A Framework for Evaluating Fishery Management Strategies Under Projected Climate Change Scenarios for the Bering Sea

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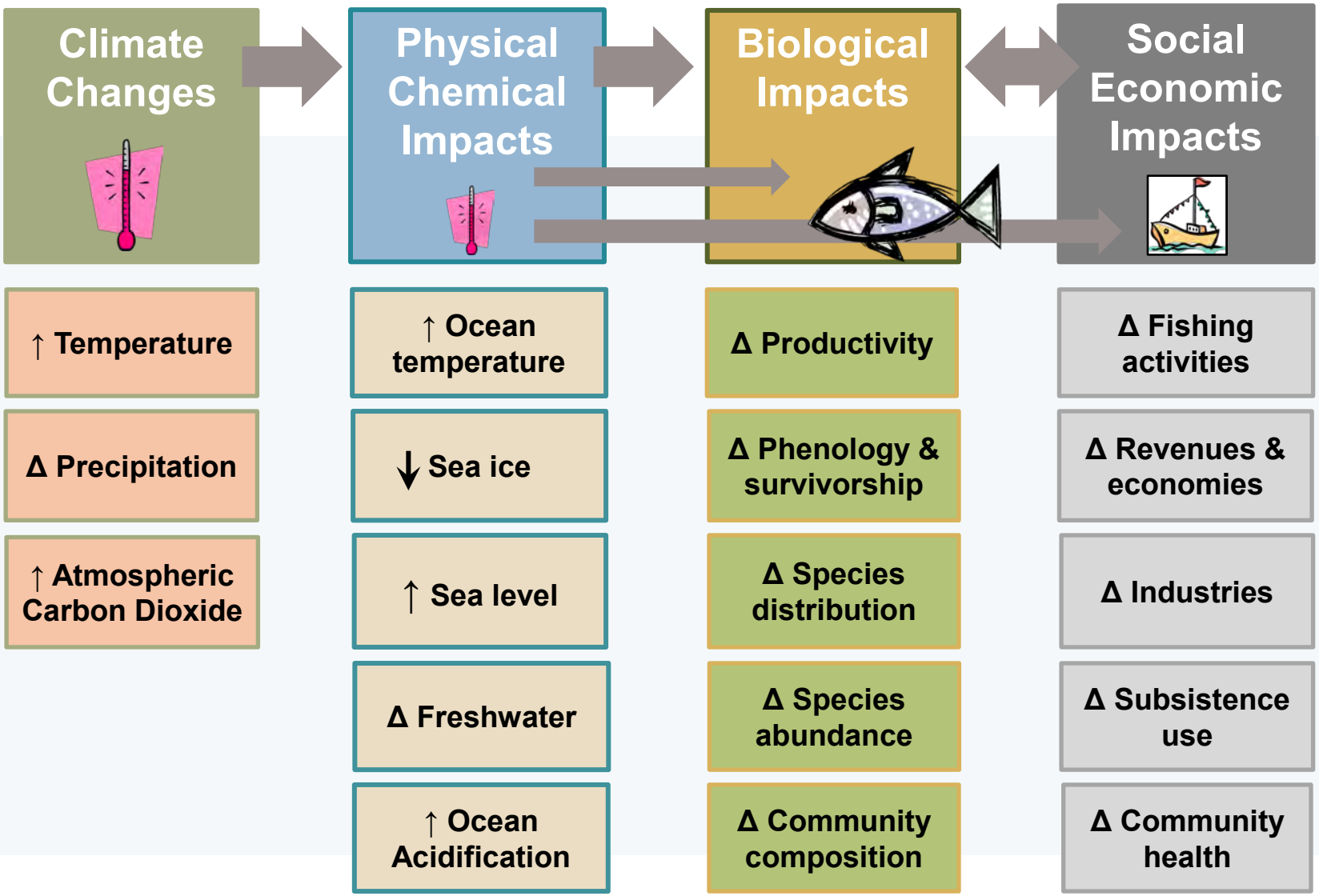
Possible Impacts of a Changing Climate



