Small Sablefish Release: DMR & Analytical Approach

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1 Introduction

In June 2023, the Council received an update[2] from staff which explained some of the challenges associated with producing a second initial review analysis for the proposed action on small sablefish release. The update evaluated the resources required to fulfill SSC recommendations coming out of the first initial review of the analysis in February 2021, and described other management tradeoffs and potential revisions to the alternatives that could mitigate these tradeoffs. Descriptions of the relative implications for workload, expected timeline for action, sablefish stock conservation, reprioritized monitoring needs, and potential implications for the fishery were included.

At that meeting, the Council revised the alternatives and included an option for a minimum size retention requirement of 22 inches total length (providing for voluntary release of sablefish under 22 inches, which corresponds to roughly 3lbs dressed weight). As part of the alternatives, the Council also added an option for a review of the resulting management measures a certain number of years after implementation.

There are several reasons for this item to come in front of the SSC at this time. The first is to help refamiliarize the SSC with this topic and highlight the previous issues with the initial review analysis presented in 2021. The second is to reduce the level of uncertainty in the next iteration of analysis by providing the SSC with the best scientific information available (BSIA) with which to recommend a discard mortality rate (DMR) for sablefish that are caught and released in the IFQ fishery. Lastly, staff are seeking SSC approval of and feedback on the analytic approach to undertake for the next iteration of the analysis (scheduled for June 2024). The goal of the analysis is to provide the SSC with sufficient information to make a final evaluation of the Council's proposed action regarding its effects on the sablefish population, given the data deficiencies and associated assumptions that need to be made. This information is separate from how the National Marine Fisheries Service (NMFS) and stock assessment

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[2] NPFMC, 2023

For definition of acronyms and abbreviations, see online list: https://www.npfmc.org/library/acronyms

authors will respond to a management change, such as how to calculate discards for unobserved trips, how to account for discards against ABCs and IFQs, and how to handle discards within the assessment model given data constraints related to discards (e.g., the magnitude and size or age composition). Decoupling these two concepts may make it easier for the SSC to evaluate whether the analysis provides sufficient information, based on the BSIA, for the analysis to be ready for final action by the Council.

Summary of Action Items for the SSC (also detailed in Section 5):

- Recommend a sablefish DMR or range of DMRs for analysis.
- Provide feedback on the proposed simulation parametrization and scenarios to be run.
- Endorse the proposed analytical simulation approach (with any requested revisions) for evaluating the effects of the proposed action on the sablefish population and fishery.

2 Background

History of this Action at the SSC/Council

At present, the IFQ sablefish longline and pot fisheries in the Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BS/AI) require full retention of any sablefish regardless of size. Beginning in 2017, unprecedented numbers of newly recruited sablefish began showing up in the GOA and BS fixed gear catches, initiating stakeholder appeal for management action to provide relief from the prohibition on sablefish discarding in the sablefish IFQ fleet. In April 2018, IFQ fishermen provided testimony to the Council that they were seeing a sudden influx of small, low-value sablefish in their catch. These fish were becoming an economic burden to fishermen because regulations prevent them from being discarded, even though, according to testimony, these fish were mostly uninjured by the fishing gear and appeared likely to survive if released. IFQ stakeholders at the meeting proposed that the Council explore an allowance to discard these fish, and the Council initiated the first of three discussion papers to explore issues related to this proposal.

Between October 2018 and December 2019, the Council reviewed three discussion papers[3] which provided information on the following topics:

- Effects of the exceptionally large 2014 and 2016 sablefish year classes.
- Sablefish DMR estimates, proxies, variability by gear type, and potential processes for establishing a DMR.
- Allowing discards during years of high abundance versus years of lower abundance.
- Whale depredation if discarding is allowed
- Gear modifications that could aid in avoiding small sablefish.
- The implications of approaching the Total Allowable Catch (TAC) or exceeding the Acceptable Biological Catch (ABC).
- Fishing down the existing spawning stock.
- Impacts of high-grading
- Varying size limits by area.
- Accounting for discards within ABC and TAC.
- Discard estimation methods, including changes to observer sampling protocols and associated monitoring and enforcement concerns.

[3] NPFMC, 2018; NPFMC, 2019a; NPFMC, 2019b

- Impacts of discarding on sablefish abundance and how that affects allocations to IFQ and trawl sectors.
- Management considerations in the IFQ program
- Additional enforcement implications

The third discussion paper also considered the contrast between a *requirement* to discard sablefish under a certain size (minimum size limit) and an *option* for discretionary release (voluntary discarding) in terms of both practical and economic impacts. A requirement to discard sablefish under a certain size would continue to require retention of all fish over that size limit. Voluntary discarding would allow for harvesters to choose what sizes of fish they would prefer to retain and could result in any size of fish being legally discarded.

In December 2019, the Council adopted a purpose and need statement and developed alternatives to initiate analysis on the proposed action. The initial review analysis was then considered at the February 2021 SSC, AP, and Council meetings.[4]

Several key findings from that analysis:

- The analysis examined a range of potential scenarios based on sizes of sablefish retained, including a minimum size limit based on 3 dressed lbs (how "small sablefish" was defined in NPFMC 2021) and a retention scenario based on processor size grade prices that may occur under a voluntary discarding program where any size of fish can be discarded. Stock related (e.g., spawning biomass) and economic (e.g., yield, ex-vessel value) impacts are dependent upon size of fish discarded and DMR (Section 2.2.3.3 in the 2021 analysis).
- Continued decline in market prices for smaller sablefish is creating suboptimal economic conditions (Figure 2-8 in the 2021 analysis; Table 2/Figure 5 in this document).
- Allowing the IFQ fishery to discard small sablefish in order to increase harvest of large sablefish would put increasing pressure on the spawning biomass (Section 3.2.2 of the 2021 analysis).
- Implementation of a voluntary discard program would greatly increase uncertainty in the sablefish stock assessment due to uncertainty in the DMR, retention selectivity (i.e., the percentage of fish at a given size or age that are retained), and a loss of information on young fish to inform recruitment estimates (Section 2.2.3.1 in the 2021 analysis).
- Implementation of a voluntary discard program will likely result in an overall decrease in ABC in order to account for modeled dead discards (Table 2-11 in the 2021 analysis).
- Impacts would vary based on management area based on differences in the size distribution of the population.
- At sea observers are currently able to capture the number of fish and size distribution of unsorted sablefish catch, but would not be able to capture the size distributions of (retained and) discarded fish separately without significant alterations to observer sampling protocols, and at the cost of other data collections.
- There are numerous challenges associated with changing at-sea observer sampling methodology to effectively estimate discards if release of small sablefish were authorized, including the potential bias introduced if discarding is voluntary.

[4] NPFMC, 2021

The February 2021 SSC report recommended that additional analyses be conducted and included prior to any final action by the Council on this issue.[5] Specifically, while the difficulties associated with the estimation of size or age distribution of discards were thoroughly considered in the analysis, the SSC concluded that there are two unresolved questions that are central to understanding the effects of the proposed amendment:

1. What is the impact on the age structure and overall productivity of the stock under different rates of discard mortality and for different gear and discard selectivity profiles?
2. What is the impact on the uncertainties in the stock assessment, and the required buffers in setting ABC, arising from knowledge gaps introduced by not knowing gear selectivity or discard selectivity and mortality in a mostly unobserved fishery?

In June 2022, the Council supported the IFQ Committee's recommendation to schedule the next initial review of the proposed action to allow small sablefish release. At that time, the Council expressed interest for the updated analysis to include recent data on recruitment, growth rates, and market conditions and to revisit the discussion on assessment uncertainty. In keeping with the IFQ Committee recommendation, the Council noted that the discussion in the previous analysis about a minimum size limit for sablefish retention should not be considered in the revised analysis. As indicated in Section 1, staff provided an update in June 2023 and the Council revised alternatives to include an option for voluntary release under 22 inches. All IFQ sablefish $\geq$ 22 inches in total length would still be required to be retained.

Purpose and Need

Beginning with the 2014 age class, a continuing series of large year classes of sablefish are resulting in significant catches of small sablefish in the IFQ fixed gear fisheries and current regulations require IFQ holders to retain all sablefish. Small sablefish have low commercial value under current market conditions. Although no scientific studies are available to estimate survival rates for Alaska sablefish, information from other areas suggests that survival rates for carefully released sablefish may be high enough to warrant consideration of relaxing full retention requirements. Limited operational flexibility to carefully release sablefish may increase the value of the commercial harvest and allow small fish to contribute to the overall biomass.

[5] SSC, 2021

Current Alternatives for Analysis

Alternative 1: No Action

Under the No Action alternative, all regulations and FMP language related to a prohibition on discarding sablefish would remain intact.

Alternative 2: Allow Release of Sablefish in the IFQ Fishery

This alternative would eliminate (Option 1) or modify (Option 2) the regulatory restrictions that prohibit release of sablefish caught by sablefish IFQ vessels as well as the FMP provision prohibiting discarding.

> **Option 1**: Eliminate the regulatory restrictions that prohibit release of sablefish caught by sablefish IFQ vessels as well as the FMP provision prohibiting discarding.
>
> **Option 2:** Require retention of sablefish 22 inches total body length or longer (provides for voluntary release of sablefish under 22 inches total body length).

Element 1: DMRs

Apply a DMR to released sablefish of:

1. *5%*
2. *12%*
3. *16%*
4. *20%*
5. *25%*
6. *SSC recommends the DMR through the stock assessment process.*

> **Sub-option:** Select different DMRs for pot gear and hook and line gear.

Element 2: Catch and Release Mortality Accounting

Sablefish catch and release mortality associated with the IFQ fishery will be accounted for in the stock assessment. The analysis should describe the potential implications of voluntary discards on the sablefish stock assessment, specifications process and catch accounting in the context of other uncertainties.

Element 3: Monitoring and Enforcement

The analysis should describe potential monitoring and enforcement provisions that could improve estimates of voluntary and regulatory discards.

Element 4: Review

> **Option 1**: The ability to release sablefish will be reviewed in a) 3 years b) 5 c) 7 years following implementation.
>
> **Option 2**: The ability to release sablefish will sunset after 5 years following implementation.

The analysis should include a discussion of selectivity in sablefish pots and whether requiring escape mechanisms meet the objective of this action.

3 Sablefish DMR

The June 2023 update received by the Council noted that an Alaska IFQ-specific DMR(s) would need to be determined by the SSC. This determination could be made through evaluation of results of any existing scientific studies along with consideration of what other agencies currently use. Previous Council documents summarized available information relevant to development of DMRs.[6] To date, no scientific studies have been conducted to estimate a DMR specific to the Alaska sablefish IFQ fishery. Therefore, a scientifically-vetted DMR based on the IFQ fleet is unlikely to be available in the near future.

A discard mortality rate must be applied to released fish to calculate the number of fish that would die due to discarding. There is limited information on these processes (number of fish discarded, and proportion of those that will die), and multiple factors to take into account when considering an appropriate DMR for sablefish in the IFQ fishery such as: gear type and soak times, depth of capture, fish size/age, handling practices, injury from gear during capture (e.g., from hooking on longlines or abrasion in pots), or unknown mortality following release due to long-term injury or predation.

