# Discussion Paper
# Stock Assessment Prioritization for the North Pacific Fishery Management Council: Methods and Scenarios

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## Introduction

Fisheries stock assessments provide quantitative information which is used by regional Fisheries Management Councils (FMCs) as a guide for setting Annual Catch Limits (ACLs), preventing overfishing and rebuilding overfished stocks. The reference points and stock status determinations derived from stock assessments are used to evaluate the Nation's responsiveness to the requirements of the Magnuson Stevens Act (MSA). In the face of the nationwide demand for timely and efficient delivery of sound stock assessment advice, the National Marine Fisheries Service established the Stock Assessment Prioritization (SAP) plan which serves as a guide for how stock assessments should be prioritized in a given year (Methot 2015). The guidelines for prioritization of stock assessments considered five themes: Fishery Importance, Stock Status, Ecosystem Importance, Assessment Information, and Stock Biology.

Implementing a stock assessment prioritization process that satisfies the needs of all six regional FMCs Councils is challenging. The nature of the fisheries, their economic and societal value, the quality of the data, and the ecology of the species varies across regions. Therefore, NMFS tasked each regional Fishery Management Council to develop their own prioritization process using Methot (2015) as an initial starting point for Council discussions.

Implementation of a prioritization process for the North Pacific Region will be done within the context of a stock assessment process that is currently successful. The North Pacific Fishery Management Council (NPFMC) has adopted an ecosystem approach to fisheries management (EAFM) that sustains some of the largest and most profitable fisheries in the Nation. Thus, the goal of the stock prioritization effort is to identify scenarios for NPFMC deliberation that simultaneously improve efficiency in the stock assessment process while maintaining the high quality and timely advice that has successfully delivered the stock assessment advice needed to build economically viable, sustainable and equitable fisheries within an ecosystem approach to fisheries management framework.

Since the NPFMC is starting from a management framework where stocks are assessed frequently (typically every one to two years), the focus of this effort is less the selection of which stocks should be assessed in a given year, and more about revising the existing Target Frequency for the delivery of stock assessment advice. Over the last decade, the AFSC has expanded the number of stock assessments and these assessments typically use recently acquired fishery dependent and fishery independent data. It is logistically difficult to complete a large number of complex stock assessments using in-year data, conduct peer reviews of the assessments and engage in the decision process for setting annual stock assessment advice. The NPFMC may benefit from the adoption of a more rational process for scheduling stock assessments and their reviews that makes better use of available human resources without jeopardizing stock status or unnecessarily affecting fishing opportunities important to diverse communities and constituents.

This white paper was developed to provide a suite of preliminary assessment frequency scenarios for groundfish resources in the Gulf of Alaska and Bering Sea Aleutian Islands. These scenarios are intended to illustrate how data is gathered, ranked and applied within the proposed guidelines as well as a series of alternative scenarios for NPFMC consideration. The document provides concrete examples of the outcomes of different scenarios which will serve as a starting point for engagement with the NPFMC in the discussion of the stock assessment prioritization process.

## Methods

The SAP plan provides a multi-variate weighting scheme to rank the relative importance of stock assessments. This weighting scheme ranks four factors: fishery importance, stock status, the role of the species in the ecosystem, and assessment-specific issues (Methot 2015). A hypothetical example of the scoring system shows how the system works (Table 1). The SAP envisioned that teams of experts would be assembled to rank stock assessments. However, in the case of the NPFMC, the status quo already places a high rank on stock assessments for managed species, and thus the primary task facing the NPFMC is to estimate the Target Frequency for stock assessments rather than developing an assessment priority ranking for all managed species.

Estimating Target Frequency requires the estimation of a mean age and the assimilation of scores for fishery importance, recruitment variability, and ecosystem importance. A team of economists, fisheries managers, and stock assessment scientists were consulted to gather the relevant information needed to develop scores for each of the four factors noted above. A brief description of the data collected and the process used to derive scores for the scenarios presented in this white paper follow.

*Fishery Importance Scores:*

Scientists at the Alaska Fisheries Science Center's Economics and Social Scientists Research (ESSR) program developed a stock assessment prioritization Fishery Importance Survey (FIS, http://goo.gl/forms/Ok2oC05dIH). This survey was used to elicit expert opinion on the importance of all of our federally assessed species (83 stocks in total). The FIS was based on the SAP plan (Methot 2015). A total of 12 surveys were completed by economists from the ESSR program and fisheries managers from the NPFMC and Alaska Regional Office. In addition, input from the stock assessment authors was added for each species for a total of 13 potential experts per stock. However, experts were given the opportunity to not assess a stock if they did not have sufficient information about it, and therefore the total number of expert scores varies by stock.

The FIS asked two questions for each stock. First, provide a score for fishery importance (from 'Not at all' to 'Very', or 'No opinion') for recreational, subsistence, constituent demand, and non-catch value. These scores were then assigned to a number; ‘Not at all’ equaled zero, ‘A little’ equaled one, ‘Somewhat’ equaled three, and ‘Very’ equaled 5. Next, provide your degree of confidence in those scores using the same scale. Overall fishery importance scores for each category were generated as a weighted average of experts’ scores for each category using their degree of confidence in their response as the weights and are presented in Table 2.

Definitions for each category, as stated in the FIS, are as follows:

a. **Recreational importance**: The importance to recreational fisheries.
b. **Subsistence importance**: The importance to subsistence fisheries.
c. **Constituent demand**: This category recognizes that some stocks have a particularly high demand from constituents for excellence in stock assessment. It might include stocks in catch share programs, choke stocks that limit access to other stocks, stocks with controversy over the existing assessment, stocks with high sociocultural fishery importance to the region, or simply stocks for which regional or national constituents have come to expect high quality, timely stock assessments.
d. **Non-catch value**: These values are not associated with any harvest value, but are instead based on the relatively undisturbed existence of the fish species in its ecosystem. A principal example would be underwater viewing of reef fish (a non-consumptive value attributable to reef fish), but this category could extend to include other species for which there is a public sentiment for protection and hence a demand for some level of assessment. A recent paper by Sanchirico et al. (2013) identified methods to estimate non-catch value and found that these may be substantial. Note that this value basically includes existence and non-consumptive use values and does not include the provision of ecosystem services (such as being prey).
e. **Commercial Fishery Importance**: Scores were calculated based on average revenue over the period 2012-2014 from a combination of catch accounting and Alaska Commercial Fisheries Entry Commission fish tickets provided by AKFIN and not expert opinion. Following Methot (2015), the commercial fishery importance was calculated as:

$$stock\ x = \frac{log10(1 + revenue\ from\ stock\ x)}{log10(1 + revenue\ from\ highest\ value\ regional\ stock)} * 5 \qquad \text{Equation 1}$$

such that scores range from 0-5, consistent with the other components of fishery importance. The highest value regional stock is Eastern Bering Sea walleye pollock. Average fishery importance scores are shown in Table 2.

