Prioritizing Fish Stock Assessments

NOAA Fisheries

February 2014

TABLE OF CONTENTS

Prioritizing Fish Stock Assessments

NOAA Fisheries

February 2014

EXECUTIVE SUMMARY

Assessments for managed fish and shellfish stocks are an important core activity of NOAA Fisheries. The Magnuson-Stevens Act (MSA) requires that fisheries management be based on the best scientific information available, thus the need for stock assessments. Well-established protocols for these assessments have been developed and highly focused deliverables satisfy the MSA requirements. Stock assessments analyze fishery catch monitoring, fishery-independent surveys of fish abundance, biological and other data to produce the required outputs. These data collection and analysis activities constitute a considerable portion of the NOAA Fisheries budget and it is important that they be prioritized to focus on the most important needs.

The prioritization system described here encompasses the updating of assessments for previously assessed stocks and first time assessments for stocks that have never been assessed. Given that the status of many stocks remains listed as “unknown”, a comprehensive scan across all stocks can guide priority for first time assessment among the unassessed stocks. These priorities should be based on fishery importance, ecosystem importance, biological vulnerability to overfishing, and preliminary information on fishery impact level (stock status). This simple overview of information may identify stocks of low importance and risk such that further assessment is a low priority. Some high priority assessments may not be feasible to immediately implement due to lack of data or staff.

For stocks that have been previously assessed, the prioritization approach has three components: (1) setting the target assessment level (how comprehensive an assessment is needed), (2) setting the target assessment frequency, and (3) setting the priority among stocks for conducting assessments to achieve their target levels and frequencies, given available data and assessment capacity. The factors that contribute to setting target levels, frequencies and priorities include: fishery importance, ecosystem importance, stock status, and stock biology. In addition, the recent history of new data acquisition and assessment updates contribute to deciding whether the next assessment should be conducted as an update, which uses the same approach as previous assessments and simply incorporates more recent data of the same types, or as a benchmark assessment that involves a more thorough analysis of alternative approaches and requires a more extensive peer review before accepting results.

A stock’s target assessment level, e.g. degree of comprehensiveness, has a large impact on the data requirements to conduct the assessment. Stocks with high fishery importance, high ecosystem importance, and biological factors that lead to high natural fluctuations will warrant high level assessments. High level assessments typically need precise and accurate fishery independent surveys and data on fish ages from the fishery and the surveys. These high level assessments provide more direct information on fishing mortality and on fluctuations in stock productivity (recruitment), and thus can be more accurate and provide better forecasts of needed changes in annual catch limits. Stocks at moderate levels of importance or expected fluctuations can suffice with less data-rich assessments. Some stocks will be identified as sufficiently minor components of the fishery such that their assessments need not extend beyond baseline monitoring of catch and simple indicators. At all assessment levels, there should be consideration of environmental and ecosystem factors to help distinguish natural from fishery effects on the stocks.

A stock's target assessment frequency should depend on its intrinsic variability over time as well as its importance to the fishery and ecosystem. The greatest fluctuations are expected for stocks with short life spans and high variability in productivity. Stocks with longer lifespans tend to fluctuate less because of the many age classes in the population. High fluctuations create a greater need for frequent updates in annual catch limits. Stocks with high fishery and/or ecosystem importance need more frequent assessment updates to quickly provide access to increases in abundance while keeping the chance of overfishing at an acceptable level. Target update periods are expected to typically be 1-3 years, but some may range up to about 10 years.

The priority for updating an assessment depends principally upon the degree to which it is overdue relative to its target frequency. Stocks that are more overdue will have highest priority for updates. For stocks that are equally due or overdue according to their target frequency, priority will be given to stocks that are on rebuilding plans or are at risk of overfishing or depletion. Among stocks that are still tied, priority would go to stocks that have new information indicating a drift from the previous forecast and to stocks with higher fishery importance.

It is not realistic to create a single national prioritization list because of the importance of regional fishing communities. Further complications include regional differences in total fishery value, assessment data availability, and long-standing processes for arriving at regional assessment prioritization decisions. Additional prioritization challenges are incurred for those Centers that engage in assessments with various international fishery management organizations. While the ideas presented here may be useful in those international settings, the principle focus of this prioritization process will be for domestic stocks in federal fishery management plans.

The proposed prioritization approach centers on the delivery of consistent information to each science/management group to help support and standardize their decision-making with regard to assessment priorities. This report and a database containing all the factor scores will be updated and made available to all parties involved in deliberations regarding assessment prioritization. The first time each Center works on prioritization with its respective management group (Fishery Management Council, regional or international commission, NMFS region or headquarters) may take some time, but subsequent updates should be straightforward and not require a large effort. A portfolio of assessments is expected to evolve, with some activity directed towards first-time assessments, some towards baseline monitoring of low priority stocks, some towards high quality assessments of high priority stocks, and some towards more intensive investigation of ecosystem linkages where needed.

As each region [1]deliberates on its assessment prioritization process, there also should be consideration of the process and time needed to conduct reviews of assessments and to move assessment results into implementation of management actions. It is recommended that each region conduct management strategy evaluations on a few representative stocks in order to understand the implications of stock variability, assessment imprecision, assessment frequency, and time lags between assessment and management implementation. In the future, this prioritization process can provide the necessary framework to guide wise national investments in improving survey and staffing capabilities for more accurate, precise, and timely scientific information in support of stock assessment requirements.

[1] The generic term "region" is used to refer to the group composed of a NMFS Science Center and its management partners.

BACKGROUND

SITUATION

The Magnuson-Stevens Act provides the foundation by which Fishery Management Plans (FMP) are created for fisheries that are in need of conservation and management. Each FMP lists fish stocks that are managed under that plan, and the FMP then specifies optimum yield for that fishery, criteria to determine whether overfishing is occurring or if any of the stocks have become overfished (depleted), and specifying annual catch limits such that overfishing does not occur. Determination of overfishing and overfished levels and annual catch limits is required to be guided by the best scientific information available. Fish stock assessments are designed to provide exactly the quantitative scientific information needed to determine the status of fish stocks and to guide annual catch limits.

Stock assessments are analyses of the population dynamics of the stock. Full assessments utilize catch data from fishery monitoring programs, stock abundance data from fishery-independent surveys or fishery catch rates, and data on the biology of the stock from various sources. These data feed into stock assessment models which integrate the information from the various sources and provide estimates of stock abundance, stock productivity, and fishing mortality over time. If the assessment is based on weak, imprecise data or has not been updated recently, there is a chance that it is providing guidance that is either allowing overfishing or is forgoing available fishing opportunities. It is impossible to confidently prevent overfishing while attaining a yield that is a large fraction of the theoretical Maximum Sustainable Yield (MSY) without having an accurate, precise and timely stock assessment to guide frequent adjustments to catch levels. With accurate and precise stock assessments, the recommended catch can approach the theoretical MSY while having only a small chance of overfishing. Thus, it is important that stocks for which the fishery strives to achieve as large an optimum yield as possible are supported by data-rich, frequently updated stock assessments.

Stock assessments are conducted principally by the six NMFS Science Centers in collaboration with State, Council, international and academic partners. Assessment results are delivered to the NMFS fishery managers, the Fishery Management Councils and international fishery management organizations for their use in developing recommendations for management of the fishery. Because assessments directly support the regulatory process, the assessment results can be contentious. For stocks managed under federal Fishery Management Plans, the MSA's National Standard 2 Guidelines defines the requirement for certifying that the assessment represents the best scientific information available. The reauthorization of the MSA in 2006 specifically addresses this review issue by establishing an opportunity for the Secretary of Commerce with each Council to establish a peer review process, and by designating the Council's Scientific and Statistical Committee with specific roles in providing the Council with scientific advice on fishing levels including the acceptable biological catch that would prevent overfishing. The relationship between NMFS science programs and the regional Fishery management Councils, NMFS regulatory offices and various international partners for highly migratory and other treaty-managed stocks, such as those off Antarctica, is important for successfully turning assessment data into useful management advice on a timely basis. These relationships should include an objective process to determine which stocks are priorities for assessment, and then to effectively conduct, review, and communicate the assessment to the affected public.

Since publication of the Marine Fish Stock Assessment Improvement Plan (SAIP) (Mace et al, 2001), numerous national programs and working groups have been developed to improve assessments. These include:

- National Stock Assessment Workshops and National SSC Workshops provide a forum for development and advancement of the scientific approaches and protocols;
- Advanced Sampling Technology Working Group develops improved data collection and processing technologies;
- Fisheries Information System program management team coordinates catch monitoring nationally;
- National Observer Program and Marine Recreational Information Program do the same for at-sea observers and recreational fishery catch monitoring, respectively;
- Assessment Methods working group focuses on improvement of the analytical stock assessment methods.
- Species Information System provides a national, web-based portal to all assessments and fishery status determinations and provides outputs that can be efficiently provided to inquiries at both the regional and national level
- Fisheries and the Environment (FATE) and the Habitat Assessment Improvement Plan work to improve the inclusion of environmental, ecosystem and habitat information in assessments.

Collectively, these national groups achieve a federated stock assessment enterprise under the leadership of the NMFS Science Board. This assessment enterprise meets national mandates established by the MSA and other legislation and executive orders, and is responsive to regional assessment needs and opportunities.

The cost associated with conducting a particular assessment is complicated. Each assessment is not an individually contracted task. There is a complex, many-to-many relationship between the several assessments conducted in each region and the several multi-species data sources that support those assessments. Most funds go into large scale, long-term data collection programs that simultaneously collect data on many co-occurring stocks. Assessment programs encompass a broad portfolio of activities from basic fishery data collection, to surveys, conducting standard assessments, and studies to improve consideration of ecosystem, environmental and habitat effects on fish stocks. The fishery-dependent aspect of the overall program is conducted in strong partnership between the Science Centers, Regional Offices, coastal states and marine fisheries commissions and Councils. The fishery-independent aspect of the program is partially conducted through use of the NOAA OMAO Fishery Survey Vessels, as well as fishing vessels contracted by the Science Centers and various partners, state surveys, and cooperative research programs. Further the costs of conducting assessments vary tremendously depending on the type of assessment, size of the stock, its range and habitat. The many-to-many relationship between funding of data collection programs and resultant assessment outcomes confounds detailed budget accounting. Thus, identification of which assessments would be conducted on the basis of new funds is fundamentally fuzzy. New funds build regional assessment capacity, including expanded data collection. The returns on these investments result in improved assessment output some years hence depending on the specifics of the situation.