Discussion and Rationale for DMRs in Council Motion

Currently, the only federal fisheries in Alaska for which discard mortality data are collected are fisheries that capture Pacific halibut. Discard mortality data from these fisheries are collected in the form of injury assessments made by fisheries observers. For fisheries that incidentally capture halibut, these data are annually reviewed by an interagency halibut DMR workgroup in order to estimate DMRs. For the directed halibut fishery, these data are used by the IPHC in order to estimate DMRs. While a similar process could potentially be developed for estimating DMRs for the directed sablefish fishery, it would involve resource dedication approximately equivalent to duplicating the directed halibut DMR estimation process. Observer sampling protocols would need to be significantly altered to collect these data, and the feasibility of this approach may be limited when applied to the sablefish fishery given current recruitment events (i.e., given the volume of fish being processed compared to the halibut fishery). For example, an observer's ability to assess injuries for multiple fish in a single pot is likely limited. As discussed more thoroughly in the section below, no information on post-release predation by whales, if occurring below the surface, could be collected.

Previous discussion papers[7] outlined the DMR process and discussed steps that the Council could initiate to begin developing DMRs specific for the sablefish IFQ fishery. However, given that this was described as a time-consuming process and the Council has stated its desire for this analysis to move forward, the Council directed analysts to consider the use of five proxy DMR options for analysis (i.e., 5%, 12%, 16%, 20%, 25%). These DMRs were identified to demonstrate the influence of the chosen value on the impact analysis, acknowledging that the actual DMR will be recommended by the SSC. The first four values roughly correspond to existing proxy DMRs determined through research studies (Stachura et. al 2012, Somers et al., 2020) or used by other agencies in sablefish management, described below. Appendix 1 includes sablefish discarding requirements and related DMRs, size limits, and monitoring requirements used in other regions or by other agencies, described below.

[6]NPFMC 2018; NPFMC 2019a; NPFMC 2019b; NPFMC 2021
[7]NPFMC 2018, NPFMC 2019a; NPFMC 2019b

5% - Described in the third discussion paper[8] as an average pot DMR value for halibut in the GOA. To our knowledge, this value has no scientific basis in regard to sablefish.

12% - Stachura et al. (2012) reviewed data on longline-survey-caught and released sablefish that were recaptured by survey and fishery gear. In the previous 2021 analysis, analysts reviewed the methods and assumptions of Stachura et al. (2012) and found they relied on the assumption that fish with 'minor hook injuries' had a 96.5% survival rate, which corresponds to a DMR of 3.5%. This assumption, which was loosely based on a study of Pacific halibut (Trumble et al., 2000), directly scales the estimate of the overall DMR. More information about the analysts' review of this study can be found in Section 2.2.3.1 of the 2021 analysis. The overall estimated DMR from Stachura et al. (2012) was 11.71%, but the authors consider this to likely be an underestimate given that handling of sablefish is different in survey versus fishery conditions, fishery gear type may vary compared to survey gear, and whale predation could potentially be higher for released fish in fishery operations.

16% - For 2019, the Alaska Department of Fish and Game (ADF&G) used a new method to estimate the probability of a sablefish being discarded based on price/lb., weight, sex, and age (Sullivan et al., 2020). This information was incorporated into the assessment model and was reflected in the ABC in the stock assessment. This DMR value was chosen both because it is the DMR used for the Pacific halibut fishery (Gilroy and Stewart, 2013) and because it is similar to the estimate for sablefish from Stachura et al. (2012) of 11.7%. The Stachura et al. (2012) estimate was based on the mortality rate of sablefish that were released carefully on a survey platform and so it was assumed that the DMR applied to commercial fishing should be higher than that estimate.

20% - Somers et al. (2017) used a stratified multistage random sampling method to estimate discard mortalities for all the West Coast groundfish observed sectors. A DMR of 20% was designated for sablefish caught in the "offshore" IFQ longline and pot gear fisheries by the Groundfish Management Team, which is used by the Pacific Fisheries Management Council. A 100% DMR was applied to fish < 28 cm (age-0 fish). See Somers et al. (2017) for a more detailed description of DMR estimation procedures.

25% - This value was added as an option for analysis by the Council in June 2023, due to consideration that a higher DMR may be more appropriate given instances of whale predation on released sablefish. Similarly, discussions noted that current DMRs applied to H&L caught sablefish in British Columbia are 30%, so a higher DMR might be warranted for this analysis. Specifically, Fishery and Oceans Canada (DFO) assumes a 15% (pot) and 30% (H&L) DMR on released sablefish under 55cm fork length (roughly 22-24 inches total length, age 3-4). However, there are no quota deductions applied to releases of sub-legal fish.

Additional DMR Information and Considerations

As further described in Section 4, previous analyses which looked at minimum size limits (MSL) for the sablefish fisheries in Alaska utilized a DMR of 35% for fixed gear (Funk and Bracken, 1984; Terry, 1987; Lowe et al., 1991). The 35% DMR assumed in these analyses was based on personal communications with skippers that the DMR was likely on order of 25-75% for longlines, as cited in Funk and Bracken (1984). It is worth noting that the sablefish fishery was an open access fishery at the time of these analyses, rather than a rationalized fishery, and it is not entirely clear how that change could affect DMR

[8] NPFMC 2019b

considerations. Other changes in the fishery since the time of these analyses that may impact discard mortality, such as increased whale depredation of H&L gear, are also worth considering.