Dilemma of Projecting Fish Recruitment

- Global analysis suggests large percentage of recruitment variability is due to factors other than spawner biomass (Szuwalski et al 2015).
- Retrospective analysis of relationships between past climate and recruitment often explain a high percentage (60-75%) of the variance, but performance into the future is mixed.
- Performance of fully mechanistic spatially explicit models often fail to reconstruct recruitment and predictive skill is mixed.
- Select harvest control that are robust to climate change (Punt et al. 2014, ICES JMS).
- Multi-model inference

Approach

Monitor Exposure
Nested biophysical Measurements
Response to Extreme Events
Seasonal Behavior

Trends
Extremes

Project Impact Scenarios and Evaluate Management Strategies

skill

Functions
Parameters

Process Studies
Extreme Events
Laboratory – Field Experiments

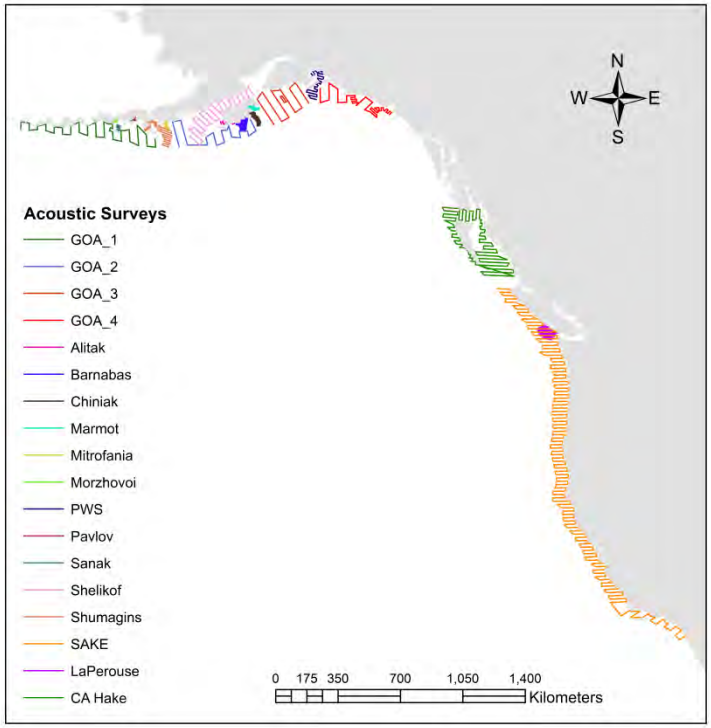
Vunerable
nodal

Vulnerability Assessment
Exposure – Sensitivity - Adaptability

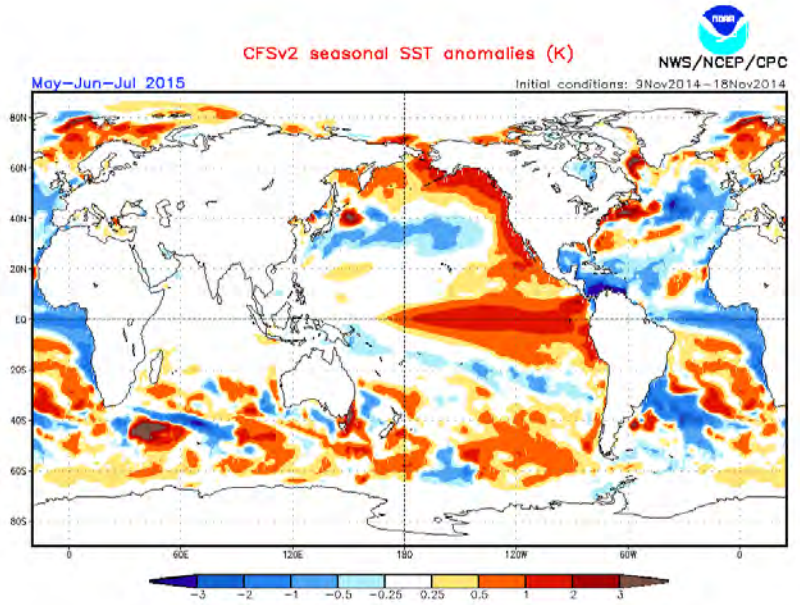
Vulnerability Assessment Methodology

Learn from Extreme Events

- Persistent warm anomaly in North Pacific 2013-2015
- Opportunity to observe shifts in fish distribution in 2015.
- US and Canada plan to conduct bottom trawl and acoustic surveys from California to the Gulf of Alaska.



