Some solutions for Marine Ecosystem-based Fisheries Management in a Changing Climate

W5: Moving Towards Climate-Ready Fishery Systems: Regional comparisons of climate adaptation in marine fisheries

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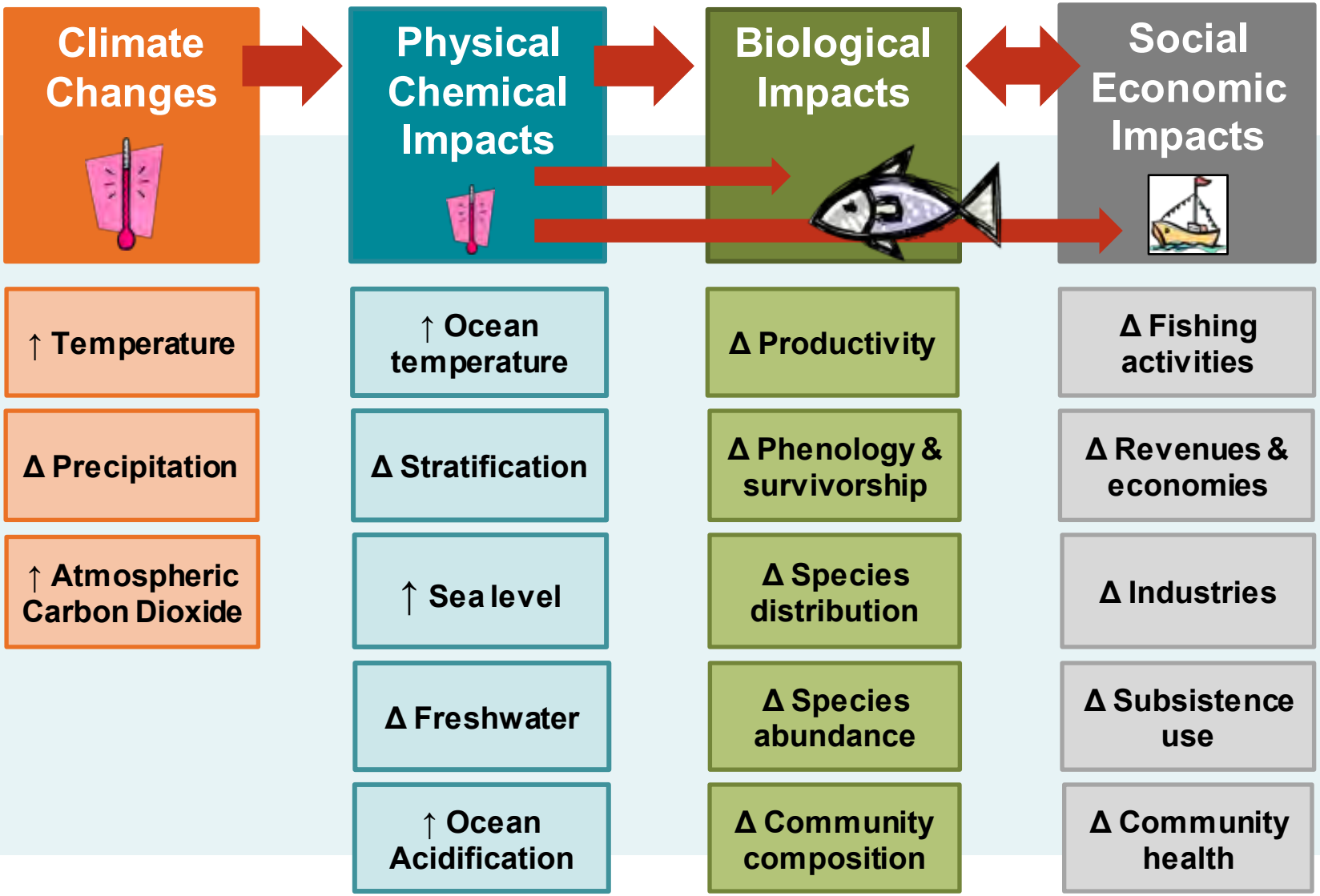
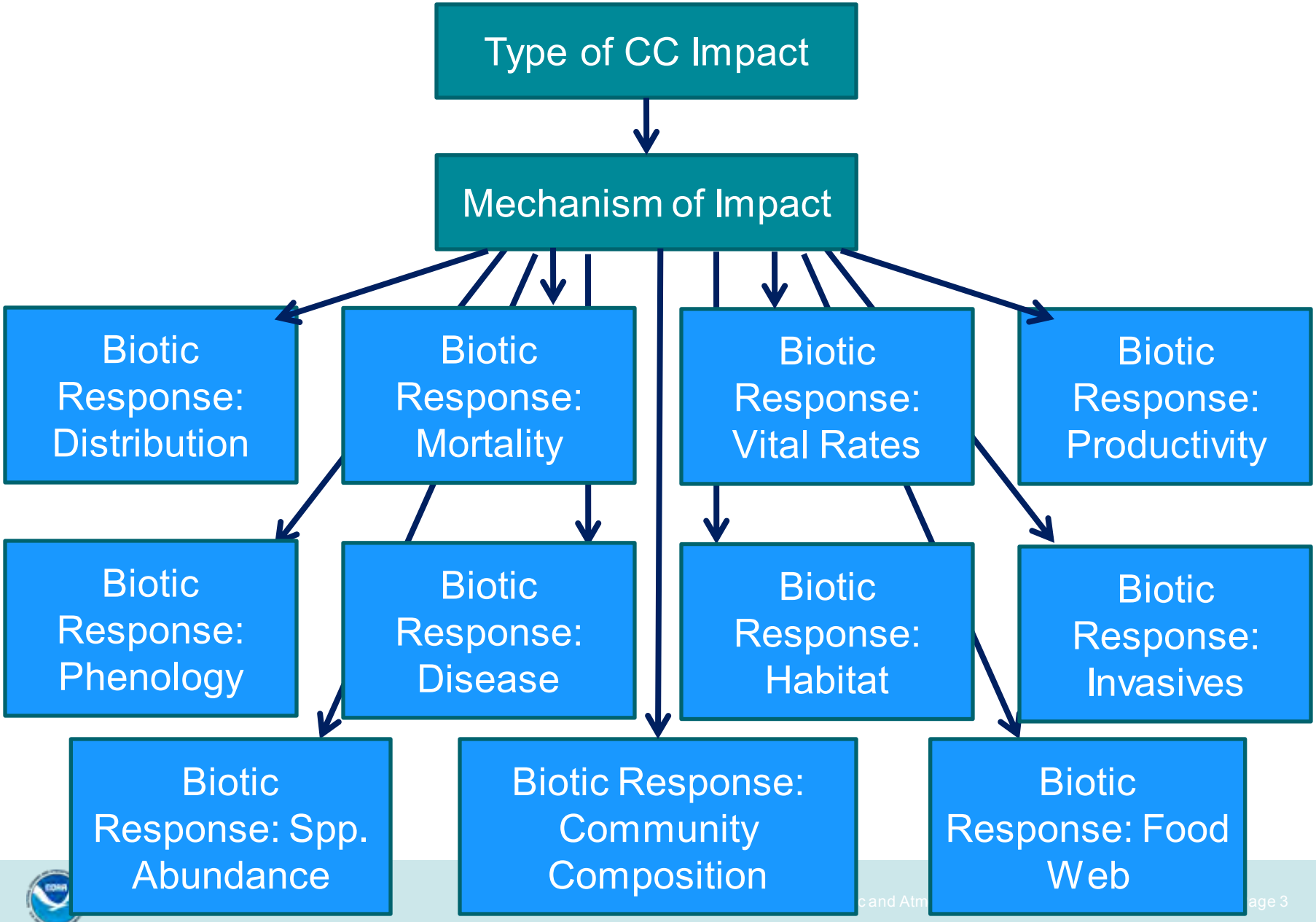
Possible Impacts of a Changing Climate



