Science, Service, Stewardship

Ecosystem-based fisheries management in the Alaska Region

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(*) Contributions from: Pat Livingston, Anne Hollowed, Jim Ianelli, Jeff Napp, Mike Sigler, Al Hermann, Ivonne Ortiz, Kirstin Holsman, Matt Baker, Olav Ormseth, Stephani Zador, Steve Ignell

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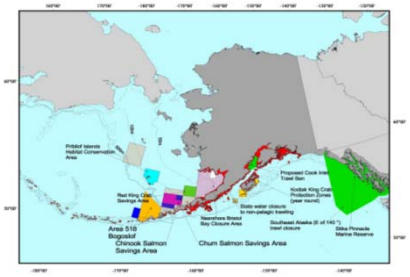
Examples of Ecosystem-based Management Actions

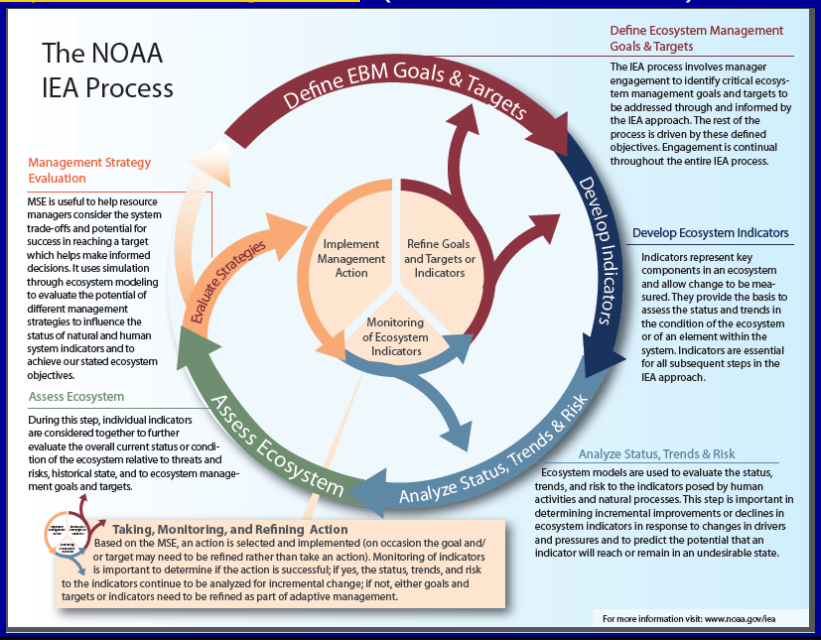
- **OY cap on total groundfish yield**
- **No target fisheries on forage – designation of ecosystem component stocks**
- **Minimum biomass threshold in harvest control rule for sea lion prey species**
- **Trawl closures, bottom trawling restrictions**
- **Single species FMPs converted to place based or multispecies based FMPs or FEPs**

CAP on TOTAL TARGET CATCH
Total yield < 2 million tonnes



NOAA Integrated Ecosystem Assessment Program

http://www.noaa.gov/iea/ (note: EBM vs. EBFM)



Ecosystem-based fishery management – Strategic planning

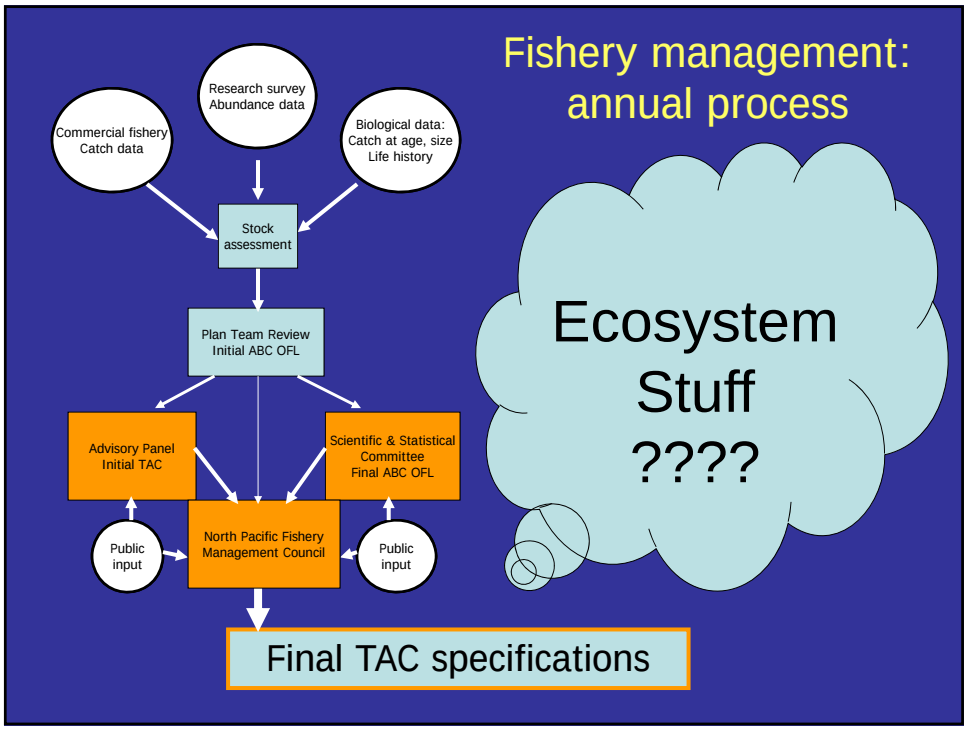
www.fakr.noaa.gov/npfmc/current_issues/ecosystem/AIFEP12_07.pdf

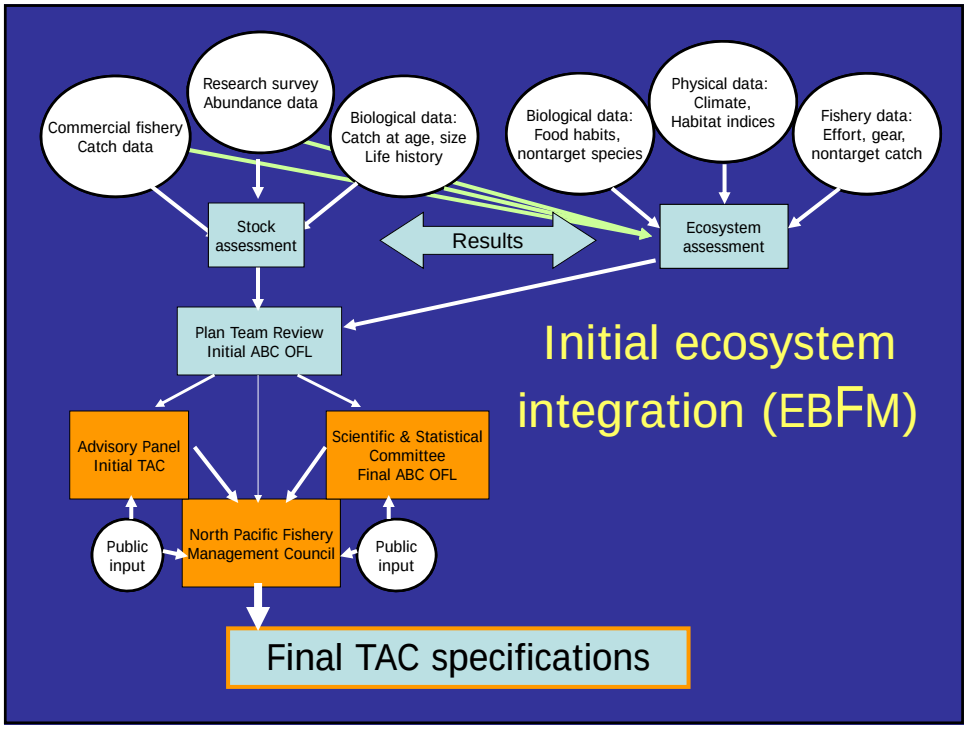
www.fakr.noaa.gov/npfmc/current_issues/Arctic/arctic.htm

alaskafisheries.noaa.gov/habitat/efh.htm

Council Research Priorities

- The Council would also like to highlight several current Council initiatives that are of high priority, and notes the research priorities that specifically relate to these initiatives:
- Build Integrated Ecosystem Management capabilities (related research priorities: 110, 125, 142, 194, 198, 200, 203, 204, 205, 216, and 217).