*Data Quality Scores:*

The SAP plan describes methods for weighting data quality that were based on the data quality ranking from the fish stock climate vulnerability analysis (Morrison et al. 2015) with an additional category of complete data as described below:

0 = No Data. No information to base an attribute score on. Very little is known about the stock or related stocks and there is no basis for forming an expert opinion (please use judiciously).

1 = General Knowledge from Expert Judgment. The attribute score reflects the expert judgment of the reviewer and is based on their general knowledge of the stock, or other related stocks, and their relative role in the ecosystem.

2 = Limited Data. The score is based on data which has a higher degree of uncertainty. The data used to score the attribute may be based on related or similar stocks or species, come from outside the study area, or the reliability of the source may be limited.

3 = Adequate Data. The score is based on data which have been observed, modeled or empirically measured for the stock in question and comes from a reputable source.

4 = Complete Data. The score is based on very complete data which have been observed, modeled, or empirically measured for the stock in question and are unlikely to be greatly improved or modified with more research or analysis.

Since the primary focus of this discussion paper is to identify methods for estimating Target Frequency, none of the data quality scores were utilized in this exercise.

*Species Importance Data:*

Scientists from the AFSCs Marine Ecology and Stock Assessment (MESA) program and NOAA Fisheries headquarters developed a google form for use in gathering relevant information for the Species Importance Scoring (SIS):

https://docs.google.com/a/noaa.gov/spreadsheets/d/1W0NM6BHVX9TsI9XIy8cW8llaoHvxiJt5negEEakDWd4/edit?usp=sharing

The form was prefilled with a limited amount of available information from the national Species Information System to create the stock profiles for assessment prioritization (and several other things like climate vulnerability and the stock specific ecosystem considerations, Table 3). The amount of pre-filled information varied depending on the stock. For example, the data that was available from the climate vulnerability analysis profiles for stocks in the Bering Sea were entered into the forms. Each stock author was responsible for checking pre-filled data and filling in the remaining information for their assigned stock(s) using two URL links to their assigned forms (Part 1 and Part 2). Part 1 consisted of sections with questions regarding stock status, biological parameters, and economics, while Part 2 had sections on distribution and biology, early life history, movement, habitat, prey, predators, and the ecosystem. Both parts ended with a few questions regarding initial stock assessment classification for the stock assessment improvement plan update.

Each question had a bolded title followed by the question text which will often include additional information to clarify the question. At the beginning of each section there was also some text to describe the purpose of the section and some look up resources with links to online information to help with the questions. Following many of the questions was a data quality multiple choice question, which was used to provide a scoring metric on the quality of data used to answer the question (see data quality ranking above). When filling out the questions (particularly paragraph questions) scientists were instructed to be as succinct as possible. An area for listing relevant citations was provided at the end of the form.

*Ecosystem Importance*

Bottom-up and top-down components of ecosystem importance were considered following the SAP plan. The maximum of the bottom-up or top-down score was used in the adjustment to the Target Frequency. Therefore, a high score could indicate the relative importance of the stock as either an important predator or important prey. Ranking ecosystem importance is an inexact science. In an attempt to calibrate scores across species, we asked the leader of AFSC's Resource Ecology and Ecosystem Modeling (REEM) program to score all of the species. The author scores were then averaged with the REEM program leader scores for the final ecosystem importance score for a given stock or stock complex.

*Assessment Frequency Estimation Methods*

The default assessment frequency scores were derived from mean catch-at-age or its proxy, following the protocols in the SAP plan. For this white paper, mean age was based on the best available information. Mean fishery age was used when it was available. If mean fishery age was not available, then survey age was converted to fishery age using a linear regression model based on the stocks that had both survey age and fishery age available. If neither catch or, survey age was available, fishery age was estimated by converting total mortality ($Z$) to fishery age. This conversion was based on a simple exponential decay model using stocks that had both $Z$ and fishery age. For the remaining stocks that only had an estimate of $M$ available, that estimate was converted to $Z$ using an estimate of $F$ that was determined by taking the ratio of catch to OFL:

$$Z = M + (catch/OFL*M) \qquad \text{Equation 2}$$

The adjustment recommended in Methot (2015) for stocks where only $M$ is available was not used because most of the stocks managed by the NPFMC where estimates of $Z$ are unavailable are not targeted and lightly exploited. Thus, an estimate of $2*M$ would yield a more truncated mean age than expected under light exploitation. As a comparison of the two different $Z$-to-fishery age methods, Figure 1 provides the estimated mean age for all groundfish stocks considered for this prioritization using the SAP guidance methodology versus the Alaska derived exponential decay model and $M$ adjustment. Approximately 32% of the stocks had an estimate for mean fishery age, 28% for mean survey age, 5% with an estimate for $Z$, and 35% with an estimate for $M$.

Target assessment frequency was then calculated by taking the best estimate for mean fishery age, multiplying by a regional scaling factor, and then adjusting by three factors; recruitment variability; fishery importance; and ecosystem importance. The default regional scalar was 0.5 while the default adjustment factors were +/- 1 for recruitment variability, fishery importance, and ecosystem importance (see Methot 2015, page 21).

*Alternative Scenarios*

The following five alternative scenarios were considered in this white paper.

**Status Quo**: Current assessment frequencies, annual and biennial schedule for all groundfish stocks

**Scenario 1 (S1):** This scenario was the "Base Case" recommended in Methot (2015): Under S1, assessment frequency ($\rho$) was estimated as: $\rho$ = mean age * $\lambda$
Where $\lambda$ is a regional scalar set at the default value 0.5. Then $\rho$ was adjusted upward or downward for: +/-1 recruitment, +/- 1 fishery, +/- 1 ecosystem. In this scenario, $\rho$ is capped at a maximum value of 10 years and a minimum value of 1 year.

Review of the adjusted assessment frequency scores revealed that under the base case, 61% of Gulf of Alaska (GOA) groundfish stock assessments and 58% of the Bering Sea Aleutian Islands groundfish stock assessment would be conducted on an assessment frequency more than every 5 years (Figure 2).

**Scenario 2 (S2)**: Base Case (S1) with a maximum cap at 5 years. The NPFMC may wish to consider capping the maximum amount of time between assessments at no more than every 5 years. The AFSC strives to conduct independent reviews of GOA and BSAI groundfish stock assessments on a 5 year time schedule. Aligning the maximum assessment frequency at 5 years would align the CIE review schedule with the cap.

**Scenario 3 (S3):** S2 with fishery importance adjustment of +/- 2 years (using -2, -1, 0, 1, 2 based on quintiles of the fishery importance score)

**Scenario 4 (S4):** S2 with regional scalar adjusted so that high commercial value stocks would be annual. In S4, the commercial value metric was used as an alternative proxy for estimating a "regional scalar". Methot (2015) noted that the *"scalar acts as a region-specific "dial" to allow each National Marine Fisheries Service (NMFS) Science Center to work with its management partners to adjust target frequencies to within a reasonable range of currently available regional assessment capacity."*

For S4, the total ex-vessel value of all the groundfish stocks being assessed in this prioritization round were sorted. The stocks considered the "highest value stocks" were those that made up 75% of the cumulative catch value. These stocks, in descending order, were EBS pollock, BS Pacific cod, AK sablefish, and BSAI yellowfin sole. The scalar was then set to make sure that the target frequency was annual for all these stocks, after having applied the standard adjustments (+/- 1 fishery, +/- 1 ecosystem, +/- 1 recruitment) used in the Base Case. That resulted in a regional scalar of 0.139 (rather than the default of 0.5).