The SAIP in 2001 provided a baseline description of the NOAA Fisheries' stock assessment enterprise. It set the goal of at least baseline monitoring (basically just catch and perhaps some simple indicators) for all stocks, standard assessments for core stocks, ecosystem-linked assessments for select stocks. The SAIP defined five levels at which an assessment could be conducted:

1. Assessment based on empirical trends in relative stock abundance;
2. Assessment based on a snapshot equilibrium calculation;
3. Assessment based on time series of catch and an abundance index to support application of a dynamic model;
4. Assessment is age-structured, so needs time series of age and/or size data and can now estimate changes in fishery characteristics over time and can estimate fluctuations in annual recruitment, and has direct information on the fishing mortality of each year class entering the stock;
5. These assessments link to ecosystem, habitat or climate factors to help explain and forecast the fluctuations that are empirically measured in a level 3 or 4 assessment.

Today, assessments at level 3 are generally considered to be able to determine overfishing and overfished status, but are marginal for the purpose of forecasting changes in annual catch limits. Most assessments are conducted at level 4 today and a few have achieved a level 5 status. Several different modeling approaches are used, but there has been evolution towards models that are internally age-structured but very flexible in data requirements. A revision of these levels is underway as an update of the SAIP.

NEED FOR PRIORITIZATION

The demand for rapid updating of assessments became acute with the requirement for annual catch limits in all fisheries. If stocks fluctuate in abundance and an annual catch limit is to be set at a level that will attain a target level of fishing mortality, then the ACL must be updated sufficiently close to the onset of a fishing season in order to take advantage of timely information on the forecast abundance of the fish stock. This is because the ACL is effectively the product of a target fishing mortality level (F) and the forecast of the available stock biomass (B) in the upcoming fishing year. So if the actual B in the upcoming year differs from the forecast B, then catching the ACL will over- or under-achieve the target F level. Hence, consideration of the target assessment frequency should also take into account the time it takes to make management updates (including ACL adjustments) on the basis of assessment updates. Where there are high fluctuations in B, there is greater need for shortening the timeframe between data collection and management implementation. For example, to the assessment to management transition is just a few months for short-lived species like Pacific salmon managed by the Pacific Fishery Management Council and by the US-Canada process managing the highly fluctuating Pacific whiting stock which begins entering the U.S. fishery at age 2. Other regions have developed short-turnaround processes for some key stocks, but there are insufficient resources to assess all stocks on an annual basis, and many stocks do not need annual assessments. Hence an objective and quantitative approach for establishing assessment priorities is necessary.

NMFS Science Centers have recognized the need for prioritization and streamlining of the assessment process. For example, the Northeast Fisheries Science Center, at the request of the Northeast Regional Coordinating Committee, created and used a revised process in conducting assessment updates in 2012 (NEFSC, 2012). A particular focus of this revision was an effort to move more assessments from a time-intensive benchmark assessment process, to a streamlined update process. Many of the concepts embodied in the NE process are represented in the national prioritization process presented here.

Other nations have also recognized the need for coordinating the pace of assessments and the expectations for timeliness of management updates. In Australia, Dowling et al. (2013) investigated the historical patterns of investment to attempt to better understand the trade-off between research and management costs, risk to the stock and ecosystem, and level of allowable catch. In Europe, the ICES organization formed a working group (WKFREQ) to investigate factors that could allow for reduced frequency from their typical annual assessment updates (ICES, 2012). In 2011, ICES conducted annual assessment updates for 144 stocks and biannual assessments for 48 stocks, thus nearly twice the number of assessments than are conducted in the U.S. each year The ICES report reached the following conclusion with regard to reducing assessment frequency and deriving multi-year management advice from some assessments:

> *"WKFREQ suggests that multiannual management approaches can only be considered for a limited subset of ICES stocks, namely those with robust assessments and modest exploitation, those with a limited amount of new information each year, those with very noisy data, those in which management is only weakly directed by assessments, and those in which individuals are very long lived and exploitation is (again) modest. Stocks in any other circumstances are unlikely to be suitable for a multiannual approach.*
>
> *Even in suitable cases, the risk of changing to a multiannual system needs to be evaluated using a quantitative approach such as an Management Strategy Evaluation. Such an evaluation needs to consider the assessment model used and its uncertainty, survey and recruitment variability, the initial state and trajectory of the stock, the management approach used, how well the fishery performs economically, and more qualitative aspects such as political sensitivity. An evaluation that ignores one or more of these aspects in determining suitability may well reach the wrong conclusion, with potentially damaging consequences."*

The U.S. situation differs from the European situation in that we have been successful in reducing overfishing, thus achieving a more modest exploitation rate for more stocks, a situation that is more amenable to reduced assessment frequency. Nevertheless, the WKFREQ recommendation for Management Strategy Evaluation holds true for the U.S. as well. A prioritization system informed by MSE will be more objective and transparent as to its expected benefits.

SCOPE: STOCKS AND REGIONAL SCALE

The species (stocks) to be considered in an assessment prioritization scheme are numerous and diverse. In some cases, a managed stock is a geographic subset of a species. In other cases, the stock is a complex containing a few to many species. The total number would be greater than 1000 if all species within complexes were counted individually. The fact that some species have been lumped into a complex for management purposes does not completely discharge stewardship responsibility to assure that members of the complex are not being unduly affected by the fishery. Across the nation, FMPs have varied tremendously in the degree to which they have included species within the plans. Some are single-species plans and some include a wide range of species that are targets of the fishery or associated with these target species in some way. In some cases, the FMPs have included a large number of co-occurring species which, by their inclusion, would inherit the requirements for status determinations and annual catch limits. The 2009 update of the National Standard 1 Guidelines recognized this conundrum and established a category termed "ecosystem component species". A species can be placed in the ecosystem component category if it is not targeted or retained by the fishery and its level of bycatch is determined to have a negligible impact to the stock. Thus, a low-level stock assessment is to determine if a species is a member of a management unit or is an ecosystem component species . In 2013, there are 478 managed stocks and stock complexes in the fishery management plans.

The species scope for this plan is also complicated by our engagement in the international arena. In some cases the managed stocks are included in fishery management plans, but the assessments occur in an international working group setting that is not under Council or NMFS control and involves factors that would not be easily incorporated into a US domestic prioritization process. In other cases, there are internationally managed stocks such as CCAMLR managed Antarctic stocks, that are outside of FMPs but still require use of US assessment resources.

In 2005, the Fish Stock Sustainability Index (FSSI) was created and the 230 stocks included in this index effectively became the previously undefined "core" stocks from the SAIP. FSSI stocks contribute 90% of the catch, although some stocks are on this list because of a history of overfishing or other reasons to establish importance. A Departmental-level performance measure was created to track progress in improving the FSSI and in providing adequate assessments for these 230 FSSI stocks. An adequate assessment is considered to be one that can provide information relative to status determination criteria[2] on both overfishing and overfished status (SAIP level 3), has been updated within the past 5 years, and has been validated as best scientific information by a review process. The breakout of stocks and stock complexes is shown in Table 1. They are unequally distributed among the jurisdictions of NMFS regions, regional Fishery Management Councils, and Fishery Management Plans. These 46 FMPs each contain from 1 to many tens of managed stocks.

The proposed schedule for application of the prioritization process would have each Center take a tiered approach with their respective Regional Council or other partners to cover all stocks in their jurisdiction. The first tier would cover the domestically assessed and managed FSSI stocks. The second tier would extend to other managed stocks, species within managed stock complexes, ecosystem component stocks, non-FMP internationally managed stocks, and state/commissioned managed stocks as appropriate for the particular Center.

---

[2] Note that level 1 and 2 assessments support some status determinations and status determinations are retained even when assessments are more than 5 years old.

We propose to take a regional scope to prioritization because of the large challenge in calculating each stock's contribution to national benefits. Optimum yield from fisheries should be defined in terms of benefits to the nation, so it is logical that the prioritization of assessments also be in national terms. In practice, however, the degree to which social, economic, ecological and biological analyses can quantify optimum yield in terms of benefits to the nation is quite limited. The importance of regional communities is a challenge to quantify. Typically, optimum yield is defined only in terms of an amount of catch for a particular stock and is not even extended to a multi-species analysis within an FMP. Consequently, it will not be feasible to quantitatively define absolute priorities for stock assessment at a national level. The assessment prioritization process described here will focus on facilitating the standardization of regional prioritization processes and providing a national reporting system for the results of this regional prioritization. Higher level decisions regarding allocation of national resources between regions can be guided indirectly by the results of the regional prioritization.

PRIORITIZATION OVERVIEW

In brief, the proposed prioritization process involves the following steps:

1. Target Assessment Level and Frequency: Among unassessed and previously assessed stocks, set medium-term assessment goals
    - Among stocks that never have been assessed, set priority for first-time assessment, if any, or conclude that current level of baseline monitoring is sufficient.
    - For stocks that need assessment, set target assessment level; this drives the data requirements
    - Set target assessment update frequency for each stock
2. Prioritize to Achieve Targets: Annually update priorities for conducting assessments, with a portfolio approach to allocate assessment capacity to achieve a mix of first-time, benchmark, and update assessments:
    - Benchmark assessments for assessments needing improvement or for which new data will allow advancing to higher level;
    - Update assessments for stocks that are at or exceed their target update period.

The Target-Setting stage is important because it is not possible to prioritize without having clear targets to be achieved. These targets relate to how comprehensive the assessment should be (e.g. its assessment level) and how frequently it should be updated. While it is inevitable that current data availability will influence consideration of a stock's target level, this should not be an overriding influence. It will be better to establish goals that are independent of current data and then to consider the gap between current data and the stock's goal. The Prioritization stage then directs assessment efforts to accomplish these targets. The "First Time Assessments" distinction is needed because it is not realistic to establish a single set of factors that encompasses both the updating of assessments for previously assessed stocks and first time assessments for stocks that have never been assessed. For stocks that have never been assessed, we lack the information needed to establish longer-term expectations for its assessment level and frequency. In the sections below, we will first describe the factors to be considered in the process, and then describe how these factors are used to assign targets and priorities to stocks.