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Methods of Using Ecosystem Information in an ACL context

- ***Tactical***
  - — Quantitative incorporation into a single species assessment model: M2, environmental or habitat variable
  - —Qualitative evaluation of ecosystem factors in annual ACL process: suites of variables that may impact production
- ***Strategic***
  - — Management strategy evaluations (MSEs) to examine robustness of harvest strategies
  - —Quantitative suites of ecosystem indicators and aggregate indices

8

Including ecosystem considerations in each stock assessment

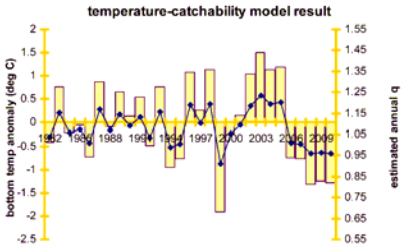
(Lowe et al. 2007)

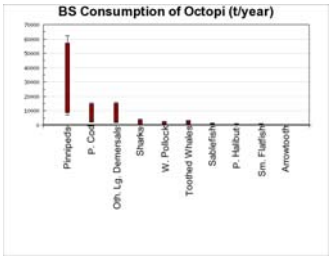
Table 15.14. Ecosystem effects

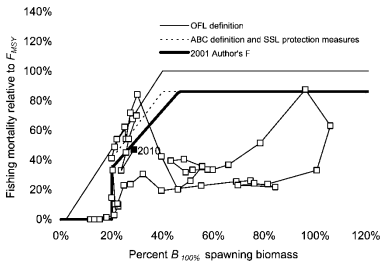
Ecosystem effects on Atka mackerel			
Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys	None	Unknown
Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	Possibly lower mortality on Atka mackerel	No concern
Birds	Stable, some increasing some decreasing	Affects young-of-year mortality	No concern
Fish (Pacific cod, arrowtooth flounder)	Pacific cod and arrowtooth abundance trends are stable	None	No concern
Changes in habitat quality			
Temperature regime	2006 AI summer bottom temperature slightly below average (excl. 2000)	Could possibly affect fish distribution	Unknown
***The Atka mackerel* effects on ecosystem**			
Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Prohibited species	Stable, heavily monitored	Likely to be a minor contribution to mortality	Unknown
Forage (including herring, Atka mackerel, cod, and pollock)	Stable, heavily monitored	Bycatch levels small relative to forage biomass	Unknown
HAPC biota (seapens/whips, corals, sponges, anemones)	Low bycatch levels of seapens/whips, sponge and coral catches are variable	Unknown	Possible concern for sponges and corals
Marine mammals and birds	Very minor direct-take	Likely to be very minor contribution to mortality	No concern
Sensitive non-target species	Skate catches are variable and have averaged 87 t from 2003-2005, which is about 14% of the AI skate catch over this time period	Data limited, need species-specific catch information	Possible concern
Other non-target species	Sculpin catch is variable, large increase in bycatch in 2004	Unknown	Unknown
Fishery concentration in space and time	Steller sea lion protection measures spread out Atka mackerel catches in time and space. Fishery has expanded and concentrates in other areas outside of critical habitat	Mixed potential impact (fur seals vs Steller sea lions). Areas outside of critical habitat may be experiencing higher exploitation rates.	Possible concern
Fishery effects on amount of large size target fish	Depends on highly variable year-class strength	Natural fluctuation	Probably no concern
Fishery contribution to discards and offal production	Offal production—unknown The Atka mackerel fishery contributes an average of 690 (58%), and 6,100 t of the total AI trawl non-target and Atka mackerel discards, respectively.	The Atka mackerel fishery is one of the few trawl fisheries operating in the AI. Numbers and rates should be interpreted in this context.	Unknown
Fishery effects on age-at-maturity and fecundity	Unknown	Unknown	Unknown

Regional Examples: Tactical

- EBS yellowfin sole temperature dependent survey Q
- GOA walleye pollock B20 threshold for Steller sea lions
- Natural mortality from predation estimates of octopus, crab







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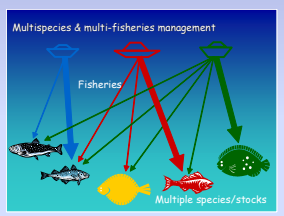
Developing and maintaining **Operational Readiness**

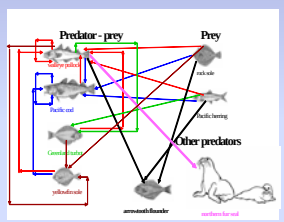
An "operational ensemble" of models be developed and kept up-to-date to address pressing ecosystem-based management concerns in a timely fashion

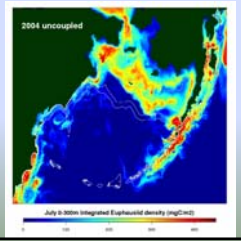
- Endangered species issues
- Bycatch impacts
- Ocean acidification
- Oil and gas development



Multispecies Bycatch Model (Ianelli)

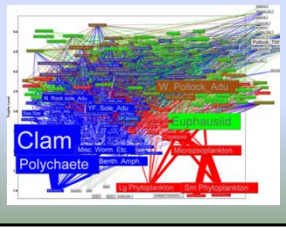
MSVPA/ Multispecies Statistical Model (Jurado-Molina et al.)



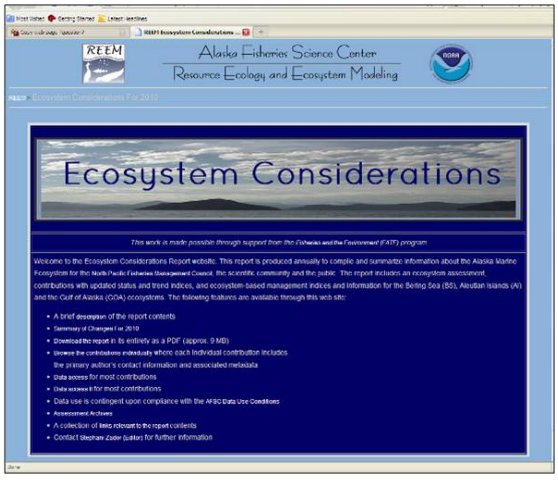


Forage and Euphausiid Abundance in Space and Time (FEAST); Aydin et al. North Pacific Research Board

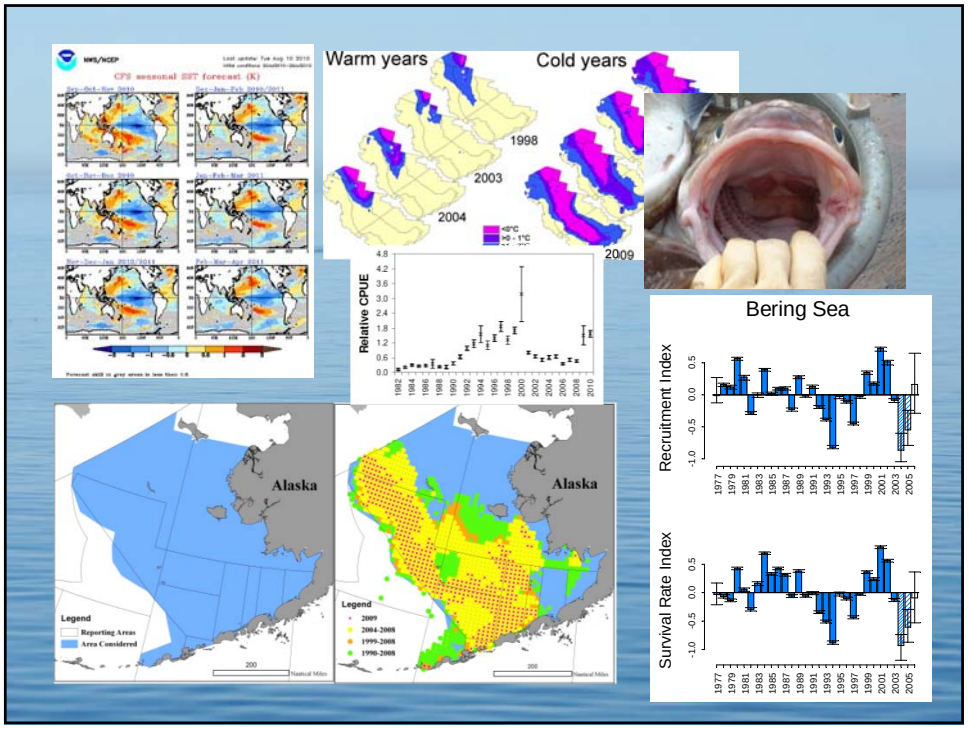
Ecopath/Ecosim and Ecosense (Aydin et al.)

