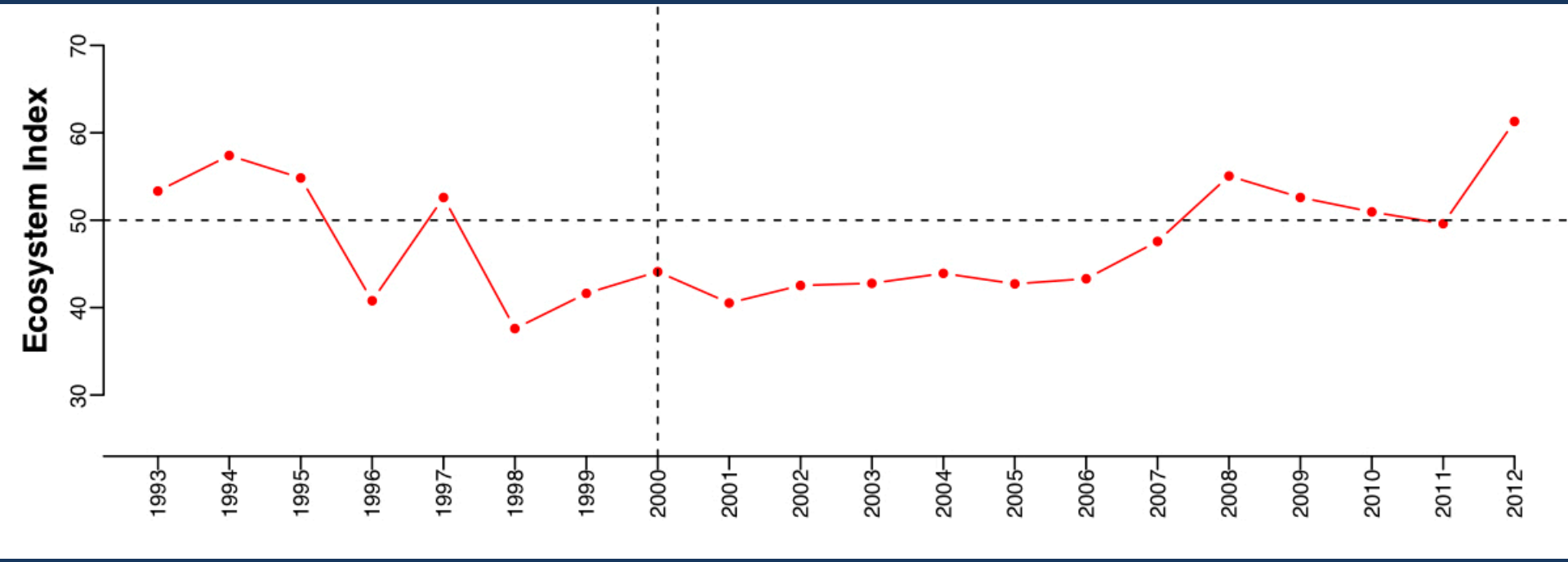
HALPERN et al. | N AT U R E | VO L 4 8 8 | 3 0 AU G U S T 2 0 1 2

Can we use the Eastern Bering Sea Report Card indicators to create an ecosystem reference point?



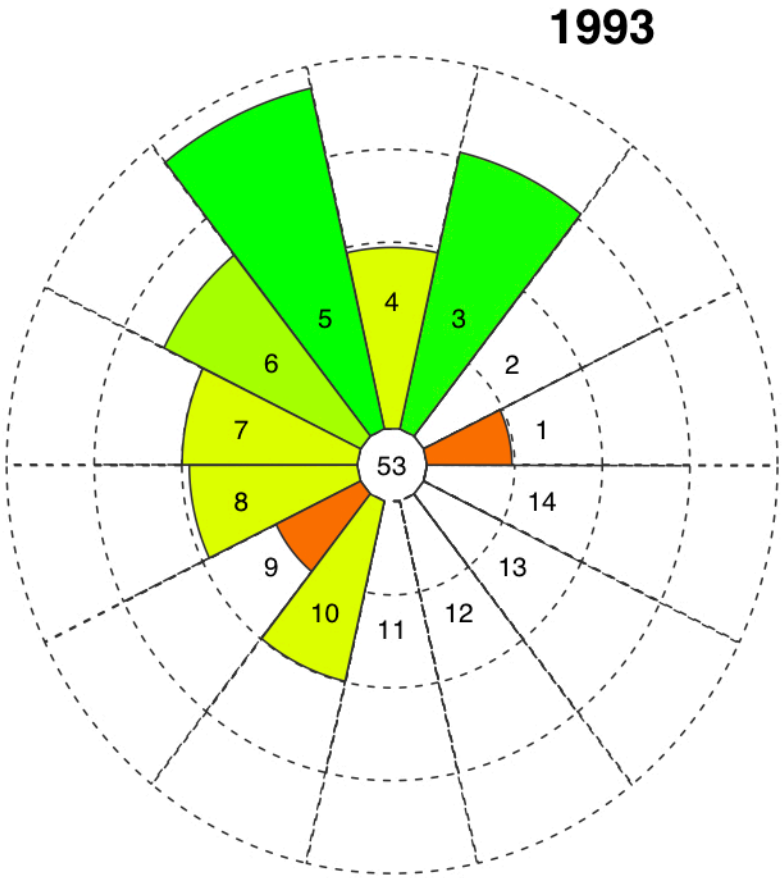
Eastern Bering Sea Ecosystem Reference Point