Increased whale depredation of sablefish on H&L gear in the IFQ fishery has led to a significant shift to use of pot gear over recent years, and in recent years, over 80% of all sablefish IFQ has been harvested using pot gear.[9] Presence of whales and interactions with both pot and H&L gear continues to be a topic of discussion amongst scientists, fishery participants, and policy makers. Unfortunately, there is currently no information or research available from which to estimate post-release mortality due to whale predation, and if whale behavior switches from depredation of sablefish from fishing gear to predation following release, the magnitude of impacts unknown. If sablefish discards in the IFQ fleet are authorized, an appropriate DMR for sablefish would not only account for mortality due to gear injury and catch handling, but also an unknown amount of mortality due to post-release predation by whales. **A DMR that accounts for whale predation on post-release sablefish is expected to be higher than the options currently proposed under Element 1.**

The alternatives include a suboption to differentiate DMRs by gear type (e.g., sablefish caught in pots may have a different DMR than H&L caught sablefish) due to variables like hooking injuries and catch handling. However, when including post-release predation as a component of a DMR, understanding the relative differences between gear types may be less critical. It is likely that the mortality due to post-release whale predation is of greater magnitude than the handling mortality component and is similar among gears. Additionally, given the level of uncertainty in total DMR (i.e., handling mortality plus mortality from predation), there is not sufficient data to accurately parse out the relative difference in DMR among gears. Therefore, focus should be placed on adequately defining a fleet-wide DMR. Consideration should be given on how to define an 'average' DMR when sablefish are released with and without whales present, since there is no information on the frequency of post-release whale predation events.

Within the assessment-management process, a DMR is applied at the total catch/removals estimation stage (within NMFS Catch Accounting System, "CAS"), then also accounted for in the stock assessment (i.e., if discards are explicitly modeled; see Shertzer et al., 2022, for discussion on how discards can be treated in an assessment). In Alaska, the CAS is where catch mortality estimates (retained and discarded) are generated for groundfish species. CAS estimates are used by in-season management to effectively open and close fisheries; analyses that would affect total catch should be applied during in-season management. In accounting for total removals, the stock assessment applies a DMR to the predicted total discard estimates to calculate the predicted dead discards. The model fitting process then uses maximum likelihood estimation to minimize differences between the CAS observed discards and model-predicted discards (along with the other data components) to estimate critical model parameters. The incorporation of a DMR and associated retention selectivity function into the stock assessment allows total fishing mortality to be partitioned into landings and dead discard components when deriving population estimates and recommended quotas.

Currently, regulations require all vessels fishing for sablefish IFQ to retain all sablefish. Multiple factors influence the survival of sablefish that are caught and then released. Any DMR estimate chosen should consider the factors described. Given the uncertainty in these factors, emphasis should be on developing a reasonable fleet-wide DMR that averages across gears and potential for whale presence/absence. It is anticipated that any DMR chosen may need adjustment as future observations or studies inform the realized impacts of sablefish discarding if the proposed action is implemented.

[9] NMFS Alaska Region Catch Accounting System

4 Analytic Approach to Address SSC Recommendations

The June 2023 update document was prepared by staff to describe to the Council the workload and resources required to adequately address the SSC's remaining questions regarding the analysis. In particular, the SSC requested further analysis of the impacts to age structure, stock productivity, uncertainties in the stock assessment, and potential ABC buffers (see Section 2 of this document), while also noting the potential associated tradeoffs with other Council-AFSC priorities. The Council chose to proceed with a second initial review of the proposed action. Thus, the analytical team has developed an approach meant to address SSC requests, given time and resource constraints. The analysts are seeking SSC feedback on this approach, as described below.

Background

For the proposed sablefish action, it is important to understand that a DMR effectively acts as a scalar on age (*a)* based mortality, including fishing mortality (*F*) and total mortality (*Z*), in a similar manner as natural mortality (*M*):

$$Z_a = F * Selectivity_a * Retention_a + F * Selectivity_a * (1 - Retention_a) * DMR + M_a \quad \textbf{(eqn. 1)}$$

When no mortality occurs due to discarding (i.e., DMR = 0 or there is a full retention fishery), then the second term in eqn. 1 goes to zero. Thus, total mortality is lower with discarding and no discard mortality than under a full retention fishery, where F is reduced by the proportion of fish that are no longer retained by the fishery (and are assumed to all survive the release process). Conversely, for non-zero values of the DMR, the total mortality increases when discarding is allowed, and is scaled in proportion with the DMR (eqn. 1). Therefore, for given fishery selectivity and retention functions, a change in DMR effectively scales total mortality analogous to a change in natural mortality (eqn. 1).

Multiple simulation analyses have explored the impacts of DMRs and MSLs in the context of optimizing management of marine species (e.g., Cox et al., 2019; Bohaboy et al., 2022). For instance, Bohaboy et al. (2022) demonstrated that, for a Gulf of Mexico red snapper assessment-simulation study, incremental changes in DMR resulted in subsequent (nearly proportional) rescaling of total mortality and spawning stock biomass (SSB). Similarly, Hanselman et al. (unpublished), in an analysis of the impacts of DMR and age of discarding for Alaskan sablefish using the 2018 SAFE model, showed that both SSB and ABC were scaled proportional to the DMR (Figure 1). Thus, by implementing reasonable upper and lower bounds on DMR, simulation analyses can demonstrate the range of impacts of DMR on resultant SSB and catch advice along with associated uncertainty. The resultant envelope of each output metric will encompass any potential alternate values for the range of DMRs simulated. Moreover, because DMR is a scalar on mortality, it is generally expected that moving from a full retention fishery to one with discarding will result in an increase in mortality, a reduction in SSB, and a decrease in ABC.

However, generalizations regarding the impacts of discarding on population and fishery dynamics are complicated by other biological and fishery processes. For instance, the impacts of retention selectivity on population trajectories and fishery performance are often nuanced, depending on the biological (i.e., growth and maturity schedule) and fishery (i.e., selectivity, retention, and DMR) processes (Bohaboy et al., 2022). Full retention fisheries have been shown to provide improved biological performance over those that allow discarding, because fishery waste (i.e., dead discards) is reduced and mortality is spread across age classes (i.e., MSLs can concentrate effort on larger, more productive fish, thereby, reducing SSB compared to full retention fisheries; Cox et al., 2019; Bohaboy et al., 2022). For instance, a management strategy evaluation for British Columbia sablefish demonstrated that conservation metrics were improved under full retention compared to discarding scenarios (Cox et al., 2019). Moreover, in the work of Hanselman et al. (unpublished) with Alaskan sablefish, the impacts of discarding and differences in DMR were much more pronounced as the MSL (i.e., the minimum age of retention) was increased (Figure 1). In that work, discarding of all fish less than age-3 had less detrimental effects on the

population and catch, while impacts of increasing DMRs was more subtle, compared to when all fish less than age-5 were discarded (Figure 1). However, similar to the Cox et al. (2019) study, Hanselman et al. (unpublished) demonstrated that full retention fisheries led to the most optimistic long-term population trajectories and associated catch (Figure 1).

