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MEMORANDUM

DATE: April 15, 2019

TO: EBFM Committee

FROM: Andrew Applegate, EBFM PDT chair

SUBJECT: Discussion document 4: Potential strategies for overfished stock status determination and rebuilding management for stocks managed as part of a stock complex

The attached document (Discussion Document 4 on the eFEP task list) discusses approaches that could be used to determine when a stock is overfished and measures that could be used to rebuild overfished stocks in the EPU. In an ecosystem context, minimum biomass thresholds for stocks could include a broader variety of factors on a case by case basis than are now considered, such as vulnerability to fishing, resilience, and the stock's role in the ecosystem. Stocks that are highly migratory or have a significant proportion of biomass that is outside of the EPU would continue to use existing reference points to determine status, until possibly replaced by an ecosystem reference points in neighboring EPUs.

The PDT does not recommend any specific values at this time, because overfished reference points should be evaluated in an operating model that evaluates harvest control rules for stock complexes. For individual stocks, a specific minimum biomass threshold may not be as important as it is now, if the stock complex harvest control rules also include a minimum biomass threshold (i.e. floor) that triggers a reduction in catch limit when the stock complex biomass declines (this is a PDT recommendation in the discussion document). Yet we recognize that a minimum biomass threshold to signal that a stock has become overfished is still required by National Standard 1, if there are sufficient data to make this determination.

As an example using an index-based approach, the discussion document suggests that a threshold based on 20% of the index time series could be used. This is for illustrative purposes only and other measures of stock status could be used to identify when a stock is considered to be overfished, including single species or multispecies assessments, or other accepted methods to determine status. Nonetheless, a 20% threshold might be considered as an effective substitute for existing proxies of ½ of B_{MSY} or another value might be chosen to take into account broader considerations that contribute to risk. For some slow growth and low fecundity stocks [such as elasmobranchs (sharks and skates)] which are less resilient, a higher threshold might be chosen. Similarly, a different reference point might be chosen because the stock plays a key role in the ecosystem, such as serving as important source of forage to fish and marine mammals.

The document also discusses several types of management measures that could be used to help an overfished stock rebuild. Most are no different than the tools that we use now, except that they rely more on measures that decrease vulnerability to fishing or discourage targeting of an overfished stock, rather than a specific catch limit for that stock. Depending on their effectiveness, these types of measures do however raise the potential that the fishery's ability to target healthier stocks in stock complex could be hampered. These sort of tradeoffs and their ecosystem effects should be taken into account in the choice of rebuilding strategies. Similarly, these tradeoffs will also be important to determine when a stock has been rebuilt or determine how long that rebuilding should take.

Discussion Document 4

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

prepared by the

Ecosystem-Based Fishery Management Plan Development Team

In defining status determination criteria (SDC) for multispecies management on Georges Bank, an FEP can extend the concepts applied to individual species/stocks under current management approaches, but in a broader, more flexible way under harvest control rules adopted to achieve FEP goals and objectives. At one level, sustainable fishing mortality rates applied to a stock complex can protect most stocks in a stock complex, but if the biomass of a stock complex becomes too low, the catch limit for a stock complex should be lower than if the ecosystem is more in balance. Nonetheless, some stocks may still become depleted or overfished due to natural variation or excess targeting of a single stock. In this case, minimum biomass thresholds based on assessments or indicators can be set to trigger stock-specific catch limits and associated measures to rebuild the biomass of that stock.

Under current management, SDCs are formulated in relation to single species Maximum Sustainable Yield (MSY) levels. Overfished status determinations are specified with respect to reference levels of biomass at MSY (B_{MSY}). MSY-based reference points used in single-species management often implicitly assume a symmetrical production function in which MSY occurs at 50% of the virgin biomass level. In this case, species are classified as overfished if they fall below one-half the B_{MSY} level (one-quarter of the unfished biomass level). For some NEFMC groundfish stocks, proxy SDCs are often employed based on defined proportions of spawning biomass per recruit. From the GARM III assessment, proxy levels for MSY were estimated by applying $F_{40\%}$ spawning biomass per recruit (SBR), with the SDC for an overfished stock being ½ of this SSB_{MSY} proxy. For many other NEFMC managed stocks, current relative biomass levels in relation to a specified historical level in available time series, such as an index from a trawl survey, are used as proxies. Currently, approximately 50% of the stocks managed by NEFMC are assessed with index-based methods using survey and/or catch data to generate proxy measures of relative biomass. These stocks currently include all the skates (7), whiting, red hake, scallops, monkfish, dogfish, two windowpane flounder stocks, wolffish, halibut, Georges Bank yellowtail flounder, Gulf of Maine winter flounder, Georges Bank cod, witch flounder, and ocean pout (see Table 1).

