# C4 Small Sablefish Release

North Pacific Fisheries Management Council
Science and Statistical Committee (SSC)
Kodiak, AK
June 2024

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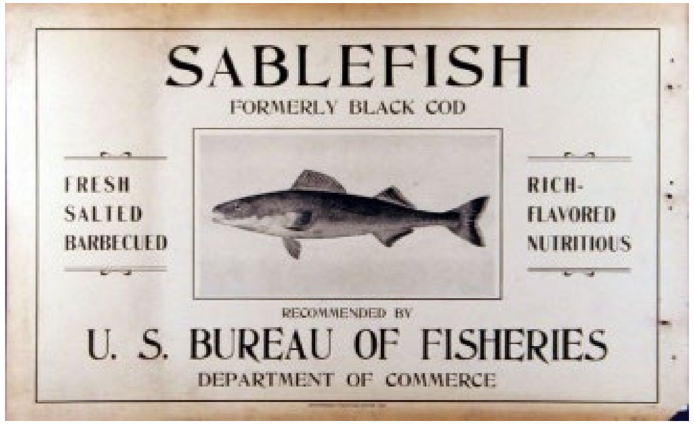
## A Projection Analysis Quantifying the Implications of the Proposed Small Sablefish Release Action

NOAA FISHERIES

# Outline

- Background on discard modeling
- Overview projection methods and input data
- Highlight scenarios explored
- Discuss results
- Identify biological and fishery implications
- Explore caveats and additional concerns
- Interactive app available to further explore results of this work: https://shinyfin.psmfc.org/small_sablefish/.





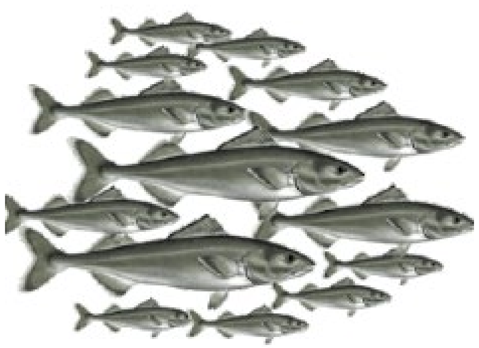
| id | recruitment | dmr | retention_age |
|---|---|---|---|
| hist-0-1 | historical | 0 | 1 |
| hist-12-3 | historical | 12 | 3 |
| hist-20-3 | historical | 20 | 3 |
| hist-35-3 | historical | 35 | 3 |

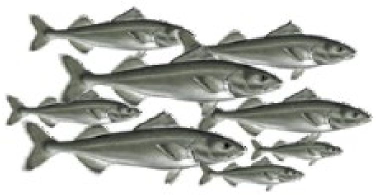
# Understanding Discard Impacts at ***a Given Age***

**Total Mortality** = Retained Fishing Mortality + Dead Discard Fishing Mortality + Natural Mortality

$$Z_a = F * Selectivity_a * Retention_a + F * Selectivity_a * (1 - Retention_a) * DMR + M_a$$

**Cohort Size**





## Impacts on a *Single Age Class*

**For a Given F, Selectivity, and Retention**

Abundance

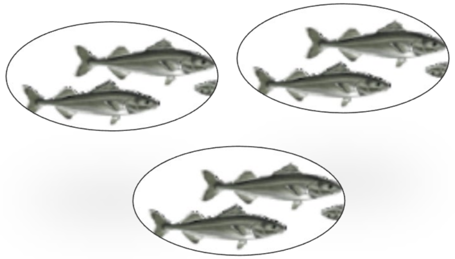
Retained Catch or Total Mortality

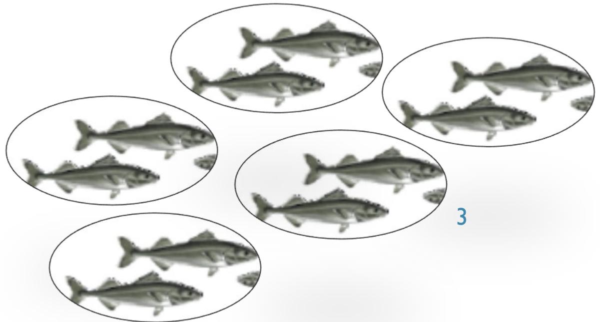
**Discarding (DMR=0)**

**Discarding (DMR>0)**

**Full Retention**

**Retained catch**





# Understanding Discard Impacts ***on the Population***

## Impacts on the *Population*

### Accounting for Biological (Weight, Maturity, and Natural Mortality) and Fishery (Selectivity and Retention) Processes Across All Ages

Minimum Size Limit (MSL) = Legal High-grading

**Discard smaller, low value fish to enable retaining a larger, more valuable fish.**

Pro: discarding small fish allows them to grow/mature, IF they survive (M, DMR).

Con: discarding allows high-grading to larger/mature fish (puts pressure on SSB) and increases effort.

