eFEP Strategies for Catch Advice, Overfished Stock Management, and Spatial Management

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Stock complexes and Fishery functional groups

- **Definitions (see also https://s3.amazonaws.com/nefmc.org/Glossary.pdf)**
- **Trophic guild -** A group of species that feed on similar items or have similar dietary requirements and therefore have a similar ecological function within the structure of an ecosystem.
- **Stock complex -** A group of related species at a defined trophic level that have similar diets and life-history characteristics. Catch limits for stock complexes would be set, their total not to exceed the overall EPU catch limit.
- **Fishery functional group -** A group of species that are typically caught together in a particular type of gear and feed on similar food items. In terms of EBFM, a functional group is the intersection of stock complexes (see definition below) with a fishery, i.e. they are caught together.

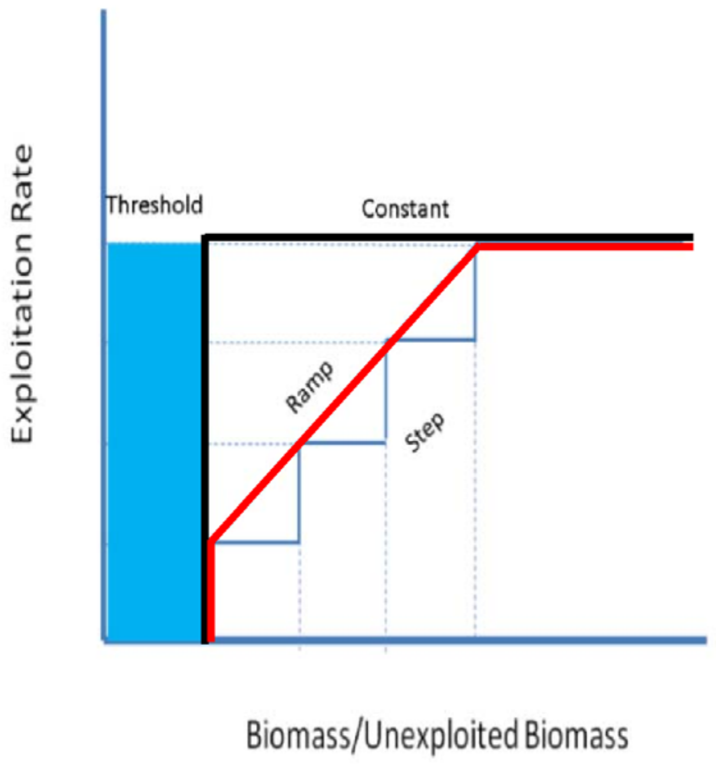
- Examples

Table 1. Example matrix of stock complexes and fishery functional groups for species that are commonly caught by commercial and recreational fisheries in the Georges Bank EPU.

Species complex	Species	Trophic group	Fishery functional group (allocation of a stock complex catch)												
			Ecosystem component	Demersal Trawl	Mid-water Trawl	Sink gillnet	Drift gillnet	Bottom longline	Drift longline	Pot	Seine	Dredge	Demersal recreational	Pelagic recreational	PS consumption
Apex Predator	1. Yellowfin Tuna	Apex Predator							X					X	
	2. Bluefin Tuna	Apex Predator							X					X	
	3. Swordfish	Apex Predator					X		X					X	
Bottom feeder	10. Black Sea Bass	Benthivore								X			X		
	12. Witch Flounder	Benthivore		X											
	13. American Plaice, > 20	Benthivore		X											
	16. Yellowtail Flounder	Benthivore		X							X				
	17. Golden Tilefish	Benthivore		X		X		X					X		
	18. Haddock	Benthivore		X		X					X		X		
	21. Northern Searobin	Benthivore	X										X		
	22. Striped Searobin	Benthivore	X										X		
	23. Winter Flounder	Benthivore		X							X		X		
	24. Scup	Benthivore		X						X			X		
	25. Tautog	Benthivore	X										X		
	26. Cunner	Benthivore	X										X		

Stock complex harvest control rules

ToR 6: Review harvest control rules embodying the proposed floors and ceilings approach using the ceiling reference points in ToR 5 to cap removals at the Ecological Production Unit and Functional Group levels, while ensuring that no species biomass falls below the single species floor reference points.