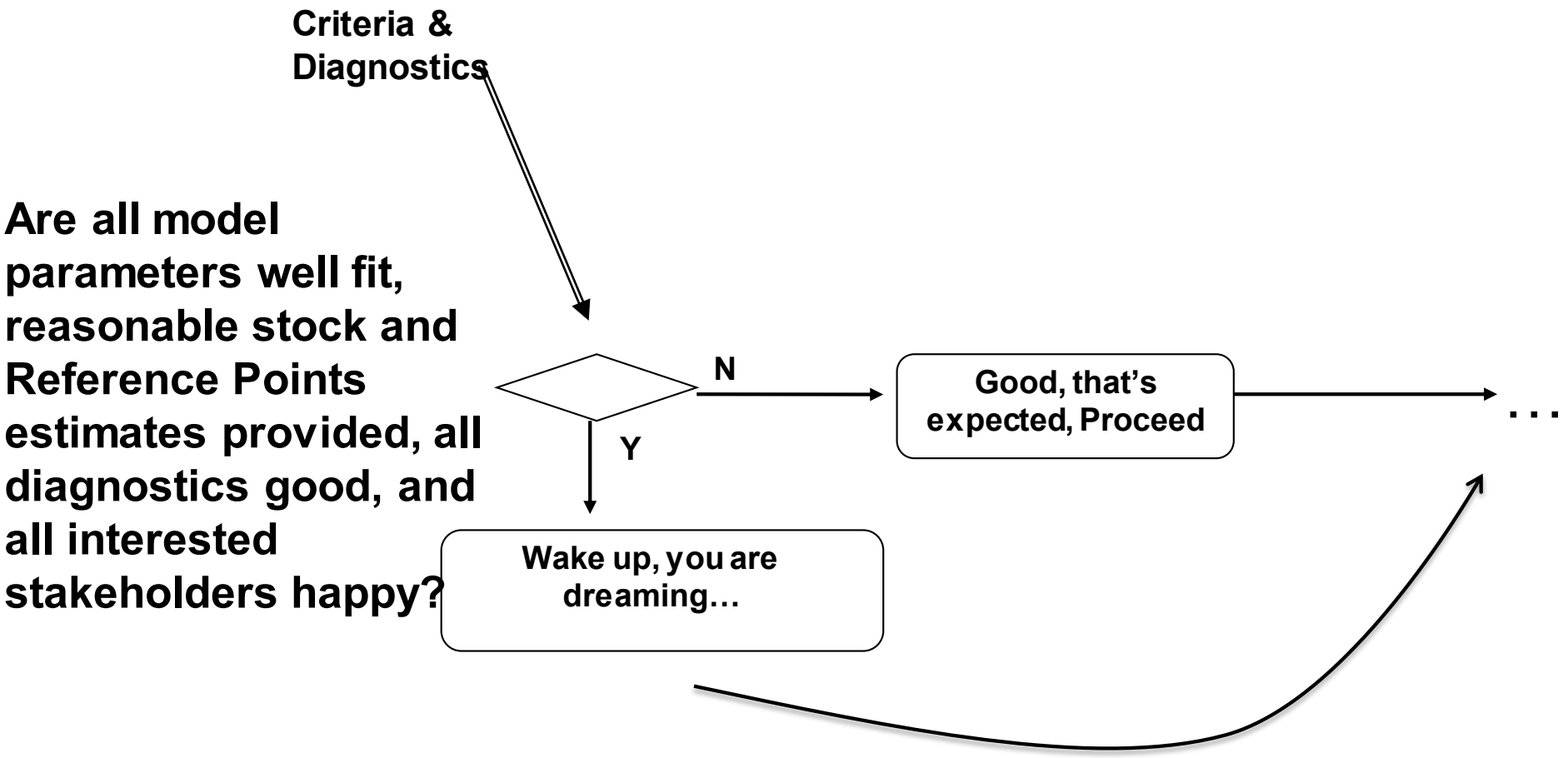
Biological Responses



So how do we know which ecosystem & climate factors to consider?

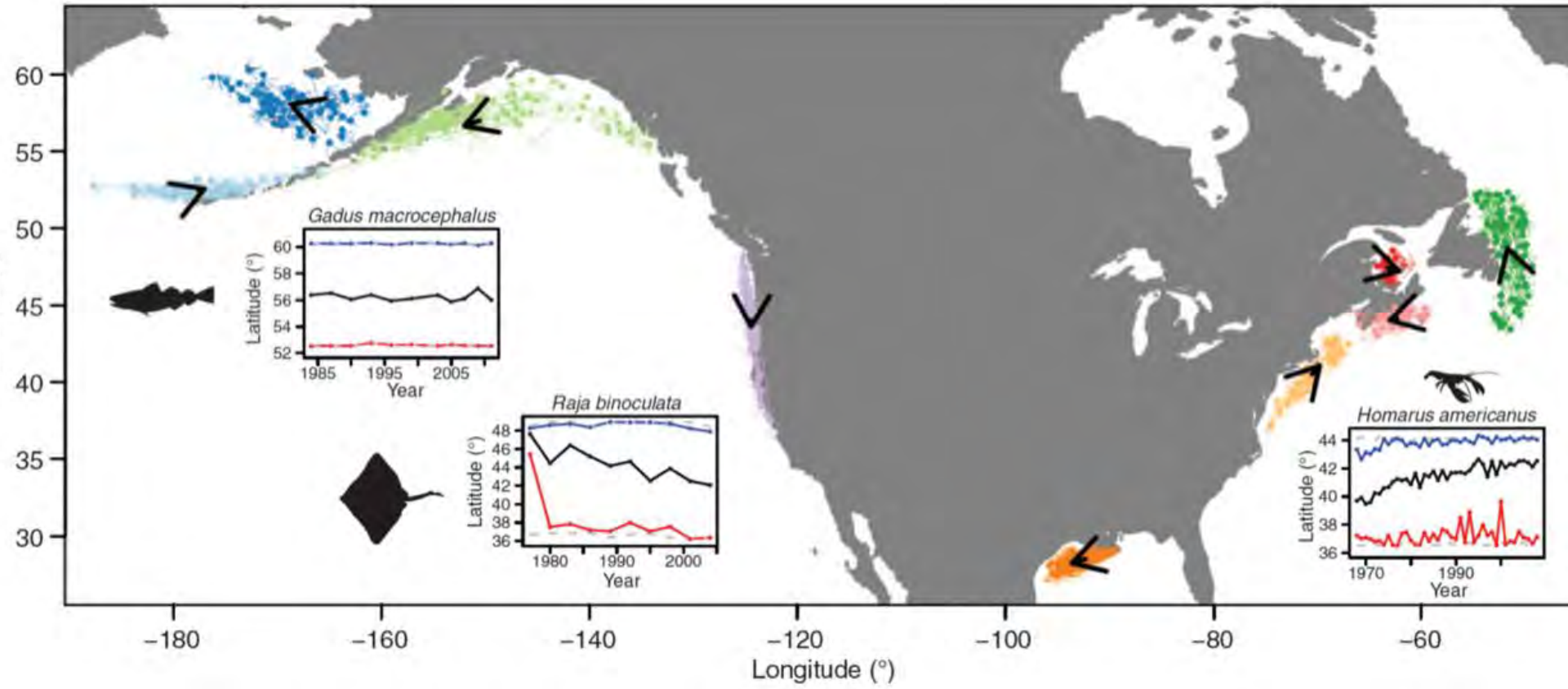
Challenges of response, topical and parameter pluralities

- The problem is this:
- Pick a parameter—
  - M, M2, q, K, R, SSB, B, B_o, F, Z, r, r_o, h, C, λ, wt/size/len-at-age, etc.
- E.g., Is a change in K due to changing ocean productivity, stock productivity, competition, warming waters, stock movement, or ???