Annual trend



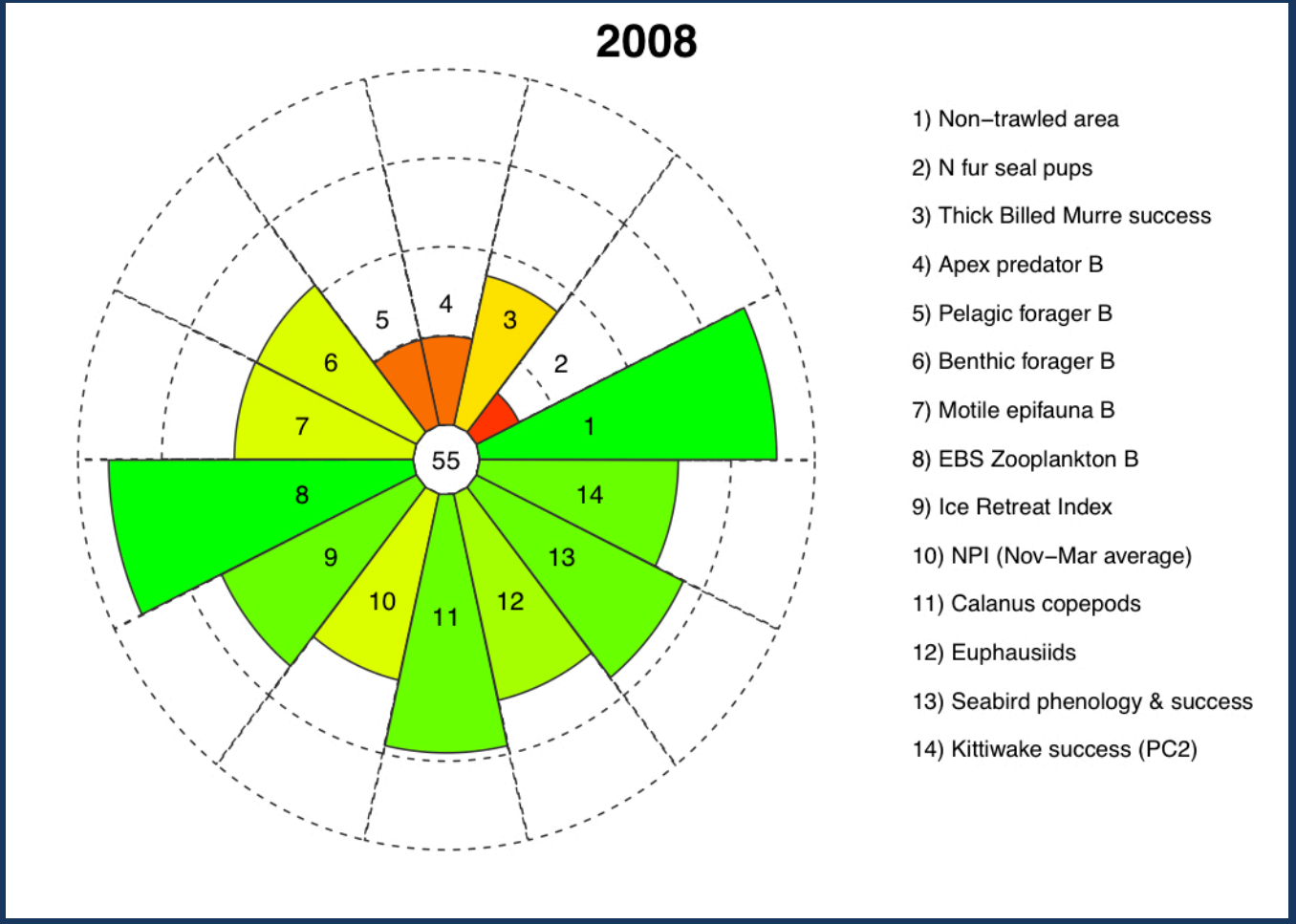
Eastern Bering Sea Ecosystem Reference Point