Approximate tracklines for the 2015 U.S. and Canadian acoustic mid-water trawl surveys. Note the La Perouse survey (pink) is not confirmed



2015 SST projection from NOAA's coupled forecast system.

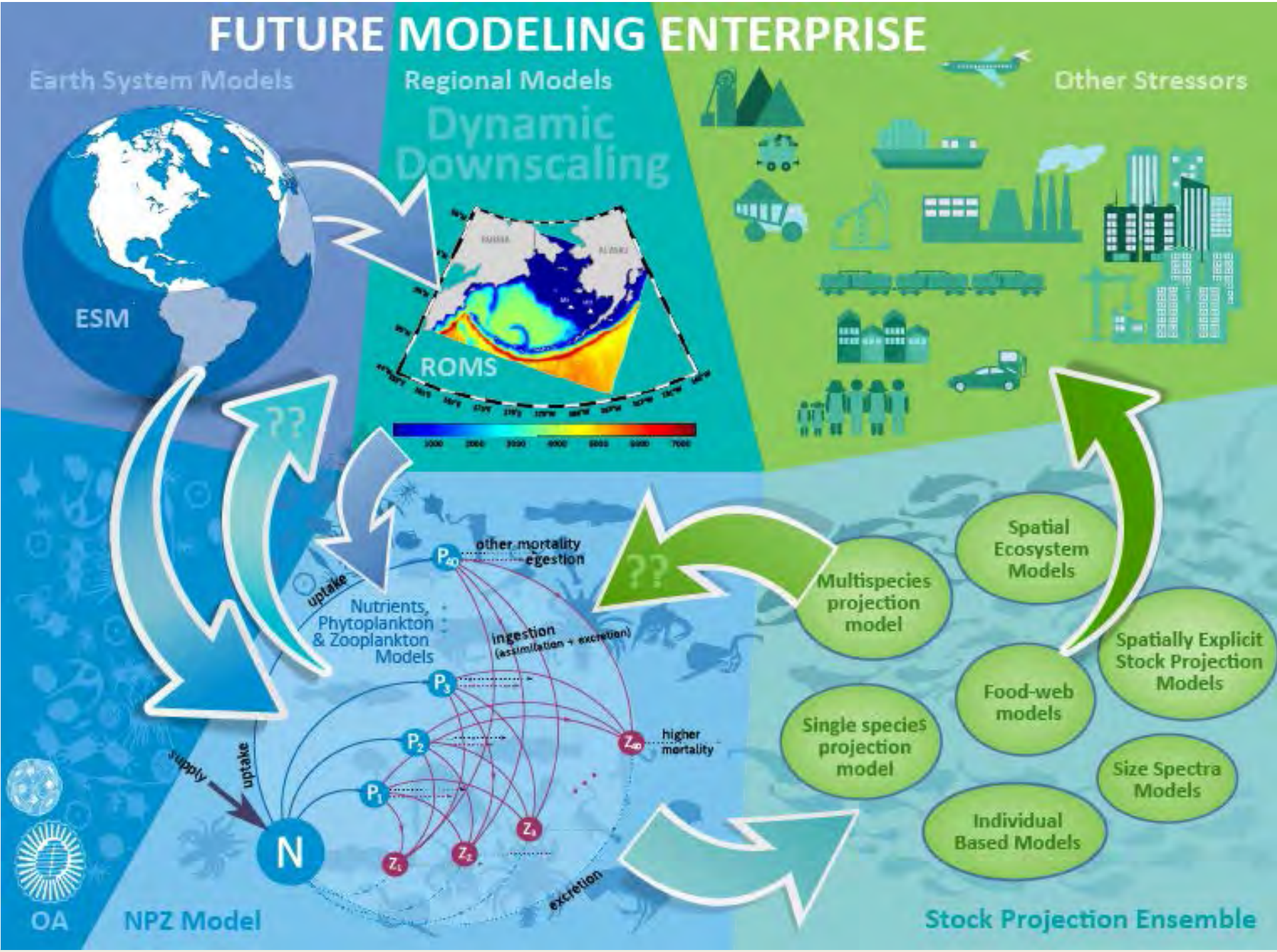
Ecosystem context: Larsen et al. 2014

- *"The physical, biological, and socioeconomic impacts of climate change in the Arctic have to be seen in the context of often interconnected factors that include not only