Implementing a MSL for Alaskan sablefish has been a widely touted management option for at least the last 40 years (Funk and Bracken, 1984; Terry, 1987; Lowe, 1991; Hanselman, unpublished). The primary tool to investigate the potential implications of a MSL has been yield-per-recruit (YPR) analysis. To understand the potential impact of moving to a MSL for sablefish in any quantitative analysis, a critical assumption is the assumed DMR. Although sensitivity to alternate DMRs were explored, Funk and Bracken (1984), Terry (1987), and Lowe (1991) all settled on a DMR of 35% as an adequate value for sablefish caught in fixed gear. Similarly, each of these studies explored the impact of varying the MSL (i.e., as indicated by knife-edge retention at the age or size associated with the MSL) across a range of values, where, for instance, Terry (1987) varied the MSL from 37cm to 61cm fork length in 4cm increments (where 37cm was deemed equivalent to full retention since few fish were harvested below this size). Based on inputs from the GOA assessment and using an equilibrium YPR model, Funk and Bracken (1984) concluded that:

> "Neither sablefish yield nor landed value per recruit are improved by the addition of size limits or market conditions which favor the retention of only large fish. By the time sablefish recruit to the fishery, their period of rapid growth is over, hence there are few advantages to be gained by delayed harvest. Although the natural mortality rate is low, apparently it is approximately equal to the rate of production due to growth by the population until sablefish reach 45 to 50 cm. At this size mortality begins to exceed growth so further delaying harvest only reduces yield and landed value....There does not appear to be any advantage to either setting a minimum size limit or delaying the harvest. The yield-per-recruit models used to investigate size limits address only the problems of growth overfishing. The problems of recruitment overfishing cannot be addressed with yield-per-recruit models."

Perhaps the most relevant of these previous analyses is that of Terry (1987), given that this work was undertaken in support of a proposed NPFMC action (Terry, 1987). The action analyzed in Terry (1987) occurred at a time when similar dynamics were occurring in the population and fishery as are currently being observed (i.e., relatively large year classes entering the fishery and extreme variability in size-based prices with smaller fish having little market value). Results indicated that when a MSL was implemented for the directed fixed gear fleet and not the trawl fleet (i.e., the closest approximation to the current proposed action), a MSL would not increase yield, but revenue could be increased by 9% with a MSL of 53cm while profit was maximized with a MSL of 45cm (and profits under full retention were similar to the other MSLs). In terms of productivity of the resource, increasing the MSL improved reproductive potential slightly, but led to large reductions in productivity at the fishing mortality levels required to maximize yield and revenue. Lowe et al. (1991) performed a similar bioeconomic YPR analysis and came to the same general conclusions as Terry (1987). Mainly, when DMR was accounted for in the model, yield and net value declined with discarding, while biomass increases were negligible. Thus, it was concluded that a MSL would be ineffective for Alaskan sablefish.

However, as noted by the authors, an equilibrium YPR model is not necessarily adequate to understand the short-term dynamics for a species like sablefish, which demonstrate high interannual variability in recruitment or year class strength. Mainly, because YPR (or associated SPR) do not account for variability in recruitment, these types of equilibrium modeling approaches cannot effectively address density-dependence, recruitment variability, and the differential impact of age-based mortality as cohorts move through the fishery. Although the results are informative for sablefish and are unlikely to change to

any great extent with the proposed simulation study, the YPR approach does not effectively account for the potential transition of mortality across age classes when transitioning from full retention to a MSL when high variability in recruitment year class strength is occurring (i.e., the negative consequences for SSB when harvest is transferred from younger to older ages with a MSL).

Proposed Simulation Study

The AFSC will develop a modified sablefish projection-simulation model to explicitly explore the potential impacts of discarding small sablefish on projected spawning stock biomass (SSB) and ABC. The general approach follows that initially explored by sablefish stock assessment authors in 2018 (Hanselman et al., unpublished). The new analysis will provide similar comparisons of ABC and SSB (see Figure 1), but with important parametrization improvements to better model the discarding process and incorporate recent biological and fishery dynamics.

A 50 year projection will be implemented to emulate sablefish dynamics utilizing outputs from the most recent assessment and the NPFMC harvest control rule, with multiple scenarios implemented to characterize uncertainty in key parameters or processes. The model will utilize the outputs of the most recent (2023) Alaska sablefish SAFE (Goethel et al., 2023) to parametrize the simulation, including biological inputs, fishery selectivity (i.e., for the fixed gear and trawl fleets), recent fishing mortality ratio among fleets, terminal year abundance-at-age, and the time series of recruitment estimates. Given that no stock-recruit relationship is estimated for sablefish, projected recruitment will be determined based on the mean recruitment from a specified time period. Discarding will be modeled using a logistic retention function (i.e., proportion of the catch at a given age that is retained) and an applied discard mortality rate (DMR). Thus, discards-at-age are the product of the fishing mortality rate, the selectivity-at-age by the fishing gear, and the retention-at-age (see eqn. 1). Dead discards are then the fraction of the discards-at-age that die based on the applied DMR (eqn. 1). Simulation scenarios will be developed to address key uncertainties, including: future recruitment, DMR, and retention function shape (see Table 1).