FACTORS TO CONSIDER IN TARGET SETTING AND PRIORITIZATION

The major factors that influence the setting of assessment targets and priorities are described in this section and summarized in Table 2. These factors are:

1. fishery importance (commercial and recreational value to the regional fishing communities, with additional considerations);
2. ecosystem importance (role of the stock in the ecosystem and strength of its interactions with other species);
3. stock status (relative to target and limit levels of abundance and fishing mortality);
4. stock biology (how much change is expected per year, on average);
5. history of assessment, including availability of new information to resolve extant issues or indicate a change in stock abundance.

FISHERY IMPORTANCE

Fishery importance on a per stock basis would best be described in terms of benefits to the nation from fishing activities affecting that stock. As described earlier, it is not feasible to quantify importance in these terms, nor would it be politically feasible to create a system that ignored the regional importance to coastal fishing communities. It would be ideal to be able to calculate the incremental value to the nation of conducting an assessment on one stock versus another stock, but such a detailed economic analysis is not feasible. Consequently, the proposed system described here will use both commercial landed value and recreational catch, while providing an opportunity to adjust a stock's importance level according to less quantifiable factors, including stocks that are limiting factors in mixed stock fisheries, stocks that have recognizable non-catch value to society, and stocks that contribute to subsistence fisheries. Importantly, the commercial and recreational scores will be provided separately and not explicitly added together.

For a stock's commercial importance, the landed value of the catch will be the data from which a non-linear ranking would be calculated. If raw catch value is used, then the most valuable stocks would overwhelm the low valued stocks and there would be little ability for other factors to establish a priority for assessment of the low valued stocks, for which there still is a mandated need to prevent overfishing. On the other hand, if the stock-specific catch values were binned into categories with equal numbers of stocks and bins were assigned scores of 1 to 5, then then high value stocks would receive only a small amount of higher priority than the low value stocks. The proposed progressive score transforms the raw catch values as $\log_{10}(1.0 + \text{landed value})$ to reduce the range, and then scales this range to have a maximum value of 5.0.

Although good databases with commercial catch by species are available, commercial and recreational catch values on a stock-specific basis for all stocks are not readily available. A preliminary exercise collected catch information from each region for all stocks in 2009. It is used here to demonstrate some general characteristics of the range of catch across stocks. Annual updating of this stock-specific catch information is underway to provide commercial and recreational catch relative to annual catch limits. These data will be used for the prioritization process when they become available.

An example exercise for fishery importance used the commercial domestic landed catch amount in 1000s of pounds of whole weight for 2009. On this basis, stocks with a catch of approximately 100 million lbs would have a score of 4.0 (after rescaling so that the maximum score would be 5.0), 5.5 million for a score of 3, 310 thousand for a score of 2, and 16 thousand for a score of 1.0. With this approach, many FSSI stocks would have values in the range of 2-3 (Figure 1a), and most non-FSSI stocks would have values less than 1.0, and many would score near 0. Note however that some of these zero scores were because catch data on some of the minor, unassessed stocks were not available.

Recreational catch in 2009 was processed in the same way as the commercial catch, e.g. the recreational score is $\log_{10}(1.0 + \text{retained catch in 1000 lbs})$, then scaled to have a maximum score of 5.0. As with commercial, this is done on a national basis. There are 134 FSSI stocks and 215 non-FSSI stocks for which we found no reported recreational catch in 2009 (Figure 1b). The top three recreational stocks (Table 3), with catches of 9-17 million pounds, were: Summer flounder - Mid-Atlantic Coast, Bluefish - Atlantic Coast, and Yellowfin tuna - Central Western Pacific.

Scaling each of commercial and recreational to have a maximum scale of 5.0 on a national basis has desirable characteristics for this exercise, but should not be interpreted as a judgment that commercial and recreational value are of equal importance. It would take a very involved economic analysis to actually place recreational value on the same basis as commercial value. Consequently, the commercial and recreational scores will be kept separate. With catch ranked nationally in this way it is still feasible to use the national values within each region or within FMP. By using a maximum of 5.0 for each, this essentially places commercial and recreational importance on the same scale nationally, however this will play out differently within each region as these scores are used to actually assign assessment priorities. Off Alaska, recreational catch of federally managed stocks is very small compared to commercial catch so the low recreational score for all stocks will have negligible effect on the relative ranking of stocks. Whereas in the Southeast, recreational catch is greater than commercial catch for many stocks, so both the commercial and recreational rankings will have an impact on prioritization. The scaling of commercial versus recreational value and the inclusion of non-catch and subsistence would need further attention if comparisons between regions are to be considered.

Figure 2 shows that the stocks with highest recreational score nationally tend to have at least a moderate score on the commercial scale. This is true for both the FSSI stocks and for the non-FSSI stocks. On the other hand, stocks with the highest commercial score nationally tend to have very low recreational catch.

The values displayed here have been based on landed catch amount, not value, and have only been displayed nationally, not regionally, so these figures and lists are preliminary and will certainly change as landed value, not catch, is used as the common metric.

Fishery Importance Modifiers

In addition to the commercial and recreational score, additional factors can contribute to the fishery importance score for a stock. These include:

- +1.0 for stocks on rebuilding plans because their recent catch value is depressed below long-term potential;
- +1.0 for stocks that have a particularly high constituent demand for excellence in stock assessment. For example, stocks that are in catch shares programs or stocks that are in a multi-stock fishery and their status is limiting the fishery's ability to harvest more productive stocks in that multi-stock fishery. In this case, good assessment of the smaller, less valuable stock is important to prevent undue restriction on harvesting of the more valuable stock. A cap on the percentage of stocks that can receive this bonus will need to be established to prevent excessive usage rendering it meaningless.
- +1.0 for stocks that have a high non-catch value (for example underwater viewing of reef fish).
- +1.0 for stocks important to subsistence fishing.

Ecosystem Importance

All species have ecosystem importance but their importance increases if they constitute a major forage species for one or more managed species, or if their role as a predator is important for structuring ecosystems, including changing the natural mortality rate of other species. Importance would increase further if the forage species was critical for an endangered or protected species. The ability to define ecosystem importance for predator species is more difficult since the consequences of apex predator depletion are often difficult to trace, much less quantify. However a mixture of food habits data, basic ecological information and model exploration (when available) can usually identify ecosystem components that have potential or likely substantive impacts on predation mortality rates or community structure. As the data and models to make such determinations are evolving, default scores of 1 are likely to be most reasonable for most species in the absence of evidence of some sort to the contrary.

Ecosystem Score considers both bottom up and top down possibilities where:

"Bottom-up" (Forage or habitat) score

1. if only a minor dietary or habitat provider for managed stocks (e.g., Pacific grenadier)
2. if major dietary or habitat component for one or more managed stocks (e.g., Pacific cod, corals)
3. if major dietary or habitat component for a broad range of managed stocks, or an endangered or otherwise protected and vulnerable stock (e.g., walleye pollock, skipjack tuna, menhaden, krill, shrimp)

"Top-down" (predator/ecosystem interaction) score

1. if change in abundance would likely have minor or unmeasurable impacts on other managed stocks (e.g., splitnose rockfish)

2. if change in abundance would likely have notable changes in predation mortality, recruitment or other vital rates for one or more managed stocks (e.g., lingcod, marlin)
3. if change in abundance would likely result in substantive changes in predation mortality, recruitment or other vital rates for one or several managed stocks (e.g., arrowtooth flounder in Gulf of Alaska).

Ecosystem score = maximum of above scores, so could be up to 3. Assignment of scores will need to be an iterative process to achieve a balanced approach across regions.

Ecosystem Effects

The discussion above with regard to ecosystems is based upon the degree to which harvested fish stocks are important to ecosystems, thus harvest levels for these fish stocks must be managed to protect the ecosystem of which they are members. The converse is also true; changes in the ecosystem, climate, and habitat will affect the productivity of fish stocks and better assessments will take these effects directly into account. More complete single species stock assessments are designed to be flexible enough to track the fish stock's response to these factors, but the assessments do not include the factors directly, so their response at best will lag behind true changes and forecasts can be biased. Here in this prioritization document, we have not attempted to include the need for studies to better understand these effects on fish stocks and to incorporate them directly into the assessments. NOAA recognizes the need for such work, otherwise we risk losing sight of the forest while focusing too closely on the trees. At this time, NOAA Fisheries is working on an update to the Stock Assessment Improvement Plan (2001). There the issue of expanding assessments to more directly account for these effects will be addressed. Future evolution of a prioritization process should seek a more broadly balanced portfolio that includes such ecosystem work.

Stock Status

The stock's status is based on the most recent estimates of the stock's abundance (spawning biomass, SB) and fishing mortality rate (F) relative to limits and targets for these quantities. For stocks that have previously been assessed, the intent would be to use the results of the most recent assessment to guide the importance of conducting an update of that assessment. The minimum score is 2 for a stock that has a low F, is abundant, and is not on a rebuilding plan. The maximum score is 9 for a stock that is overfished, is experiencing overfishing, and is on a rebuilding plan. Stocks that are near their target level of F and SB will have a score of 4. Stocks that are currently unknown with regard F and SB will have a score of 6.

F Category	Score		Abundance Category	Score
LOW IMPACT $F_C <= 0.25*F_{MSY}$	1		ABOVE TARGET $SB_C > 1.25*SB_{MSY}$	1
MODERATE IMPACT $0.25*F_{MSY} < F_C <= 0.9*F_{MSY}$	2		NEAR TARGET $MSST < SB_C < =1.25*SB_{MSY}$	2
CAUTION or UNKNOWN $F_C <> F_{MSY}$ is unknown	3		CAUTION or UNKNOWN $SB_C <> MSST$ is unknown	3
HIGH IMPACT $F_C > 0.9*F_{MSY}$	4		OVERFISHED $SB_C <= MSST$	4
			On Rebuilding Plan	" +1"

Where:

F_C is the most recent (e.g. current) fishing mortality rate

SB_C is the most recent spawning biomass

SB_{MSY} is the target spawning biomass level, or suitable proxy such as 40% of $SB_{unfished}$

F_{MSY} is the limit fishing mortality rate, or suitable proxy, above which overfishing is occurring

MSST is the limit spawning biomass level, or suitable proxy, below which overfished status occurs.