**Scenario 5 (S5):** Combination of S3 and S4, fishery adjustment of +/-2 years with the regional scalar according to the high value stocks applied after taking adjustments into account. This resulted in a regional scalar of 0.209.

## Target Frequency Estimates

Results of Scenario 1 is shown in Figure 2. Results for scenarios S2-S5 for the Bering Sea Aleutian Island stocks and Gulf of Alaska stocks are shown in Figures 3 and 4 respectively. The black dots show the frequency under status quo. Species are color coded by species groups. Scenario S1 is not shown in Figures 3 and 4 because results were very similar to S2 except for the location of the cap at 10 years.

Scenarios S1 - S5 all result in a substantial change in the frequency of rockfish and flatfish assessments. In contrast for some short lived species, especially forage species and squid assessments would be conducted annually where under status quo they are assessed on a biennial time step.

It is unclear how changes in the halibut Prohibited Species Cap will impact the ability of the fleet to more fully utilize flatfish in the GOA. If markets developed for minor flatfish in the GOA, then ranks based on commercial value should be re-evaluated.

Steller sea lion prey species Atka mackerel, Pacific cod and walleye pollock were scored as annual assessments under all scenarios. Therefore, application of this prioritization process would not trigger additional consultation with respect to the requirements for stock assessments under the Steller sea lion recovery plan.

Scenarios S4 and S5 primarily impact the yellowfin sole and sablefish assessments. When selecting scenarios, the Plan Teams, SSC and NPFMC will have to consider whether or not annual updates for these two stocks (or additional high valued stocks) is needed to build sustainable fisheries within an EBFM framework.

## Future Issues

The assessment team discussed different approaches to evaluating the implications of changing the Target Frequency of groundfish assessments in the BSAI and GOA. The group considered the merits of conducting a Management Strategy Evaluation or a qualitative assessment based on expert opinion. An outline of a possible MSE was developed (See Appendix) but it was not clear that in this context, the information obtained by conducting an MSE would be substantially different from that extracted from expert opinion. The group did recommend that an MSE should be explored as a separate research activity on a timeline different from the current prioritization effort.

The prioritization process is designed to evolve over time and to be responsive to NPFMC changing priorities. However, for planning purposes some stability in short to medium term planning is needed. Therefore, it is anticipated that once the NPFMC has selected their preferred scenario, that this will be the schedule for the next 5 years.

The SAP plan anticipated that some stocks will exhibit unexpected changes in production (growth, maturation, distribution, abundance, recruitment) or in fishing pressure that will necessitate an off - cycle assessment. These events are expected to be somewhat rare but the Agency should be able to accommodate some off year assessments if they are encountered.

*Next Steps and Time Line*

September - Plan Team Review
October - SSC and NPFMC review
October - December Revisions as necessary and addition of potential impacts of selected option relative to status quo.
February - Review of final protocols and discussion of potential impacts.

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Table 1. Example of Stock Assessment Prioritization Ranking (Methot 2015).

| Category | Factor | Source | Scores | Potential Weight Range |
|---|---|---|---|---|
| Fishery Importance | Commercial | Calculated as in Equation 1 | 0-5 | 0-40 |
| | Recreational | Expert opinion | 0-5 | 0-40 |
| | Subsistence | Expert opinion | 0-5 | 0-20 |
| | Rebuilding Status | National database | 0-1 | 0-20 |
| | Constituent Demand | Expert opinion | 0-5 | 5-25 |
| | Non-catch Value | Expert opinion | 0-5 | 0-20 |
| Stock Status | Stock Abundance | $SSB/SSB_{MSY}$ | 1-5 | 5-25 |
| | Fishing Mortality | $F/F_{MSY}$ | 1-5 | 5-25 |
| Ecosystem | Role in Ecosystem | Expert opinion; maximum of bottom-up and top-down components | 0-5 | 0-20 |
| Assessment Factors | Unexpected Changes in Stock Indicators | Expert opinion, where indicators are available | 0-5 | 5-25 |
| | New Type of Information | Expert opinion | 0-5 | 5-25 |
| | Years Assessment is Overdue | Calculated based on target frequency | 0-10 | 10-30 |

Table 2. Average fishery importance scores for groundfish off the coast of Alaska.