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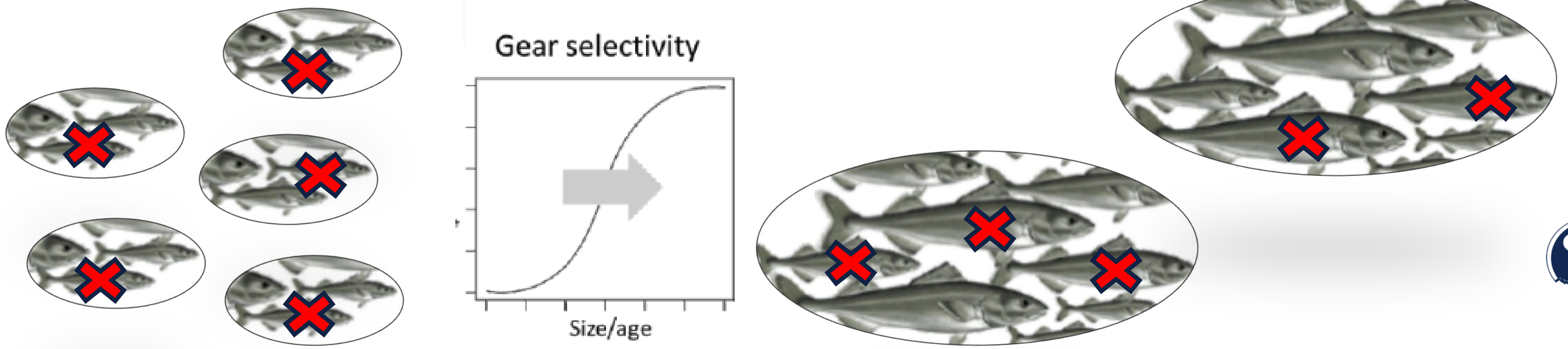
Full Retention



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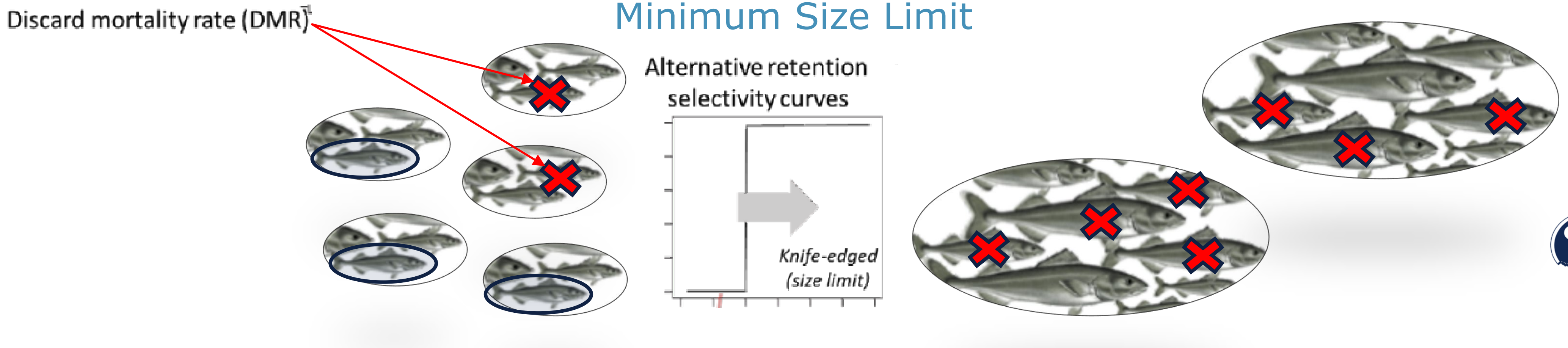
Minimum Size Limit



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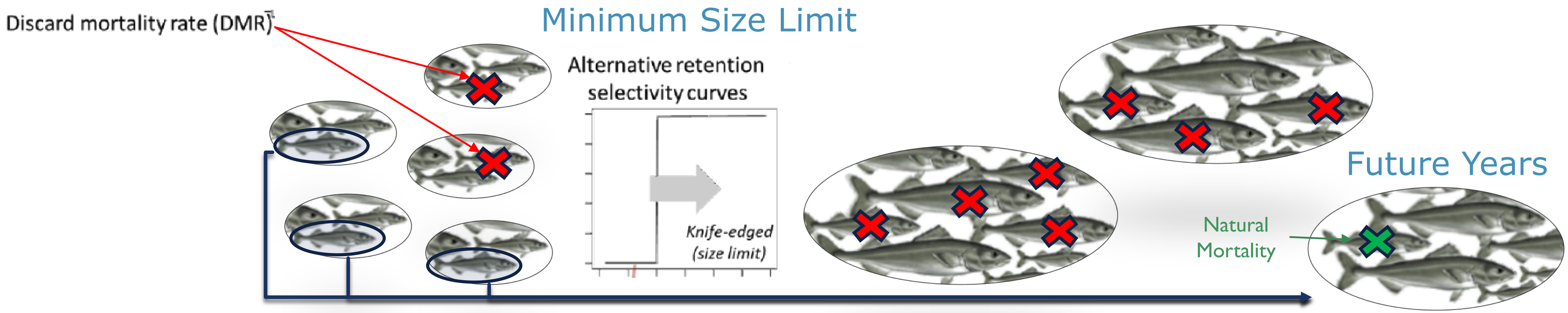