Table 1. Summary of ABC control rules used in NEFMC Fishery Management Plans

Species	ABC CR
Herring	3 year average with 50% probability of overfishing in Year 3
Scallops	Catch associated with fishing rate that has no more than a 25% chance of exceeding OFL (including discards)
Skate	Aggregate ABC for all 7 species combined; Long-term median catch/biomass ratio x 3-year avg. biomass
Monkfish	$B_{CURRENT}$ x Avg expl. rate 1996-2006 (North) $B_{CURRENT}$ x Avg expl. rate 2000-2006 (South) CR not used in the 2017-2019 specifications based on SSC advice. SQ ABC used based on recent data. This method may be used until age validation research is complete.
Whiting (silver and offshore hakes)	P*[1] = 25th percentile of estimated scientific uncertainty for silver hake. 4% added to southern whiting stock ABC to account for mixed catch including offshore hake
Red Hake	P* = 40th percentile of estimated scientific uncertainty
Red crab	long-term average catch
Groundfish stocks	For most stocks with approved assessment: 75% Fmsy x B current. Other methods used for stocks with rejected assessment or other issues

[1] P* is a measure of the scientific uncertainty that an ABC is less than estimated fishing mortality that is consistent with producing MSY. P*=50% means that there is a 50/50 chance. Lower P* values are associated with less risk.

The revised National Standard One Guidelines [50 CFR 600.310(d)(2)(i)] state: "…Stocks may be grouped into complexes for various reasons, including where stocks in a multispecies fishery cannot be targeted independent of one another; where there is insufficient data to measure a stock's status relative to SDC {Status Determination Criteria}; or when it is not feasible for fishermen to distinguish individual stocks among their catch. Where practicable, the group of stocks should have a similar geographic distribution, life history characteristics, and vulnerabilities to fishing pressure such that the impact of management actions on the stocks is similar. The vulnerability of individual stocks should be considered when determining if a particular stock complex should be established or reorganized, or if a particular stock should be included in a complex...".

Of a total of 913 individual stocks of fish currently under management in U.S. waters, 658 are currently aggregated into various stock complexes for management purposes (Gamble et al. In Review). Although the motivation for management at an aggregate level is often related to data limitations or difficulties in species/stock identification, the above language in the guideline clearly recognizes the need to consider the problems in managing mixed species fisheries where targeting capabilities and species-level control on fishing mortality rates are subject to inherent limitations. There is in fact an extensive history in identification and analysis of species assemblages as management units as a way to address the effects of both technical and biological interactions (e.g Tyler et al. 1982). Under current NEFMC management, seven species of skates are treated as a stock complex as are two hake species (silver and offshore hakes of the genus *Merluccius*), due mainly to their mixing in the catch and unidentified species in the landings. There is accordingly precedent for managing aggregate groups of species in the Northeast U.S.

As a precaution against depletion of entire stock complexes and an unhealthy ecosystem structure, status determination criteria for species complexes could also follow the approach described for individual species. In this case, if the biomass of the complex as a whole falls below a threshold, remedial action would be taken as in the individual species case. The strategy of implementing remedial action at the individual species level is necessarily more conservative than similar action taken for the species complex as a whole. It could however also result in increased invocation of choke stocks in the management process.

8.3.1 Overfished SDC for Individual Species

For an assemblage of interacting species in an FEP, no single MSY level is appropriate as often assumed in single species management. Rather, any MSY-related reference points are conditioned on the abundance of interacting species. Instead, an FEP could apply a SDC derived from empirical time series a species biomass based on the best available scientific information (survey time series, assessment, minimum standardized catch per unit effort, etc.). As noted above, information from research vessel surveys are currently used as an SDC for about one half of NEFMC-managed stocks to determine whether a stock is overfished. For consistency and overall context, biomass reference points can be derived for all species using research vessel survey data as a starting point.