The NPFMC sloping B40% harvest control rule (HCR) will be implemented to project future catch. The catch is differentiated by the proportion retained (i.e., the landings) and the proportion discarded. Discards are further differentiated by the proportion assumed to survive (i.e., live discards) and those assumed to die due to the DMR (i.e., dead discards). All dead fish (i.e., the sum of retained catch and dead discards) are assumed to count against the ABC for a given fleet. In other words, the HCR will utilize a total removals-based quota accounting as opposed to a landings-only system (see Bohaboy et al., 2022). Thereby, all fish that die due to fishing (i.e., landings plus dead discards) count towards the quota (i.e., IFQ and ABC), not just those fish that are landed. Removals by fishing sector will be determined by partitioning the yearly fishing mortality rate to sector based on the terminal year ratio of fishing mortality among sectors from the stock assessment. Projections will assume that the entire ABC is harvested in each year.

The simulation model will track abundance-at-age, SSB, ABC, total removals by age and fleet, landings by age and fleet, and discards by age and fleet. A number of performance metrics will be highlighted and compared across simulation scenarios with emphasis on mean values and associated CV in these values over the first 10 and last 10 (i.e., implicit equilibrium) years. In particular, comparisons will highlight the fleet-specific mean ABC as well as the CV in fleet-specific ABC. For the fixed gear fleet, the mean landings and associated CV will be compared, given that landings will be less than the ABC due to dead discards. Similarly, the mean dead discards and associated CV will be reported to identify the level of biological waste under each scenario. Finally, the mean SSB and associated CV will help determine the biological implications, while the number of times the stock falls below B40% will also be reported.

A handful of simulation scenarios will be developed to address key uncertainties (Table 1). The *Base_Mean-Recr* scenario will assume the same dynamics as the current assessment and associated projections used to develop sablefish ABCs. Mainly, mean recruitment from the modern time series (1978 year class onwards) will be assumed with a full retention fixed gear fishery. The *Base_High-Recr* scenario will then be run using mean recruitment from the 2014 year class onwards to demonstrate how performance metrics change under an assumption of a regime shift in recruitment.

Multiple combinations of assumed retention, discard mortality, and recruitment will then be implemented to identify the impacts of and uncertainty associated with various discard and recruitment dynamics. A full factorial design will be implemented for each of the three factors. The long-term mean and high recruitment scenarios for all subsequent simulations will match those dynamics assumed in the associated no discarding scenarios that were just described. Three DMR rates will be simulated, which are meant to envelope a plausible range of DMRs, including a lower bound, an upper bound, and an expert judgment value. It is expected that, given the linear scaling of DMR and total mortality, using a plausible range of DMRs will enable adequate representation of the impacts of discarding. Similarly, it will avoid implementing incremental DMRs, which would greatly inflate the number of potential simulation scenarios. The upper bound on DMR is meant to better encapsulate uncertainty in the DMR due to the potential for increased predation by whales under a discarding scenario. The lower bound on DMR should likely reflect the situation where the DMR is solely due to handling mortality assuming there is no post-release whale predation but should be greater than zero as some degree of handling mortality is expected to occur under normal fishery operations where discarding is occurring.

For retention, a logistic function with infinite slope (i.e., knife-edge) will be assumed at age-3, because a 22 in (total length) MSL roughly corresponds to the average length at age-3. The knife-edge retention function is maintained for all simulations, because a) for the purpose of enforcement of a MSL, it is not feasible to have an 'optional' release (which would result in a non-knife-edge retention function), and b) given the lack of data on discarding (since the proposed action has yet to be implemented), the eventual assessment will not be able to directly estimate retention and will need to rely on a similar knife-edge assumption. Thus, though a non-knife-edge retention function could be simulated (i.e., if the authors are provided with the exact parameters of the function to be used), there is no data from which to realistically determine the parameterization of this function. Moreover, under the assumption of full compliance there should only be discards of fish at or below the MSL (i.e., resulting in a knife-edge retention function).

The results of the projection simulations will help identify the impacts of discarding on the sablefish resource and potential future ABCs. The goal is to provide insight into key uncertainties regarding the proposed small sablefish release action, including how DMR and assumed MSL might impact catch and SSB. However, the assumptions of these projection scenarios are highly uncertain and based on expert judgment as to appropriate values. For instance, very limited information exists as to the true discard mortality rate of released sablefish. Moreover, knife-edge retention functions assume full compliance and no high-grading of the catch. Without any existing data on sablefish discarding, it is very difficult to parametrize functions that model potential future dynamics. Additionally, the level of future recruitment is always an important uncertainty in projections, especially the further into the future that the simulation is run. Therefore, any results, especially those beyond a few years into the future, should be analyzed with caution. Further work to explore uncertainty in the assessment would best be achieved with a full management strategy evaluation (MSE), which represents the ideal analytical approach to adequately identify the tradeoffs among performance metrics, quantify risk, thoroughly address the potential for increased uncertainty or bias in the assessment model due to the proposed action, or determine HCRs that are more robust to sablefish dynamics (e.g., to address spasmodic recruitment).

5 SSC Action Items

- Recommend a sablefish DMR. If the SSC is not comfortable selecting a single value, another option for the SSC is to provide an upper and lower bound along with a preferred or expert judgment value that represents a plausible range to consider in the June analysis. Providing an envelope would reduce the number of simulation runs, while still encompassing the plausible impacts of discarding and enable quantification of the associated uncertainty.
- Provide feedback on the proposed simulation parametrization and scenarios to be run, including minor adjustments that should be made to the proposed methods (e.g., minimum size limits or retention selectivity), to ensure that the SSC's concerns and recommendations are being addressed. Given the factorial design of the study, any recommended changes should acknowledge the potential exponential increase in the number of simulation runs that will need to be analyzed. It is recommended that a discrete number of scenarios be maintained that represent only the most plausible options for the proposed action.
- Endorse the proposed analytical simulation approach (with any requested revisions) for evaluating the effects of the proposed action on the sablefish population and fishery. This approach would form the basis of the other sections of the environmental and socioeconomic impact assessments.