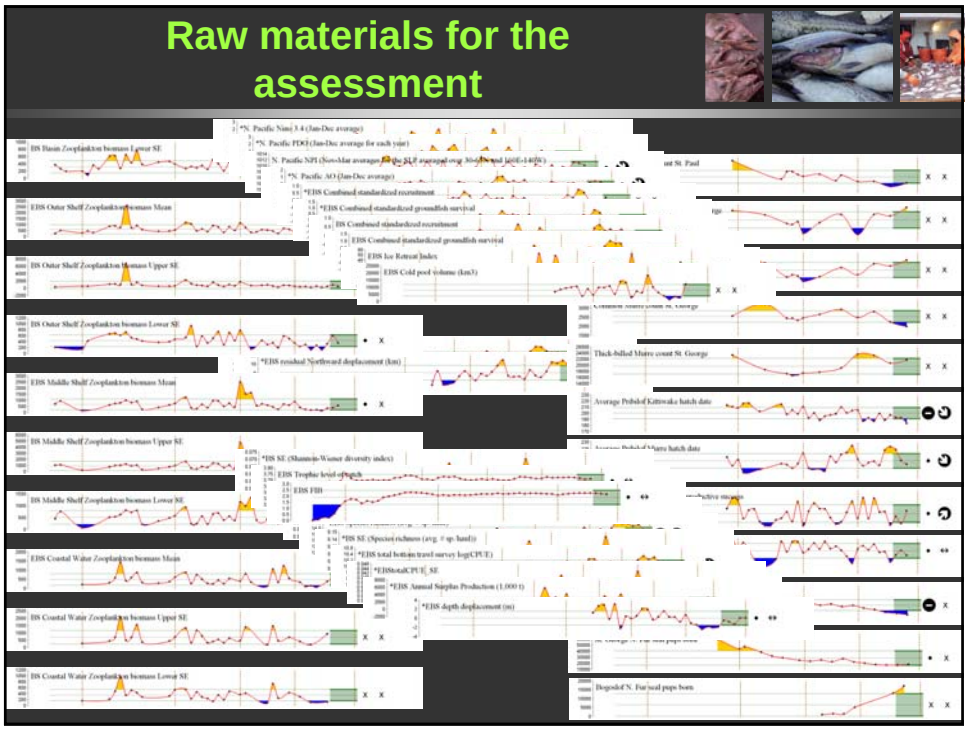


http://access.afsc.noaa.gov/reem/ecoweb/index.cfm



- **Current and archived versions available**
- **Ongoing support from the FATE program**


CFS seasonal SST forecast (K)
Warm years
Cold years
1998
2003
2004
2009
Relative CPUE
Bering Sea
Recruitment Index
Survival Rate Index
Alaska
Alaska
Legend
Reporting Areas
Area Considered
Legend
2009
2004-2008
1999-2008
1990-2008


Raw materials for the assessment

Ecosystem Assessments at the Alaska Fisheries Science Center

- Goal: to provide a synthesis of current and relevant scientific advice for fisheries managers
- New indicator-based assessments:
  - Eastern Bering Sea (2010)
  - Aleutian Islands (2011)

Same method → *Different product*

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	17	10
Academia	2	4
Management	1 (3)	1
Commercial		1
Other Fed		2
Non Profit		1
Research sponsor		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

Results

- 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

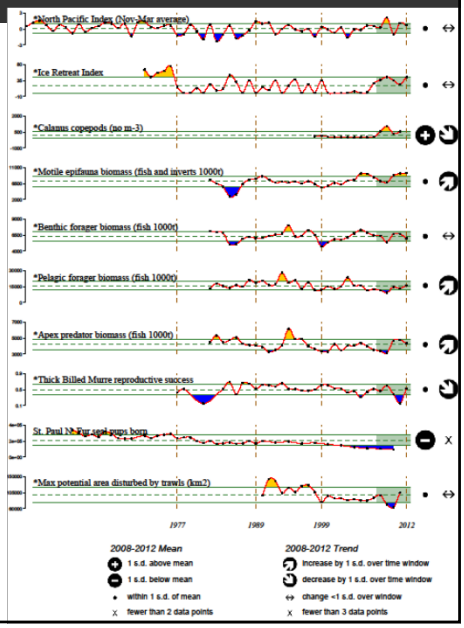
- North Pacific Index
- Auklet reproductive success
- Tufted puffin chick diets
- Pelagic foragers biomass
- Fish apex predator biomass
- Sea otters
- Steller sea lion non-pups
- Area trawled
- K-12 enrollment

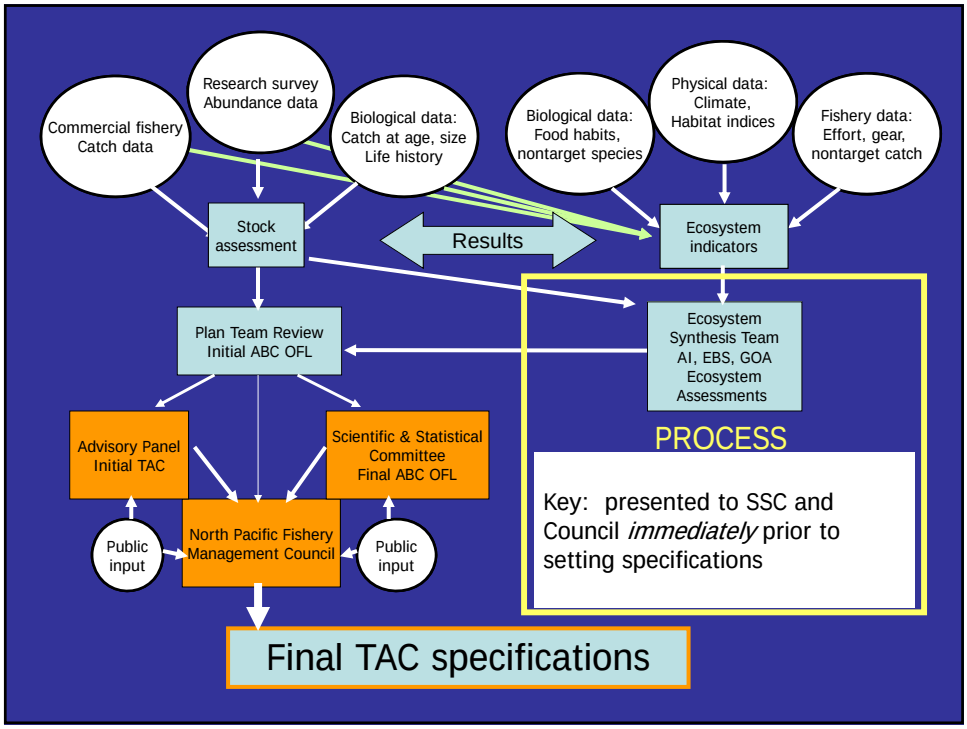
Report Card

Eastern Bering Sea 2012 Report Card

- The North Pacific atmosphere-ocean system reflected a combination of a **response to La Niña and intrisic variability**. The combination of the **neutral to weak El Niño expected this winter** and a continuation of reduced ice cover in the central Arctic should yield **a lighter ice year for the Bering in 2013**.
- **Ocean temperatures remained cold and sea ice remained extensive**, similar to 2008 and 2010. Ice retreat this year (and 2009) was the latest recorded since 1985. Summer was calm and cool, but had the **most extensive cold pool area of the recent decade**.
- The summer ***Calanus*** **copepod time series showed an increase in abundance** in 2011 relative to 2010, but remained below the 2009 peak. 2011 was **the fourth year that concentrations remained well above average**, following patterns also seen in fall zooplankton abundance during cold years. This suggests that prey availability for planktivorous fish, seabirds, and mammals continued to be high during the summer of 2011.
- **Jellyfish remain abundant**, although peak abundances observed in fall 2010 and summer 2011 declined by fall 2011 and summer 2012.
- **While commercial crab stocks are relatively low**, overall **motile epifauna biomass remains stable or increasing** since the late 1980s. Higher levels since 2003 are driven by increases in brittle stars and echinoderms, although these series show high within-year variances in the survey.
- **Biomass of benthic foragers has remained stable** since 1982, with interannual variability driven by short-term fluctuations in yellowfin and rock sole abundance.
- **Biomass of pelagic foragers has increased to nearly average** from record survey lows in 2009. While pollock has increased from low levels, this is additionally driven by increases in capelin seen in 2010-2012.
- **Fish apex predator biomass has increased appreciably in the last few years**, driven primarily by the increase in Pacific cod from lows in 2007-2009 to higher levels in 2010-2012. Arrowtooth flounder biomass has decreased from all-time survey highs during 2004-2005, though it remains high relative to pre-1989 levels.
- **Thick-billed murre reproductive success on St. George Island was near average** in 2012, a substantial increase from the record low in 2011. This suggests that **foraging conditions were favorable for piscivorous seabirds.**
- **Northern fur seal pup production for St. Paul Island has declined over the long term.** The most recent pup production estimates for St. Paul and St. George Islands in 2010 were 8.8% and 1.0% less than the 2008 estimates.
- The maximum potential **area of seafloor habitat disturbed by trawl gear increased in 2011** to the highest level since 1998. The cause of this increase is currently unknown.

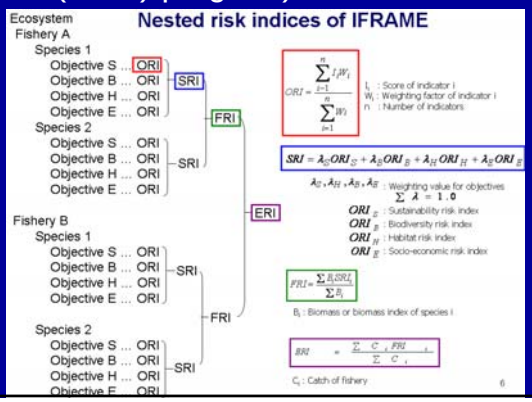
Hot topic In September the Department of Commerce declared commercial king salmon fisheries in the Yukon and Kuskokwim rivers failures after extremely low returns over the summer. The two leading hypotheses for the reduced runs are climate change and fishing.