| Region | AFSC_Stock | Commercial Index | Constituent Demand Index | Non-Catch Value Index | Recreational Index | Subsistence Index | Rebuilding Status | Fishery Importance Total Score |
|---|---|---|---|---|---|---|---|---|
| Alaska | Sablefish - EBS/AI/GOA | 4.63 | 4.58 | 1.72 | 1.65 | 1.21 | 0 | 13.80 |
| BSAI | Pacific cod - BS | 4.72 | 4.96 | 2.63 | 0.64 | 1.59 | 0 | 14.54 |
| GOA | Walleye pollock - W/C GOA | 4.37 | 4.92 | 2.77 | 0.31 | 0.57 | 0 | 12.95 |
| GOA | Pacific ocean perch - GOA | 3.95 | 4.33 | 2.70 | 0.49 | 0.55 | 0 | 12.03 |
| GOA | Arrowtooth flounder - GOA | 3.95 | 3.19 | 1.07 | 0.22 | 0.02 | 0 | 8.44 |
| GOA | Pacific cod - GOA | 4.45 | 4.95 | 2.72 | 1.44 | 1.75 | 0 | 15.31 |
| BSAI | Atka mackerel - BSAI | 4.26 | 4.57 | 1.31 | 0.17 | 0.45 | 0 | 10.77 |
| GOA | Atka mackerel - GOA | 3.38 | 2.42 | 1.37 | 0.26 | 0.27 | 0 | 7.69 |
| BSAI | Pacific cod - AI | 4.02 | 4.63 | 2.72 | 0.31 | 1.07 | 0 | 12.75 |
| BSAI | Walleye pollock - AI | 3.38 | 4.71 | 2.26 | 0.25 | 0.30 | 0 | 10.90 |
| BSAI | Walleye pollock - Bogoslof | 2.76 | 3.18 | 2.52 | 0.24 | 0.30 | 0 | 9.00 |
| BSAI | Walleye pollock - EBS | 5.00 | 4.96 | 2.34 | 0.24 | 0.57 | 0 | 13.12 |
| GOA | Walleye pollock - Eastern GOA | 3.41 | 3.33 | 2.47 | 0.31 | 0.45 | 0 | 9.98 |
| BSAI | Alaska plaice - BSAI | 3.89 | 2.94 | 0.97 | 0.00 | 0.00 | 0 | 7.80 |
| BSAI | Arrowtooth flounder - BSAI | 3.95 | 2.89 | 0.98 | 0.00 | 0.00 | 0 | 7.81 |
| BSAI | BSAI Flathead Sole Complex | 3.87 | 4.39 | 1.34 | 0.00 | 0.09 | 0 | 9.69 |
| BSAI | BSAI Other Flatfish Complex | 3.20 | 2.95 | 0.90 | 0.00 | 0.28 | 0 | 7.33 |
| BSAI | BSAI Rock Sole Complex | 4.25 | 4.86 | 1.43 | 0.00 | 0.15 | 0 | 10.69 |
| BSAI | Greenland turbot - BSAI | 3.37 | 3.35 | 1.53 | 0.00 | 0.16 | 0 | 8.41 |
| BSAI | Kamchatka flounder - BSAI | 3.72 | 3.87 | 1.03 | 0.00 | 0.00 | 0 | 8.63 |
| BSAI | Yellowfin sole - BSAI | 4.48 | 5.00 | 1.71 | 0.13 | 0.41 | 0 | 11.73 |
| GOA | Flathead sole - GOA | 3.39 | 3.39 | 1.17 | 0.12 | 0.31 | 0 | 8.37 |
| GOA | GOA Deep-water Flatfish Complex | 2.70 | 2.92 | 1.14 | 0.05 | 0.42 | 0 | 7.24 |
| GOA | Northern rock sole - GOA | 3.37 | 3.17 | 1.00 | 0.38 | 0.17 | 0 | 8.09 |
| GOA | Rock sole - GOA | 3.24 | 2.92 | 1.12 | 0.50 | 0.29 | 0 | 8.06 |
| GOA | GOA Shallow-water Flatfish Complex | 2.71 | 2.69 | 1.19 | 0.13 | 0.17 | 0 | 6.89 |
| GOA | Butter sole - GOA | 3.15 | 2.00 | 1.26 | 0.36 | 0.38 | 0 | 7.16 |
| GOA | Rex sole - GOA | 3.47 | 3.51 | 1.08 | 0.00 | 0.35 | 0 | 8.42 |
| BSAI | Capelin - BSAI | 0.25 | 2.19 | 3.19 | 0.42 | 1.46 | 0 | 7.50 |
| BSAI | Eulachon - BSAI | 0.92 | 2.81 | 3.19 | 1.11 | 2.08 | 0 | 10.11 |
| GOA | Capelin - GOA | 0.93 | 2.54 | 3.19 | 0.65 | 1.50 | 0 | 8.80 |
| GOA | Eulachon - GOA | 2.15 | 2.81 | 3.19 | 1.21 | 2.50 | 0 | 11.85 |
| BSAI | Grenadiers - BSAI | 1.10 | 1.29 | 1.29 | 0.00 | 0.00 | 0 | 3.69 |
| BSAI | BSAI Octopus Complex | 2.75 | 2.97 | 2.96 | 0.60 | 0.92 | 0 | 10.19 |
| GOA | Grenadiers - GOA | 2.35 | 1.19 | 1.29 | 0.00 | 0.00 | 0 | 4.83 |
| GOA | GOA Octopus Complex | 3.20 | 2.08 | 2.85 | 0.88 | 1.27 | 0 | 10.28 |
| BSAI | BSAI Blackspotted/Rougheye Rockfish Complex | 2.93 | 3.05 | 2.09 | 0.00 | 0.50 | 0 | 8.57 |
| BSAI | Dusky rockfish - BSAI | 3.05 | 2.23 | 2.07 | 0.00 | 0.19 | 0 | 7.54 |
| BSAI | Shortspine thornyhead - BSAI | 3.19 | 2.17 | 1.97 | 0.00 | 0.04 | 0 | 7.37 |
| BSAI | BSAI Other Rockfish Complex | 2.61 | 2.62 | 2.37 | 0.12 | 0.12 | 0 | 7.83 |
| BSAI | Northern rockfish - BSAI | 3.50 | 3.67 | 2.55 | 0.00 | 0.56 | 0 | 10.27 |
| BSAI | Pacific ocean perch - BSAI | 4.16 | 4.55 | 3.19 | 0.21 | 0.66 | 0 | 12.77 |
| BSAI | Shortraker rockfish - BSAI | 2.98 | 2.69 | 2.50 | 0.15 | 0.15 | 0 | 8.48 |
| GOA | Dusky rockfish - GOA | 3.60 | 4.08 | 2.81 | 2.30 | 1.38 | 0 | 14.17 |
| GOA | GOA Rougheye/Blackspotted Rockfish Complex | 3.24 | 3.45 | 2.03 | 0.77 | 0.52 | 0 | 10.00 |
| GOA | GOA Other Rockfish Complex | 3.18 | 3.67 | 2.46 | 1.83 | 1.97 | 0 | 13.11 |
| GOA | Sharpchin rockfish - GOA | 2.47 | 2.93 | 2.40 | 0.96 | 0.62 | 0 | 9.38 |
| GOA | GOA Thornyhead Rockfish Complex | 3.46 | 3.15 | 2.28 | 0.14 | 0.18 | 0 | 9.22 |
| GOA | Northern rockfish - W/C GOA | 3.67 | 4.00 | 2.32 | 0.11 | 0.46 | 0 | 10.56 |
| GOA | Shortraker rockfish - GOA | 3.24 | 3.38 | 2.88 | 1.56 | 0.64 | 0 | 11.69 |
| GOA | GOA Sculpin Complex | 2.74 | 1.21 | 1.24 | 0.74 | 0.38 | 0 | 6.31 |
| GOA | GOA Shark Complex | 2.40 | 2.76 | 3.57 | 1.14 | 0.92 | 0 | 10.78 |
| GOA | Pacific sleeper shark - GOA | 1.37 | 2.92 | 3.52 | 0.74 | 0.48 | 0 | 9.04 |
| BSAI | BSAI Sculpin Complex | 2.62 | 1.31 | 1.29 | 0.17 | 0.54 | 0 | 5.93 |
| BSAI | BSAI Shark Complex | 1.63 | 2.68 | 3.69 | 0.16 | 0.16 | 0 | 8.32 |
| BSAI | Alaska skate - BSAI | 3.87 | 2.79 | 3.19 | 0.00 | 0.17 | 0 | 10.02 |
| BSAI | BSAI Skates Complex | 3.50 | 2.32 | 2.79 | 0.00 | 0.00 | 0 | 8.61 |
| GOA | GOA Skate Complex | 3.26 | 2.83 | 3.23 | 0.31 | 0.21 | 0 | 9.85 |
| GOA | Big skate - GOA | 3.47 | 3.66 | 3.00 | 0.68 | 0.47 | 0 | 11.27 |
| GOA | Longnose skate - GOA | 3.39 | 2.83 | 2.67 | 0.38 | 0.34 | 0 | 9.62 |
| BSAI | BSAI Squid Complex | 2.89 | 3.54 | 2.52 | 0.00 | 0.00 | 0 | 8.95 |
| GOA | GOA Squid Complex | 2.99 | 2.45 | 2.44 | 0.09 | 0.21 | 0 | 8.18 |