6 Tables and Figures

Table 1. Proposed simulation scenarios to project the impact on sablefish dynamics under different assumptions of discarding, recruitment, and discard mortality rate (DMR).

Abbreviation	Recruitment	Retention	DMR	Rationale
Base_Mean-Recr	Mean (1978+)	Full	None	Current biological and fishery dynamics, which match the 2023 SAFE ABC projections.
Base_High-Recr	Hi (Mean 2014+)	Full	None	Current dynamics, but assuming a recruitment regime shift.
Ret_Age-3_DMR-Low_Mean-Recr	Mean (1978+)	Age-3 (Knife-edge)	Lower Bound	Discarding action using the lower bound on DMR to address uncertainty.
Ret_Age-3_DMR-Low_High-Recr	Hi (Mean 2014+)	Age-3 (Knife-edge)	Lower Bound	Discarding action using the lower bound on DMR to address uncertainty and assuming a recruitment regime shift.
Ret_Age-3_DMR-Exp_Mean-Recr	Mean (1978+)	Age-3 (Knife-edge)	Expert Judgment	Best approximation of discarding action using expert judgment for the DMR.
Ret_Age-3_DMR-Exp_High-Recr	Hi (Mean 2014+)	Age-3 (Knife-edge)	Expert Judgment	Discarding action using expert judgment for the DMR and assuming a recruitment regime shift
Ret_Age-3_DMR-High_Mean-Recr	Mean (1978+)	Age-3 (Knife-edge)	Upper Bound	Discarding action using the upper bound on DMR to address uncertainty concerns (e.g., an increase in DMR to address whale predation).
Ret_Age-3_DMR-High_High-Recr	Hi (Mean 2014+)	Age-3 (Knife-edge)	Upper Bound	Discarding action using the upper bound on DMR to address uncertainty concerns (e.g., an increase in DMR to address whale predation) and assuming a recruitment regime shift.

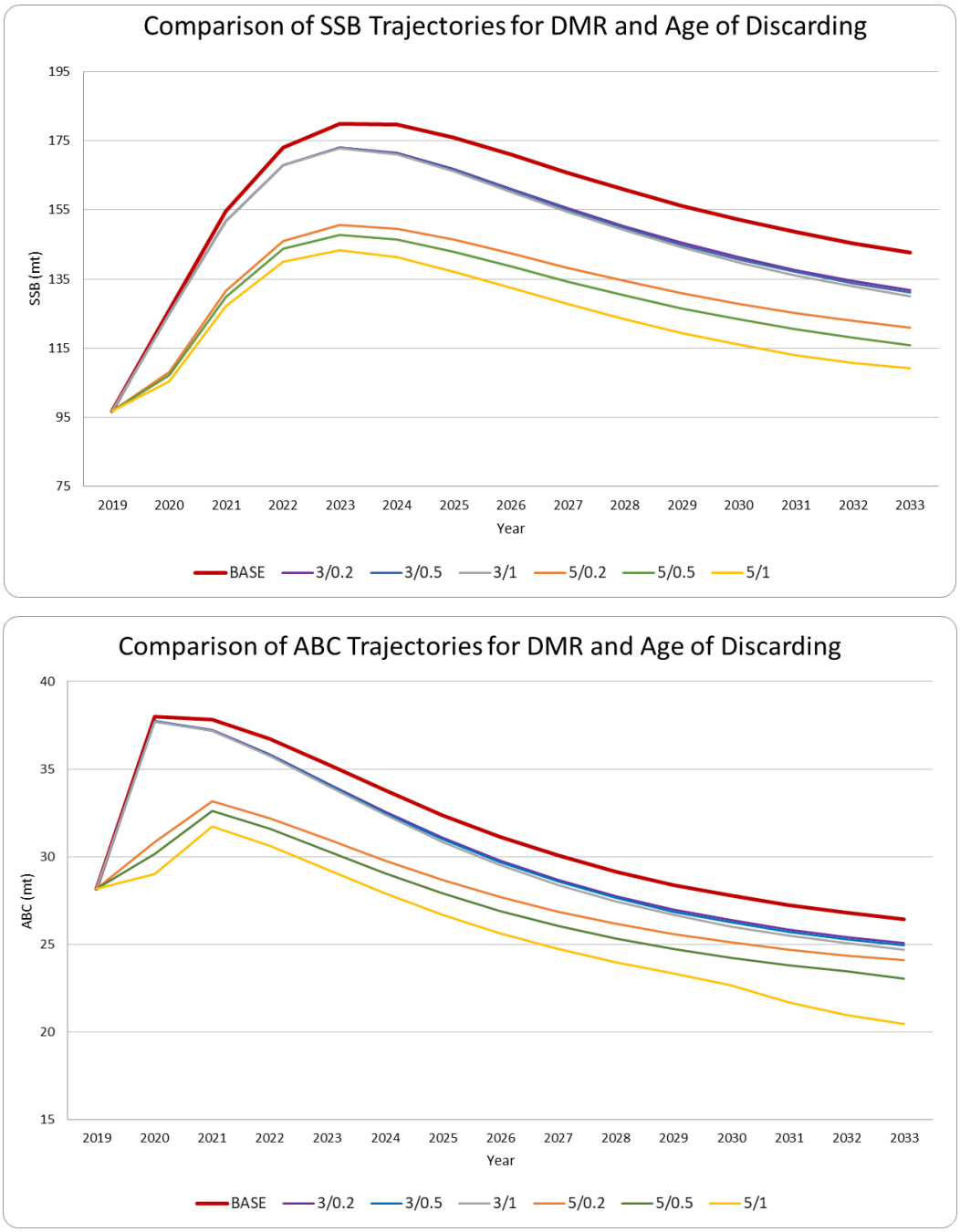

Figure 1. **Comparison of SSB (top panel) and ABC (bottom panel) trajectories under different assumptions of age at discarding (first number in each label) and discard mortality rate (second number in each label). For example, label 3/0.2 indicates knife-edge retention at age-3 with an assumed discard mortality rate of 20%. The 'BASE' model assumed full retention (i.e., no discarding). Results are from Hanselman et al. (unpublished) and utilize the parameters and assumptions of the 2018 sablefish SAFE.**