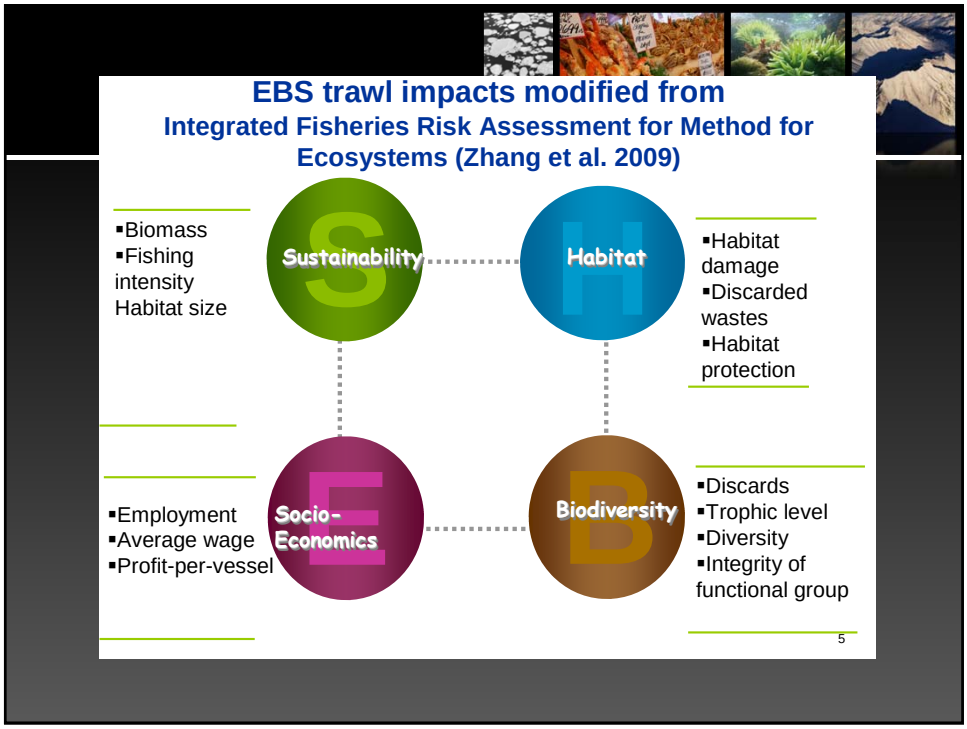




Goal: formal ecosystem thresholds

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





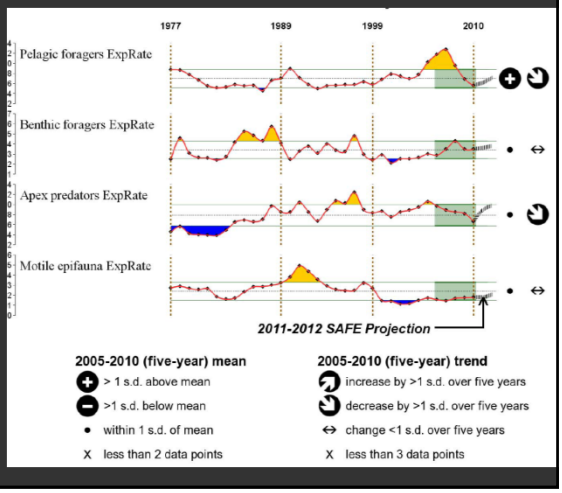
Guild Catch and Exploitation Rates

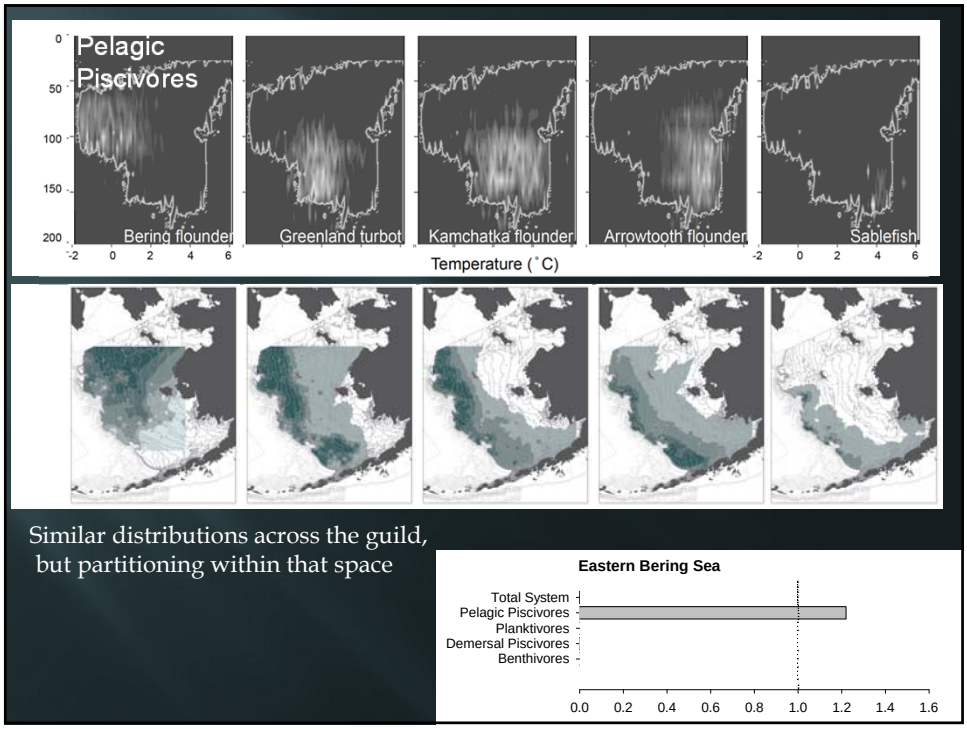
Pelagic foragers aggregate biomass

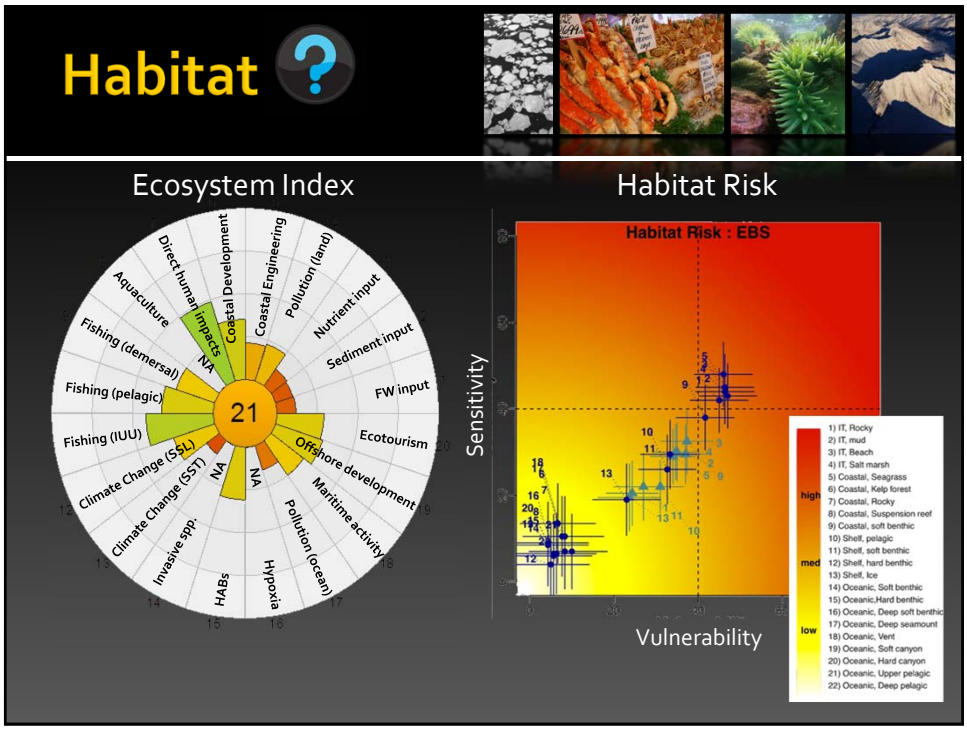
Benthic foragers aggregate biomass

Fish apex predators aggregate biomass

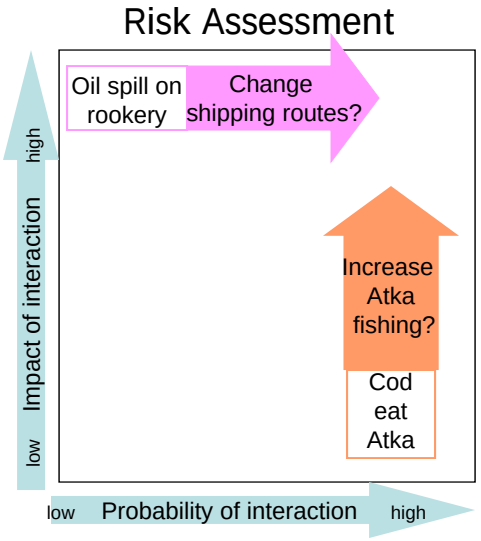
Motile epifauna aggregate biomass




Pelagic Piscivores
Bering flounder
Greenland turbot
Kamchatka flounder
Arrowtooth flounder
Sablefish
Temperature (˚C)
Similar distributions across the guild, but partitioning within that space
Eastern Bering Sea
Total System
Pelagic Piscivores
Planktivores
Demersal Piscivores
Benthivores