environmental changes caused by drivers other than climate change but also demography, culture, and economic development."*

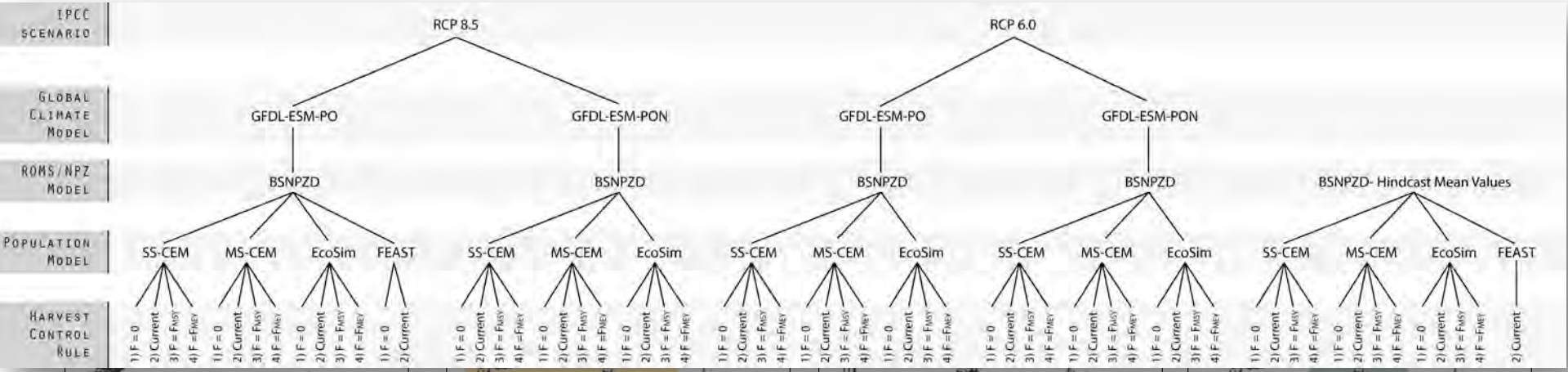
Future Fisheries

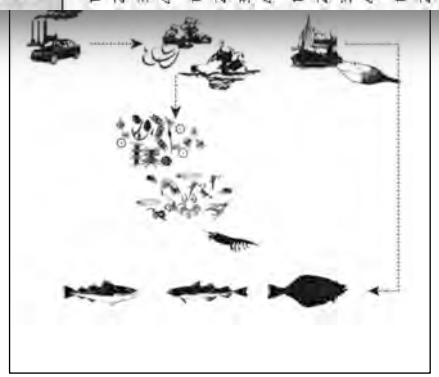
- Demand for protein
- World markets
- Range expansion to north uncertain
- Infra-structure
- Bio-economic considerations (fuel, risk)
- Sustainable fisheries – Ecosystem Based Fisheries Management
- International cooperation