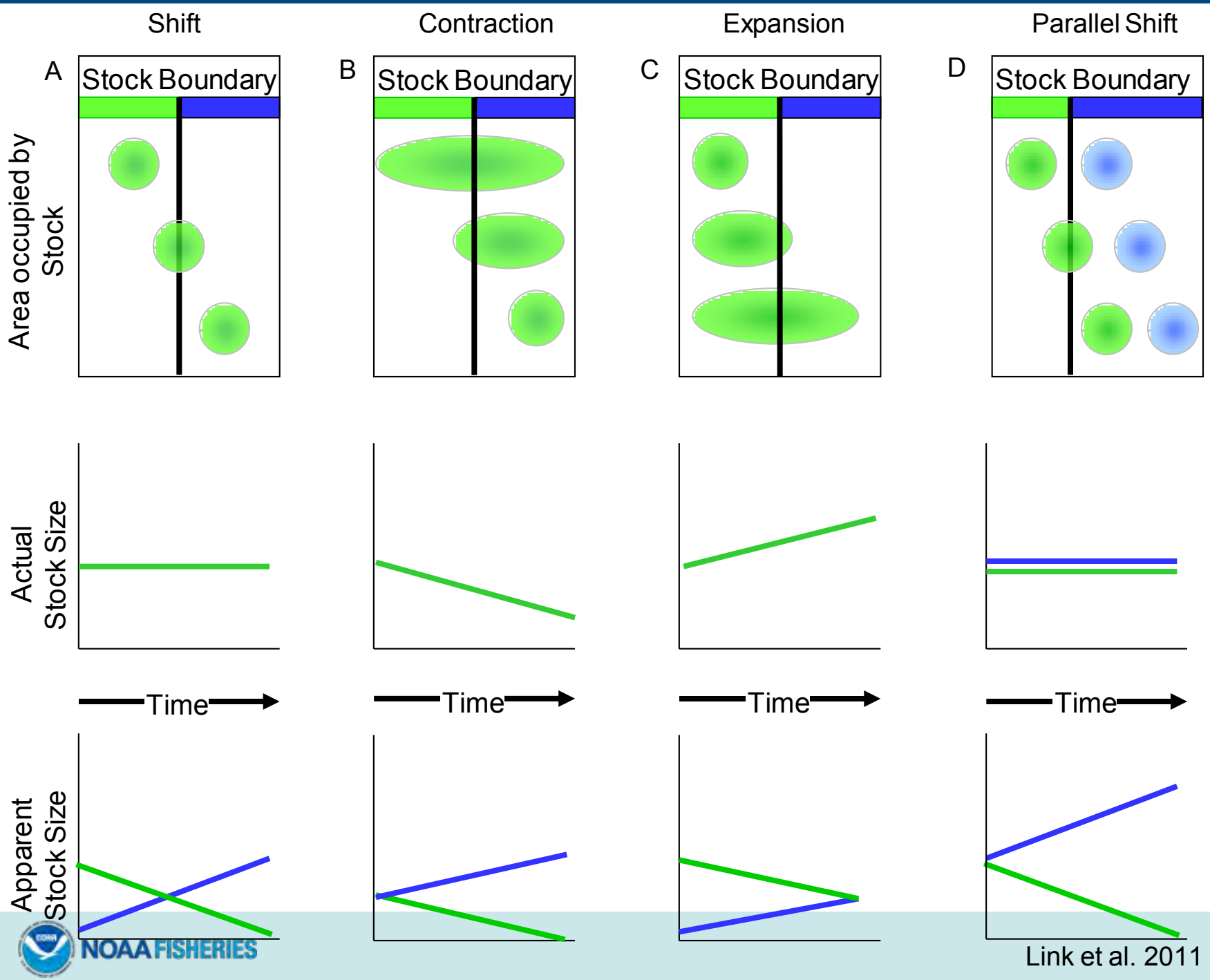

Criteria &
Diagnostics
Are all model parameters well fit, reasonable stock and Reference Points estimates provided, all diagnostics good, and all interested stakeholders happy?
N
Y
Good, that's expected, Proceed
Wake up, you are dreaming…
. . .