Among 220 assessed stocks with information on F/Fmsy in 2013, the range of values is displayed in Figure 3. 88% have F/Fmsy < 1.0. Below that level, there is no obvious clustering or breakpoints; stocks are nearly uniformly distributed according to this ratio as shown by the nearly linear pattern for the lower 80% of the stocks. There are 187 stocks in 2013 with information on B/Bmsy. Of these, there are 49% with B/Bmsy > 1.25 and 65% with B/Bmsy > 1.00.

Over time, the boundaries between the levels may needed to be adjusted, or replaced by a system that uses the estimated ratios directly rather than use scores associated with binned values. For example, the F score could be equal to 4.0*F/Fmsy, and the B score could be 2.0*Bmsy/B (note the inverted ratio). For now, the binned approach has the advantage of providing a scoring system even when only approximate values are available.

Stock Biology

The consideration of stock biology is important because it sets the scale for how much the stock abundance, and hence its ACL, is expected to change between assessments. This will be a factor in determining the types of data needed and a primary factor in setting the target frequency of assessment updates. There are two counter-acting forces to consider.

- One factor is the annual fluctuations in recruitment of young fish into the stock. This “recruitment variability” has a coefficient of variation often near 60% and can be greater than 100% for some stocks. Stocks may also fluctuate over time if there are changes in adult natural mortality and/or growth.
- The counter-acting force is the inertia to change that result from the fact that there typically are many age groups in the stock, so the total stock abundance tends to average out the fluctuations. When adult mortality is high, the occurrence of older age

groups is diminished. Since the goal is inertia that opposes too frequent changes in annual catch limits, a suitable proxy is the mean age of fish in the catch multiplied by some factor to be determined later. The mean age should be measured as an average over several years to smooth out the effect of recruitment fluctuations, and in cases where it cannot be directly calculated, it should be estimated from life history correlates.

For the purposes of setting target levels for various data types (see Target Assessment Level below), it is suitable to simply categorize stocks as having a low, moderate, or high expected degree of fluctuation. For the purposes of setting the target period between assessments, the protocol will use the mean age of fish in the catch multiplied by a factor, and then to add or subtract one year based on the degree of recruitment variability.

Another aspect of stock biology that was considered, but not quantitatively included here, is the susceptibility of the stock to the adverse effects of overfishing. Here the arguments with regard to overfishing and overfished are different, but both related to the inertia concept. For short-lived stocks, which have high natural mortality rates, the target levels of fishing mortality are correspondingly high, and the fraction of the stock that is caught each year is high. Thus, if the ACL is set too high due to scientific uncertainty, or it is exceeded, then the fraction of the stock that escapes the fishery could be quite low. If the stock is able to continue to produce good recruitment from this low spawning biomass (i.e. high recruitment resiliency), then it should recover quickly from this overfishing event. On the other end of the spectrum are stocks with low natural mortality rates and low target fishing mortality rates (sometimes <5% of the available stock). In this case, a one year excess catch will have little impact on the fraction of the stock that escapes the fishery that year. However, if the assessment is not updated for several years, or the same assessment bias persists for several assessment updates, then the catch overage will compound annually. Although such long-lived stocks are only slowly affected by short-term moderate overfishing, if they do decline into an overfished condition then it could take many years for them to rebuild because annual recruitment is a small fraction of the standing stock. The Productivity-Susceptibility Analysis (PSA) (Patrick et al. 2010) includes vulnerability due to slow-recovery and low M, and will be used in the examination of stocks for first-time assessments in the next section. For the prioritization of previously assessed stocks, we have not included the PSA score directly because several of the PSA factors (natural mortality rate, F/Fmsy, etc.) are already included elsewhere in the prioritization.

History of Assessment and New Information

Some new information is simply the addition of a new data point to the end of a time series in order to track changes in the stock. These new data will not perfectly match the forecast from the previous assessment because of two primary factors. One is that all data have some measurement error so they individually will not perfectly represent the state of the fish stock. The other is that all models are simplifications of the processes in nature so cannot take into account all factors that cause changes in fish stocks over time; if the forecasts could be perfect, new data would not be needed. So the new data are used to update the calibration of the model, but the updated model should not overreact to the new data because all data have measurement error. Assessment models are designed to get a good balance between tracking the process over time while not getting off track due to noisy data. When data are noisy, it is best to wait a few years to accumulate data points to better average out the noise. But when data are of high quality, then they can be used to quickly update stock status.

Another kind of new information is of a more fundamental nature. For example, the introduction of a new survey that directly measures fish abundance, or the completion of a new research project that provides a more accurate measure of natural mortality. When situations like this occur, then it is important to conduct an assessment to take into account this new information. However, all assessments have some number of factors, such as natural mortality, for which the information has uncertainty. It is not useful to simply redo the assessment to re-examine these issues unless it is known ahead of time that new information to help resolve the issue will be available. Otherwise, the assessment effort is better directed to other stocks.

PRIORITIZATION PROCESS

The prioritization process uses the above factors in two steps. First is the setting of goals for the comprehensiveness and timeliness of assessments for each stock (Figure 4). This needs to be done as an initial step and updated occasionally, but not annually. This step includes consideration of which stocks need assessments and which of these assessments can be simple baseline monitoring. It is expected that these goals will outreach current capacity to conduct assessments. The second prioritization step is near annual evaluation of changing stock status, new information, fishery importance, etc. in order to establish priorities for conducting assessments (Figure 5) to achieve, to the extent possible, goals of comprehensiveness and timeliness.

SETTING ASSESSMENT GOALS

FIRST-TIME ASSESSMENTS

Many stocks, most with low amounts of catch, have never been assessed and have little data suitable for use in an assessment. Consequently, much of the information needed to establish targets and priorities for future assessments are not available. These unassessed stocks need a quick examination to determine which of these can stay at an unassessed level, which can be adequately tracked with simple baseline monitoring, and which need a first time assessment. Two recently developed tools can assist in this task.

One tool is the Productivity-Susceptibility Analysis (PSA) (Patrick et al., 2010). This procedure looks at simple information regarding the productivity of each stock and its exposure (susceptibility) to the fishery. Together these produce a score that ranks stocks according to their vulnerability to being overfished. Application of this procedure can identify those stocks that are potentially at risk and thus in need of assessment to provide a more complete evaluation of the status of the stock.

Another useful tool is designed to provide a data-poor approach to setting an Annual Catch Limit (Only Reliable Catch – ORCS) (Berkson et al., 2011). This tool looks at available information regarding catch, other species in the fishery, and simple indicators of trends in stock abundance (see Table 4 which reproduces Table 4 from the ORCS report). It evaluates whether recent exploitation rate is light, moderate, or heavy; then provides advice on an Annual Catch Limit that should prevent overfishing until a more complete assessment can be completed.

The priority for first-time assessment of stocks can then be based on the PSA's biological vulnerability to overfishing, the ORCS' information on fishery impact level (stock status), and fishery and ecosystem importance. PSA scores range from 1.0 for the lowest vulnerability to 3.0 for the highest vulnerability. The ORCS score for exploitation status also ranges up to a maximum value of 3.0. These two scores will be added to a fishery importance score and ecosystem importance score to obtain an overall score. In some cases, data to even implement PSA and ORCS will be lacking and expert judgment will be needed. The result will be a set of scores within a region to rank stocks according to their need for a first time assessment. Some of these will show a high need, but sufficient data to conduct the assessment may be lacking. Others may have sufficient data for an assessment, usually because data has been collected by a multi-species sampling program that provides data on all encountered species. Some species will score low on this scale, so have low priority for immediate assessment. They should not be ignored. Baseline monitoring to the extent feasible should continue and PSA and ORCS should be updated on a 5-10 year basis.

Previously Assessed Stocks

After a stock has been assessed once, there should be enough information available to evaluate medium term goals for future assessments. Ideally the goal would be stated in terms of a desired degree of statistical confidence in assessment results. While many assessments present results with confidence intervals, the methods are too diverse to support direct comparison and all are not yet able to incorporate the effect of changing ecosystem factors on uncertainty in assessment results. Consequently, a simpler approach is to establish a target for the comprehensiveness (level) of each assessment, and a target frequency for updating the assessment.

Level and frequency are considered separately because the types of resources needed to accomplish them are quite different. Increasing the level of an assessment generally requires acquiring a new kind of information. For example, going to an age-based assessment requires routine collection of data on fish ages. Addition of fishery-independent survey is another type of investment that can improve assessments. Increasing the frequency of assessments does not require new kinds of data, but does require addressing bottlenecks that impede conducting more assessments each year. For example, these bottlenecks could be more age readers to process existing age samples more quickly, more scientists to simultaneously work on more assessment updates, and/or better assessment standardization to streamline the assessment review process.

Target Assessment Level

High level assessments that need more types of data should be reserved for situations with high ecosystem importance, high fishery importance, and/or biological factors that create a high level of natural fluctuations. Stocks that are only moderately important to the fishery and ecosystem and which are not expected to fluctuate much in abundance (and hence ACL) can suffice with a lower level assessment and may not warrant the extra expense to develop a targeted fishery-independent survey and collect extensive age data in order to conduct a higher level assessment.

Fishery importance affects the target level because higher assessment levels (e.g. with routine age-structured data) are more responsive to changing conditions, so can more closely track stock abundance for these high value stocks. Models that use age data can have improved forecasts of upcoming changes in stock abundance and potential yield. Low value stocks are unlikely to warrant the extra expense for collection of age data or instituting a dedicated fishery-independent survey. High value species tend to be more abundant and thus easier to survey because they are detected in most samples. Paradoxically, species that are less common are difficult to survey because their low encounter rate means that even more sampling stations may be needed to attain adequate precision. Fortunately, many fishery-independent surveys are able to simultaneously collect data on a wide range of species regardless of their value to the fishery.