- Two main forms of harvest control rules:

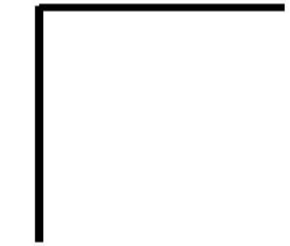
1) Threshold exploitation
2) Ramp-down exploitation

Worked example

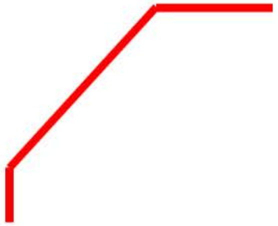
ToR 9: Review simulation tests and performance of the proposed management procedure incorporating the floors and ceilings approach, given the set of EBFM goals and objectives.

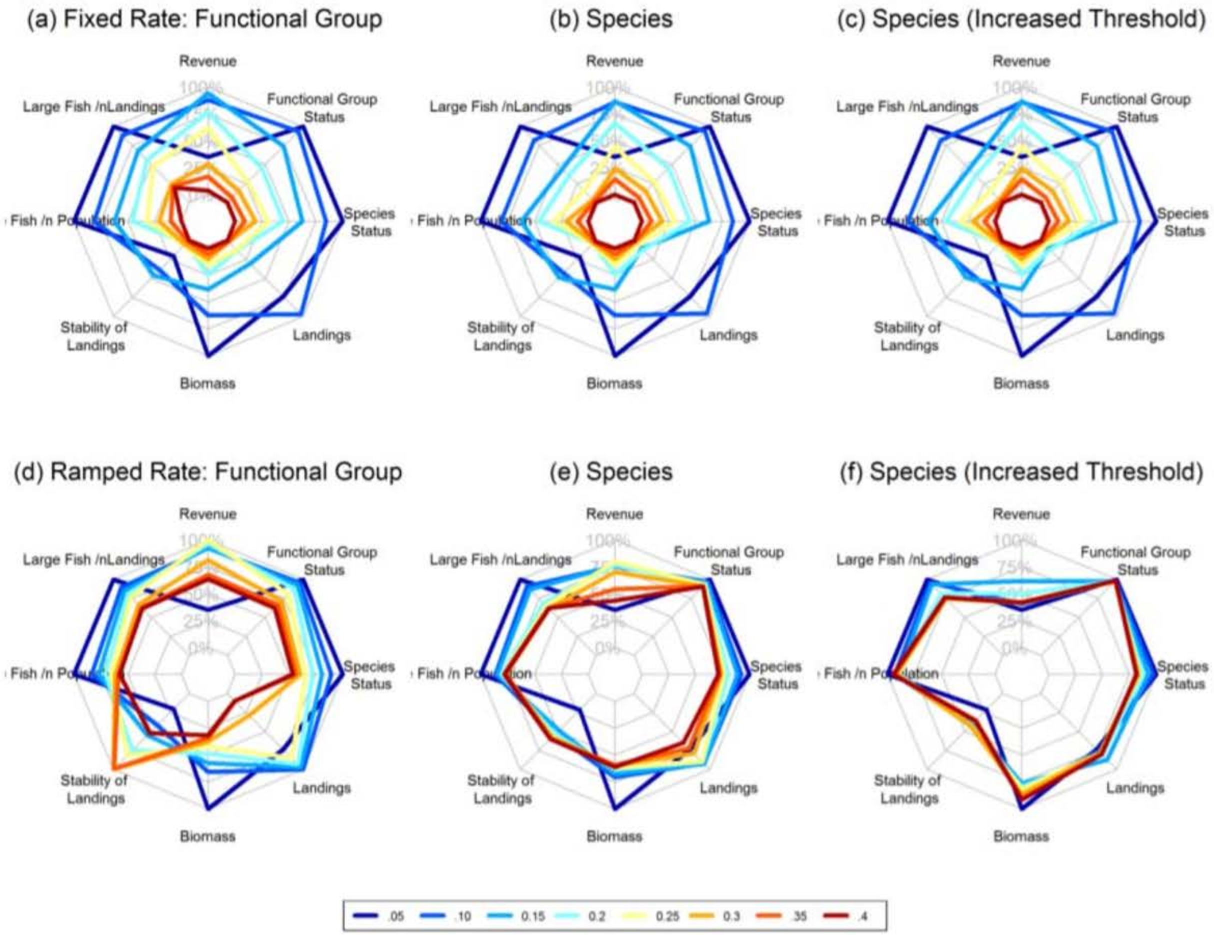
Performance of Harvest Control Rules

Fixed Rate HCR



Ramped Rate HCR

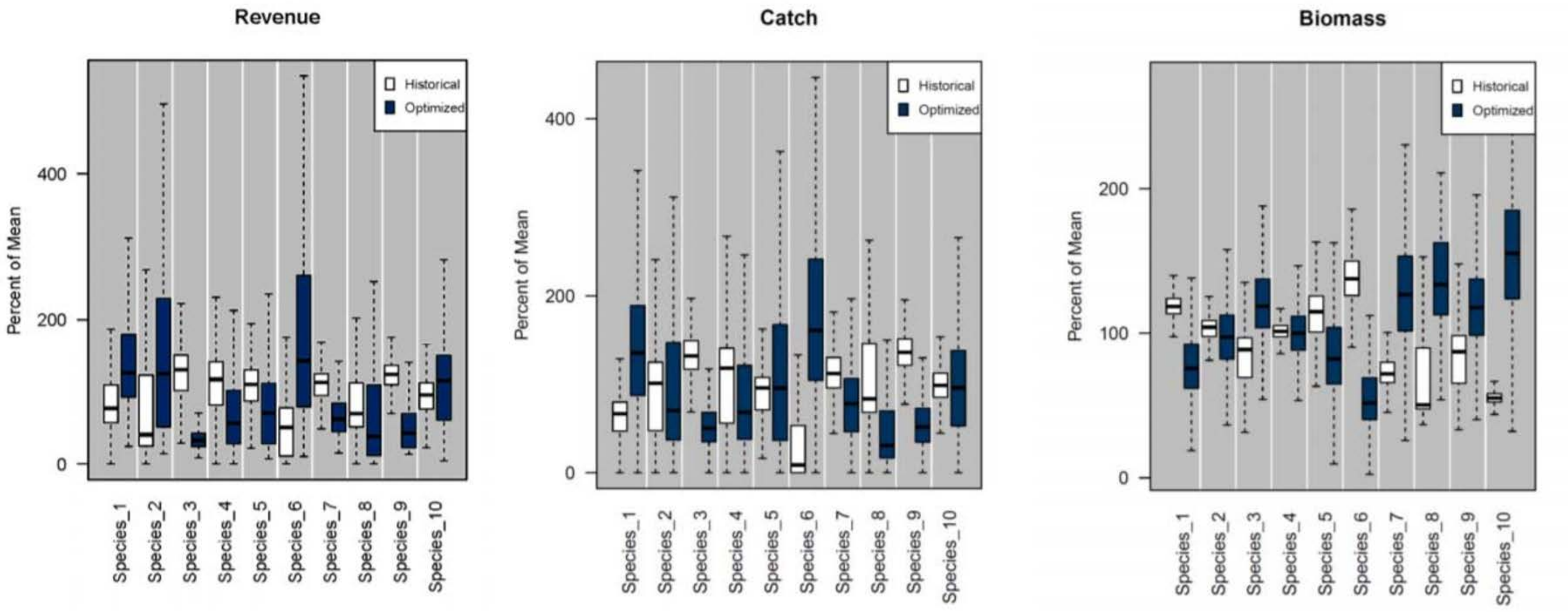




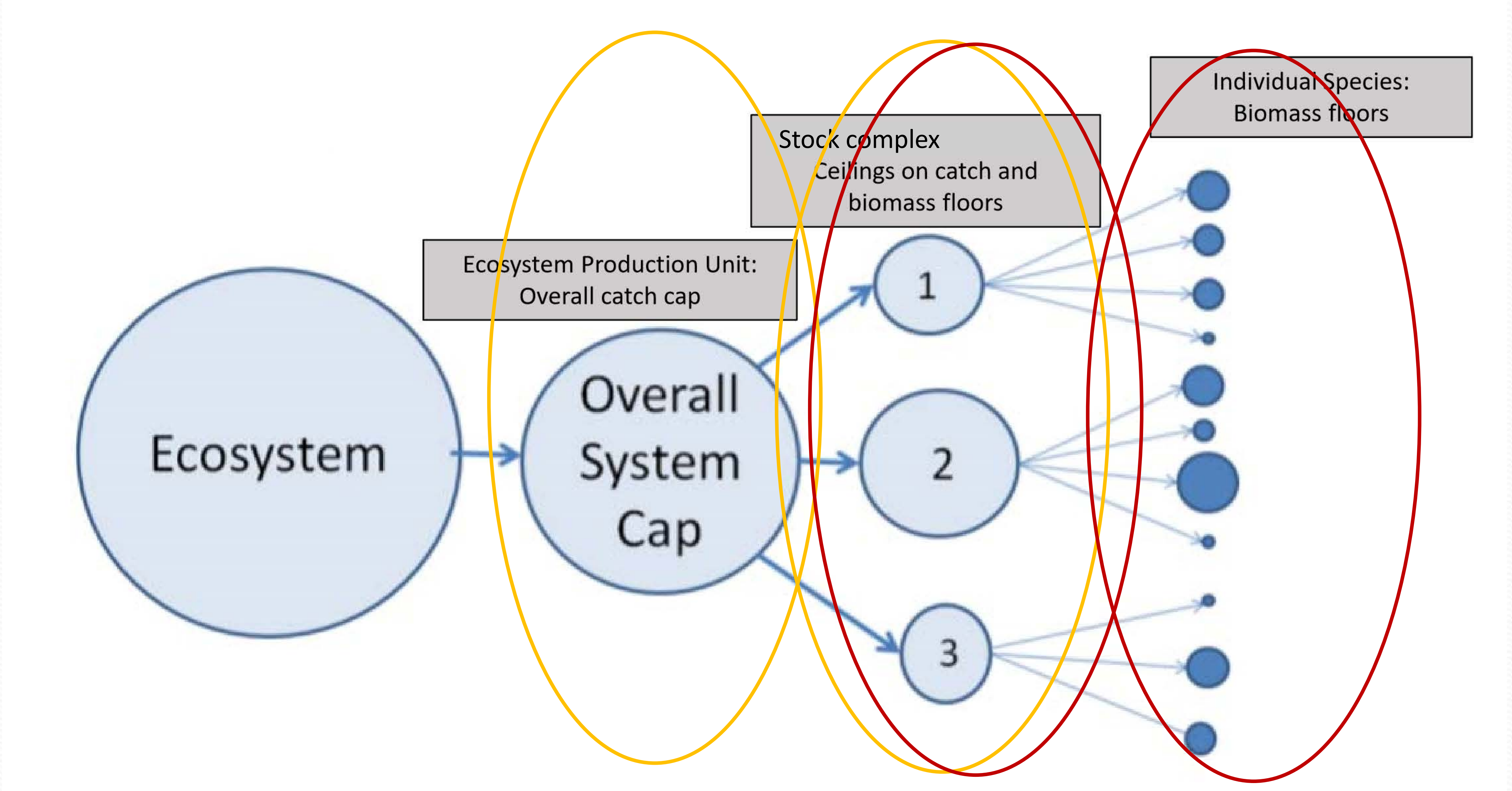
ToR 9: Review simulation tests and performance of the proposed management procedure incorporating the floors and ceilings approach, given the set of EBFM goals and objectives.

Worked example

Portfolio Analysis



Stock complex harvest control rules



A framework for providing catch advice for a fishery ecosystem plan (FEP)

- Binder Document 2, eFEP discussion document 3
- Ecosystem catch limit – Indicators and pressure field
- Stock complex catch limit
  - Aggregate production models
  - Multispecies assessments
  - Index-based trends methods
- Catch limits derived from stock complex harvest control rules designed to achieve FEP goals and objectives

A framework for providing catch advice for a fishery ecosystem plan (FEP)

Ecosystem catch limit

– Indicators and pressure field

- NEUS 300,00 to 400,000 t or 20% exploitation

BOX 1: Example estimation of catch cap: Large et al. (2013, 2015) and Tam et al. (2017) used survey data to identify values of total catches from ecosystems that were associated with large changes in the values for a set of ecosystem indicators. These thresholds could be used as a reference level for the total catch cap.