Within year indicator influences

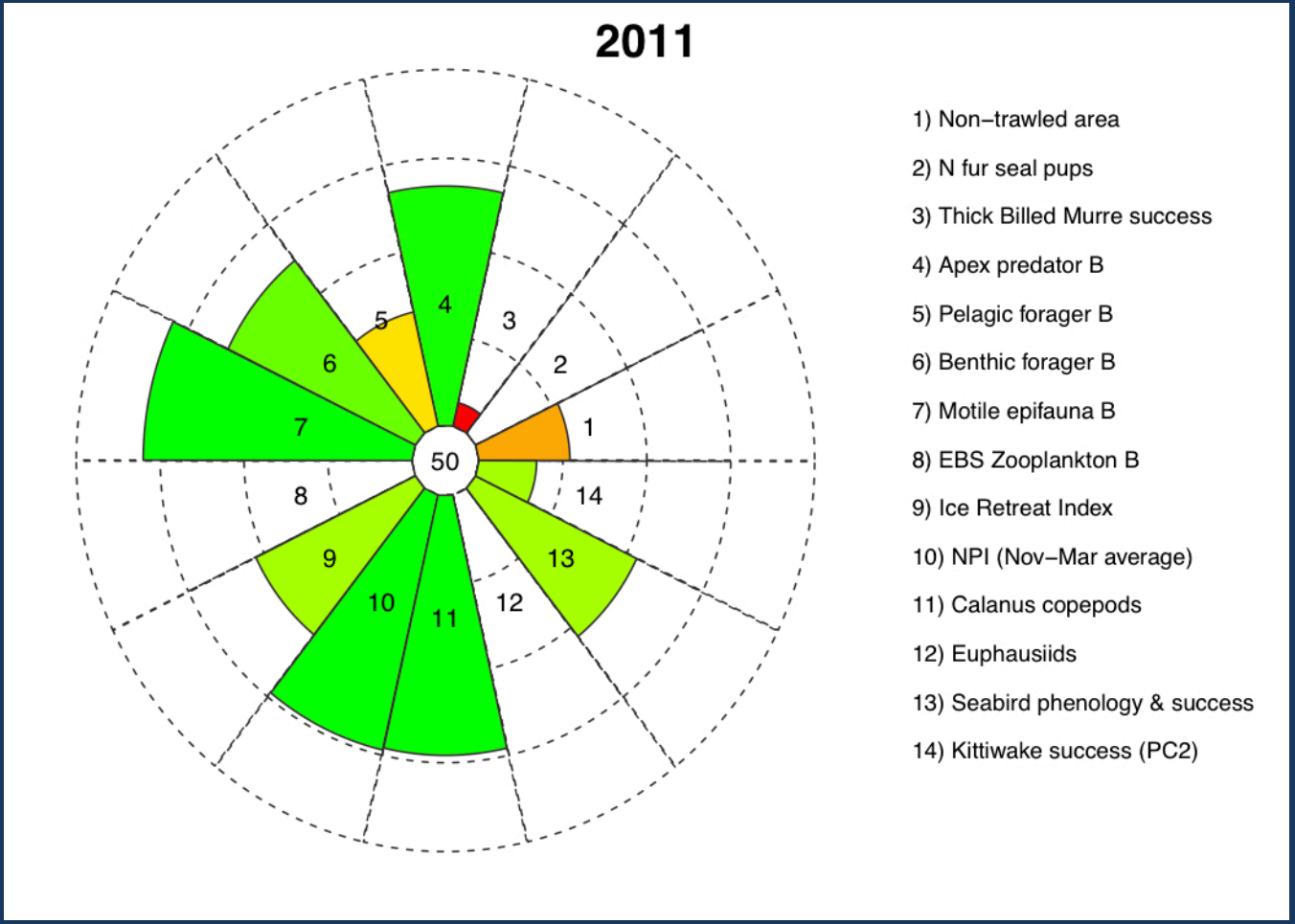


1) Non–trawled area
2) N fur seal pups
3) Thick Billed Murre success
4) Apex predator B
5) Pelagic forager B
6) Benthic forager B
7) Motile epifauna B
8) EBS Zooplankton B
9) Ice Retreat Index
10) NPI (Nov–Mar average)
11) Calanus copepods
12) Euphausiids
13) Seabird phenology & success
14) Kittiwake success (PC2)

Eastern Bering Sea Ecosystem Reference Point



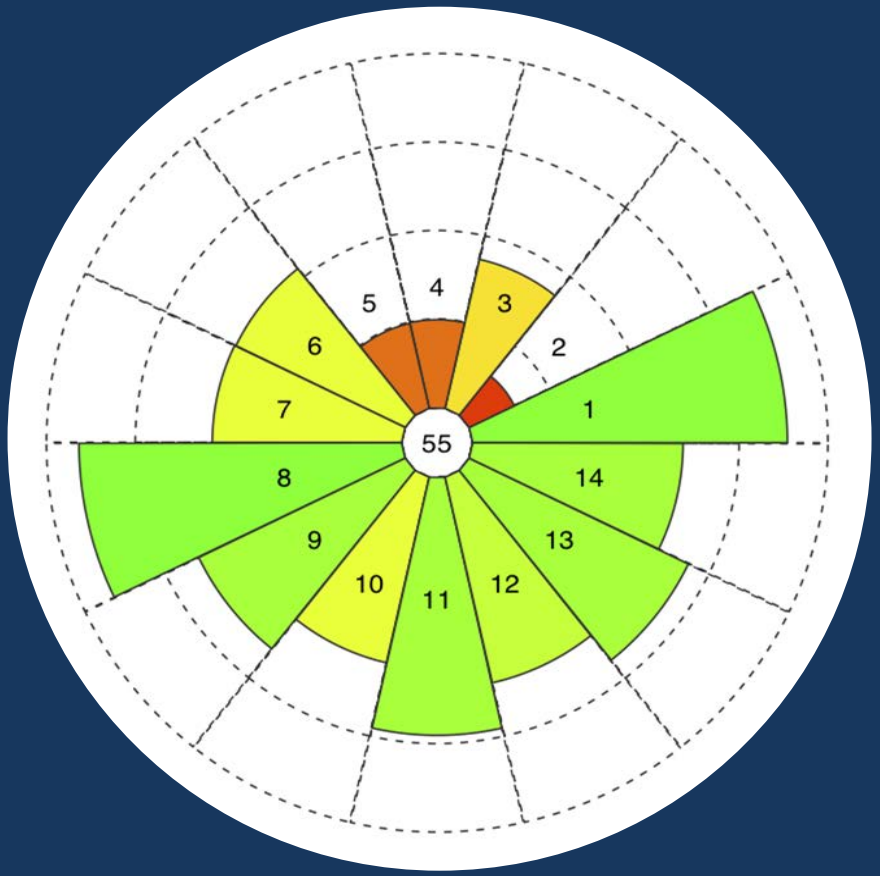
Eastern Bering Sea Ecosystem Reference Point



Next Steps

Will this allow us to:

- Evaluate risk under various management actions?
- Detect effects of management actions on ecosystem indices?



Final Comments

Final comments

- What do the indicators indicate?
- Change management system or work with system?
- Increase dialogue
- Qualitative to quantitative
- Seabird opportunities

Acknowledgements

Kerim Aydin, Kirstin Holsman, Sarah Gaichas, George Hunt, Ivonne Ortiz, Andy Whitehouse, Geoff Lang, Shannon Fitzgerald, Heather Renner, John Piatt, Yumi Arimitsu, Rebecca White

Data: Heather Renner, Scott Hatch, Sonia Batten, Nick Bond, Joe Orsi, Jamal Moss, Dan Urban, Olav Ormseth, Howard Freeland, John Piatt, Alaska Maritime National Wildlife Refuge biologists

FATE (Fisheries and the Environment)