Stocks with high ecosystem importance warrant higher level assessments to guard against ecosystem harm. Assessments backed by fishery-independent surveys and age composition are better able to investigate ecosystem interactions and work towards taking these interactions into account in the assessment.

The biology of the stock influences the assessment level. Stocks with high fluctuations in productivity benefit from age-structured assessments that can better track and forecast the fluctuations. These stocks are exhibiting sensitivity to ecosystem/habitat/climate shifts that warrant age-structured assessments to track these fluctuations and perhaps ecosystem investigations to incorporate the factors causing the fluctuations into the assessment. Note that a stock's sensitivity to ecosystem and environmental change is different from a stock's importance to the ecosystem.

Additional types of data allow for improved assessment calibration. Some assessments simply use a sufficiently long time series of a fishery-dependent stock abundance indicator and catch to calculate the degree to which changing levels of catch cause changes in the stock indicator. A more important stock may warrant requesting a more expensive fishery-independent stock abundance indicator, rather than a fishery-dependent indicator, to have more confidence in the standardization of the indicator over long time periods. Moving to an age-based assessment can provide a more direct indicator of the level of fishing mortality and an ability to account for natural fluctuations in stock productivity (recruitment). These assessments require addition of size and/or age data. These data require biological sampling of the fisheries and surveys, followed by laboratory processing to determine the ages of the sampled fish. Where time series are short and not informative about the impact of the fishery on the stock, then addition of advanced technology data collection can provide a directly calibrated measure of fish abundance. Where changes in fish stocks over time are not explainable simply by fishery effects, then addition of information about changing ecosystem/environmental/ habitat factors can help resolve the impact of fisheries.

The assessment levels in the SAIP (Mace et al, 2001) were described in terms of the type of model used. Separate factors were used to score the quality of the fishery-dependent biological data and the fishery-independent survey data. Since that time, evolution of assessment software has blurred these assessment model levels such that it now seems more important to focus on the types of data available than the model itself. For the purposes of prioritization, a system that relates directly to possible investment decisions is more pertinent. Higher levels of assessment modeling require more types of data and it is the acquisition of these data on an ongoing basis that constitutes much of the cost of more comprehensive and more completely calibrated assessments. The SAIP is currently being updated and a revision of the categorization used to describe the level of data available for each stock will be included and then used for this prioritization process also. While the SAIP will be descriptive of the current state of data availability, the prioritization process will add consideration of whether this state is satisfactory or if improvements are needed.

These target assessment levels will serve two purposes. First, as new data become available to move a stock up to its target level for a data type, then priority for updating that stock's assessment to use these new data will increase. Second, investment decisions can be guided by the gap between current data availability and the data needed for that target level.

Target Assessment Frequency

The period between assessments defines how closely the assessment will be able to track fluctuations in stock abundance and to forecast corresponding changes in the annual catch limit. Stocks with short life spans and/or high fluctuations in productivity are most in need of frequent updating to keep catch limits up-to-date. Fishery importance also is recognized as a factor in the frequency of updates.

One paradox occurs when the survey or fishery data used to track stock abundance are noisy relative to the magnitude of the real fluctuations in the stock. Often the new survey result will lead to constituent requests to quickly update the assessment because the data seem to indicate a change in stock abundance. Unfortunately, the models will tend to track the noise in the latest datum and cause excessive fluctuations in management advice. A better response when the signal/noise ratio is low could be to slow down the frequency of assessment updates so that a modified assessment setup is better able to smooth out these data fluctuations and provide more stable management advice. Ideally, one would conduct a management strategy evaluation to determine the degree to which uncertainty in the assessment increases as the interval between assessments increases. It is recommended that such evaluations occur on some example stocks in each region.

Stocks that are expected to have high natural fluctuations not only need frequent updating, they also need suitable data to use in this updating. For short-lived species, this means an indicator of changes in stock abundance must be very quickly (months) turned into management advice on catch limits for the upcoming fishery season. This is a major rationale for the exemption from ACLs for stocks with one-year life spans; otherwise the ACL would always be out of date relative to the current fluctuation in actual stock abundance. For medium lifespan species, this generally means that size and/or age data needed for estimation of incoming recruitment will need to be collected and processed quickly to enable a quick turnaround from data collection to management action.

Factors Affecting Target Assessment Frequency

A pragmatic starting point is to use the mean age of fish in the catch as the target interval between assessments. Alternatively, one could use a formula based on total mortality (Z) or natural mortality (M) as roughly equivalent (Fig. 6). If all fish are recruited at age 1, then mean age in the catch is closely approximated by 0.5+(1/Z), or by 0.5+(1/(2*M)). It may be necessary to multiply this mean age by a scaling factor to achieve a good overall level of assessment frequency, and to average mean age data over several years to remove the effect of variable recruitment. The value of this scaling factor will be set after enough of the data elements are collected to do a preliminary application of the target setting process. Then decrease this interval by a specific amount for stocks with high levels of recruitment variability, or increase by a specified amount for stocks with low variability. A nonlinear scale or a cap may be needed so that very long-lived stocks are not assigned an unreasonably long assessment interval. Evaluation and refinement of this approach and consideration of additional biological factors must wait for collation of life history information for more stocks.

Fishery importance and ecosystem importance should affect the target frequency of assessments because of the improved fishing opportunity obtained by quickly tracking upturns in stock abundance, and conversely the fishery and ecosystem risk avoided by preventing acceleration of downturns.

Arguably, stock status could influence the target frequency because stocks that are known to be approaching an overfished or overfishing condition need to be watched more closely to enable ACL adjustments to avoid crossing into overfishing or overfished conditions. Because stocks that are approaching overfishing or overfished status will also tend to be stocks that have high fishery importance, and because a stock's status is constantly changing, it seems preferable to use fishery importance in setting the target assessment frequency and then use stock status in the prioritization step as a tie-breaker among stocks that are equally due for assessment. While stocks that are on rebuilding plans, or approaching an overfishing or overfished condition need somewhat more frequent updates because these conditions are indications of changing stock abundance or fishing mortality rates, the prioritization system should ward against excessive diversion of assessment efforts from healthy stocks that are supporting major fisheries. Doing so will weaken tracking of these stocks and hinder close tracking of their available yield. The proposed system will prevent this diversion because the years overdue will be a primary factor in setting assessment priorities.

Target Assessment Frequency

1. **Mean Age of Fish in Catch * Scaling Factor**
2. **Adjust for recruitment variability:**
    a. **-1 year(e.g. more frequent) for stocks with high recruitment variability;**
    b. **+ 1 year for stocks with low recruitment variabilityvariability**
3. **Adjust for fishery value:**
    a. **– 1 year for stocks with commercial or recreational score above a level to be specified**
    b. **+ 1 year for stocks with commercial and recreational score below a level to be specified**
4. **Adjust for ecosystem importance similarly to fishery value**

EXAMPLE:

1. **Mean age in catch is 4.5 years and scaling factor is 1.0;**
2. **Recruitment variability is high (so subtract 1 year);**
3. **Fishery value is high for commercial but low for recreational (so subtract 1 year);**
4. **Ecosystem importance is moderate (so no change to target);**
5. **Target Assessment Frequency = 4.5*1.0 -1 -1 +0 = 2.5 years**
6. **Round down to 2 years.**

SETTING PRIORITIES FOR ASSESSMENTS

The priority for updating an assessment starts with the number of years that it is overdue relative to its target update frequency, but allows for new data availability, fishery importance and stock status to adjust this priority.

Once a target frequency for assessment updates has been established, the goal is to keep as close to this schedule as possible given available resources. Conducting assessments more frequently is an inefficient use of assessment expertise and burdens the regulatory system with too frequent and unnecessary changes. Waiting too long to conduct an update means that management is based upon increasingly stale information. With each passing year, there is a greater chance that the stock has drifted off the previous forecast and the fishery is being overly or insufficiently restricted.

After accounting for the years overdue, then additional factors of stock status, new information, and fishery importance are added as fractional values in order to keep them from overly influencing the prioritization. First, stock status (which has values of 1 to 9) is divided by 10 and added to the number of years overdue. This means that stocks on rebuilding plans, or stocks approaching an overfished or overfishing condition, will have priority over stocks that are equally due/overdue but have a less at-risk status. However, at-risk stocks that are not yet due relative to their target frequency will not leapfrog ahead of stocks that are overdue for assessment. This approach will provide a balanced portfolio that will address the most overdue assessments, then the stocks with more at-risk status, and then the less at-risk stocks that are at their target frequency of updating.

When the target interval between assessment updates is several years, then it may be possible to make a quick evaluation of new information as it becomes available and adjust the stock's priority for assessment up or down based upon how closely the new data match expectations from forecasts from the previous assessment. Note that adjustments of this sort are disruptive to an organized planning process and should be applied cautiously. Even making these quick evaluations involves data preparation, staff analysis, and report writing that will detract from the program's capability to conduct planned assessments. A score of up to 1.0 is allowed for this factor.

Fishery importance has already been taken into account when setting the target assessment frequency. However, it is reasonable to use fishery importance as a small factor when other factors are equitable. This is accomplished by adding the fishery value score divided by 10.

Assessment uncertainty is not included as a quantitative factor. For example, some assessments have high uncertainty because the time series of data is short. For these assessments, more frequent updates in the short-term could improve the assessment because data are accumulating rapidly. On the other hand, some assessments have high uncertainty because the data are inherently noisy or there are unknown factors causing fluctuations or retrospective patterns in the assessment. In such cases, it seems better to not shorten the time between assessments and instead to put the effort into better understanding of the factors causing the uncertainty. Consequently, past assessment uncertainty is only used as a factor if there are new information or research results available that are expected to resolve some of that uncertainty. Simply re-doing an assessment because the past assessment had uncertainty is undesirable because that assessment effort could more productively be directed to other stocks.