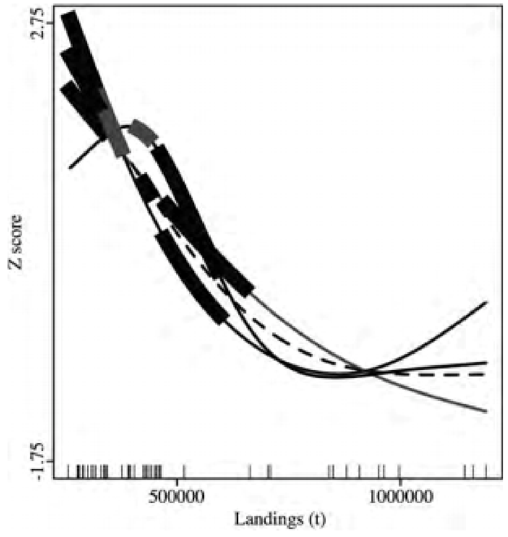


Figure 6. Centred and scaled (z-score) ecological indicators with a significant GAM (with smoothing term included) in response to landings. Rug plot represents the spread of the data, and significant derivatives are highlighted accordingly.

Tam et al.   Comparative Thresholds in Marine Ecosystems

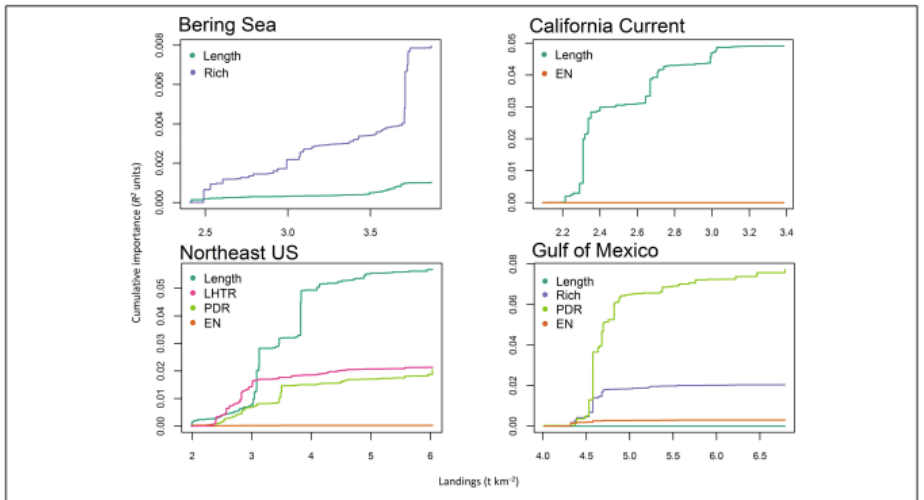


FIGURE 4 | Cumulative shifts (in R^2 units) of ecological indicator value in response to landings (t km^{-2}) from the gradient forest analyses for Alaska (Bering Sea), California Current, Northeast US, and Gulf of Mexico. Thresholds are defined as a steep increase in ecological indicator response to a pressure. Ecological indicators are mean length of catch (Length), species richness (Rich), pelagic to demersal ratio (PDR), low to high trophic ratio (LHTR), species diversity (EN).

(*Figures from Large et al. 2013, Tam et al. 2017 showing responses of ecosystem indicators to system-wide landings*)

Aggregate production models

BOX 2: Estimating catch advice for a stock complex based on an assessment using an aggregated production model.

Application of surplus production models have a long history in assessment of fishery population dynamics in the Northeast US. These have often been for individual species. The methodology used in an aggregated production model is exactly the same as for the single-species case but the data being fit to represent a stock complex. This approach is used for assessment and management of other species groups in the US, for example for the bottomfish complex in Hawaii (Brodziak et al. 2011). The application of aggregate production models was used to set management advice on the Northeast U.S. Continental shelf during management by the International Commission for Northwest Atlantic Fisheries (ICNAF; Brown et al. 1976) before the 200-mile limit was established.

Lucey et al. (2012) fitted aggregate surplus production models to stock complexes by summing estimates of biomass (e.g. from surveys) and catch over species within complexes, and modeling the biomass dynamics at this level, to estimate MSY and BMSY reference points, and current aggregate biomass status relative to these reference points.
Catch advice for the aggregate (stock complex) level could then be derived by applying the model-estimated F_{MSY} (or the appropriate proxy level) to the estimate of current aggregate biomass.