An example

Shifting distribution of stocks

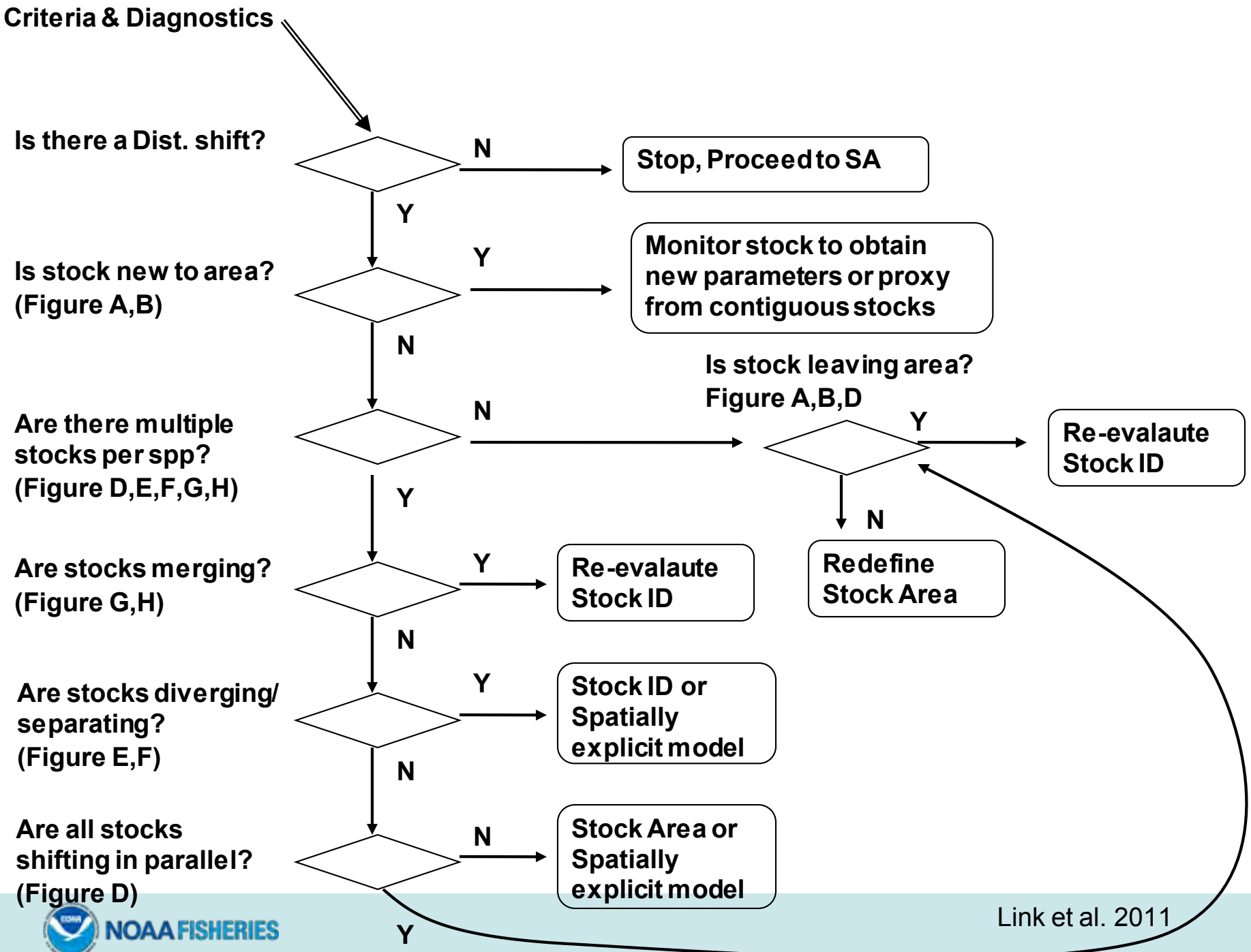


Pinsky et al. 2013



NOAA FISHERIES

Link et al. 2011



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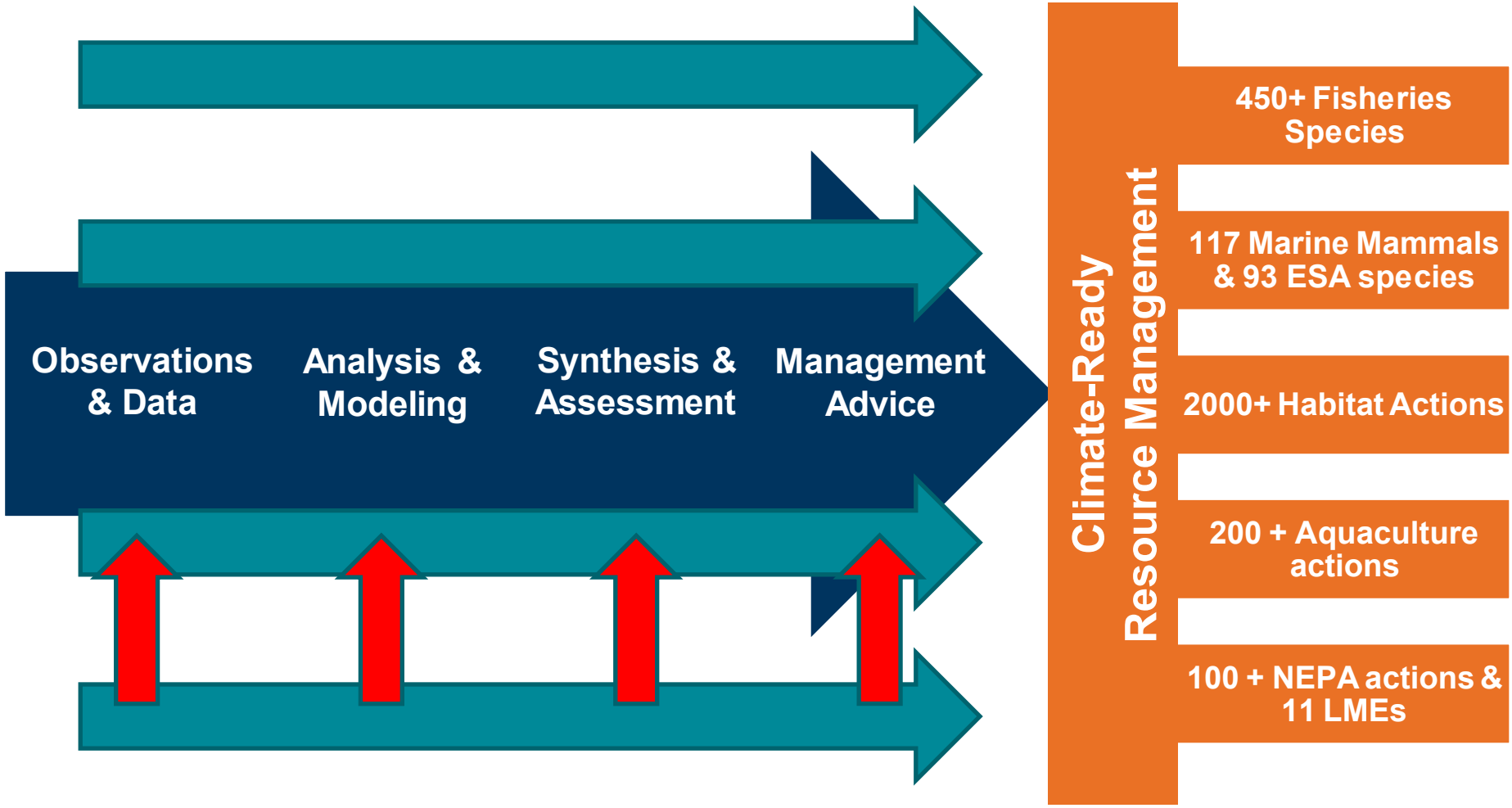
Link et al. 2011

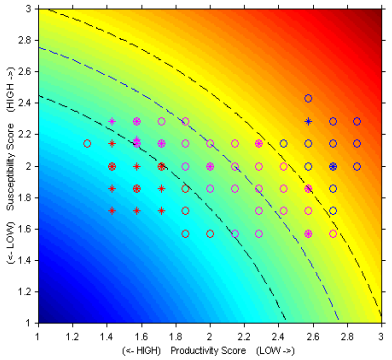
So how do we address Ecosystem & Climate considerations in LMR Management?

Living Marine Resource Management

What are the cross-cutting tools we can use?



EBFM Options

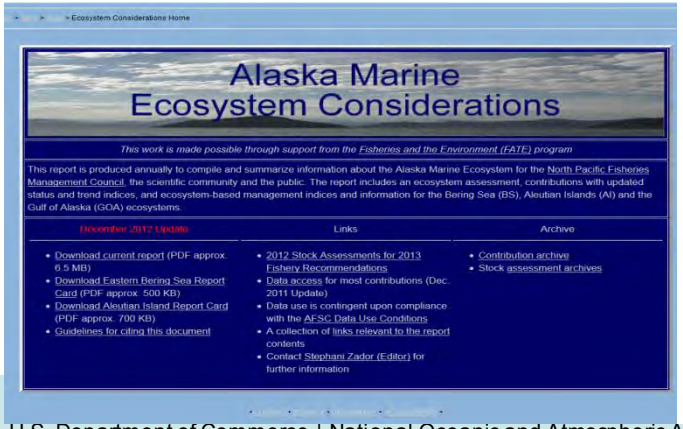


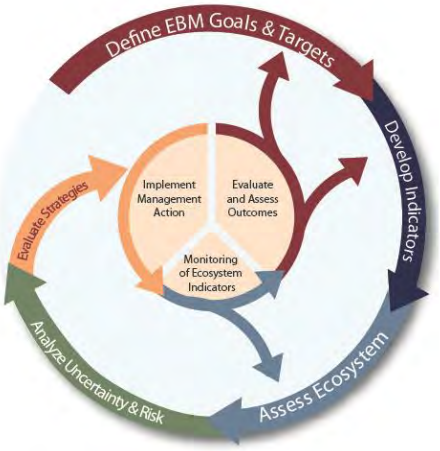
Technical

- Triage
- Coupled Models
- Indicators
- Constraints/thresholds
- Scenario Testing

Governance

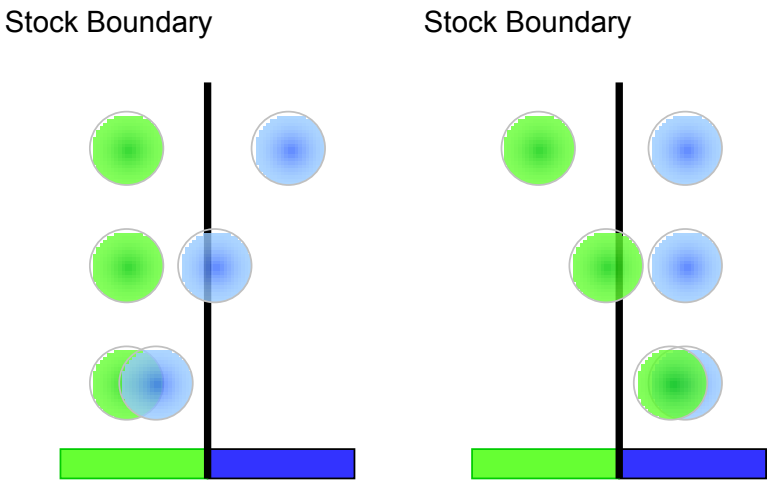
- Adaptive Processes
- Fishery Ecosystem Plans
- Performance Evaluation