Prioritizing Assessments Updates

1. **Years overdue relative to target frequency;**
2. **Add stock status score divided by 10;**
3. **Add up to 1.0 if there is new information that indicates a chance from the past assessment;**
4. **Add fishery importance divided by 10;**

EXAMPLE:

1. **Assessment is 2 years past its target date for updating;**
2. **Stock status score is 6;**
3. **There is no new information that indicates an obvious change**
4. **Commercial value score is 3.5 and recreational score is 1.4 and no additional fishery importance factors;**
5. **Priority score = 2.0 + 6.0/10 + 0.0 + (3.5+1.4)/10 = 3.09**

Benchmark vs. Update Assessment

The history of recent assessments is primarily a factor in deciding between doing another update, or doing a full benchmark assessment[3]. The staff time and review effort needed to conduct a benchmark assessment is substantially greater than that needed to provide an update, so decisions to do full benchmarks should carefully consider the forgone opportunity to do updates for several stocks instead of the benchmark. There are three issues that contribute to a decision to do the benchmark assessment:

1. A new data type or research finding is available. A benchmark assessment is needed to fully investigate the assessment performance with this new information, especially if it would lead to elevating the level of the assessment.
2. The previous assessment identified a shortcoming that is not feasible to investigate with available methods and data. Simply re-doing a benchmark should be avoided unless there is good reason to expect more certainty to come from the new benchmark.
3. Several updates have been conducted and a refresh of selected aspects of the assessment is reasonable, although not specifically identified by either issue 1 or 2 above.

[3] An update assessment uses a previously reviewed modeling approach and data types and simply updates the assessment using the most recent data. Only minimal review is needed. A benchmark assessment introduces new methods or data types and may involve a thorough investigation of all aspects of the assessment. A fuller review commensurate with the degree of innovation and controversy is warranted.

Benchmarks should not be done if none of the three criteria are met, irrespective of the age of the assessment. Most of a region's assessments need to be conducted as simple updates if a high pace of assessments is to be accomplished, as in the North Pacific. The fact that a stock has high importance or a low status should not be a primary driver for doing full benchmark assessments. These factors have already contributed to setting target assessment frequency and prioritizing stocks relative to this update frequency. When benchmark assessments are done without having fundamentally new information to consider, the assessment generally treads over the same issues that were unresolved in the earlier assessment.

Challenges

This proposed prioritization system is a first attempt at a comprehensive approach. It will need adjustments as it begins to be applied. Nevertheless, the compilation and presentation of information described in this document can immediately improve the basis on which priorities are set.

One challenge will be to ward against a lopsided application of the system. The goal is somewhere in between a situation in which all stocks are perceived to need equally good assessments, and a situation in which only the most important stocks get assessed. All stocks need some level of baseline assessment and the most important and vulnerable stocks need better assessments. The proposed system is designed to help achieve such a balance, but adjustments may be needed after a few years of implementation.

The degree to which this prioritization system addresses the need for inclusion of ecosystem factors is preliminary, at best. The focus has been upon getting basic assessments done. Ongoing work on an update of the Stock Assessment Improvement Plan should provide additional guidance on how to determine which stocks are most in need of a broader ecosystem consideration. All assessments should recognize that every fish stock exists within a regional ecosystem and the effect of ecosystem changes on the stock should always be considered to the extent feasible.

Many aspects of this prioritization approach are somewhat ad hoc. The ICES investigation of factors affecting assessment frequency clearly indicated that only through a management strategy evaluation can one ascertain the expected improved performance from better data and shorter time lags. This same situation is true for assessments and fishery management in the U.S.

Application of this prioritization system will not get more assessments done each year. The goal is to be more objective about which assessments get done. It is likely that many stocks will be identified as needing better assessments than present data allow, and many stocks for which more frequent assessments are needed. These gaps can identify needs, but filling these needs will require an expanded assessment program. Alternatively, the system could be used to determine what target level of assessment frequency is achievable given current assessment capacity.

The complete science-management system has more elements than the assessments themselves. There are potential bottlenecks associated with timing of peer reviews, time needed to develop management responses to updated assessments, alignment of assessments with start dates of fishing years, etc. These additional steps in the overall process also warrant consideration as overall improvements in throughput are sought.

Implementation Plan

- Distribute draft to Fishery Management Councils, NMFS Regional Offices, Fishery Commissions for comment – February 2014;
- Create database of needed information as an added table in the Species Information System – spring 2014;
- Each region begins work on comprehensive Productivity-Susceptibility Analysis and Only Reliable Catch Analysis to serve as baseline for determining which stocks need assessments – begin spring 2014;
- Test prioritization system to determine if adjustments to scaling factors are needed to achieve reasonable results – summer 2014;
- Make database available to regional coordinating committees charged with setting priorities for regional assessments – fall 2014; Create access through SIS public portal;
- Commission Management Strategy Evaluations to test the expected performance of this prioritization system over time – 2015;
- Explore Decision Support System facilitators to guide regional coordinating committees through application of the prioritization process – 2016.

REFERENCES

Berkson, J., L. Barbieri, S. Cadrin, S. L. Cass-Calay, P. Crone, M. Dorn, C. Friess, D. Kobayashi, T. J. Miller, W. S. Patrick, S. Pautzke, S. Ralston, M. Trianni. 2011. Calculating Acceptable Biological Catch for Stocks That Have Reliable Catch Data Only (Only Reliable Catch Stocks – ORCS). NOAA Technical Memorandum NMFS-SEFSC-616, 56 P.

Dowling, N.A., C.M.Dichmont, W.Venables, A.D.M.Smith, D.C.Smith, D.Power, D.Galeano. 2013. From low-to high-value fisheries: Is it possible to quantify the trade-off between management cost, risk and catch? Marine Policy 40: 41-52.

ICES. 2012. Report of the Workshop on Frequency of Assessments (WKFREQ). ICES CM 2012/ACOM34.

Mace, P.M., N.W. Bartoo, A.B. Hollowed, P. Kleiber, R.D. Methot, S.A. Murawski, J.E. Powers, G.P. Scott. 2001. National Marine Fisheries Service Stock Assessment Improvement Plan. Report of the NMFS National Task Force for Improving Fish Stock Assessments. NOAA Technical Memorandum NMFS-F/SPO-56. 76 pages.

Northeast Fisheries Science Center. 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dept Commer, Northeast Fish Sci Cent Ref Doc.12-06; 789 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

Patrick, W. et al. 2010. Using productivity and susceptibility indices to assess the vulnerability of United States fish stocks to overfishing. Fish. Bull. 108:305–322.

TABLES

Table 1. This table presents the distribution of FSSI and non-FSSI stocks among Councils and Science Centers in 2014. Each row in this table represents a category within which prioritization could occur, with exceptions in the note below.

Council	Centers	Non-FSSI	FSSI	All
CFMC	SE	37	8	45
Atl_HMS	SE	6	21	27
GMFMC	SE	15	23	38
SAFMC	SE	21	22	43
NEFMC	NE	2	37	39
MAFMC	NE	0	11	11
NPFMC	AK	30	35	65
PFMC	NW-SW	17	45	62
PFMC_salmon	NW-SW	67	0	67
Pac_HMS	SW-PI	14	18	32
WPFMC	PI	42	7	49
		251	227	478

Note: HMS refers to Highly Migratory Species. Stocks that are shared between the GMFMC and SAFMC would be covered by the GMFMC unless otherwise arranged by the SEDAR (Southeast Data and Assessment Review) committee. The MAFMC and NEFMC could be covered by the same prioritization process, as occurs now with the Northeast Regional Coordinating Committee.

Table 2. Summary of factors considered.

FACTOR	First-time assessments	Target assessment level	Target Assessment frequency	Priority for assessment	Priority for benchmark
Fishery importance	Yes	Yes	Yes	Yes	
Ecosystem importance	Yes	Yes	Yes		
Stock status	Yes, from ORCS & PSA			Yes	
Stock biology		Yes	Primary		
Assessment history; Due or overdue?				Primary	
New data indicates drift from forecast				Yes	
New data can raise level or resolve uncertainty					Yes

Table 3. This table shows the ranking of stocks with the largest commercial and recreational catch levels in 2009. Note that values are whole weight, not meat weight, so quahog and clam are higher than one would expect.