Lucey et al.: Aggregate surplus production comparisons 225

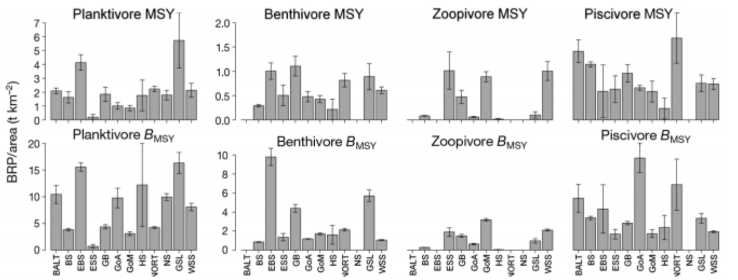


Fig. 4. Area-corrected maximum sustainable yield (MSY) and biomass at maximum sustainable yield (B_{MSY}) derived from the process error model for the feeding guild aggregation type by ecosystems. Note the different scale for the planktivore aggregate group than the other 3 aggregate groups. See Table 1 for definition of ecosystem abbreviations

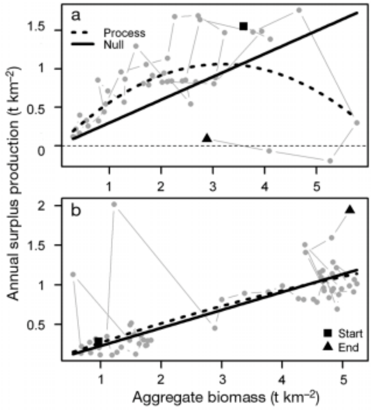


Fig. 2. Examples of the fit by the models to the data. (a) Example where the process error model (thick dashed line) fits the data well (North Sea pelagic aggregate group). This occurs for the majority of the aggregate groups across the ecosystems. (b) Example of where the null model (solid line) fits the data well (Gulf of Alaska 'large' aggregate group). This occurred in only 3 aggregate groups. The thin dashed line shows where annual surplus production equals 0

(from Lucey et al. 2012; estimates of MSY and BMSY for different stock complexes, example of aggregate production model fit)

Multispecies Assessments

BOX 3: Stock-complex level catch advice using a multispecies assessment model.

Aggregate production models do not account for individual species dynamics, varying species productivity, or varying availability to survey gear. Multispecies assessment models make these assumptions more explicit, by modeling the dynamics of several species simultaneously. These models are fit to data in the same way as single-species stock assessments, and the complexity spectrum of available models mimics that of single-species stock assessments. As an example, a multispecies production model was used by Gaichas et al. (2012) to define reference points for stock complexes. These reference points were based on a model with trophic interactions and interspecific competition. Multispecies production models in which interactions among species are explicitly considered has a long history in this region (e.g. Sissenwine et al. 1982; Overholtz and Tyler 1986). When appropriate data are available, advice can also account for environmental factors, such as trophic interactions, drivers of ecosystem productivity, and changes in habitat quality.

Once the models are fit, target rates of fishing mortality can be obtained from the mortality associated with maximum sustainable yield across all stocks, or some level of this based on objectives associated with low expected levels of stock collapse. This is akin to stock projections in a single-species model. After defining the target level of fishing mortality for catch calculations, the catch advice can be derived by applying this level of F to the estimate of current biomass for each species as estimated by the multispecies assessment model.

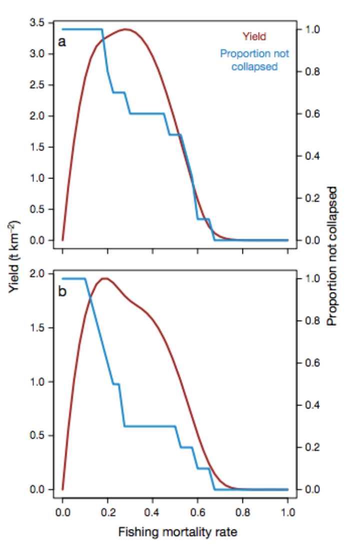


Fig. 2. Full 10-species system aggregate yield and collapse curves (where collapse is defined as biomass <10% of unfished biomass) for (a) Georges Bank and (b) Gulf of Alaska

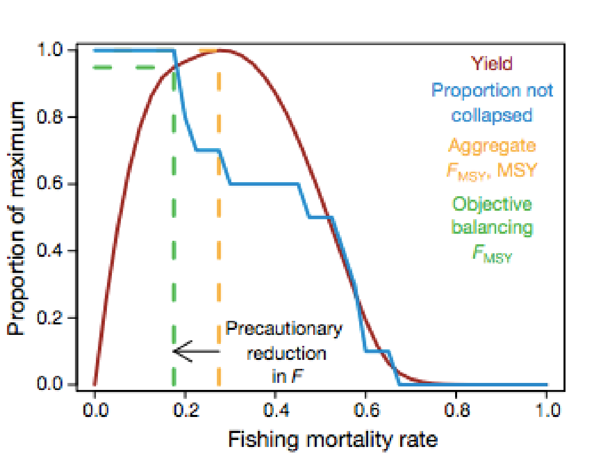


Fig. 4. In multispecies complexes, fishing mortality rate F can be reduced from aggregate F_{MSY} (MSY, maximum sustainable yield) to prevent collapses. For the full 10-species Georges Bank model, nearly 95% of MSY can be achieved with no species dropping below 10% of unfished biomass