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**When is a Minimum Size Limit utilized to address conservation concerns?**

*Avoid harvesting too many small fish before they can spawn, when...*

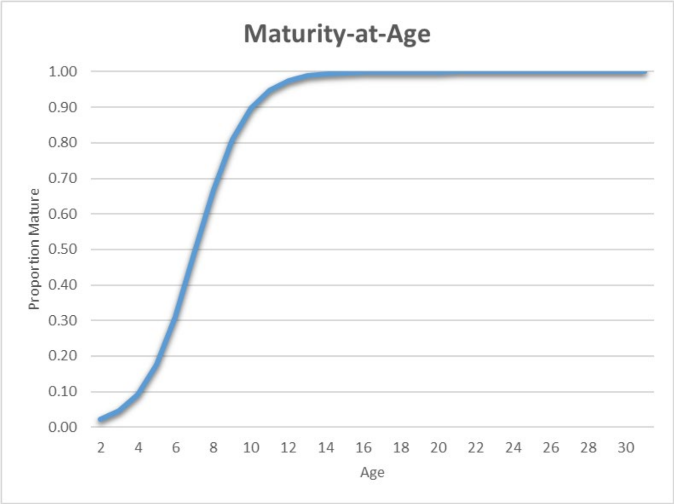
1. **High selectivity/F at young ages:** limit fishery to avoid overfishing.
2. High growth/maturation after recruitment: improve yields and SSB by delaying harvest.
3. Low M/DMR: high probability to survive (often why gear restrictions—larger mesh/hooks—preferred).
4. In combo with max size limit: harvest slots to protect mature fish from redirected effort.

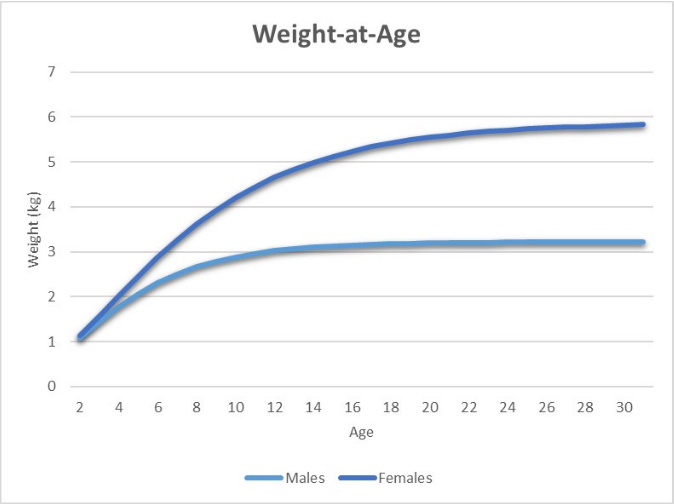
*Impacts depend on the interaction of biology and fishery processes.*

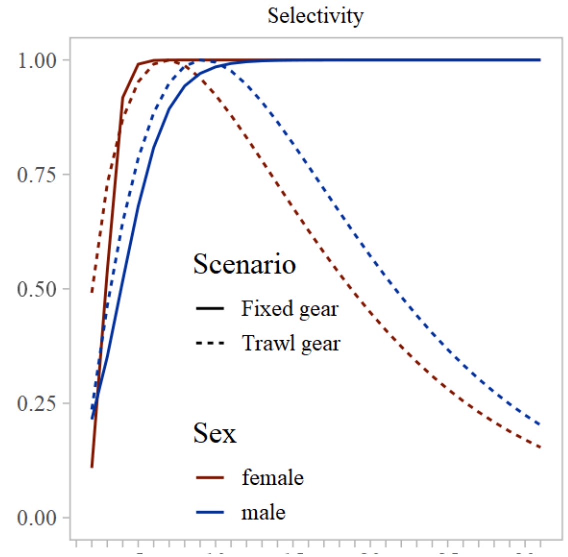
# Understanding Discard Impacts *for Sablefish*

## Impacts on the *Population*

### Accounting for Biological (Weight, Maturity, and Natural Mortality) and Fishery (Selectivity and Retention) Processes Across All Ages




Recruitment to sablefish fishery is already delayed (i.e., ~Age-2).
Selectivity of sablefish is generally low on small/young fish.
Survival to mature size/ages is moderate, with strong natural mortality tradeoff (M >> F at age-2).
Growth is moderate after recruitment, but maturation occurs well after recruitment.