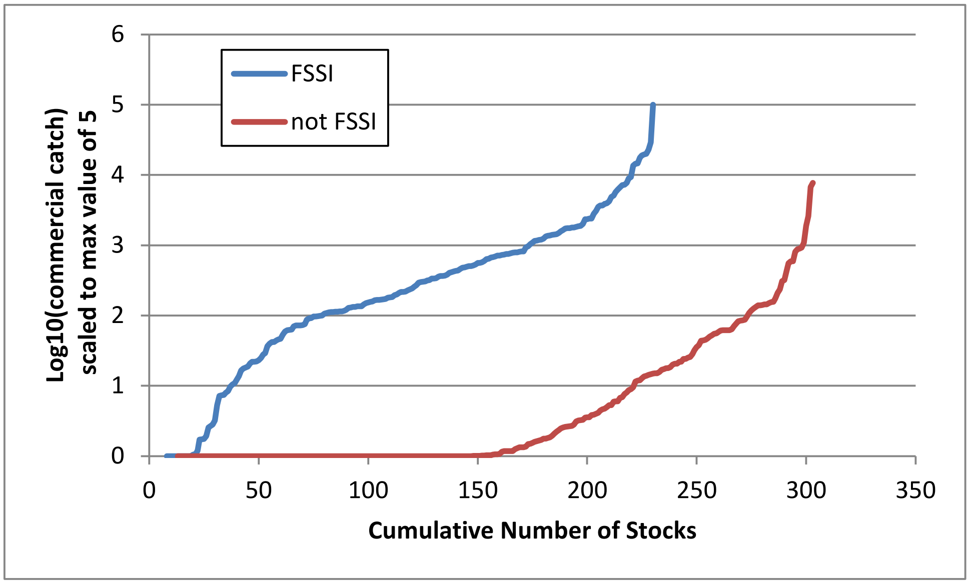
Top 20 Commercial Catch	Top 20 Recreational Catch	High Recr and Comm
Walleye pollock - Eastern Bering Sea	Bluefish - Atlantic Coast	Atlantic mackerel - Gulf of Maine / Cape Hatteras
Pacific cod - Bering Sea / Aleutian Islands	Yellowfin tuna - Central Western Pacific	Pollock - Gulf of Maine / Georges Bank
Ocean quahog - Atlantic Coast	Summer flounder - Mid-Atlantic Coast	Scup - Atlantic Coast
Yellowfin sole - Bering Sea / Aleutian Islands	Red snapper - Gulf of Mexico	Pacific chub mackerel - Pacific Coast
Atlantic surfclam - Mid-Atlantic Coast	King mackerel - Southern Atlantic Coast	Summer flounder - Mid-Atlantic Coast
Atlantic herring - Northwestern Atlantic Coast	Scup - Atlantic Coast	Dolphinfish - Southern Atlantic Coast / Gulf of Mexico
Opalescent inshore squid - Pacific Coast	Gag - Gulf of Mexico	Red grouper - Gulf of Mexico
Atka mackerel - Bering Sea / Aleutian Islands	Black sea bass - Mid-Atlantic Coast	Bluefish - Atlantic Coast
Pacific hake - Pacific Coast	King mackerel - Gulf of Mexico	Caribbean spiny lobster - Southern Atlantic Coast / Gulf of Mexico
Pacific sardine - Pacific Coast	Skipjack tuna - Central Western Pacific	Spanish mackerel - Southern Atlantic Coast
Walleye pollock - Gulf of Alaska	Spanish mackerel - Southern Atlantic Coast	Vermilion snapper - Gulf of Mexico
Pacific cod - Gulf of Alaska	Dolphinfish – Pacific	Yellowfin tuna - Central Western Pacific
Brown rock shrimp - Gulf of Mexico	Spanish mackerel - Gulf of Mexico	King mackerel - Southern Atlantic Coast
Brown shrimp - Gulf of Mexico	Little tunny - Gulf of Mexico	King mackerel - Gulf of Mexico
Bering Sea / Aleutian Is. Arrowtooth Flounder	Gray snapper - Gulf of Mexico	Red hake - Southern Georges Bank / Mid-Atlantic
White shrimp - Gulf of Mexico	Red grouper - Gulf of Mexico	Atlantic Large Coastal Shark Complex
Bering Sea / Aleutian Islands Other Species	Atlantic mackerel – Gulf Maine / Cape Hatteras	Red snapper - Gulf of Mexico
Sea scallop - Northwestern Atlantic Coast	Greater amberjack - Gulf of Mexico	Atlantic Small Coastal Shark Complex
Arrowtooth flounder - Gulf of Alaska	Cobia - Gulf of Mexico	Yellowtail snapper - Southern Atlantic Coast / Gulf of Mexico
Atlantic mackerel - Gulf of Maine / Cape Hatteras	Greater amberjack - Southern Atlantic Coast	

Table 4. Table of attributes for assigning stock status for historical catch-only assessments (from Berson et al 2011).

Overall scores are obtained by an unweighted average of the attributes for which scoring is possible, although alternative weighting schemes could also be considered. An initial assignment to a stock status category is: mean scores>2.5—heavily exploited; stocks with mean scores 1.5-2.5--moderately exploited; and stocks with mean scores<1.5--lightly exploited. When the attribute does not apply or is unknown it can be left unscored.

Attribute	**Stock status**		
	Lightly exploited (1)	**Moderately exploited (2)**	**Heavily exploited (3)**
Overall fishery exploitation based on assessed stocks	All known stocks are either moderately or lightly exploited. No overfished stocks	Most stocks are moderately exploited. No more than a few overfished stocks	Many stocks are overfished
Presence of natural or managed refugia	Less than 50% of habitat is accessible to fishing	50%-75% of habitat is accessible to fishing	>75% of habitat is accessible to fishing
Schooling, aggregation, or other behavior responses affecting capture	Low susceptibility to capture (specific behaviors depend on gear type)	Average susceptibility to capture (specific behaviors depend on gear type)	High susceptibility to capture (specific behaviors depend on gear type)
Morphological characteristics affecting capture	Low susceptibility to capture (specific characteristics depend on gear type)	Average susceptibility to capture (specific characteristics depend on gear type)	High susceptibility to capture (specific characteristics depend on gear type)
Bycatch or actively targeted by the fishery	No targeted fishery	Occasionally targeted, but occurs in a mix with other species in catches	Actively targeted
Natural mortality compared to dominant species in the fishery	Natural mortality higher or approximately equal to dominant species ($M \geq M$)	Natural mortality equal to dominant species ($M \approx M$)	Natural mortality less than dominant species ($M < M$)
Rarity	Sporadic occurrence in catch	Not uncommon, mostly pure catches are possible with targeting	Frequent occurrence in catch
Value or desirability	Low value (< $1.00/lb, often not retained (< 33% of the time)	Moderate value ($1.00 - $2.25), usually retained (34-66% of the time)	Very valuable or desirable (e.g., > $2.25/lb), almost always retained (>66% of the time).
Trend in catches (use only when effort is stable)	Catch trend increasing or stable (assign score of 1.5)	Catch trend increasing or stable (assign score of 1.5)	Decreasing catches

FIGURES



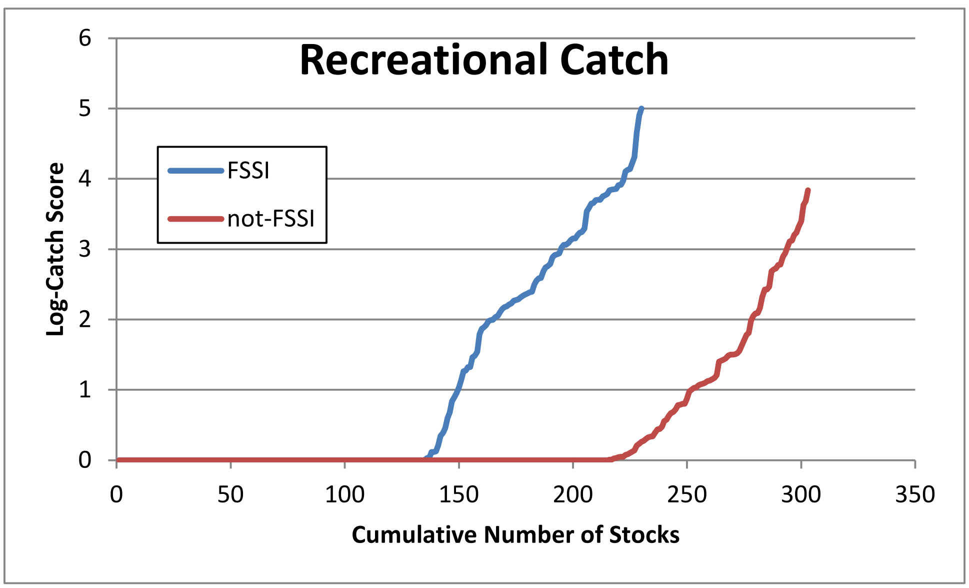
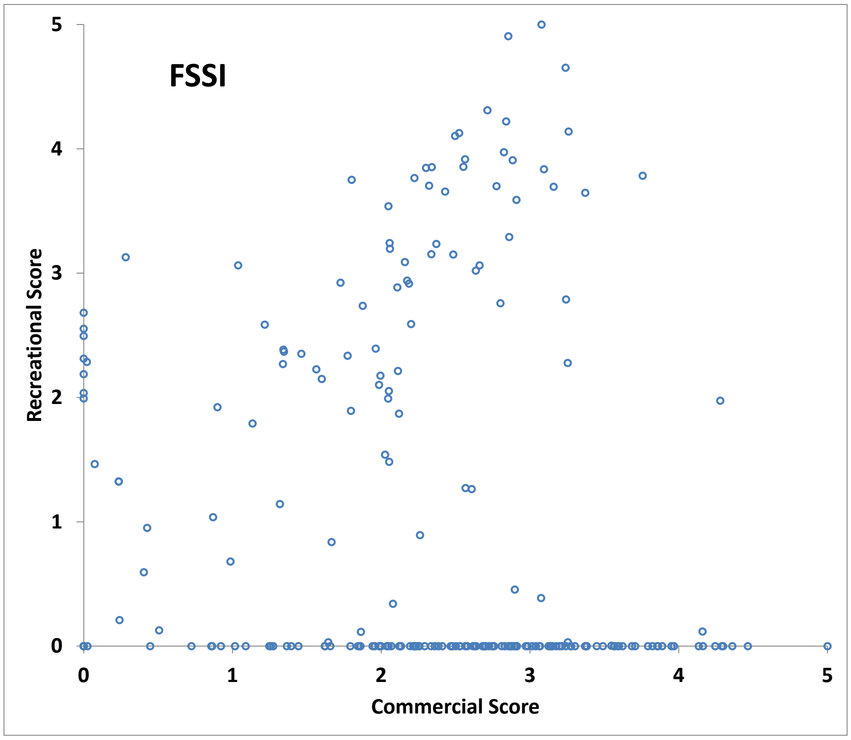


Figure 1. Ranking of stocks according to the amount of catch. Each stock's score is calculated as the log10(1.0+catch (in thousands of pounds)). (a) commercial catch results are shown at the top and (b) recreational catch is shown at the bottom. Results are shown separately for the 230 stocks included in the Fish Stock Sustainability Index (FSSI) and for the other stocks in Fishery Management Plans. For each plot, the stocks are re-ordered according to their catch.



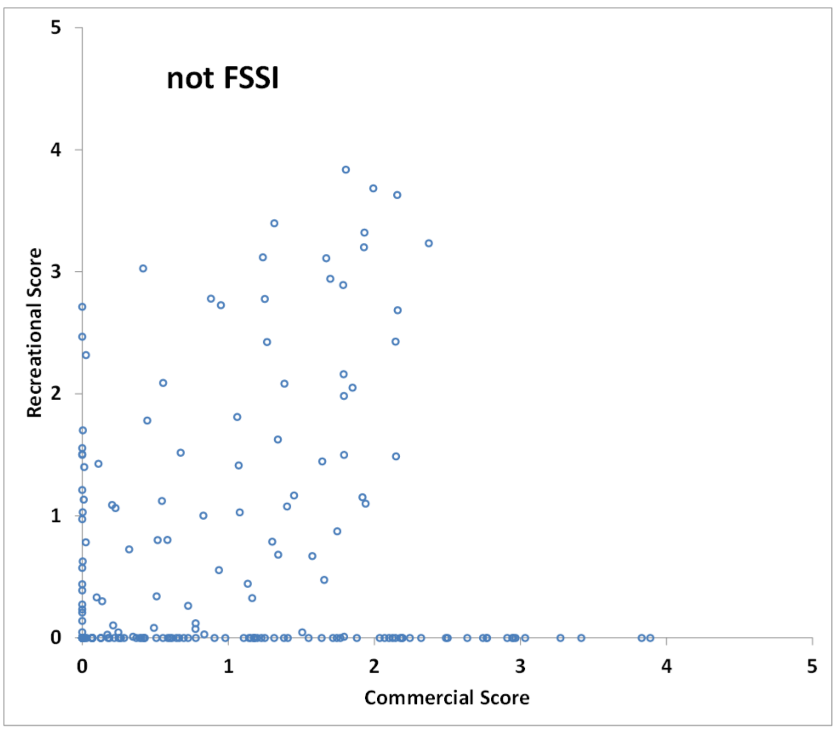


Figure 2. Preliminary relationship between commercial score and recreational score for FSSI stocks and non-FSSI stocks..