Table 3. Fishery importance adjustments with maximum +/- 1 or 2, ecosystem importance adjustments and recruitment importance adjustments, and best mean age estimates (without λ adjustment).

| Group | Region | AFSC_Stock | Fishery Importance Adjustment 1 | Fishery Importance Adjustment 2 | Ecosystem Importance Adjustment | Recruitment Importance Adjustment | Best Mean Age |
|---|---|---|---|---|---|---|---|
| Roundfish | Alaska | Sablefish - EBS/AI/GOA | -1 | -2 | 0 | -1 | 15.0 |
| Roundfish | BSAI | Pacific cod - BS | -1 | -2 | -1 | 0 | 5.4 |
| Roundfish | GOA | Walleye pollock - W/C GOA | -1 | -2 | -1 | -1 | 4.9 |
| Rockfish | GOA | Pacific ocean perch - GOA | -1 | -2 | -1 | 0 | 13.0 |
| Flatfish | GOA | Arrowtooth flounder - GOA | 0 | 1 | -1 | 0 | 12.6 |
| Roundfish | GOA | Pacific cod - GOA | -1 | -2 | -1 | 0 | 6.3 |
| Roundfish | BSAI | Atka mackerel - BSAI | -1 | -1 | -1 | 0 | 4.5 |
| Roundfish | GOA | Atka mackerel - GOA | 1 | 2 | 0 | N/A | 6.4 |
| Roundfish | BSAI | Pacific cod - AI | -1 | -2 | -1 | N/A | 6.7 |
| Roundfish | BSAI | Walleye pollock - AI | -1 | -1 | -1 | 0 | 7.7 |
| Roundfish | BSAI | Walleye pollock - Bogoslof | 0 | 0 | -1 | N/A | 9.6 |
| Roundfish | BSAI | Walleye pollock - EBS | -1 | -2 | -1 | 0 | 5.6 |
| Roundfish | GOA | Walleye pollock - Eastern GOA | 0 | 0 | -1 | N/A | 6.6 |
| Flatfish | BSAI | Alaska plaice - BSAI | 1 | 2 | 1 | 0 | 16.7 |
| Flatfish | BSAI | Arrowtooth flounder - BSAI | 1 | 1 | -1 | 0 | 7.5 |
| Flatfish | BSAI | BSAI Flathead Sole Complex | 0 | 0 | 0 | 0 | 13.0 |
| Flatfish | BSAI | BSAI Other Flatfish Complex | 1 | 2 | 1 | N/A | 12.8 |
| Flatfish | BSAI | BSAI Rock Sole Complex | -1 | -1 | 0 | 0 | 12.8 |
| Flatfish | BSAI | Greenland turbot - BSAI | 1 | 1 | 1 | 0 | 16.2 |
| Flatfish | BSAI | Kamchatka flounder - BSAI | 0 | 0 | 0 | 0 | 13.5 |
| Flatfish | BSAI | Yellowfin sole - BSAI | -1 | -2 | 0 | 0 | 14.3 |
| Flatfish | GOA | Flathead sole - GOA | 1 | 1 | 0 | 0 | 6.6 |
| Flatfish | GOA | GOA Deep-water Flatfish Complex | 1 | 2 | 1 | 0 | 21.0 |
| Flatfish | GOA | Northern rock sole - GOA | 1 | 1 | 1 | 0 | 9.2 |
| Flatfish | GOA | Rock sole - GOA | 1 | 1 | 1 | 0 | 9.5 |
| Flatfish | GOA | GOA Shallow-water Flatfish Complex | 1 | 2 | 1 | N/A | 10.5 |
| Flatfish | GOA | Butter sole - GOA | 1 | 2 | 1 | N/A | 10.5 |
| Flatfish | GOA | Rex sole - GOA | 0 | 1 | 1 | 0 | 10.8 |
| Ecosystem | BSAI | Capelin - BSAI | 1 | 2 | -1 | N/A | 3.0 |
| Ecosystem | BSAI | Eulachon - BSAI | 0 | -1 | -1 | N/A | 3.0 |
| Ecosystem | GOA | Capelin - GOA | 0 | 0 | -1 | N/A | 3.0 |
| Ecosystem | GOA | Eulachon - GOA | -1 | -2 | -1 | N/A | 3.0 |
| Ecosystem | BSAI | Grenadiers - BSAI | 1 | 2 | 0 | N/A | 21.0 |
| Octopus | BSAI | BSAI Octopus Complex | 0 | -1 | 1 | N/A | 4.7 |
| Ecosystem | GOA | Grenadiers - GOA | 1 | 2 | 0 | N/A | 19.9 |
| Octopus | GOA | GOA Octopus Complex | -1 | -1 | 0 | N/A | 3.5 |
| Rockfish | BSAI | BSAI Blackspotted/Rougheye Rockfish Complex | 0 | 1 | 1 | -1 | 28.0 |
| Rockfish | BSAI | Dusky rockfish - BSAI | 1 | 2 | 1 | N/A | 16.1 |
| Rockfish | BSAI | Shortspine thornyhead - BSAI | 1 | 2 | 1 | N/A | 26.6 |
| Rockfish | BSAI | BSAI Other Rockfish Complex | 1 | 1 | 0 | N/A | 16.1 |
| Rockfish | BSAI | Northern rockfish - BSAI | -1 | -1 | 1 | 0 | 20.6 |
| Rockfish | BSAI | Pacific ocean perch - BSAI | -1 | -2 | 0 | 0 | 16.0 |
| Rockfish | BSAI | Shortraker rockfish - BSAI | 0 | 1 | 0 | N/A | 27.6 |
| Rockfish | GOA | Dusky rockfish - GOA | -1 | -2 | 0 | 0 | 12.0 |
| Rockfish | GOA | GOA Rougheye/Blackspotted Rockfish Complex | 0 | -1 | 1 | 0 | 31.0 |
| Rockfish | GOA | GOA Other Rockfish Complex | -1 | -2 | 1 | N/A | 23.2 |
| Rockfish | GOA | Sharpchin rockfish - GOA | 0 | 0 | 1 | N/A | 16.0 |
| Rockfish | GOA | GOA Thornyhead Rockfish Complex | 0 | 0 | 1 | N/A | 26.6 |
| Rockfish | GOA | Northern rockfish - W/C GOA | -1 | -1 | 0 | 0 | 18.7 |
| Rockfish | GOA | Shortraker rockfish - GOA | -1 | -2 | 1 | N/A | 27.1 |
| Sculpins | GOA | GOA Sculpin Complex | 1 | 2 | 0 | N/A | 8.9 |
| Shark | GOA | GOA Shark Complex | -1 | -1 | 0 | N/A | 17.3 |
| Shark | GOA | Pacific sleeper shark - GOA | 0 | 0 | 0 | N/A | 17.3 |
| Sculpins | BSAI | BSAI Sculpin Complex | 1 | 2 | 0 | N/A | 5.5 |
| Shark | BSAI | BSAI Shark Complex | 1 | 1 | 0 | N/A | 18.2 |
| Skate | BSAI | Alaska skate - BSAI | 0 | -1 | 0 | 0 | 9.8 |
| Skate | BSAI | BSAI Skates Complex | 0 | 0 | 1 | N/A | 13.7 |
| Skate | GOA | GOA Skate Complex | 0 | 0 | 1 | N/A | 13.5 |
| Skate | GOA | Big skate - GOA | -1 | -1 | 1 | N/A | 8.8 |
| Skate | GOA | Longnose skate - GOA | 0 | 0 | 1 | N/A | 15.4 |
| Squid | BSAI | BSAI Squid Complex | 0 | 0 | -1 | N/A | 2.0 |
| Squid | GOA | GOA Squid Complex | 1 | 1 | -1 | N/A | 2.0 |