Photo Credit: Sam Zmolek, NOAA Fisheries.
Photo of Dutch Harbor, Alaska

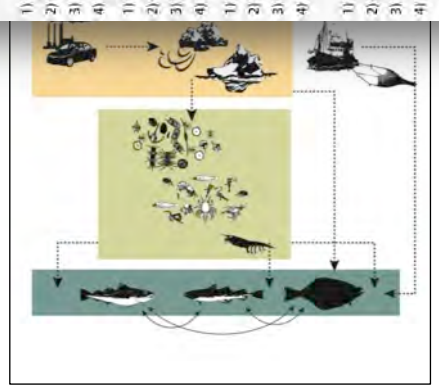

FUTURE MODELING ENTERPRISE
Earth System Models
Regional Models
Dynamic Downscaling
Other Stressors
ESM
ROMS
??
other mortality
egestion
uptake
Nutrients, Phytoplankton & Zooplankton Models
ingestion
(assimilation + excretion)
higher mortality
supply
uptake
N
excretion
OA
NPZ Model
??
Multispecies projection model
Spatial Ecosystem Models
Spatially Explicit Stock Projection Models
Food-web models
Single species projection model
Size Spectra Models
Individual Based Models
Stock Projection Ensemble

(FATE-SAAM)ACLIM: Bering Sea Models





Single Species



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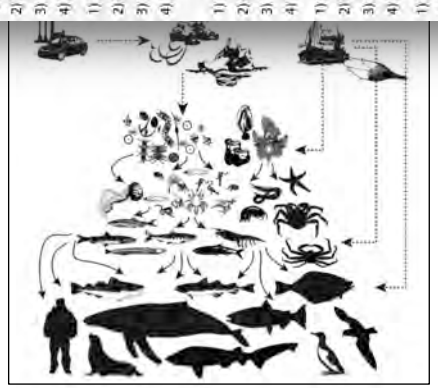
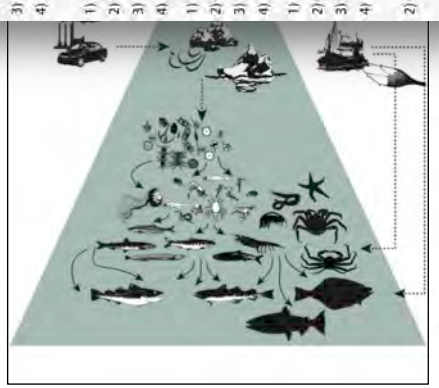


Ecosim



FEAST

Additive Pressures

Multiple Interacting (non-linear) Pressures

Non-linear Species Interactions; Non-linear Cumulative Effects

Estimation of Error/ multiple random iterations

Challenges to Projecting the Future

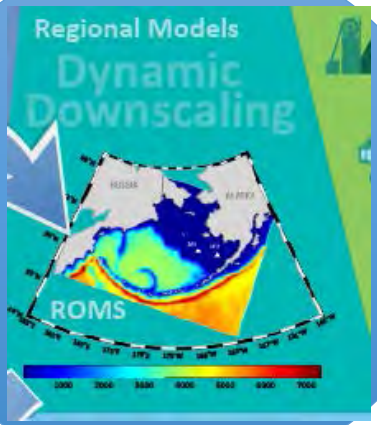
- Shifting Baselines (growth rates, maturation rates, reproductive success)
- Shifting fishing characteristics (gear modifications, selectivity, locations)
- Shifting distribution (survey catchability & selectivity)
- Tipping Points (ecosystem re-organization)
- Representing uncertainty
    - Process errors
    - Measurement error
    - Model mis-specification

IPCC: Climate Model Intercomparison (CMIP)

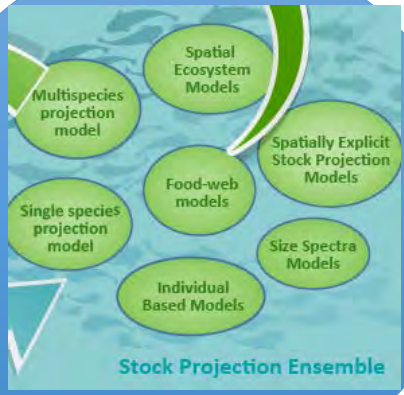
United Nations Environment Program, Global Programme of Research on Climate Change Vulnerability Impacts and Adaptation (PROVIA); Intersectoral Impact Model Intercomparison (ISI-MIP)

Regional Fisheries Management Councils

Sustainable-
Strategies
Adaptation
Fisheries Policies
Allocation
Food Security
Aquaculture
/ranching