Habitat
Ecosystem Index
Habitat Risk
Habitat Risk : EBS
Sensitivity
Vulnerability
21
Coastal Development
Coastal Engineering
Pollution (land)
Nutrient input
Sediment input
FW input
Ecotourism
Offshore development
Maritime activity
Pollution (ocean)
Hypoxia
HABs
Invasive spp.
Climate Change (SST)
Climate Change (SSL)
Fishing (IUU)
Fishing (pelagic)
Fishing (demersal)
Aquaculture
Direct human impacts
NA

Interactions → Ecosystem Assessment



Risk Assessment

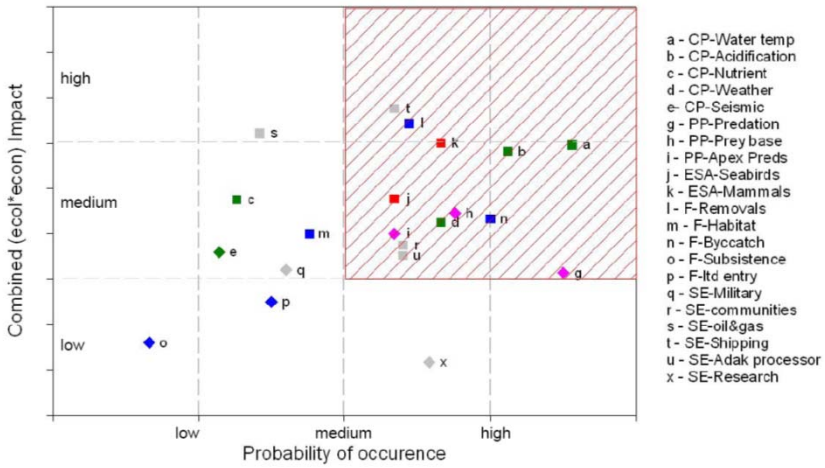
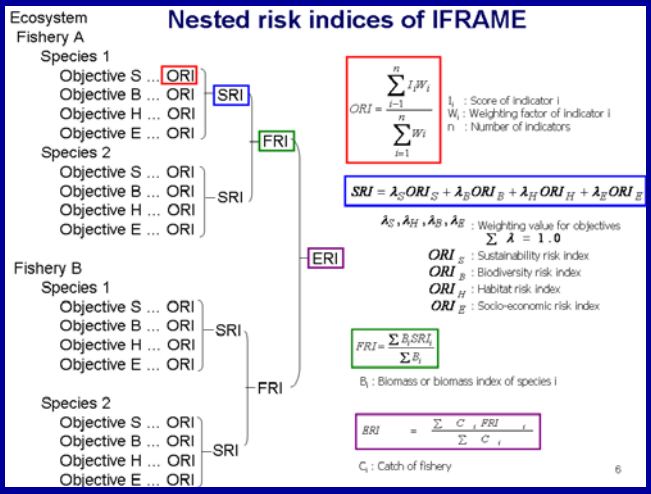


Figure 4-4 **Characterization of interactions in terms of probability of occurrence and a combined ecological multiplied by economic impact. Shaded area in upper right quadrant highlights those interactions with a medium to high probability of occurring and likely impact.**

Challenge 1: Ecosystem Science



BEST-BSIERP Bering Sea Project

bsierp.nprb.org

What Controls Trophic Interconnectivity in the eastern Bering Sea?

Bering **E**cosystem **St**udy
(BEST)
+
Bering **S**ea **I**ntegrated **E**cosystem **R**esearch **P**rogram
(BSIERP)

Alaska Marine Science Symposium
Anchorage, Alaska
January 23rd, 2013

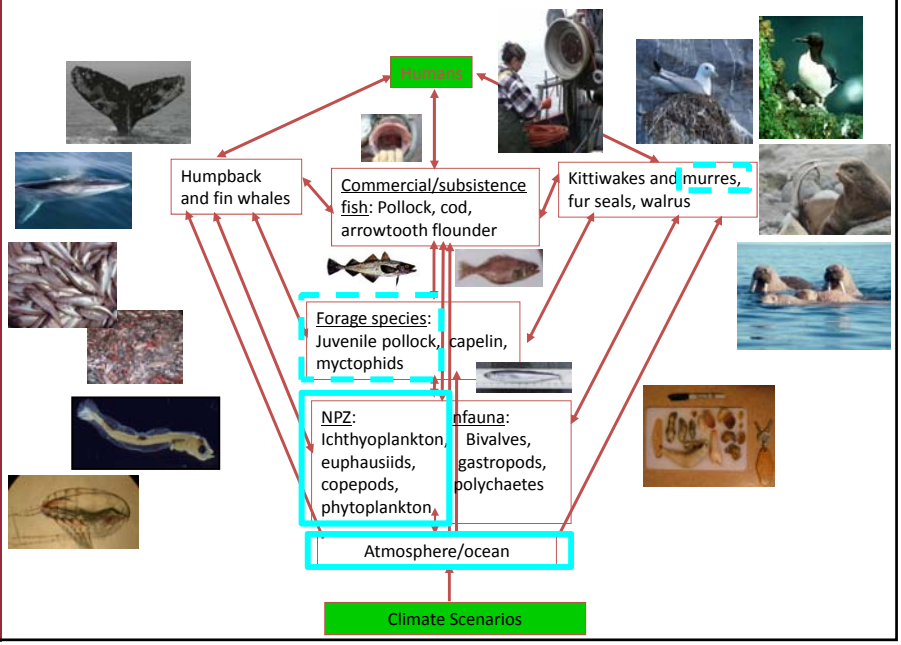
Michael Lomas (Bigelow Lab) &
Phyllis Stabeno (PMEL)
(on behalf of the larger program)

http://bsierp.nprb.org/

BEST-BSIERP Bering Sea Project

bsierp.nprb.org

The Project is an 'End-to-End Ecosystem Study'

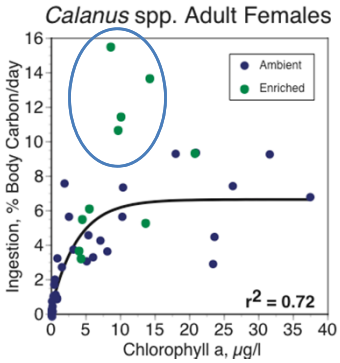


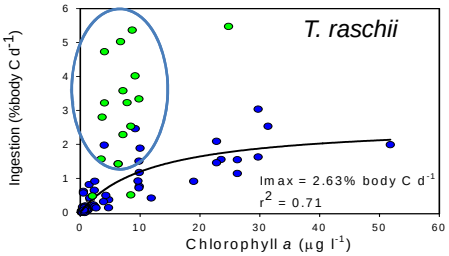
BEST-BSIERP Bering Sea Project

bsierp.nprb.org

Importance of Seasonal Sea Ice:

Ice algae: Importance to early reproduction in copepods





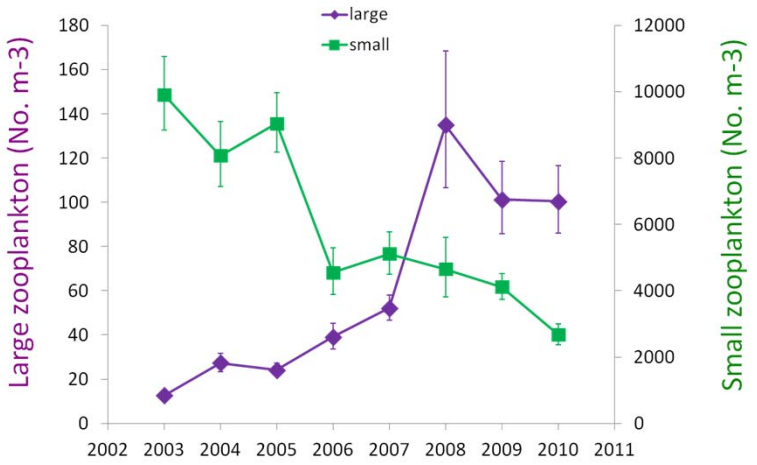
Both *Calanus* spp. and *T. raschii* have higher ingestion when feeding on ice algae (green) than when feeding on ambient water column phytoplankton (blue)

Campbell, Lessard, Ashjian

BEST-BSIERP Bering Sea Project

bsierp.nprb.org

Large Zooplankton Increase in Cold Years:



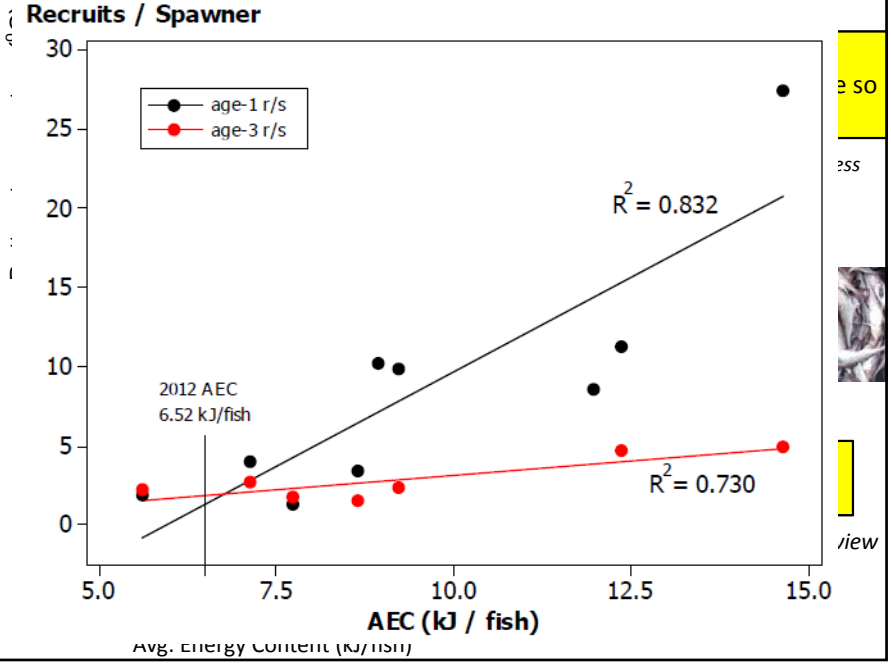
Cold years favor the increases in abundance of large zooplankton at the expense of small zooplankton.

L. Eisner et al., submitted.

BEST-BSIERP Bering Sea Project

bsierp.nprb.org

Water Temperature, pollock and euphausiids:



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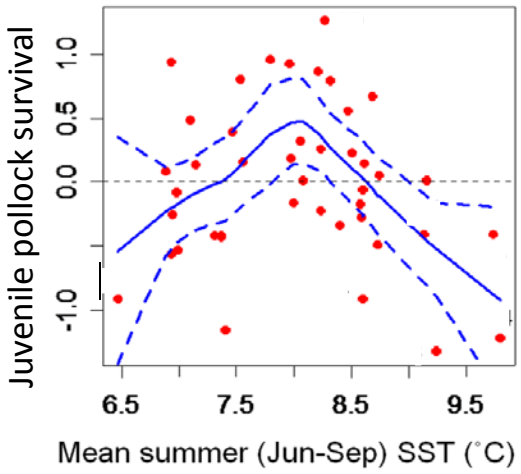
Water Temperature, pollock and euphausiids:

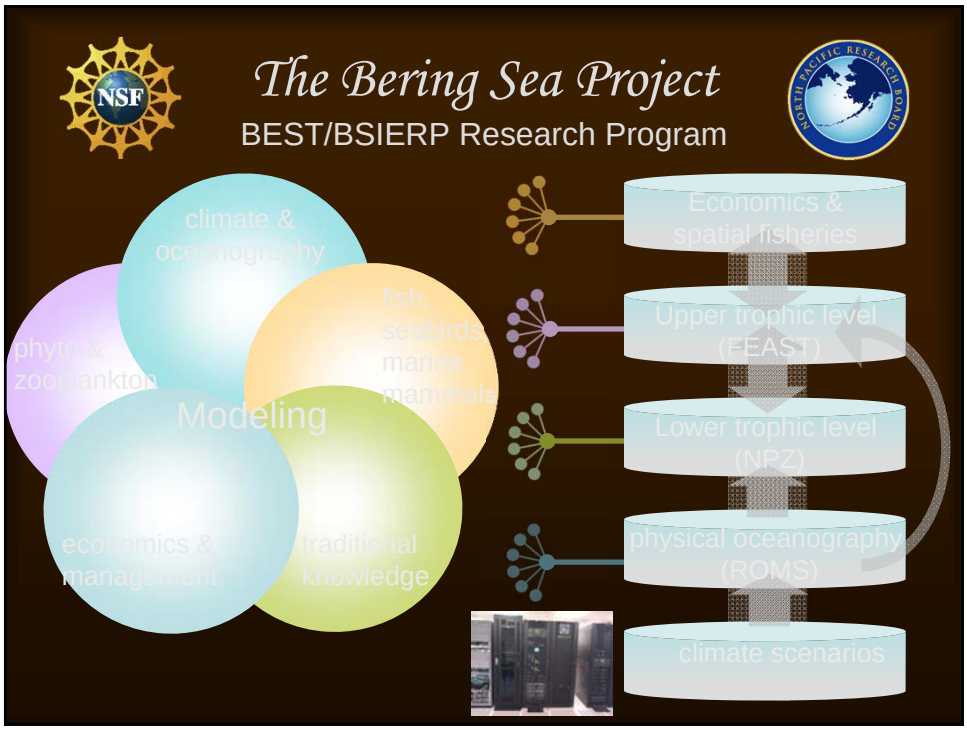


Above average

Below average

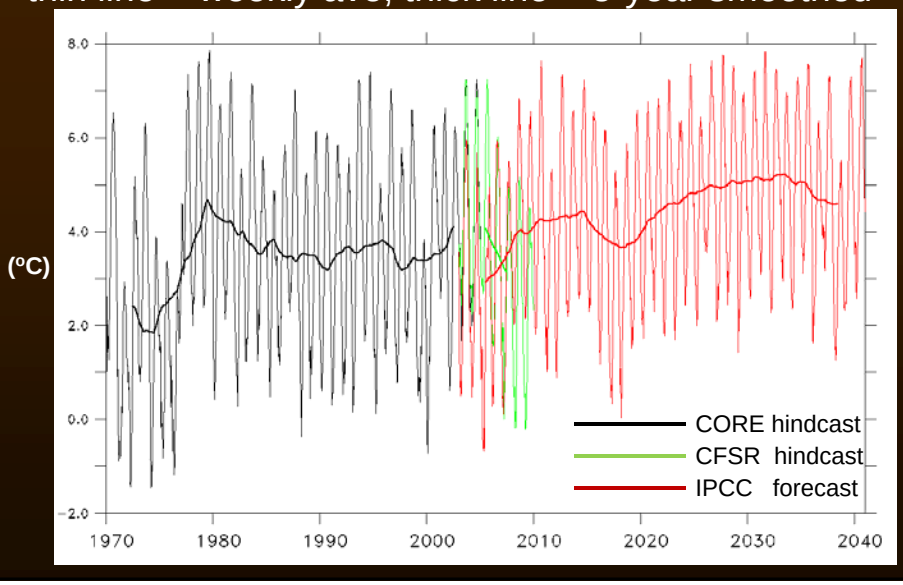
Modelled conditions for juvenile pollock survival are associated with moderate temperatures

Meuter

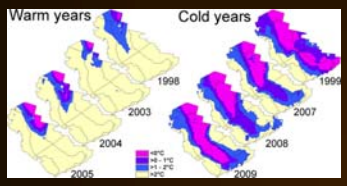


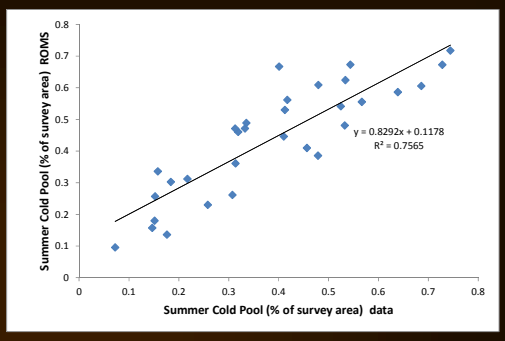
Southeast Bering depth-averaged temperature

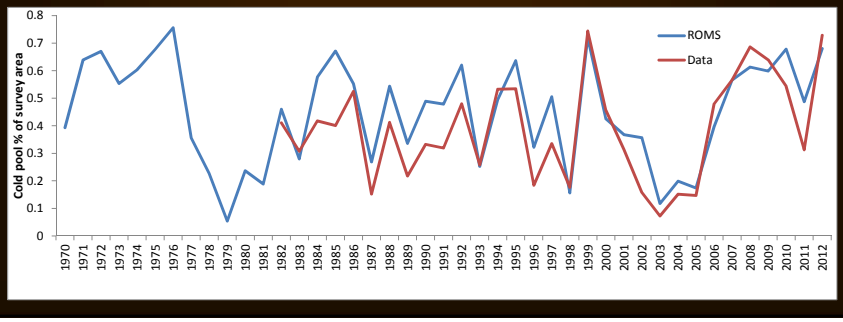
thin line = weekly ave; thick line = 5-year smoothed