For species with alternative biomass estimates derived from other fishery-independent and fishery-dependent sources or other options (including catch-based methods) the best available scientific measure of biomass could be chosen by scientists and managers. For species with restricted movement patterns, biomass indices would be derived for the Georges Bank ecological production unit. Many migratory species reside on Georges Bank for only part of the year. In these cases, the biomass indices used would be derived for Northeast U.S. Continental Shelf as a whole, with catch limits applied proportionally to the Georges Bank EPU.

As an example of one possible approach, an illustration of the survey-based component of this process is shown in Figure 8.3.1. Here, NEFSC research vessel indices for 13 species on Georges Bank are shown, with a Kalman filter applied as a smoother for the mean biomass per tow. Although many alternatives for defining the floors can be identified, for simplicity, a suitable threshold (i.e. floor) is given by the lower 20th percentile of the observed survey time series as an example.

Threshold levels for individual stocks within a stock complex could also be established based on the following considerations (which area often related to its life history characteristics (Table 8.3.1).

- Vulnerability to fishing (i.e. how quickly biomass declines to excessive mortality),
- Resilience (how quickly will a stock recover when biomass below the threshold), and
- Role in the ecosystem (less risk allowed for species that play a key role, e.g. forage fish).

Higher (more conservative) thresholds could be chosen for species with high risk to overfishing. Life history traits typically identified with higher vulnerability include low fecundity, delayed maturation, larger maximum body size and slower individual growth rates. Collectively, these traits are often reflected in lower intrinsic rates of population increase. Table 8.3.1 provides metrics related to these traits for NEFMC-managed stocks.

In principle, each stock could have an individual biomass threshold for the overfished status determination. In practice, it may be desirable to identify groups of species with similar life-history characteristics and assign common thresholds within groups. Final choices of threshold values for overfished status will be made in relation to NEFMC risk policy guidelines and performance of harvest control rules relative to the metrics associated with the goals and objectives of the FEP.

8.3.2 Management Options for Overfished Species

Rebuilding strategies for overfished species could be specified based on approaches currently employed in single species/stock management. One or more of the following options can be considered. Measures that are established to promote rebuilding of one or more overfished stocks should remain in place until the its biomass reached an appropriate target, taking into consideration its role and relationship to other species in the stock complex and the ecosystem. A major objective is to reduce fishing mortality and rebuild the age-structure of depleted population in a way that will enhance prospects for successful recruitment. Recruitment of fish populations is variable and often highly episodic. Rebuilding the age composition of the stock to encompass more older individuals can increase the probability of large recruitment events. High recruitment events can be husbanded to rebuild the overall population biomass and make the transition from overfished status to a rebuilt status.

- Targeted Area Closures: Particularly for species with high habitat fidelity, areas with high concentration of an overfished stock can be identified and targeted spatial closures implemented. In contrast to other spatial measures (see Discussion Document 9 on spatial management), the use of area closures here would be intended to reduce the availability of a species to fishing. This type of rebuilding measure would be intended to enhance survival and growth, or spawning, of an overfished stock, rather than enhancing productivity for a range of stocks (as discussed as a general ecosystem management approach in Document 9). In this case, targeted area closures may also be of limited duration while stock rebuilding occurs. One of the weaknesses of this approach is that it could restrict the ability for a fishery to target healthy stocks that are found predominately within a targeted area closure.

- Effort Restrictions: Particularly for the case where several species fall below the designated threshold for overfished status, overall reductions in fishing effort can be implemented to aid the recovery of the depleted species. This can be effective, particularly when a stock complex is deemed overfished, but may also be effective if the overfished stock is the primary target of a fishery. Its weakness is that effort restrictions can be too general and prevent vessels from fishing for other stocks which are not overfished.

- Species-specific ACLs for Overfished species: Because of the mixed-species nature of many of the fisheries in the Northeast and the difficulty of exerting exact compositional control of the catch, this document includes the possibility of setting ACLs at the species complex level. One option for enhancing the prospects of recovery of overfished stocks is to set species-specific ACLs for them. Strong constraints on permissible landings levels of vulnerable species can increase the incentives to avoid catching them Of note is that the current Sector-based groundfish quota management system is nested within this option. A strength of this approach is that it directly affects catch of an overfished species. A weakness is that it often puts the onus on industry to fish in ways that do not exceed the ACL for a stock and can be costly to monitor the catch.