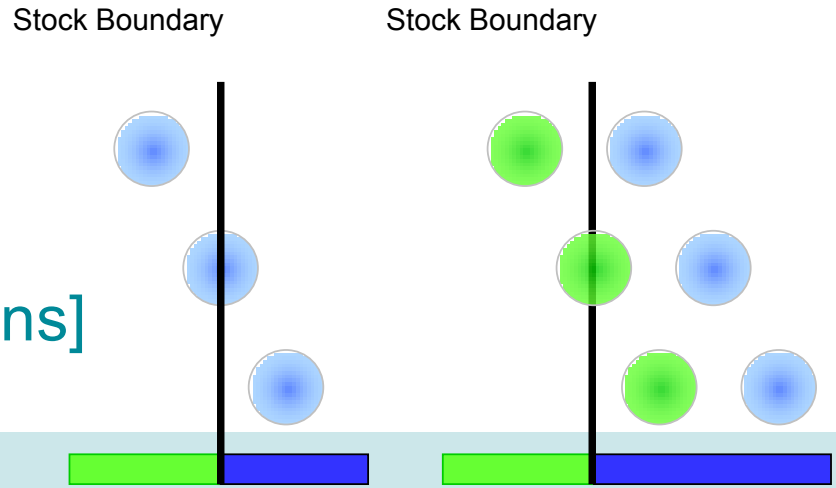


How LMR Mgt Processes/Models can handle CC

- Change (Δ) input data
  - Δ Stock ID, Δ stock unit area
  - Δ vital rate estimates
  - Δ to adaptive Monitoring programs
- Add covariates
- Δ model parameters
  - M, q, r, K, h, R, λ
- Explore simulations and MSEs
- Explore alternate functional forms
- Explore alternate Harvest Control Rules
- [Track species & habitat interactions]



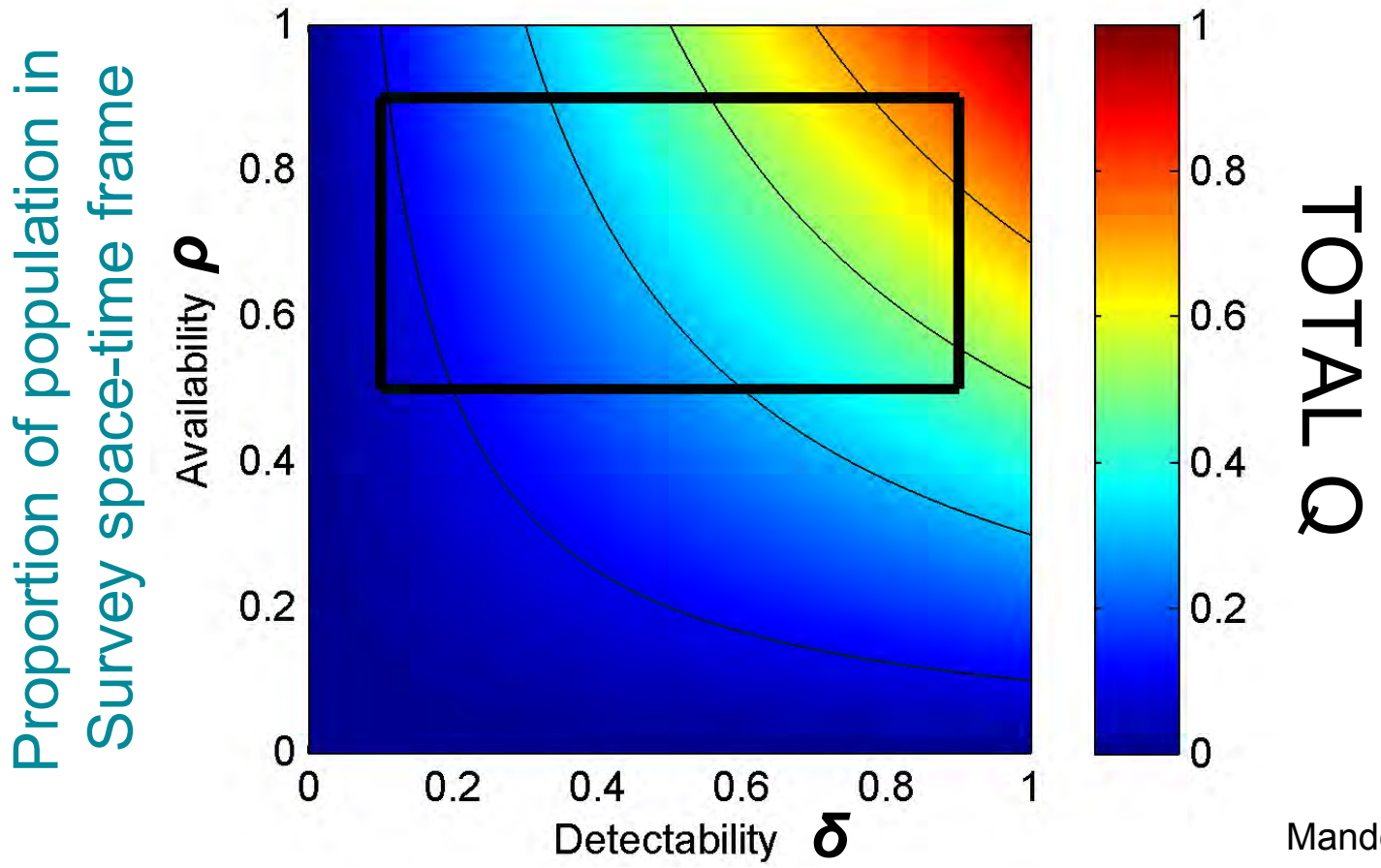
$$R = SSBe^{(a+b\cdot SSB+c\cdot T+\varepsilon)}$$