# Understanding Discard Impacts *for Sablefish*

## Impacts on the *Population*

### Accounting for Biological (Weight, Maturity, and Natural Mortality) and Fishery (Selectivity and Retention) Processes

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. Altering minimum retention sizes below 45 cm will have little noticeable effect on either yield or landed value.

**--Funk and Bracken, 1983**

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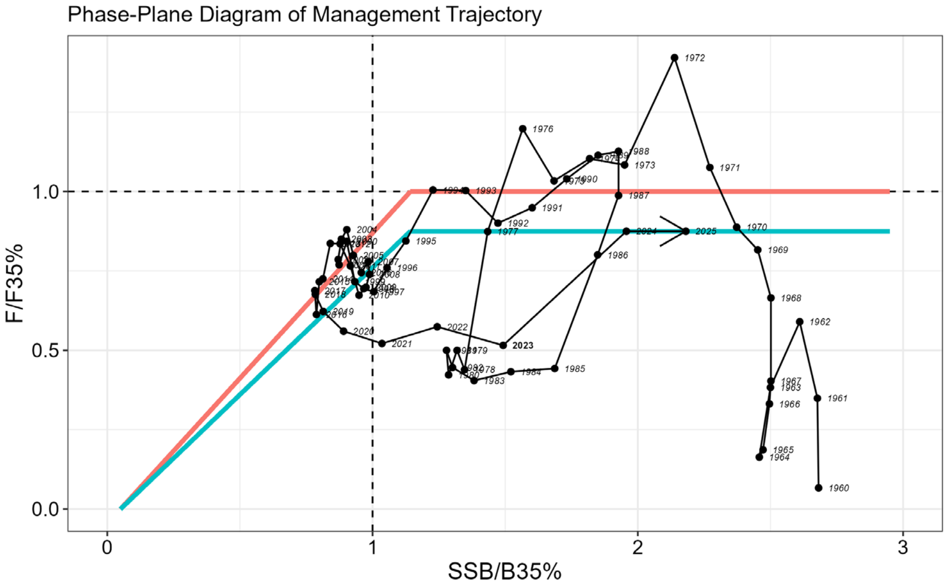
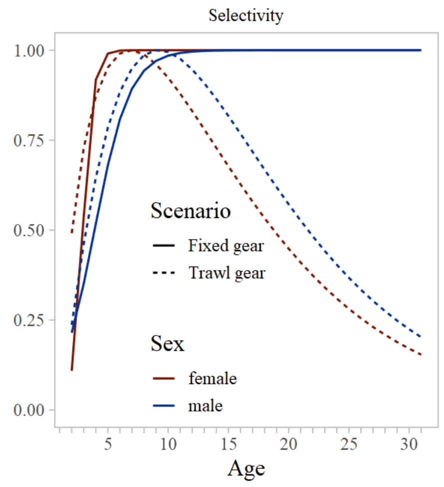
# Methods: Projection Framework

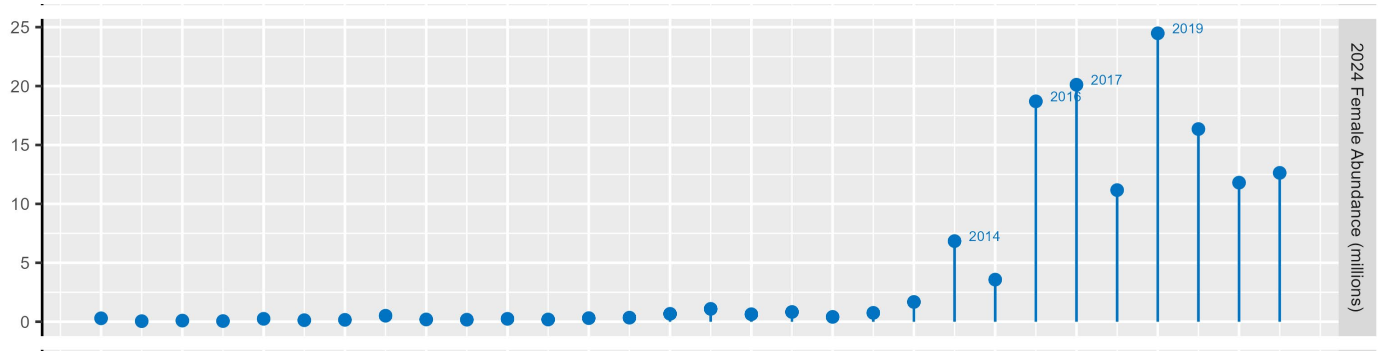
- Adapt the NPFMC ABC catch projection model to allow for discarding.
  - **Similar to NPFMC (2019) projections.**
- Model structure:
  - **Age- and sex-structured forward simulation for 50 years.**
  - **Catch projected using the NPFMC $F_{40\%}$ sloped HCR (stock status determines F).**
    - **Assume a dead removals-based (retained landings + dead discards) ABC accounting (as opposed to landings only as in NPFMC, 2019).**
  - **Recruitment sampled with replacement from the SAFE time series (typical projections use a probability distribution).**
  - **500 iterations to encapsulate variation (primarily in recruitment).**
- ***No economic or fishery behavior integrated.***
  - ***Biological model only.***