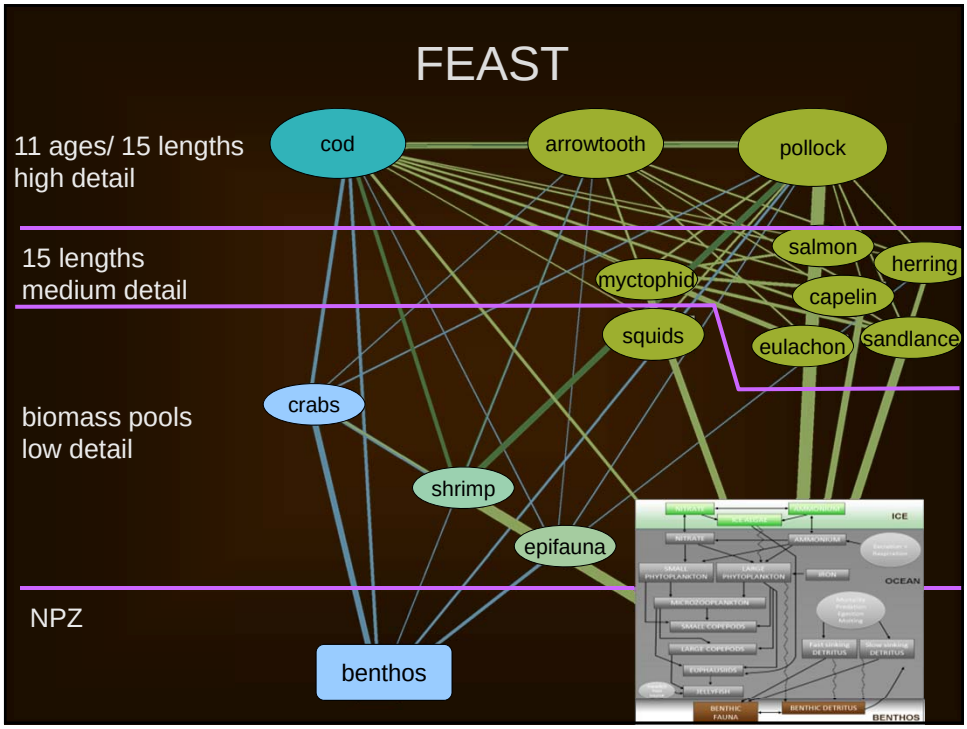


Focus on dynamic habitat (e.g. Barbeaux, Spencer et al.)

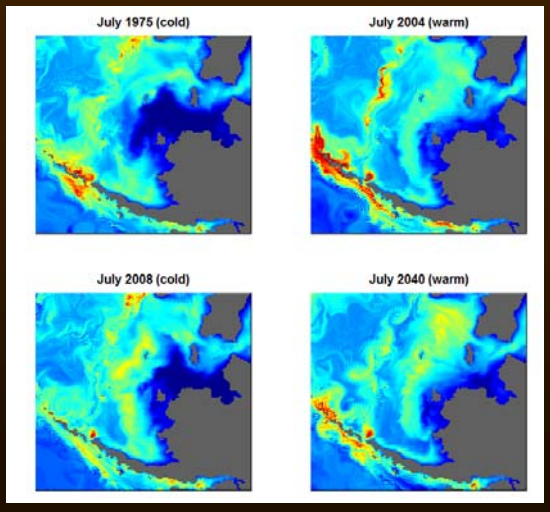




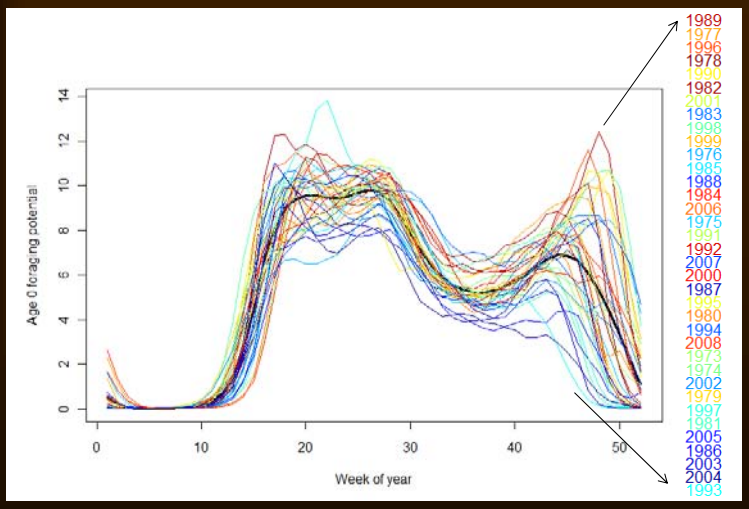




Prey Fields and temperature – foraging potential for an 8 cm (age 0) pollock

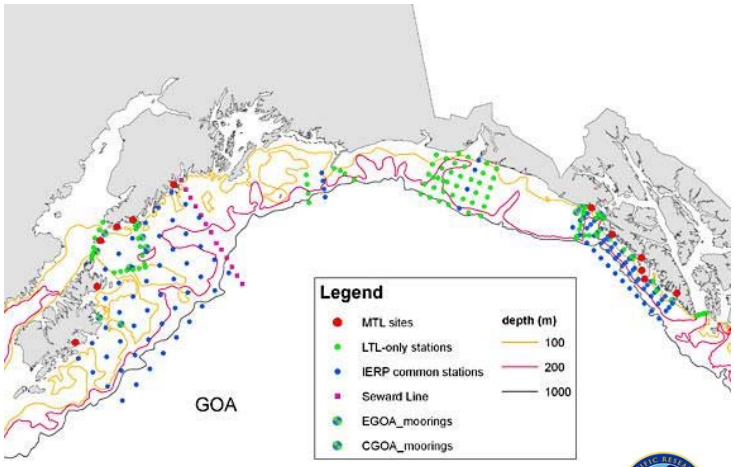


Age 0 pollock seasonal Forage Potential (FP) and stock-assessment estimate of year-class strength



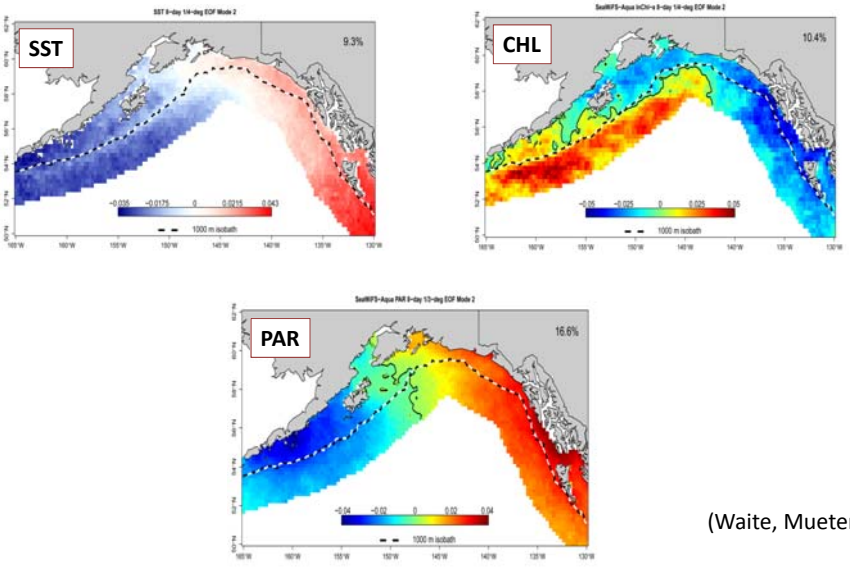
Colors show ranked stock-assessment year-class strength from weakest (blue) to strongest (red)

Gulf of Alaska IERP



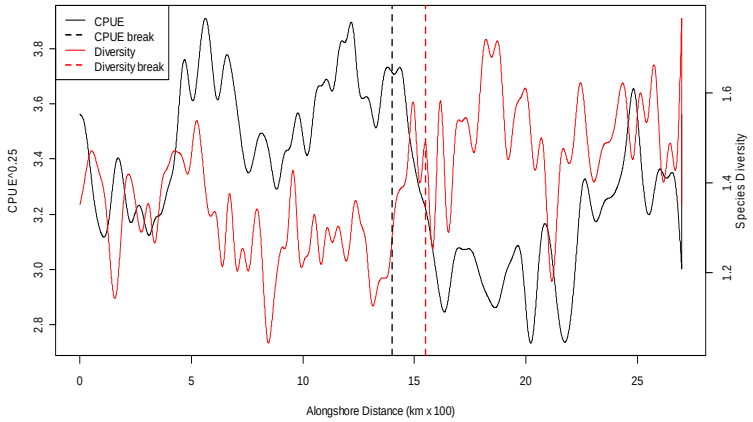
Comparative approach

GOA breakpoints - oceanography



(Waite, Mueter)