ICES/PICES/IOC/ SICCME



PICES: Coordinated Ocean downscaling Experiment Analysis Network (COCEAN)

Fish model Inter-comparison (Fish-MIP)/SICCME/ACLIM

Strategic Issues

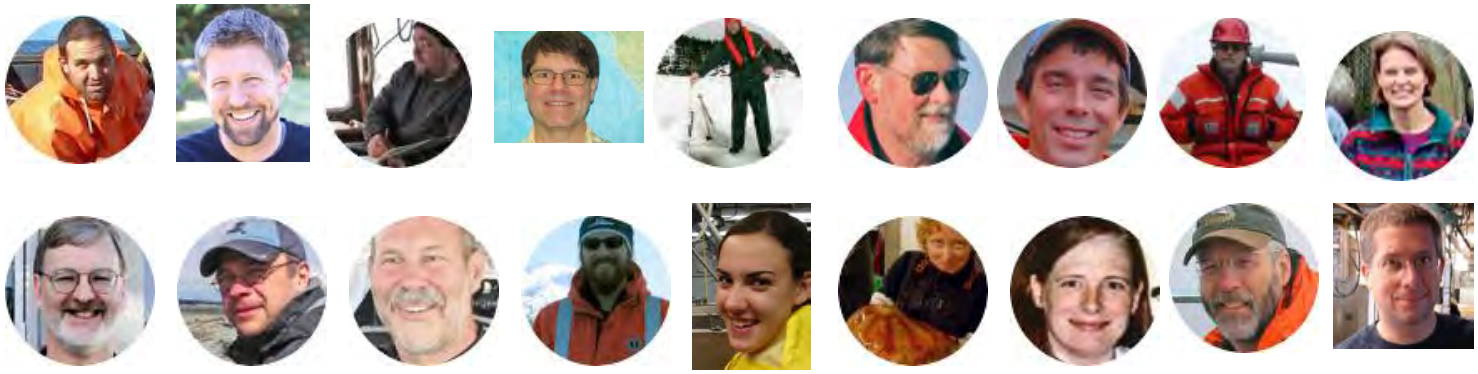
- Defining management goals
  - Short-term vs long-term trade-offs
  - Stock boundaries
  - Biological reference points
  - Importance of portfolio (genetic or trophic)
  - Preserve trophic structure perhaps by system level aggregate caps
- Catch shares under shifting access to resource
- Projecting fishers responses.

Summary

- Climate Change will impact marine ecosystems and thus fish and fisheries
- So far, quantitative projections of the magnitude of change have been completed for only a few target species
- National and international modeling teams are striving to produce quantitative scenarios for major stocks by 2019
- Expect that scenarios may differ depending on the climate model, the RCP scenario, and the complexity of ecosystem models.
- Manager/Fisher Inputs:
  - Identifying a reasonable range of management responses (or fisher responses) for projections
  - Selection of performance criteria
  - Identifying (or commenting on) management strategies

Acknowledgements

Fish Component Group



Modeling Component Group:
Kerim Aydin, Mike Dalton, Georgina Gibson, Alan Haynie, Kirstin Holsman, Al Hermann, Jim Ianelli, Liz Moffitt, Franz Mueter, Andre Punt, Muyin Wang, Ivonne Ortiz,

Kate Hedstrom, Enrique Curchister

SICCME Meetings of Interest

- **July 2015:** Our Common Future Under Climate Change, Paris, France

http://igbp.us4.list-manage.com/track/click?u=30a05ea40bc18b7ad922a413e&id=f1cea3b8c3&e=5c8429dd43>

- **August 2015:** ICES/PICES inter-sessional workshop (Seattle or Princeton)
  - Select suite of species/fisheries for assessment of fish and fishers response projections.
  - Select suite of future fishing scenarios (harvest strategies; aquaculture; market forces; capture technologies, technical interactions)
  - Select suites of models for comparative studies
  - Discuss methods for treatment of uncertainty – draw inference from simpler models?
  - Agree on strategies to address boundary issues