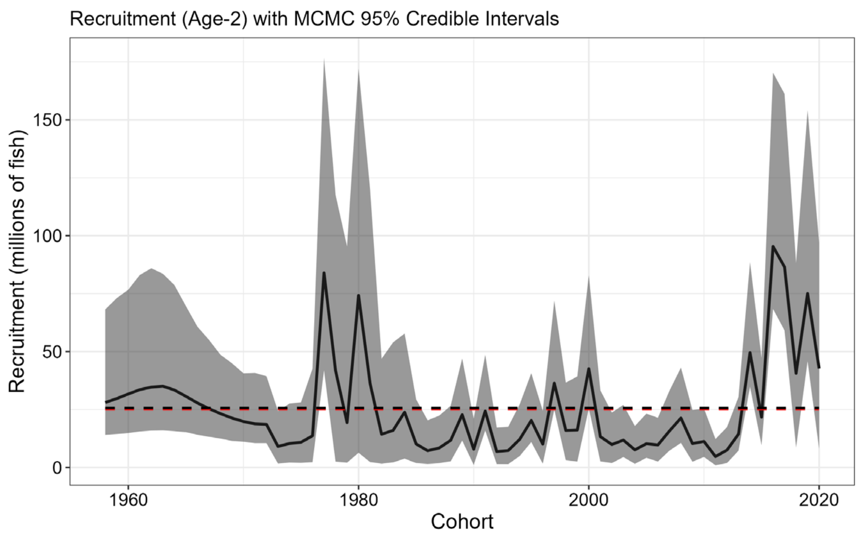


# Methods: Data Inputs

- Inputs from 2023 SAFE:
  - **Biology (i.e., weight-at-age, maturity, and natural mortality).**
  - **Fishery selectivity (i.e., for the fixed gear and trawl fleets).**
  - **Terminal year fishing mortality ratio among fleets (74.5% : 25.5%, Fixed Gear : Trawl)**
  - **Three year average % ABC harvested (66%) to perform more realistic ‘specified catch’ projections.**
  - **Terminal year abundance-at-age.**
  - **Recruitment estimates.**



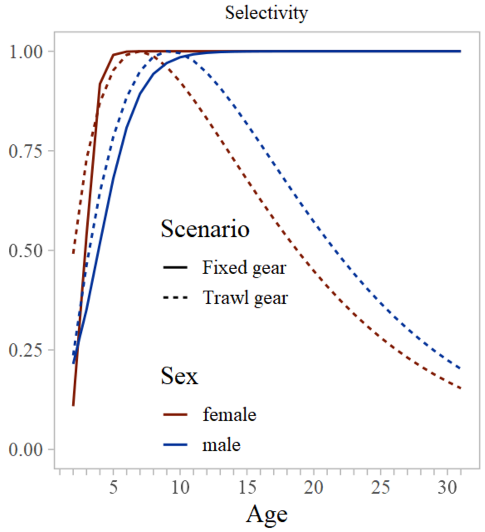



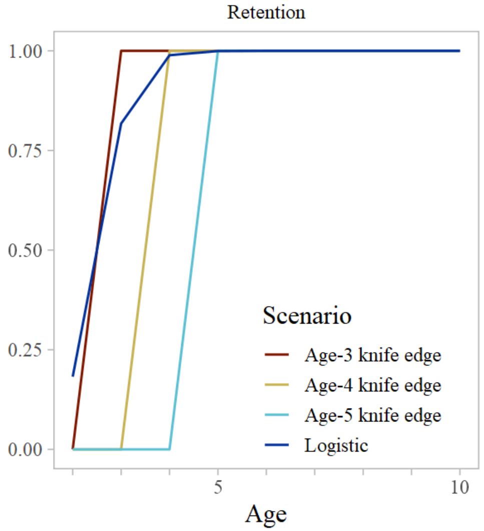



# Methods: Assumptions

- Primary Uncertainties and Comparison Axes:
  - **Retention (trawl fleet is full retention):**
    - **Full retention (status quo).**
    - **Minimum Size Limit (MSL) .**
      - **22in total length ( = 56cm TL or 52-53cm FL) MSL.**
      - **Assume knife-edge retention at age-3.**
        - **Cannot effectively model ‘voluntary’ release, so this represents the maximum discarding (i.e., a minimum size limit with full compliance).**
        - **All fish < age-2 are discarded, all fish age-3 or older are retained.**
  - **Discard mortality rate (DMR):**
    - **12%, 20%, and 35%.**
    - **Values specified by SSC in Feb. 2024.**