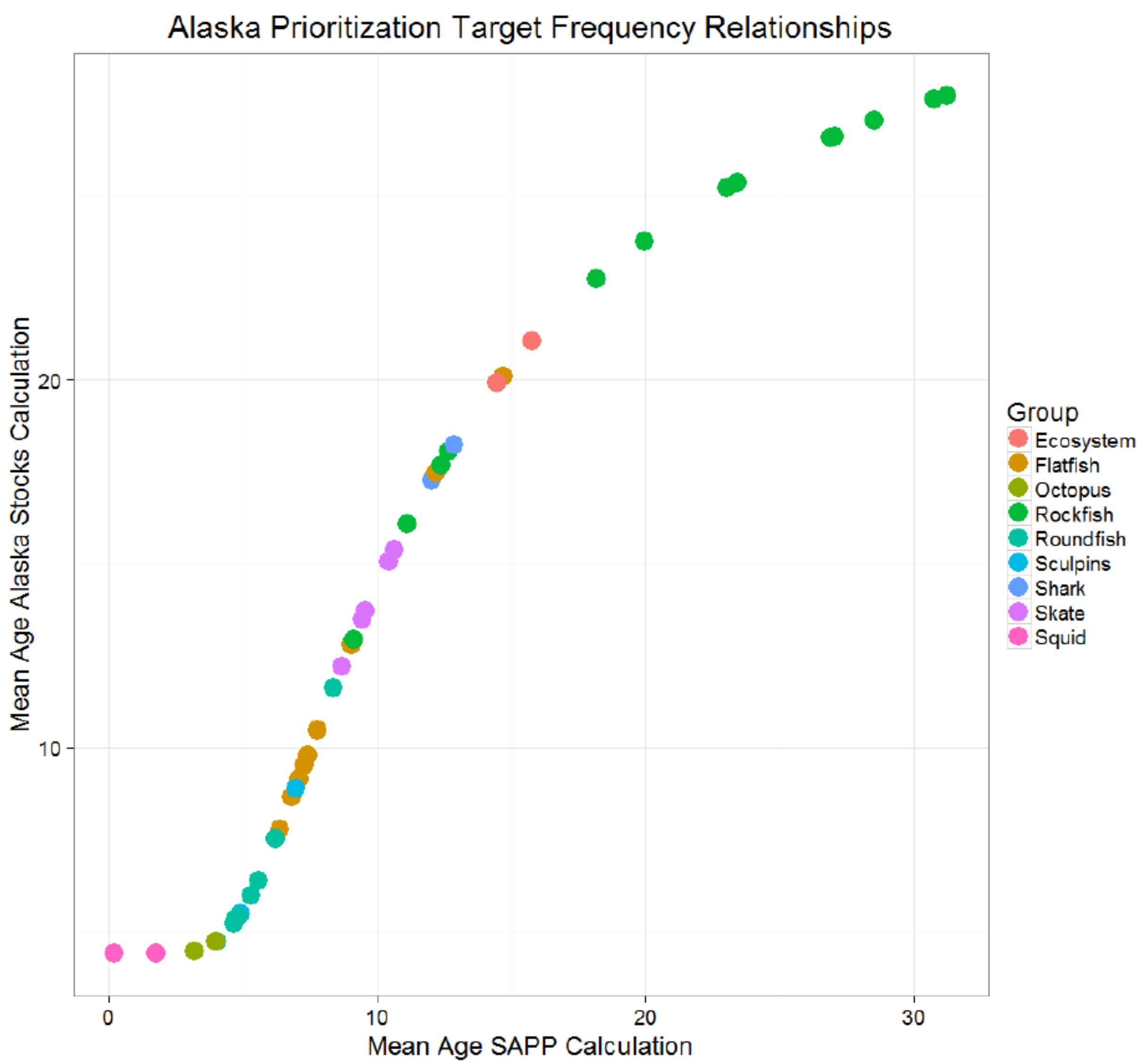


Figure 1. Comparison of mean age based on estimates of natural mortality rate using the methods suggested in the Stock Assessment Prioritization Plan and the preferred method.