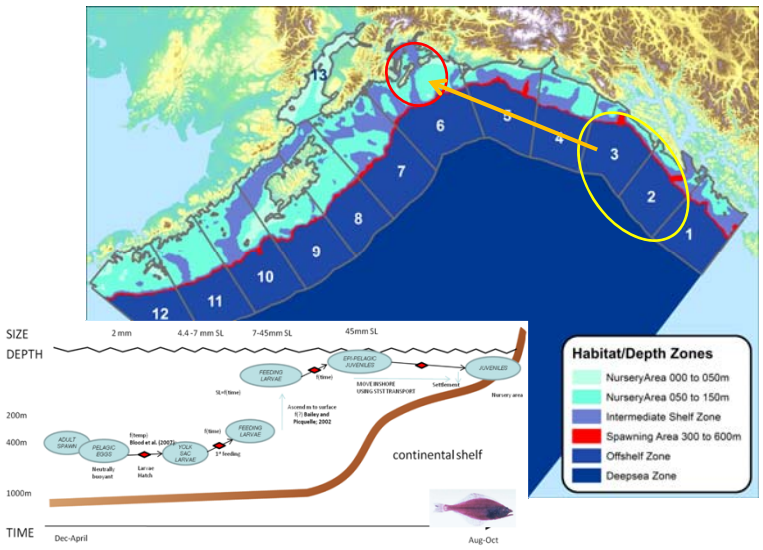
GOA breakpoints – fishes – CPUE & diversity



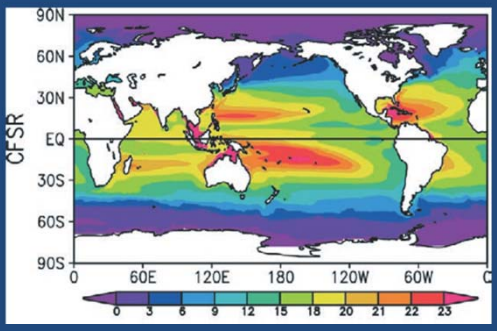
(Waite, Mueter)

individual-based model (IBM): arrowtooth flounder

(Buck Stockhausen)



MOVING TO PREDICTION



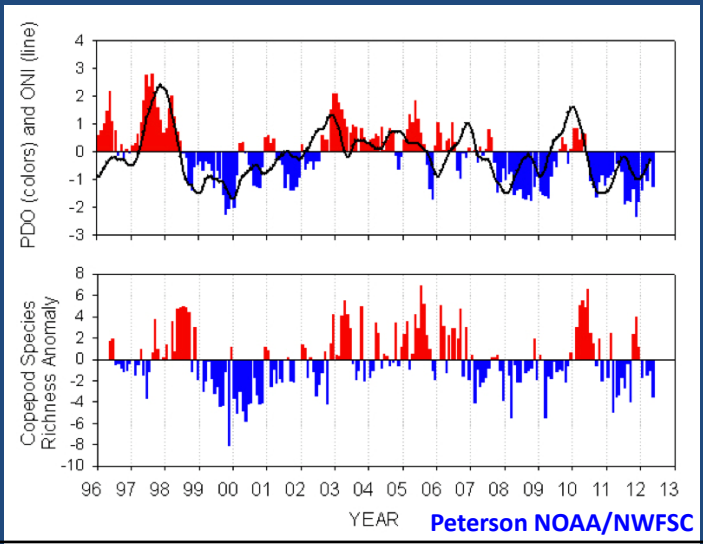
- The Climate Forecast System (CFS) – a global coupled air/sea/land model –is used for boundary conditions and atmospheric forcing of an established ROMS-based regional model

CFS prediction of ENSO and PDO

FIG. 5. Time series of (a) the PDO index and (b) the Niño-3.4 SST anomaly during 1981–2006. Black line denotes observation, and blue, green, and red lines denote CFS predictions at 0-, 3-, and 6-month lead, respectively.

Wen et al, 2012

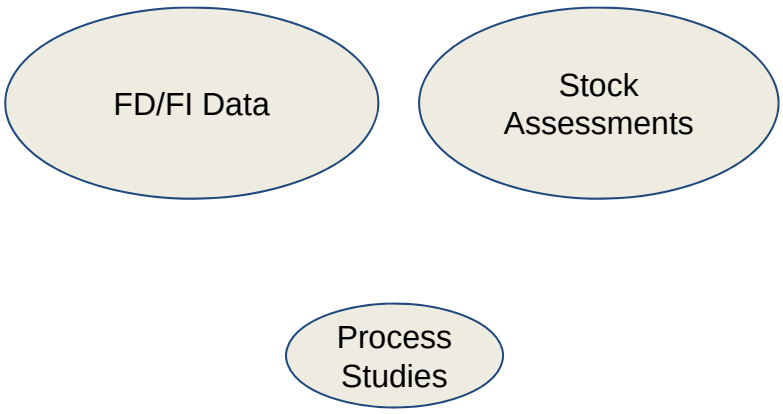
May actually be better at predicting biology due to biological integration



Recruitment Processes Alliance

- Goals
  - Improve walleye pollock stock assessment
  - Address salmon bycatch
- Alliance of major AFSC programs
  - Eco-Fisheries Oceanography Coordinated Investigations (with Pacific Marine Environmental Laboratory)
  - Ecosystem Monitoring and Assessment
  - Resource Ecology and Ecosystem Modeling

Balance of process studies and stock assessments



Data collections used in process studies

- Moorings
- Ichthyoplankton surveys
- Bottom trawl surveys
- Acoustic surveys
- Surface trawl/acoustic surveys (aka BASIS)
- Nearshore surveys
- Many of these surveys also conduct measurements of physical and biological (e.g., zooplankton) oceanography

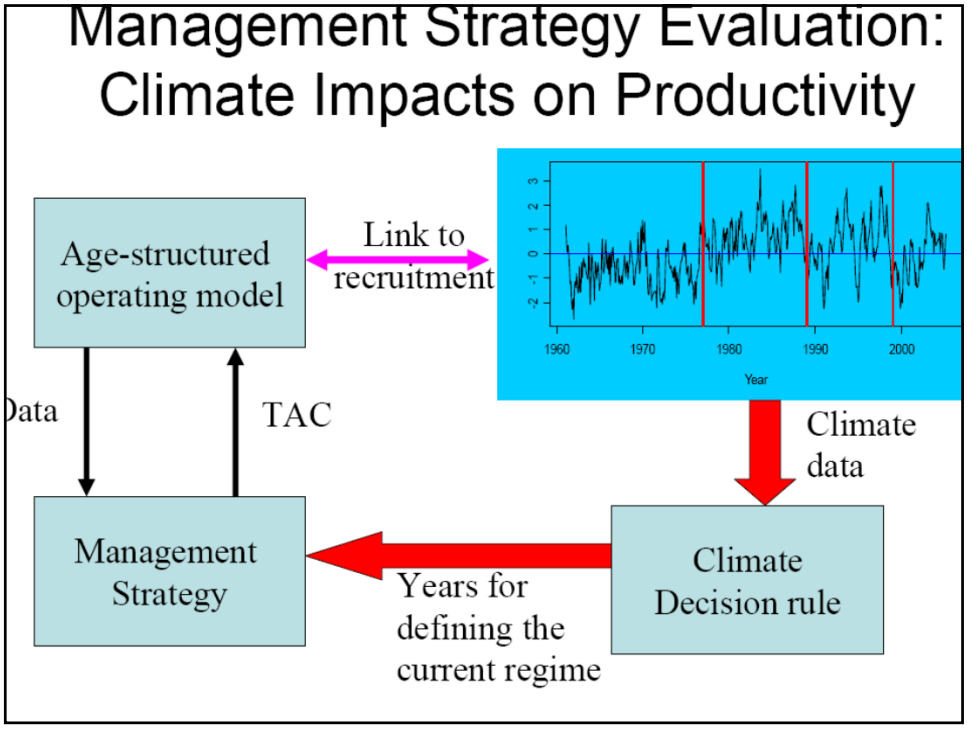
Ongoing Projects

- Integrated Ecosystem Research Programs
- Recruitment Processes Alliance
- Spatially-explicit ecosystem models (FEAST)
- Management Strategy Evaluations (MSE)
- IPCC-scenario driven projections (e.g., Mueter et al 2011; Ianelli et al. 2011)
- Bioeconomic modeling of crab fisheries and ocean acidification
- *(Does not cover substantial socioeconomic work)*

Short Term Objectives for Improvement

- ***Continue to address ecosystem terms of reference in stock assessments (M2, environmental drivers of recruitment and growth, habitat covariates)***
  - ***Develop regionally specific priorities for species and processes to be considered***
- ***Continue development of integrated ecosystem assessment frameworks***
  - ***Estimate and implement system level thresholds***
  - ***Improve modeling capabilities (multispecies, ecosystem)***
  - ***Improve integration of environmental data***
- ***More explicit rules or processes for defining where ecosystem considerations should play into ACL decisions for information not already captured in the current management process***
  - ***Work with Councils/SSCs/Regions and stock assessment review panels to develop structured process for considering ecosystem factors***
  - ***Develop processes within Science Centers to bring scientists doing stock assessment, habitat science and ecosystem research together (improve data access)***
- ***Continued and enhanced funding for National programs that focus on ecosystem data collection and integration (FATE, IEA, Habitat, ESA)***
  - ***Improve ecosystem data collection***
  - ***Continue integration into single species models***
  - ***Improve integrated assessments at the regional level***

Challenges: IEA, EBFM versus EBM, PSEIS, mandates


Management Strategy Evaluation:
Climate Impacts on Productivity
Age-structured operating model
Link to recruitment
Data
TAC
Climate data
Management Strategy
Climate Decision rule
Years for defining the current regime
1960
1970
1980
1990
2000
Year