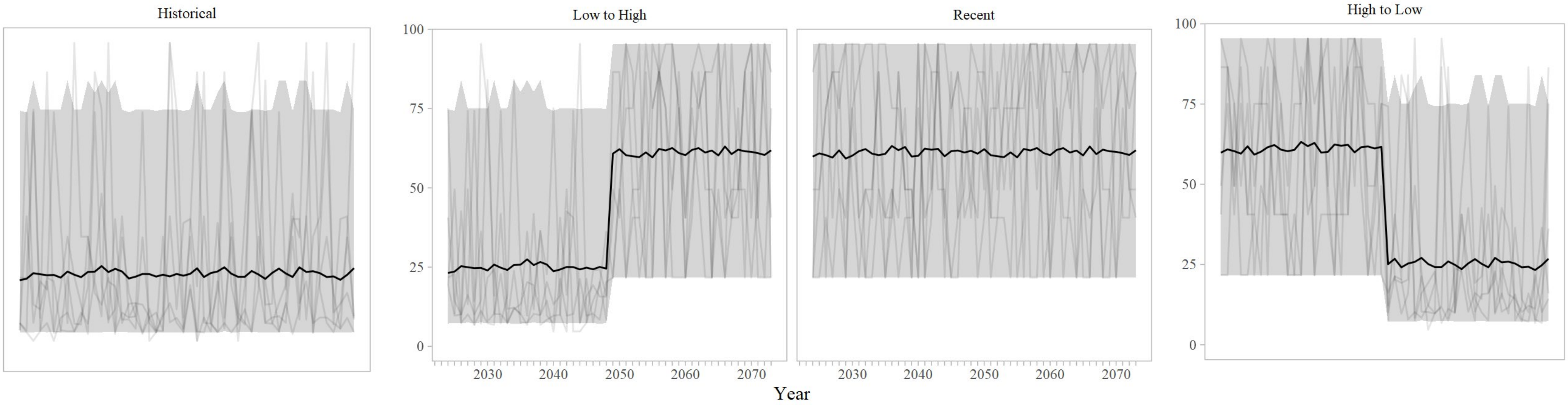
| | Fork Length (cm) | | Round Weight (kg) | |
|---|---|---|---|---|
| **Age** | Male | Female | Male | Female |
| **2** | 47.9 | 48.0 | 1.1 | 1.1 |
| **3** | 52.0 | 53.2 | 1.4 | 1.6 |
| **4** | 55.3 | 57.6 | 1.8 | 2.0 |
| **5** | 57.9 | 61.3 | 2.1 | 2.5 |
| **6** | 60.0 | 64.4 | 2.3 | 2.9 |
| **7** | 61.6 | 67.0 | 2.5 | 3.3 |
| **8** | 62.9 | 69.2 | 2.7 | 3.6 |
| **9** | 64.0 | 71.1 | 2.8 | 3.9 |
| **10** | 64.8 | 72.7 | 2.9 | 4.2 |



# Methods: Assumptions

- Primary Uncertainties and Comparison Axes:
  - **Projected recruitment time series:**
    - **Chosen with replacement from SAFE time series.**
    - **4 scenarios (determined by SSC) differing by the portion of the time series (historical: 1979-2021, or recent: 2016-2023) recruitment was chosen from and whether a transition (at mid-point of projection period) among regimes occurs.**



# Methods: Assumptions

- Primary Uncertainties and Comparison Axes:
  - **Price (for calculating gross revenue, tabulated for *fixed gear only*):**
    - **Price grades assigned to age based on dressed weight in lbs.**
    - **Price per lbs. (dressed weight) converted to price per kg (whole weight).**
    - **Main scenarios assumed time-invariant 2023 prices for all years.**
    - **Naïve evaluation of fishery performance, but improved resolution over landings only.**

| | Price Grade | | | | | |
|---|---|---|---|---|---|---|
| **Year** | 1/2 | 2/3 | 3/4 | 4/5 | 5/7 | 7+ |
| **2015** | $4.22 | $4.27 | $5.19 | $6.09 | $7.55 | $8.94 |
| **2016** | $4.85 | $5.05 | $5.78 | $6.63 | $8.16 | $10.04 |
| **2017** | **$5.70** | **$6.05** | **$7.16** | **$8.25** | **$9.34** | **$10.70** |
| **2018** | $1.63 | $2.89 | $4.13 | $5.28 | $8.27 | $9.14 |
| **2019** | $1.49 | $2.06 | $2.71 | $3.56 | $5.88 | $6.69 |
| **2020** | $0.45 | $1.19 | $1.74 | $2.17 | $3.33 | $4.97 |
| **2021** | $0.96 | $1.91 | $2.46 | $2.84 | $3.78 | $5.60 |
| **2022** | $0.84 | $1.75 | $2.40 | $3.57 | $5.97 | $6.94 |
| **2023** | **$0.43** | **$0.95** | **$1.34** | **$1.88** | **$4.33** | **$5.35** |
| **Mean** | **$2.29** | **$2.90** | **$3.66** | **$4.47** | **$6.29** | **$7.60** |