- Conservation Engineering (gear technology) Solutions: Incentives to develop gear modifications to reduce the probability of capture of overfished species can be put in place. Recent examples include the haddock-separator trawl to allow capture of abundant haddock resources while affording protection to cod and other depleted species. To be effective to rebuild an overfished stock, such measures and technology need to be developed before they are actually needed for a rebuilding measure.

- Point Allocation System: Incentive structures can be put in place to encourage enhanced targeting of species in robust condition while establishing disincentives for the capture of overfished species. In the 1990s, the Northeast Seafood Coalition proposed a system in which fishers were awarded a specified number of points to spend rather than being awarded an individual quota allocation for individual species. Depleted species would require the expenditure of more points per unit weight than ‘healthy’ species, providing an incentive structure to catch and land species that are abundant while discouraging the pursuit of overfished stocks.

A similar concept ‘ the Credit System’ has been suggested for use in EU-managed fisheries. In this case , fishing credits are equivalent to points. The allocation of points could be structured as a dynamic process, responding to changes in resource abundance over time. Unlike the above-mentioned options, there is no experience in the implementation of a points allocation scheme in the Northeast U.S. and detailed evaluation of the strengths and weaknesses of this approach would have to be undertaken. An example of a fishery credit-based system under European Union management is provided by Riell et al. (2015).

A point allocation system would need to be implemented at the outset, not just in response to an overfished status, but could allow the Council more flexibility in responding to an overfished condition by triggering an increased ‘penalty’ or cost for catching overfished stocks. It could also be used to increase the ‘penalty’ or cost for catching species that are vulnerable to overexploitation or are less resilient, relative to other stocks in a stock complex. Alternatively, stocks in a stock complex that are at high biomass levels could see a reduction in the point cost.

Current management practice specifies a time frame within which an overfished species must be rebuilt. The base period is as quickly as practicable but no more than 10 years, with the potential for extension for species with low intrinsic rates of increase or other life history traits such as delayed maturity and long life span, i.e. stocks that cannot be rebuild in 10 years or less. In principle, similar criteria could be applied in the multispecies context for species that fall below a specified biomass threshold. We note however, that delayed recovery can be due to other ecological conditions. For example, increased biomass of predators or competitors of a depleted species could impede the rate of recovery. In this case, consideration of the impact of interacting species, or changes in environmental conditions could be taken into account in specifying a recovery period in concert with life history considerations.

Currently, stock status determinations are performed on a one to five year cycle, some assessments occurring less frequently. Based on the range of available data and methods for determining stock status, it is possible to utilize a tiered approach for evaluating stocks and complexes. Based on Council and Center priorities and capacity, determining stock status at approximately three-year intervals, similar to the current scheme would likely be a reasonable approach. Annual determinations would also be possible for indicator based methods using trawl survey data on biomass and age-composition, catch and effort data and for ecosystem information such as is provided through the Ecosystem Status Report. In season changes of indicators based on catch, effort and environmental data could also be used to track ecosystem conditions and alter catch advise contingent on predefined triggers. The basic premise of this tiered approach is currently in place within the Council-GARFO system. Increased use of indicators, thresholds and predefined triggers, could track stocks and conditions and add some flexibility to respond to the current situation. Seasonal distribution shifts that are different than previous years may enable increased fishing opportunities for some stocks or create bycatch issues for others. Such approaches could enable more adaptive management.