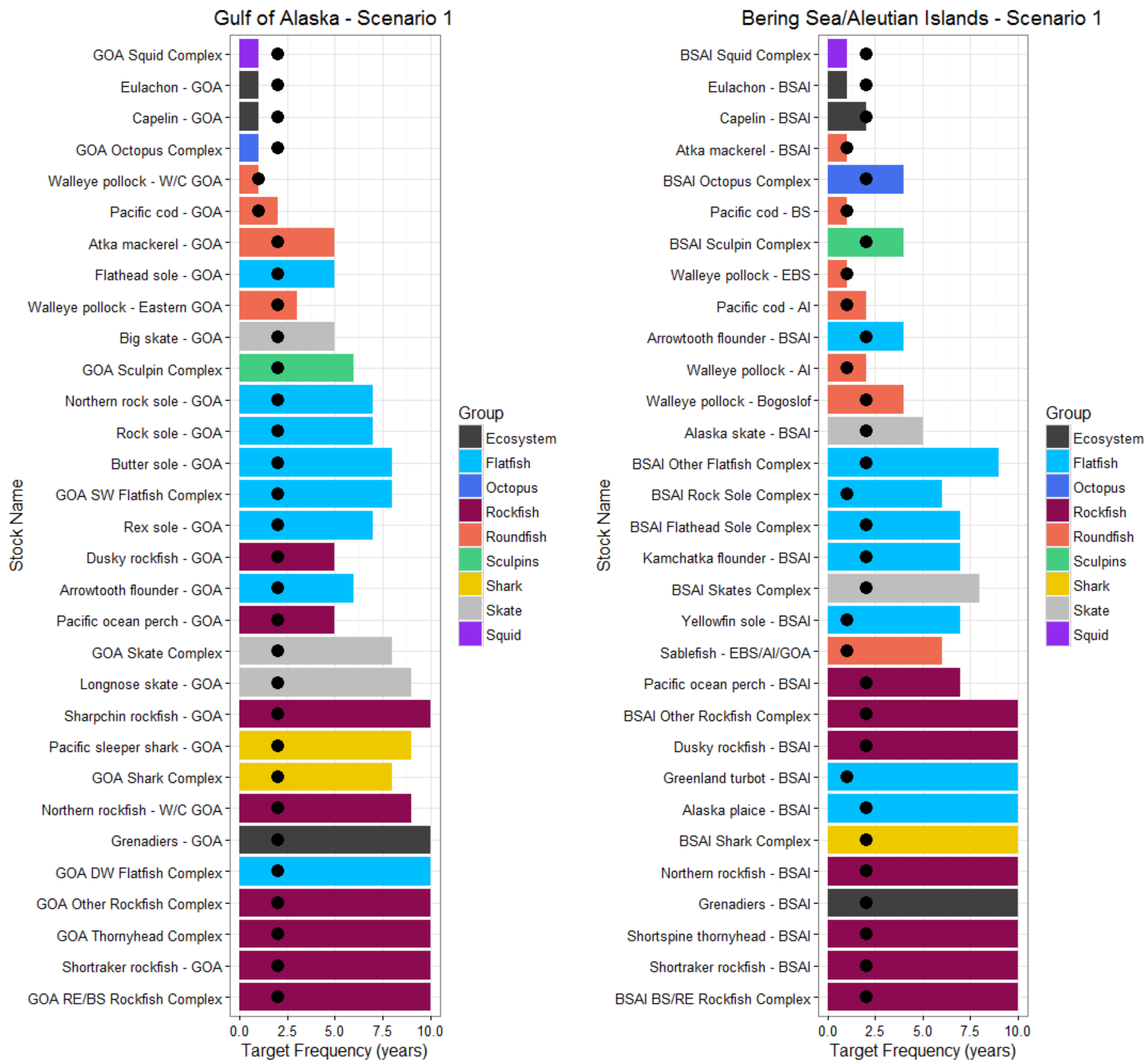


Figure 2. Target frequency for scenario S1 for Gulf of Alaska and Bering Sea Aleutian Islands groundfish stocks. Black dots represent status quo target frequencies.

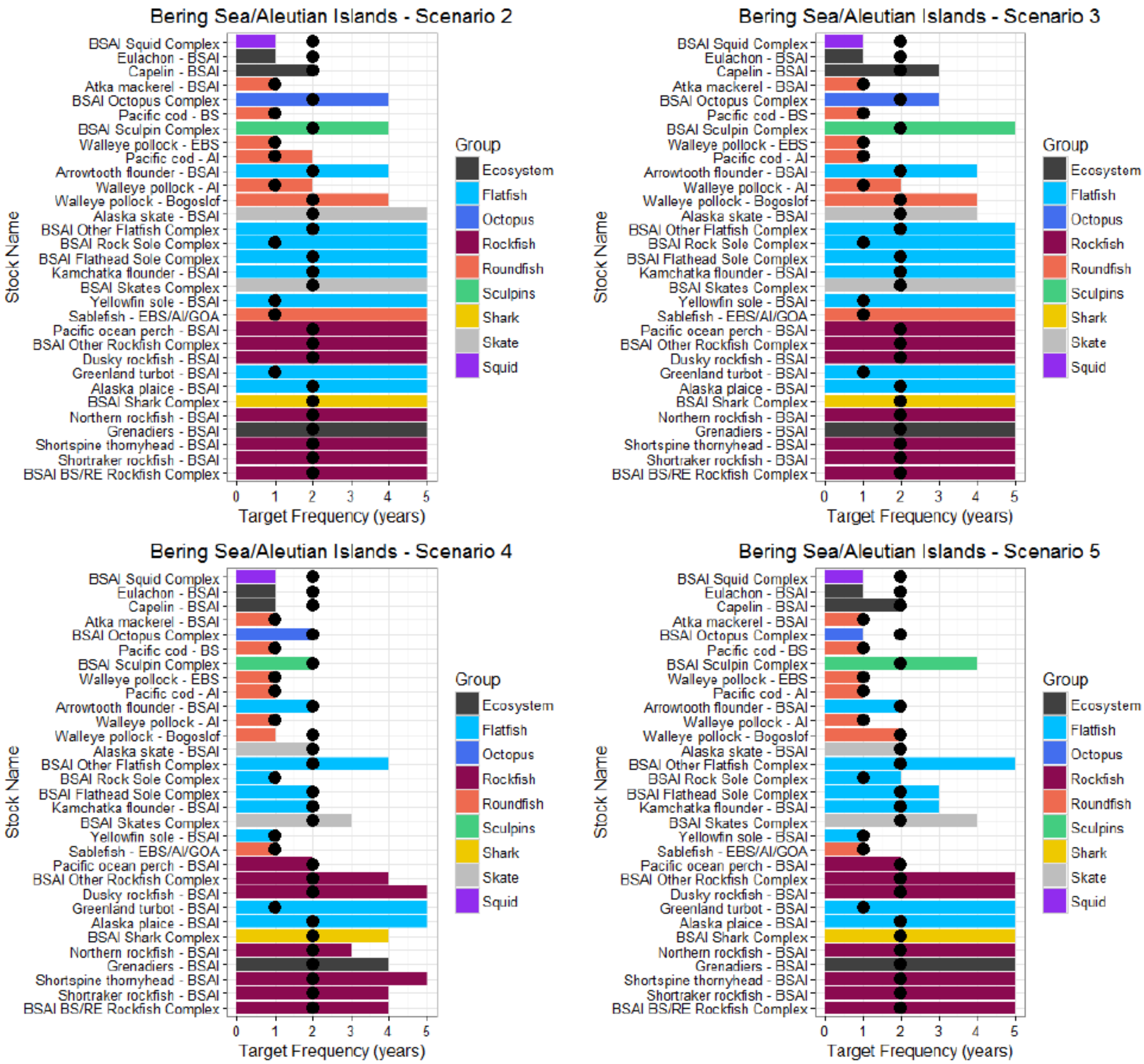


Figure 3. Target frequency for scenarios S2 - S5 for Bering Sea Aleutian Islands groundfish stocks. Black dots represent status quo target frequencies.