Examples

Butterfish assessment

Focus on observation process:
Catchability Q = availability ρ * detectability δ



Manderson et al. 2014

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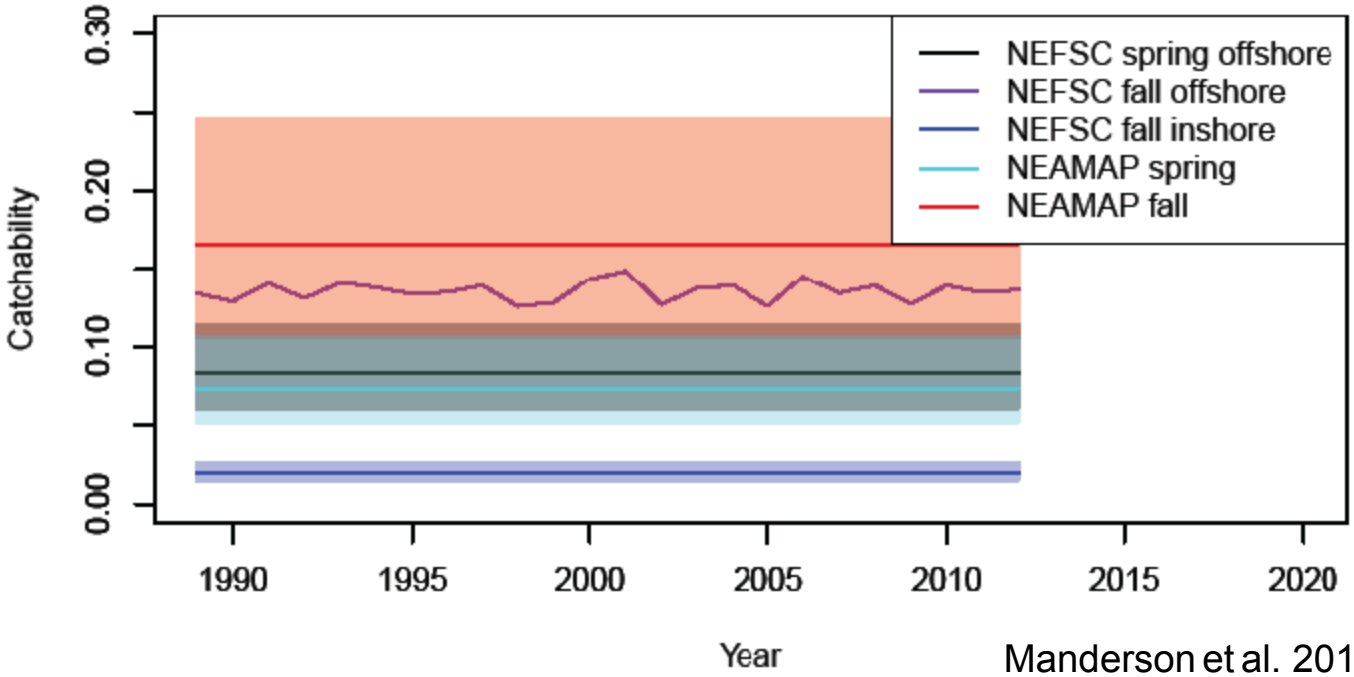
Proportion of fish occupying station caught in net

Butterfish assessment

$$B_t = \frac{A}{\rho \delta a} \mathrm{I}_t$$

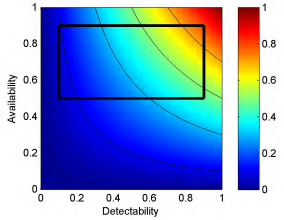
B_t: Population Biomass estimate
A: Area covered by survey
ρ: Availability to the survey
δ: Detectability
a: Swept area of a single trawl
I_t: Index value at year t (kg tow^{-1})

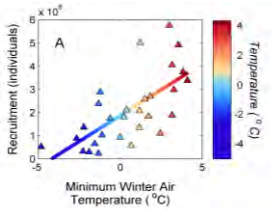


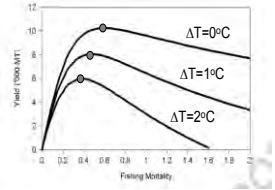
Manderson et al. 2014

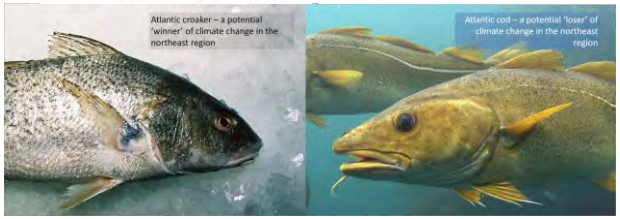
Examples of climate/environmental factors incorporated into assessments in MA-NE Shelf

- Butterfish & thermal, oceanographic habitat for environmentally driven q's
- MA-SNE yellowtail flounder & cold pool volume for recruitment
- Northern shrimp & thermal considerations for distribution and productivity
- Atlantic croaker & thermal relationship to recruitment, productivity and projected distribution
- Atlantic cod & thermal relationship to recruitment, productivity and projected distribution
- Cusk & thermal and habitat features for distribution
- Distribution change noted for 30+ spp., but not yet incorporated into models
- Does not include ecological interaction e.g.s









Hare, pers. comm.

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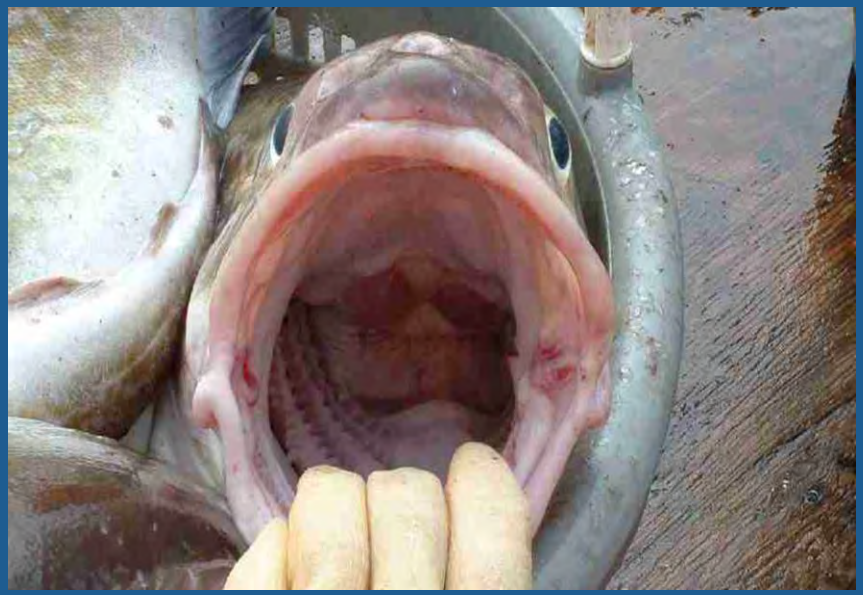
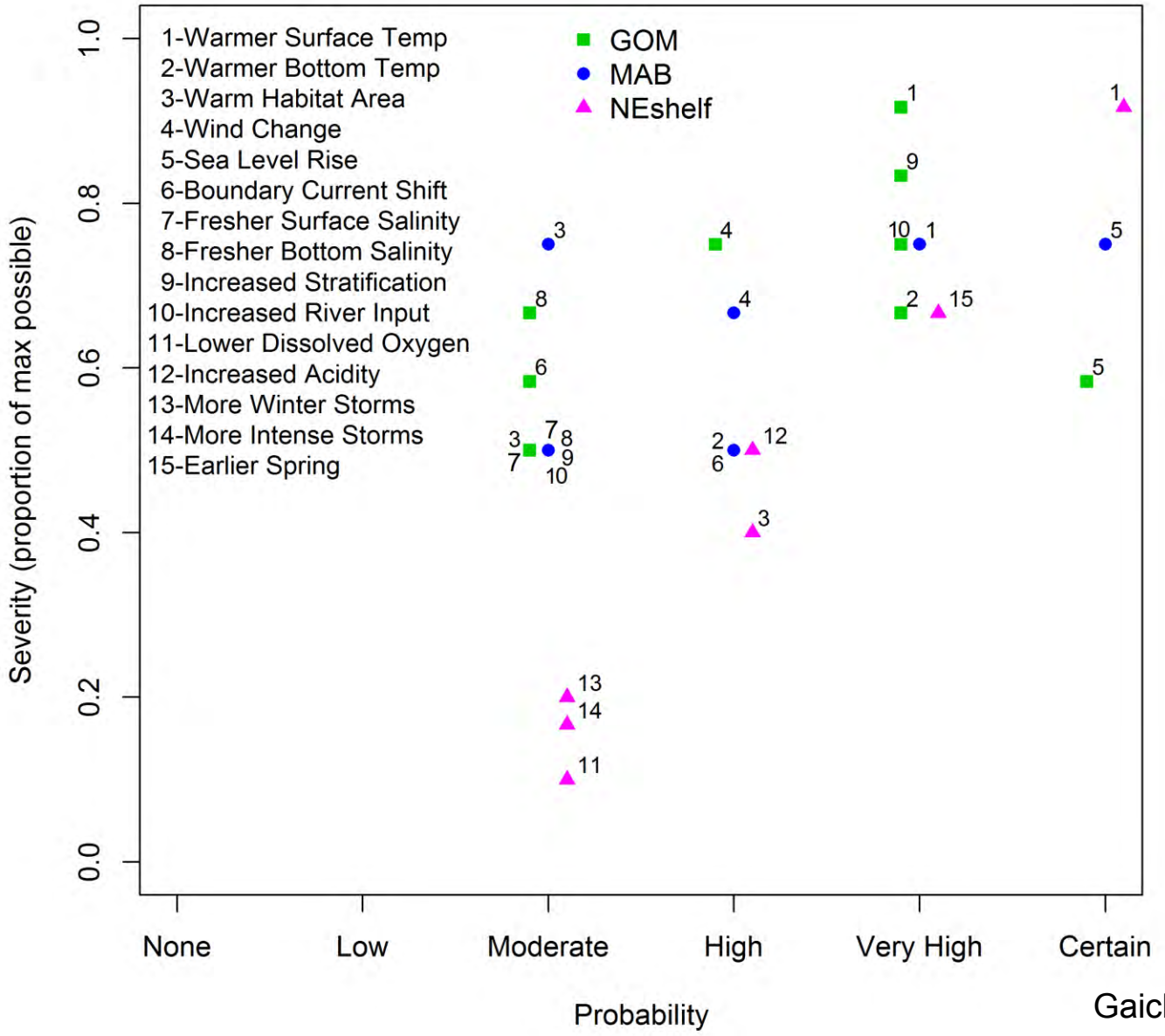
So how do we prioritize Ecosystem & Climate considerations for LMR management?