| | Price Grade | |
|---|---|---|
| **Age** | Male | Female |
| **2** | 1/2 | 1/2 |
| **3** | 2/3 | 2/3 |
| **4** | 2/3 | 2/3 |
| **5** | 2/3 | 3/4 |
| **6** | 3/4 | 3/4 |
| **7** | 3/4 | 4/5 |
| **8** | 3/4 | 4/5 |
| **9** | 3/4 | 5/7 |
| **10** | 4/5 | 5/7 |
| **11** | 4/5 | 5/7 |
| **12** | 4/5 | 5/7 |
| **13** | 4/5 | 5/7 |
| **14** | 4/5 | 5/7 |
| **15** | 4/5 | 7+ |
| **16** | 4/5 | 7+ |
| **17** | 4/5 | 7+ |
| **18** | 4/5 | 7+ |
| **19** | 4/5 | 7+ |
| **20** | 4/5 | 7+ |
| **21** | 4/5 | 7+ |
| **22** | 4/5 | 7+ |
| **23** | 4/5 | 7+ |
| **24** | 4/5 | 7+ |
| **25** | 4/5 | 7+ |
| **26** | 4/5 | 7+ |
| **27** | 4/5 | 7+ |
| **28** | 4/5 | 7+ |
| **29** | 4/5 | 7+ |
| **30** | 4/5 | 7+ |
| **31+** | 4/5 | 7+ |

# Methods: Output Metrics

- Outputs:
  - **Trajectory of population and fishery (SSB, retained catch, dead discards, and gross revenue) over the time series.**
  - **Summary of mean/median values for first 10 years and all years (Table in doc).**
- ***Primary comparisons:***
  - **What is the impact on population and fishery of moving from full retention to a MSL (discarding of age-2 fish) under differing DMRs?**
  - **How does future recruitment impact interpretation of results?**
- Sensitivity comparisons:
  - **What is the impact of increasing the age of retention (i.e., to account for uncertainty in implementation or enforcement)?**
  - **How do price assumptions impact gross revenue calculations?**
  - **Does ABC utilization or proportion of catch from trawl fleet impact interpretations?**

# Methods: Main Scenarios

- Emulated the release motion while addressing SSC requests to encapsulate uncertainty.
- Differ in recruitment, retention, and DMR assumptions.

| Abbreviation | Recruitment | Retention | DMR | % ABC Harvested | % Catch from Trawl | Price |
|---|---|---|---|---|---|---|
| *Full_Retention* | Historical | Full | None | 66% | 25.5% | 2023 (Fixed) |
| *Hist_Recr_DMR_12%* | Historical | Age-3 (Knife-edge) | 12% | 66% | 25.5% | 2023 (Fixed) |
| *Hist_Recr_DMR_20%* | Historical | Age-3 (Knife-edge) | 20% | 66% | 25.5% | 2023 (Fixed) |
| *Hist_Recr_DMR_35%* | Historical | Age-3 (Knife-edge) | 35% | 66% | 25.5% | 2023 (Fixed) |
| *Rec_Recr_Full_Ret* | Recent | Full | None | 66% | 25.5% | 2023 (Fixed) |
| *Rec_Recr_DMR_12%* | Recent | Age-3 (Knife-edge) | 12% | 66% | 25.5% | 2023 (Fixed) |
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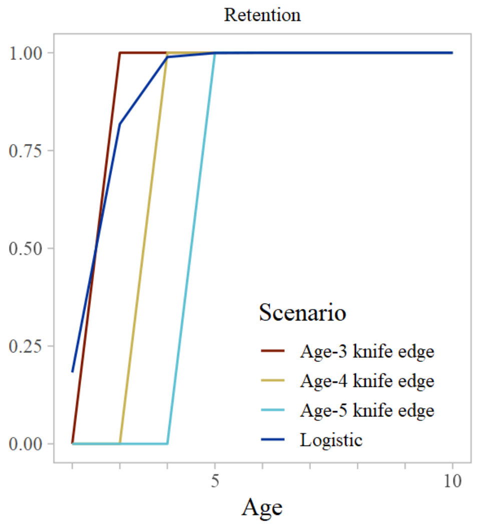
| *Rec_Recr_DMR_35%* | Recent | Age-3 (Knife-edge) | 35% | 66% | 25.5% | 2023 (Fixed) |
| *Lo_Hi_Recr_Full_Ret* | Low-High | Full | None | 66% | 25.5% | 2023 (Fixed) |
| *Lo_Hi_Recr_DMR_12%* | Low-High | Age-3 (Knife-edge) | 12% | 66% | 25.5% | 2023 (Fixed) |
| *Lo_Hi_Recr_DMR_20%* | Low-High | Age-3 (Knife-edge) | 20% | 66% | 25.5% | 2023 (Fixed) |
| *Lo_Hi_Recr_DMR_35%* | Low-High | Age-3 (Knife-edge) | 35% | 66% | 25.5% | 2023 (Fixed) |
| *Hi_Lo_Recr_Full_Ret* | High-Low | Full | None | 66% | 25.5% | 2023 (Fixed) |
| *Hi_Lo_Recr_DMR_12%* | High-Low | Age-3 (Knife-edge) | 12% | 66% | 25.5% | 2023 (Fixed) |
| *Hi_Lo_Recr_DMR_20%* | High-Low | Age-3 (Knife-edge) | 20% | 66% | 25.5% | 2023 (Fixed) |
| *Hi_Lo_Recr_DMR_35%* | High-Low | Age-3 (Knife-edge) | 35% | 66% | 25.5% | 2023 (Fixed) |