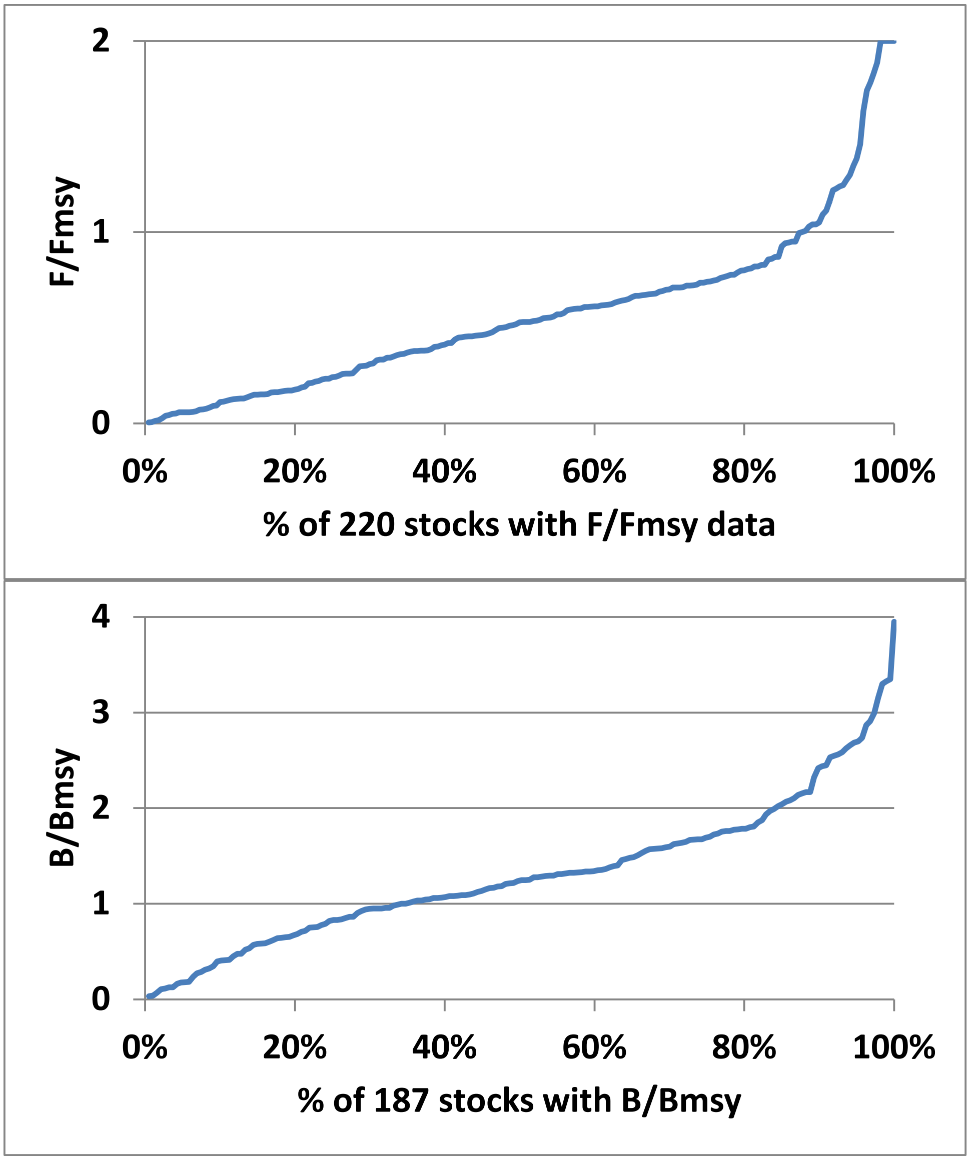


Figure 3. Cumulative distribution of the ratio of F to Fmsy in the most recent assessment of 220 stocks (upper panel), and cumulative distribution of B to Bmsy for 187 stocks in the lower panel

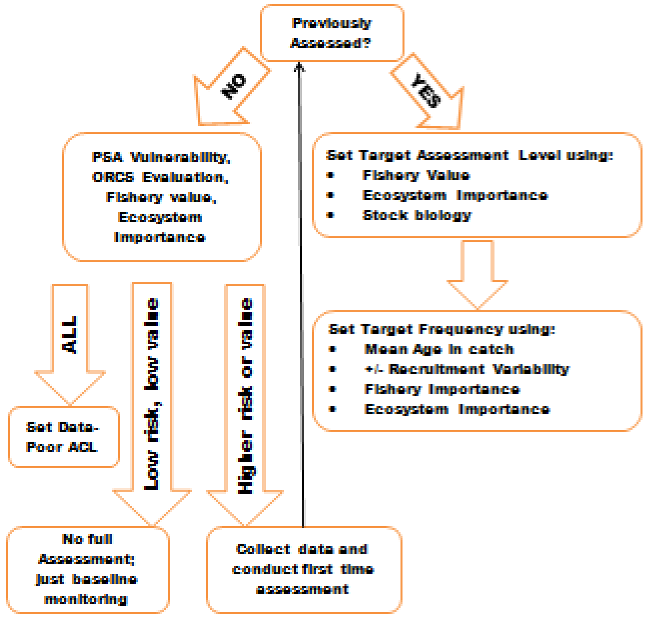


Figure 4. Flowchart showing steps in the setting of assessment target levels and assessment frequencies.

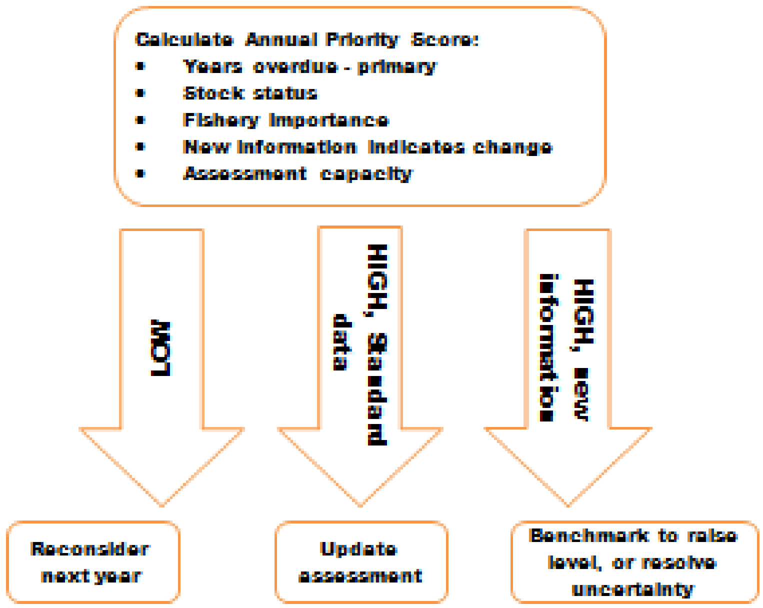


Figure 5. Flowchart showing steps in the setting of annual assessment priorities.

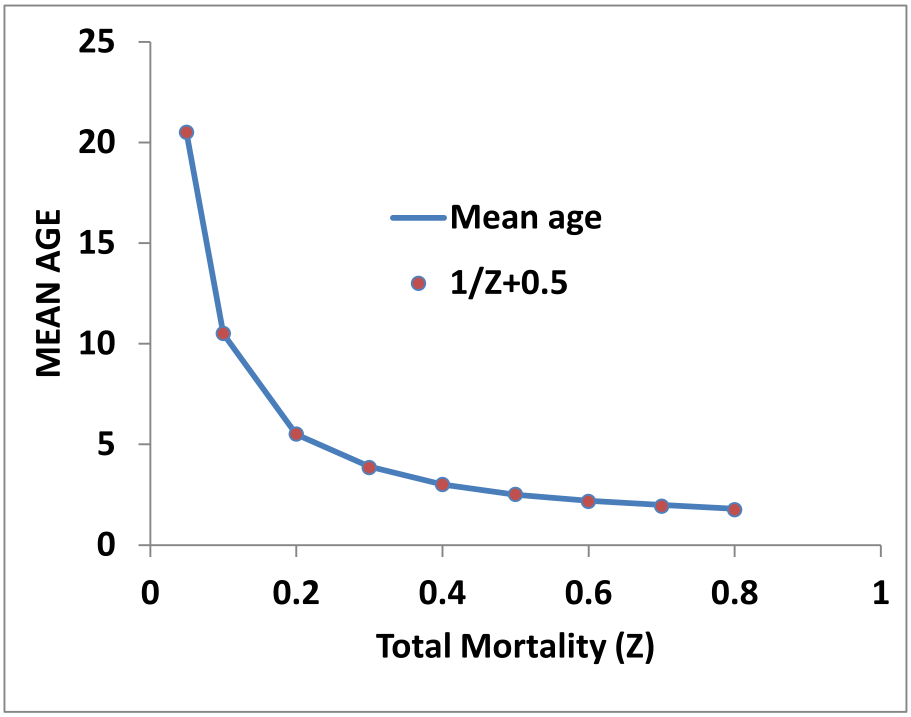


Figure 6. Relationship between total mortality rate (Z) and the expected mean age of fish in the stock.