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Appendix 1. Requirements applicable to sablefish discarding in other regions/ fisheries

Region	Management program	Gear type	Regulations related to discarding (e.g., size limits, escape rings, application to quota)	At-sea monitoring	Port sampling
Alaska (federal waters)	Individual Fishing Quota	Hook-and-line	Mandatory full retention, no size limit, no discarding allowed	Mix of zero coverage (<40 foot vessels), human observers (target in 2022: 19% trip-level selection), and electronic monitoring (target in 2022: 30% trip-level selection).	None
Alaska (federal waters)	Individual Fishing Quota	Pot	Mandatory full retention, no size limit, no discarding allowed	Mix of zero coverage (<40 foot vessels), human observers (target in 2022: 17% trip-level selection), and electronic monitoring (target in 2022: 30% trip-level selection).	None
Alaska (state waters, Chatham Strait and Clarence Strait)	Equal Quota Share	Hook-and-line and Pot	Voluntary release program, no size limit, 3.75" escape rings required on all pots, flea bitten or dead fish must be retained. https://www.akleg.gov/basis/aac.asp#5.28.170 --- see (f) and (g) "A permit holder must retain all visibly injured or dead sablefish. Sablefish that are not visibly injured or dead may be released unharmed, but the permit holder must record the live releases in a logbook by gear settings."	None	Yes -- during Mark-Recap years, as many landings as possible are sampled. For all other years, we sample Mon-Fri work hours.
British Columbia	Individual Transferable Quota	Pot	All traps (pots) require two 3.5-inch escape rings. Minimum size limit for retention of 55 cm (approx. 21.65 in.). Sablefish <55 cm fork length are released by regulation in all fisheries. There are no quota deductions applied to releases of sub-legal fish (0% DMR). For legal sized sablefish that are released, there is a 100% DMR (100% of discards apply towards quota).	Electronic monitoring. 10% of hauls are video reviewed and tested against logbooks. It is up to fishery manager discretion to determine if 100% video review is required.	100% dockside monitoring provided by third party service provider

Region	Management program	Gear type	Regulations related to discarding (e.g., size limits, escape rings, application to quota)	At-sea monitoring	Port sampling
British Columbia	Individual Transferable Quota	Hook & Line	Minimum size limit for retention of 55 cm (approx. 21.65 in.). Sablefish <55 cm fork length are released by regulation in all fisheries. There are no quota deductions applied to releases of sub-legal fish (0% DMR). 100% DMR for legal sized sablefish (100% of discards apply towards quota). Exception is troll gear for which there is a DMR of 15% for legal sized sablefish.	Electronic monitoring. 10% of hauls are video reviewed and tested against logbooks. It is up to fishery manager discretion to determine if 100% video review is required.	100% dockside monitoring provided by third party service provider
British Columbia	Individual Transferable Quota	Trawl	Minimum size limit for retention of 55 cm. Sablefish <55 cm fork length are released by regulation in all fisheries. There are no quota deductions applied to releases of sub-legal fish (0% DMR). DMR for legal-sized fish is a function of towing time (25% discard mortality rate for the first hour fished or portion thereof and, 25% for each additional hour)	Electronic monitoring. There are several categories of audit of trip data. Baseline video to logbook review is 10% of fishing events for wetboats and 25% of fishing events for receiving tank vessels (RTVs). Additional review is required for larger discrepancies between EM and at-sea log data.	100% dockside monitoring provided by third party service provider
West Coast	Limited Entry/Individual Fishing Quota	Trawl	Discarding allowed for all IFQ vessels EXCEPT "shoreside whiting" vessels (land >50% hake/whiting) engaged in maximized retention. Maximized retention allows for the discard of minor operational amounts of catch at sea if the observer has accounted for the discard. All IFQ discards count towards quota with 100% mortality applied to fish < 28 cm (age-0 fish) and 50% mortality rate applied to fish >= 28 cm	100% observed with a human observer or EM. ~20% of EM trips also carry an observer. Vessels 125 ft or longer engaged in at-sea processing (e.g., at-sea whiting catcher-processors and motherships) must carry two observers; all others must carry one.	100% dockside catch monitoring provided by third party service provider to verify landings, as well as generally less than 100% port sampling of biological data by the respective state departments of fish and wildlife.

Region	Management program	Gear type	Regulations related to discarding (e.g., size limits, escape rings, application to quota)	At-sea monitoring	Port sampling
West Coast	Limited Entry/Individual Fishing Quota	Hook-and-line and Pot	Discarding allowed, discards count towards quota with 100% mortality applied to fish < 28 cm (age-0 fish) and 20% mortality rate applied to fish >= 28 cm	About 30% coverage on average with human observer but varies depending on WCGOP capacity. Vessels 125 ft or longer engaged in at-sea processing must carry two observers; all others must carry one. VMS required when fishing in federal waters.	Generally less than 100% port sampling of biological data by the respective state departments of fish and wildlife.
West Coast	Open Access	Hook-and-line	Discarding allowed, 100% mortality applied to observed discarded fish < 28 cm (age-0 fish) and 20% mortality rate applied to fish >= 28 cm	About 5% coverage on average with human observer but varies depending on WCGOP capacity. VMS required when fishing in federal waters.	Generally less than 100% port sampling of biological data by the respective state departments of fish and wildlife