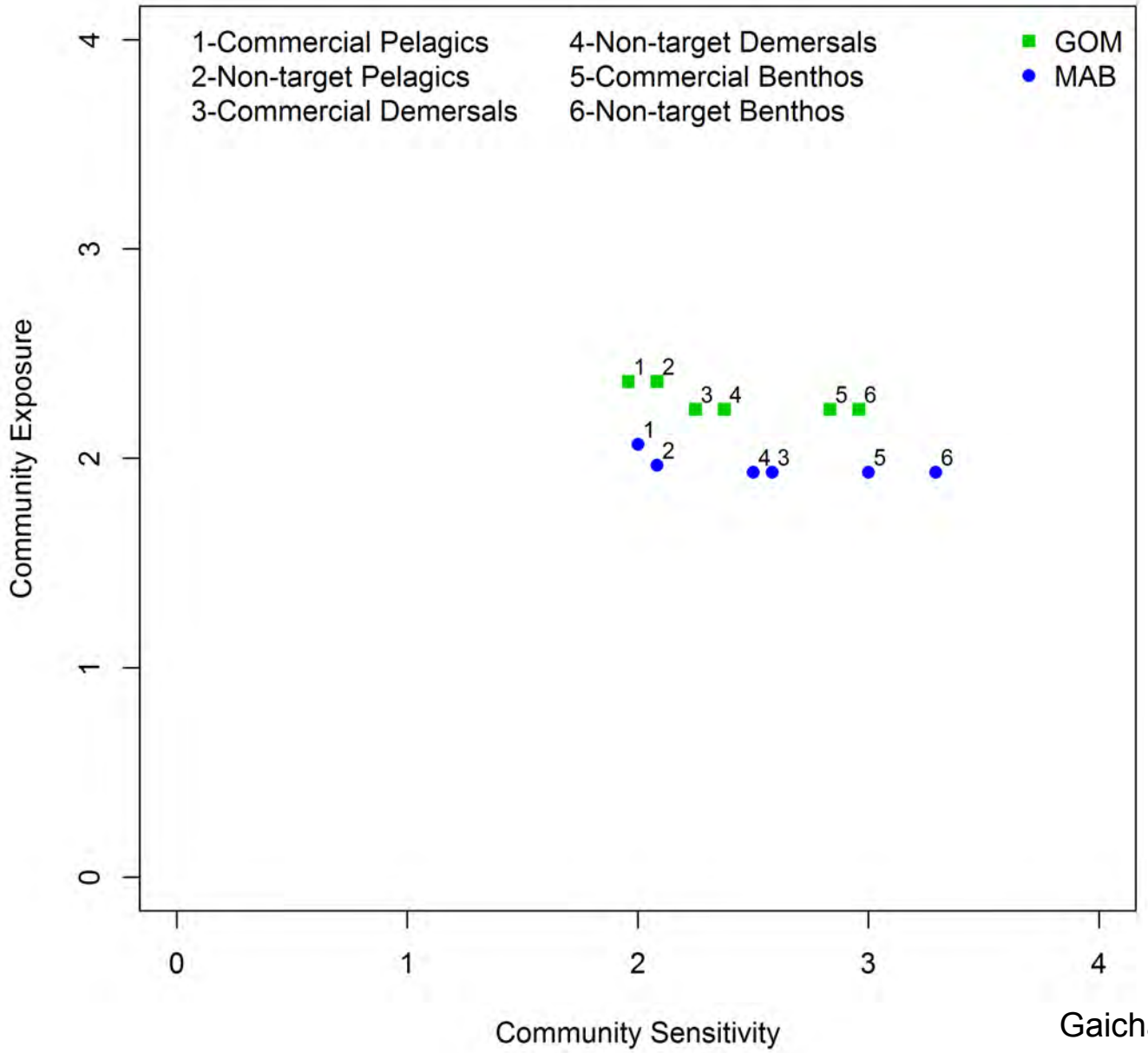


Ranking short term regional climate risks



Gaichas et al. 2014

Putting it all together: 5-10 year risk



Gaichas et al. 2014

So how do we develop science to support ecosystem-based, climate-informed LMR management?

Shifting Distribution

The Problem- oceanic habitats are shifting and shrinking for many important (economic, ecological) spp in response to climate-induced changes in ocean conditions

What is the technical solution- predict where species are moving

What is the mgt solution- Reevaluation of stock ID, unit area, etc.;

Consider new, distribution-shift informed RPs for spp;

Plan to establish data streams and mgt plans for emerging fisheries on fishes moving into area

Science needed for solution-

Downscaled models of climate forecasts projected to appropriate temporal and spatial scales

Links of thermal change to local or regional conditions

Identification of important metrics to track

Dynamic models of thermal habitat for a suite of spp, not just one or two

Linkages between thermal tolerance and vital rates for spp

Projections of distribution shifts

Ensemble testing of said projections

Surveys, Tagging or similar studies to field validate model projections

Strategy evaluations of related control rules for suite of spp, including econ

Ecosystem Productivity Change

The Problem- overall oceanic production is changing, is hard to predict, and constrains total yield

What is the technical solution- predict systemic and aggregate production for upper trophic-levels

What is the mgt solution- Reevaluation of definitions of MSY, ACLs, HCRs, from a systemic perspective

Provide for catch flexibility within "floors and ceilings"

Adopt risk policies linked to changing ocean production

Science needed for solution-

Downscaled models of climate forecasts projected to appropriate temporal and spatial scales

Projections of global and regionally downscaled primary productivity

Identification of important metrics to track

Linkages between key climate measures and primary production

Models of trophic transfer, production capacity, and food webs to estimate UTL production