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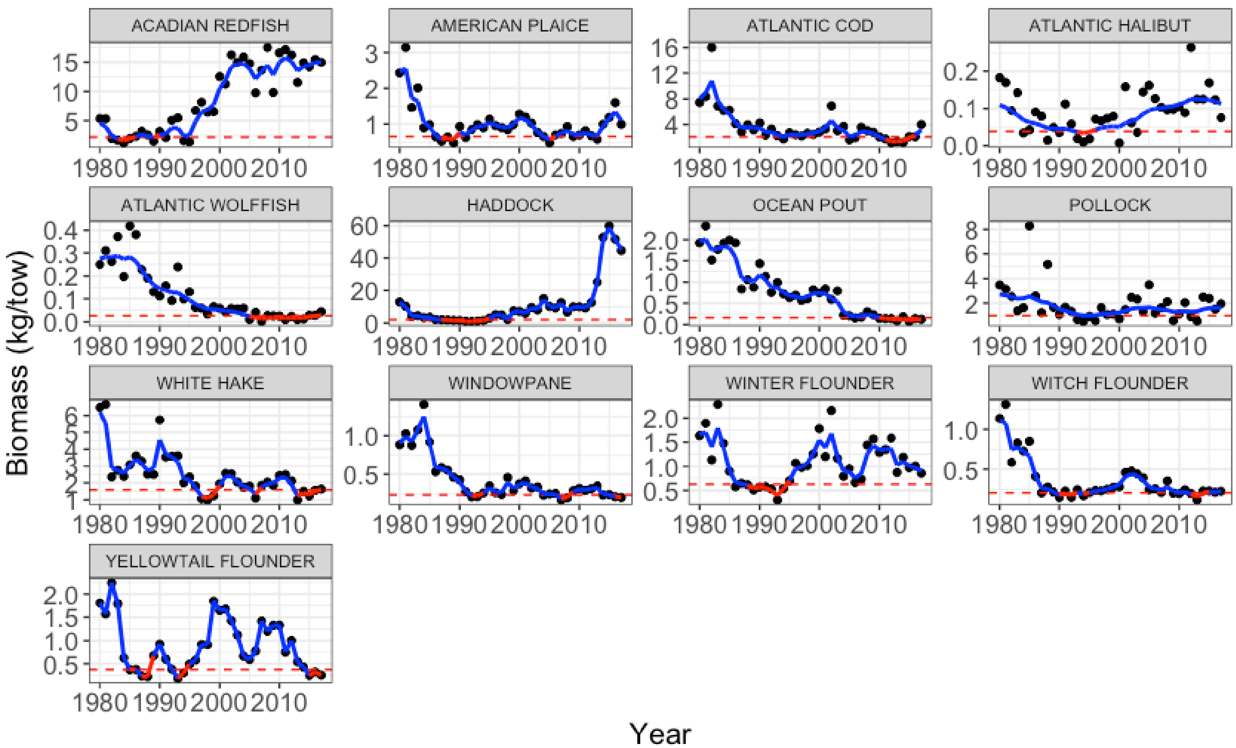

Figure 8.3.1 NEFSC averaged spring and autumn research vessel surveys for 13 species on Georges Bank (closed circles 1980-2015). Lines show smoothed estimates from application of a Kalman filter for each. Portions of the time series in red indicate periods when abundance was at or below the 20th percentile for the entire series.

Table 8.3.1 Life history metrics and mean trophic level (TL) for species managed by the New England Fishery Management Council. Life history metrics include the intrinsic rate of increase (r), the vonBertalannfy growth coefficient (k), mean age at maturity (AgeMat, yr), longevity, and the maximum size attained (MaxSize, cm).

Species	TL	r	k	AgeMat	Longevity	MaxSize
Barndoor Skate	3.5	0.2	0.14	6.5	11	150
Clearnose Skate	4	0.2	0.15	5.5	7	94
Cod	3.79	0.66	0.115	1.8	17.5	148
Cusk	4	. -	.	8	14	110
Goosefish	4.45	0.3	0.1	4.7	13	126
Haddock	3.67	0.51	0.29	3	9	73.8
Halibut	3.8	0.212	0.02	12	35	190
Herring	3.38	0.62	0.32	2.95	16.5	35
Little Skate	3.6	0.2	0.19	9.5	12.5	53
Ocean pout	3.11	0.12	0.095	2	18	97.8
Offshore Hake	3.42	0.9	0.174	3	14	70
Plaice	3.86	0.31	0.17	3.7	24	61
Pollock	3.72	0.88	0.14	6	24	111
Redfish	3.2	0.17	0.145	7	40	45.7
Red Hake	3.69	0.88	0.19	1.6	14	60.2
Silver Hake	3.42	0.9	0.42	2.5	14	65.4
Spiny Dogfish	3.39	0.11	0.116	17	38.6	100
Thorny Skate	4	0.2	0.12	11	16	89.5
White Hake	3.89	0.45	0.165	1.5	20	136
Windowpane	3.89	0.50	0.255	3.5	7	41
Winter Flounder	3.36	0.66	0.34	1.9	15	45.5
Winter Skate	4	0.25	0.1414	6.5	11	114.1
Witch	3.61	0.23	0.15	5.25	30	39.3
Wolfish	3.3	. -	0.04	5.5	22	98
Yellowtail Flounder	3.86	0.79	0.34	2.1	17	50