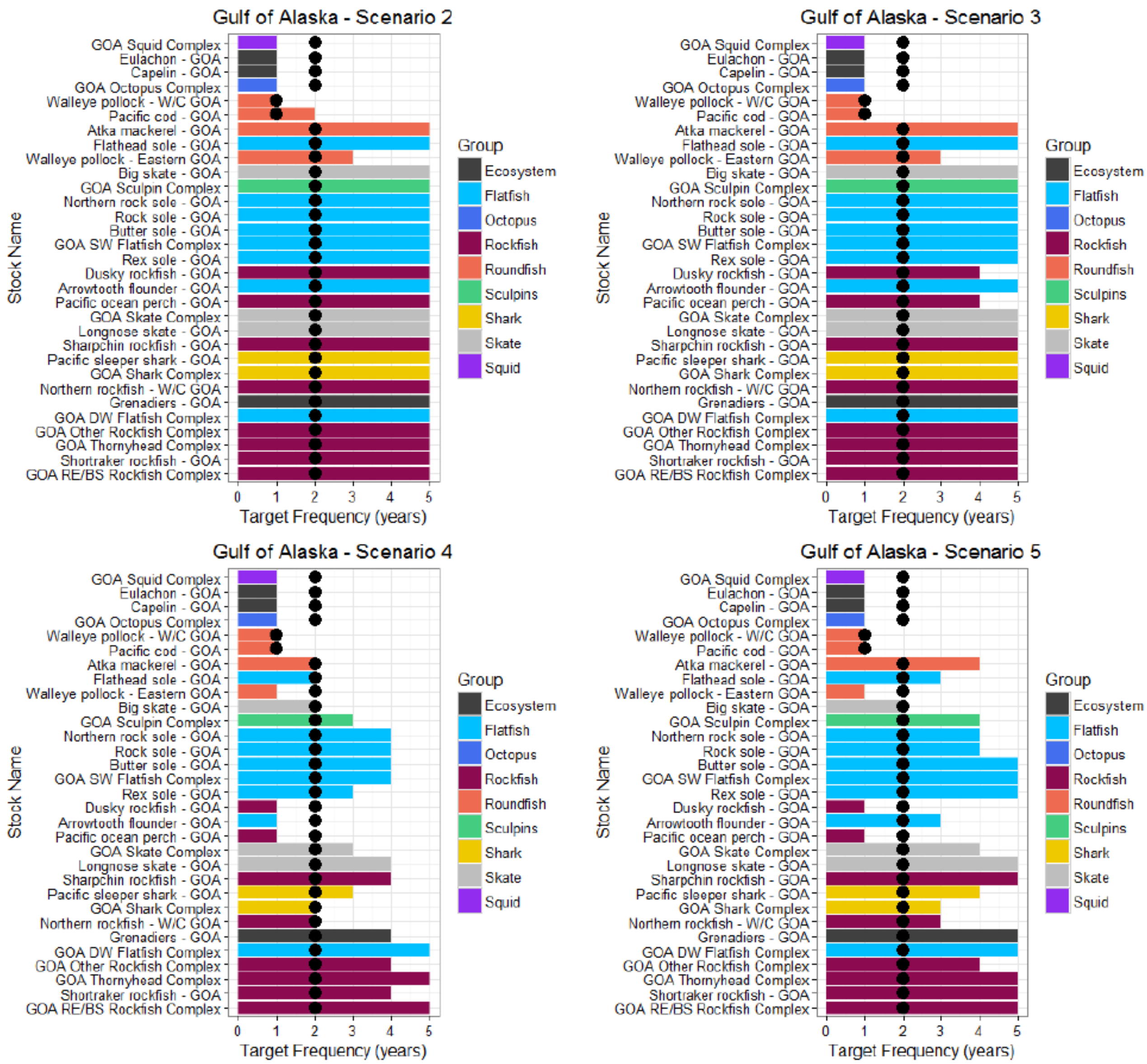


Figure 4. Target frequency for scenarios S2 - S5 for Gulf of Alaska groundfish stocks. Black dots represent status quo target frequencies.

## Appendix: Proposal to conduct an MSE for NPFMC stock prioritization

The NPFMC's impetus for completing the stock prioritization differs from the other Councils. Other Councils do not have the capacity to conduct, review and approve multiple assessments on an annual cycle. Therefore, other Councils need an objective way to prioritize which stocks will be assessed in a given review cycle. In contrast, all of the stocks in the NMFMC's groundfish and crab FMPs are assessed in some way either annually or on a biennial schedule, but many assessments are routine updates that use the most recent assessment information.

The NPFMC could benefit from a more rational process for scheduling stock assessments and their reviews to make better use of available resources without jeopardizing stock status or unnecessarily constraining fishing opportunities for diverse communities and constituents. For example, the catches of many flatfish stocks are well below their ABCs, and thus the NPFMC might be able to set ABCs and associated TACs for several years without constraining fishing opportunities and with low risk of exceeding the OFL. Given that the primary focus of Alaska's prioritization process is to identify a target assessment frequency, the MSE could help inform the NPFMC on implications of changes to allow evaluation of the potential benefits and drawbacks of reducing assessment frequency.

The proposed approach for the Management Strategy Evaluation (MSE) is to cross life history types with assessment frequency in a factorial design using several generic life history types (rather than real stock examples). The factorial design will allow performance metrics to be compared between life history types as assessment frequency is varied from high (annual) to low (once in every ten years). In addition to the factorial analysis, a number of robustness tests will be done in which a base case is contrasted with a case where one factor is perturbed.

The operating model would run for an initial thirty year period during which assessment data are simulated. The data available will be typical for stock assessments conducted in the North Pacific, rather than the extremes of data poor or data-rich stocks. Following the thirty-year period, assessments will be conducted according to the specified assessment frequency, and the assessment results will be used to calculate the ABCs (Tier 3) with alternative TACs and catches specified according to current levels relative to ABC for North Pacific groundfish stocks. These catch scenarios will be removed from the "true" population. We will consider annual surveys as the base case (as in the eastern Bering Sea), but do a sensitivity run with biennial surveys (as in the Aleutian Islands and Gulf of Alaska).

**Life history types.** The three basic life history types are:

> Gadid, high productivity/high turnover, (type species walleye pollock).
>
> Flatfish, intermediate productivity, (type species rock sole).
>
> Rockfish, low productivity (type species Pacific ocean perch).
>
> These life history types represent nearly all of the age-structured stock assessment conducted in the North Pacific, but there are several species that do not belong in these categories and may need to be considered separately (e.g., squid, sharks and skates, sablefish)

**Assessment frequency.** The assessment frequencies that will be evaluated are the following:

a) Annual (base for Gadids).
b) Every 2 years (base for flatfish).
c) Every 3 years.
d) Every 5 years (base for rockfish).
e) Every 10 years.

**Performance metrics.** The following performance metrics will be tabulated over a 20-year performance period:

a) Average catch when fishing at ABC control rule.
b) Interannual variability in catch when fishing at ABC control rule.
c) Socio-economic metrics.
d) Probability of exceeding the OFL
e) Probability that stock becomes overfished.
f) Average biomass
g) Variability in biomass
h) Biomass relative to target levels
i) Propagation of uncertainty in OFL and biomass in years after an assessment is conducted.

**Robustness tests.** The standard analysis will consider a situation in which the assumptions of the assessment model correspond to those of the operating model. Sensitivity tests will also be done where performance metrics for a base case are compared to scenario that represents a strong departure from the base case. The following sensitivity tests will be done:

a) A scenario where annual catches are a small fraction of the ABC to evaluate this fairly common occurrence in the North Pacific
b) A scenario with an anomalous survey biomass estimate
c) A scenario with an exceptional recruitment event, either a very strong recruitment, or a run of five years of poor recruitment.
d) A scenario with a continuous downward trend in stock abundance
e) A scenario with continuous upward trend in stock abundance
f) Scenarios that employ interim management procedures between assessments, such as using an unexpectedly large or small survey estimate as a trigger to conduct a new assessment.