(*example multispecies yield curves for stock complexes; from Gaichas et al. 2012*)

Index-based trends methods

BOX 4: Stock complex catch advice from index-based trends method

Trends-based assessments (commonly used in ‘data poor’ situations) take a current estimate of a trend in a stock indicator, applying a multiplier of sustainable catch (proxy for F_{msy}) to derive advice. Such methods may or may not include explicit reference points for the stock indicator. Several stock indicators could be used but a common one is a biomass index from survey (here an index of the biomass of a stock complex). If found to be a reliable index of trend, additional indicators of stock biomass could be used or augment the survey data.

An example used in the Northeast US by the NEFMC is a survey-based ‘Plan B’ approach for developing catch advice for stocks that do not have accepted stock assessments (e.g. NEFSC 2015). This type of method can also be applied at the stock complex level. The method currently used fits a LOESS smooth through the spring and fall survey indices obtains an estimate of the smoothed (averaged) trend from recent years. The resulting slope of the trend scales an estimate of current catch to provide catch advice (the ‘current catch’ estimate is often averaged over recent years).

This approach could also be used for a stock complex by calculating the biomass indices for the stock complex (e.g. summing over species in the complex), applying a catch multiplier for the reference period to current biomass indices. The number of years over which to calculate the trend and estimate of current catch are not prescribed here, though there are several examples of this method being tested with alternative specifications for these decision points.

This approach assumes a ‘complex’ level biomass. Thus, it does not model single stock dynamics, and is implicit in its treatment of interactions, etc. The method could also be applied to individual stocks (as currently done) to obtain species-specific trends, and then some part of the distribution of these trends (e.g. median, or minimum) could be applied to the recent complex-level catches to derive catch advice. This approach would allow the stock complex catch advice to be more sensitive to apparent dynamics of individual species. Implementations of these approaches have shown they perform best when a reference point for the stock indicator and catch level are used (e.g. Little et al. 2008).

Potential strategies for overfished stock status determination and rebuilding management for stocks managed as part of a stock complex

- Binder Document 3, eFEP discussion document 4
- Stock complex harvest control rule biomass floors
- Approaches to determine stock status – address risk and ecosystem considerations
  - Vulnerability to fishing
  - Resilience
  - Role in the ecosystem

Example status determination and rebuilding strategies

- Example using index based approach – 20% of index time series
- Other sources of data including assessments can be used
- Other thresholds may be appropriate, stock specific
- Rebuilding through stock specific management measures, e.g.
  - Selective gear
  - Temporary area closures
  - Point system (general management strategy to be moved to a different eFEP section)

Spatial management measures for habitat, spawning, and endangered/threatened species protection

- Binder document 4, eFEP discussion document 9
- Spatial processes and species demographics are important for the ecosystem, improving productivity, and achieving FEP goals
- Focus on improving productivity: habitat impacts on recruitment, survival, and growth of juvenile fish; forage

Spatial management measures for habitat, spawning, and endangered/threatened species protection

1. Assessing spatial distribution of effort by gear type and fishery functional group
2. Evaluate allocations of catch to fishery functional groups to achieve management objectives
3. Estimate effort and gear impacts to habitat for each managed species (or complex/functional group) regarding variation in productivity (growth, survival, reproduction)
4. Effects of spatial variation in demographics of prey species for managed and protected species
5. Incentivize use of less impactful gears
6. Allocation and selectivity measures applied to sub-ACL

Spatial management measures for habitat, spawning, and endangered/threatened species protection

1. Currency catch vs. effort?
   1. How to measure it for different gears and modes of fishing?
   2. Simulations use effort as control variable – translated to catch by catchability coefficient
   3. Effort related to cost and profitability, protected species and habitat effects.
   4. More closely relates to achieving optimum yield.