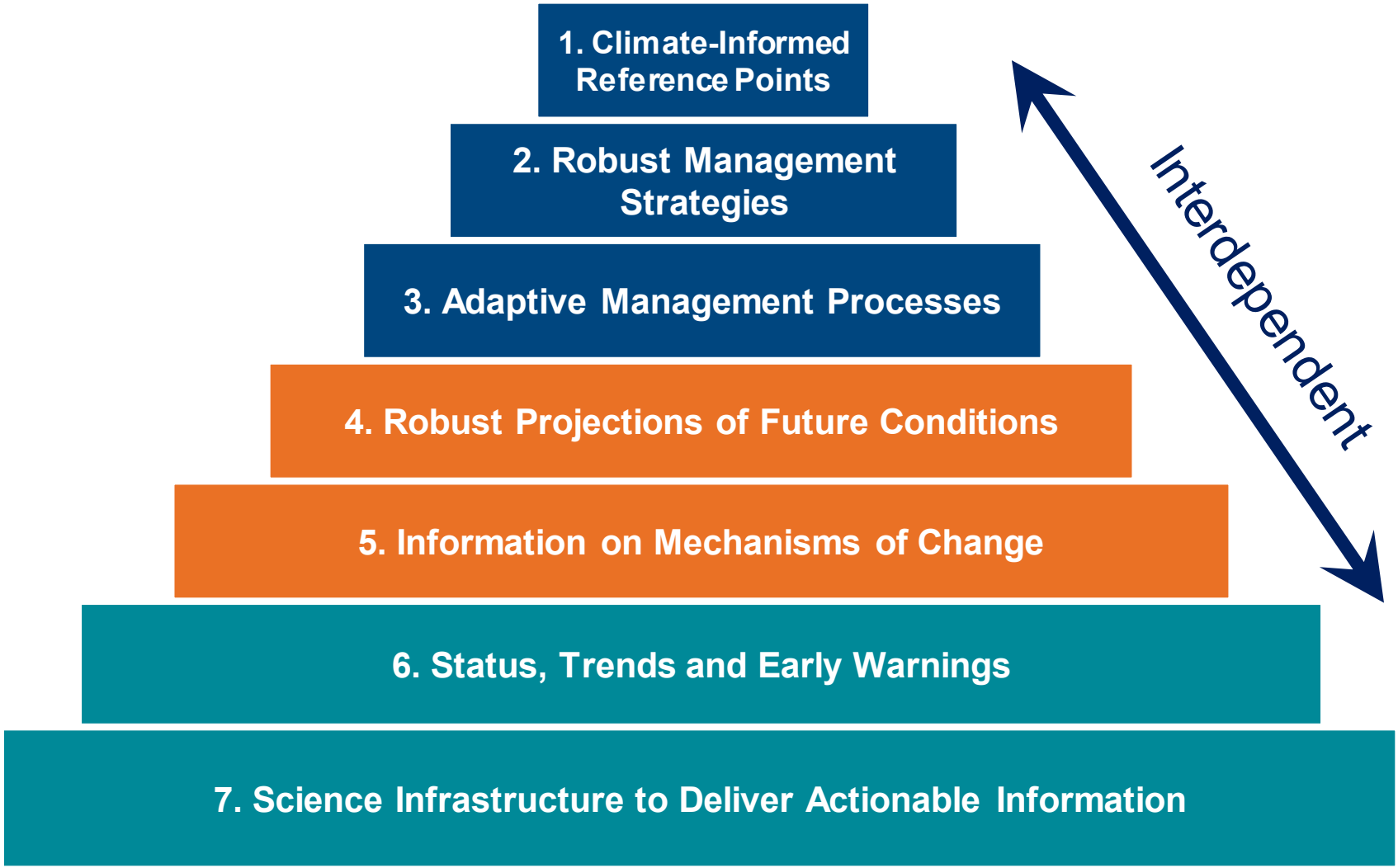
Linkages among production of key groups of spp, PP, and key climate measures

Ensemble testing of said estimates

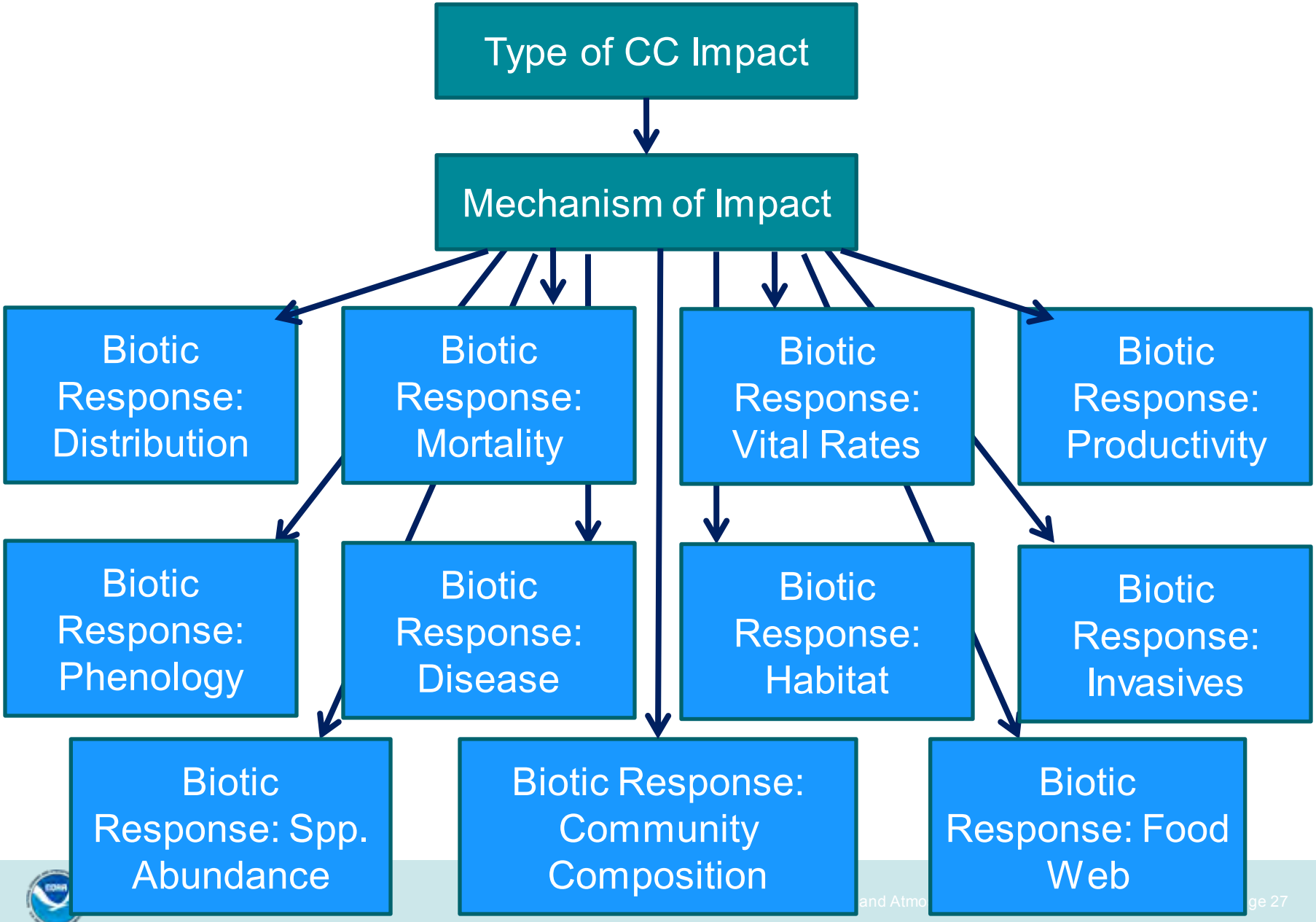
Measures of landings, bycatch

Strategy evaluations of control rules for systemic yield, including econ

Draft Climate Science Objectives



Hypotheses


Type of CC Impact
Mechanism of Impact
Biotic Response: Distribution
Biotic Response: Mortality
Biotic Response: Vital Rates
Biotic Response: Productivity
Biotic Response: Phenology
Biotic Response: Disease
Biotic Response: Habitat
Biotic Response: Invasives
Biotic Response: Spp. Abundance
Biotic Response: Community Composition
Biotic Response: Food Web

Questions?

www.st.nmfs.noaa.gov/ecosystems/climate