# Methods: Sensitivity Scenarios

- Sensitivity runs for:
  - **Retention (knife-edge at age-4 or age-5; logistic with limited age-3 + age-4 discarding)**
  - **ABC utilization (100%)**
  - **Proportion trawl F (decreased to 10%)**
  - **Price (average price; price inversely proportional to landings)**

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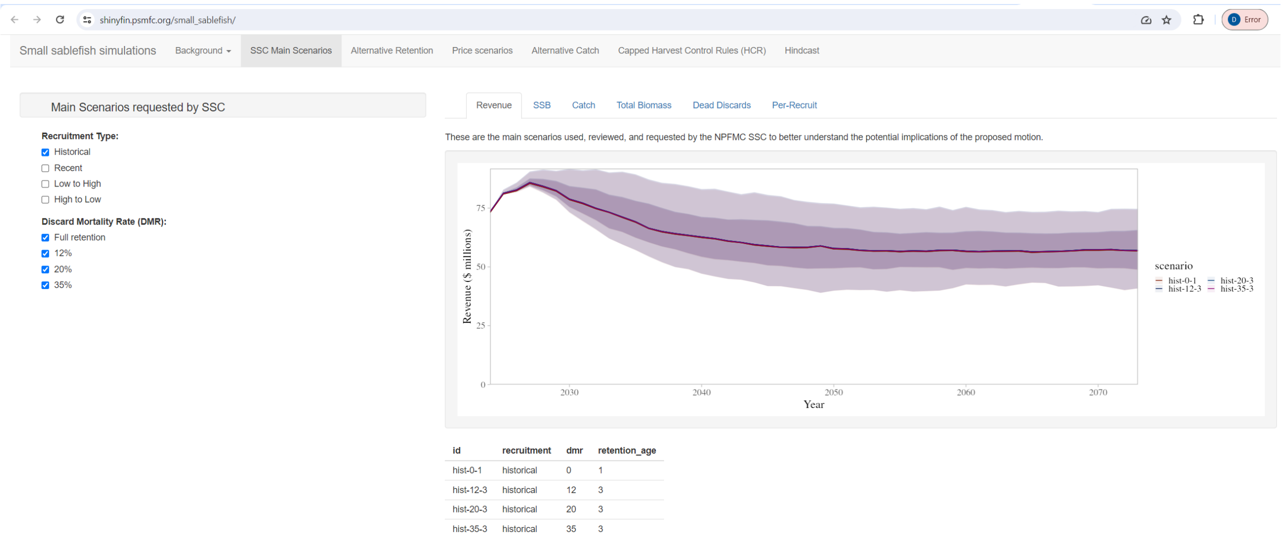
| *Hist_Recr_DMR_20%* | Historical | Age-3 (Knife-edge) | 20% | 66% | 25.5% | 2023 (Fixed) |
| *Age-4_Ret_Hist_Recr_DMR_20%* | Historical | Age-4 (Knife-edge) | 20% | 66% | 25.5% | 2023 (Fixed) |
| *Age-5_Ret_Hist_Recr_DMR_20%* | Historical | Age-5 (Knife-edge) | 20% | 66% | 25.5% | 2023 (Fixed) |
| *Log_Ret_Hist_Recr_DMR_20%* | Historical | Logistic | 20% | 66% | 25.5% | 2023 (Fixed) |
| *Full_ABC_Hist_Recr_Full_Ret* | Historical | Full | None | 100% | 25.5% | 2023 (Fixed) |
| *Trwl_10%_Hist_Recr_DMR_20%* | Historical | Age-3 (Knife-edge) | 20% | 66% | 10% | 2023 (Fixed) |
| *Price_Avg_Hist_Recr_DMR_20%* | Historical | Age-3 (Knife-edge) | 20% | 66% | 25.5% | Average (2015—2023) |
| *Price_Var_Hist_Recr_DMR_20%* | Historical | Age-3 (Knife-edge) | 20% | 66% | 25.5% | Variable (Inversely Proportional to Landings) |

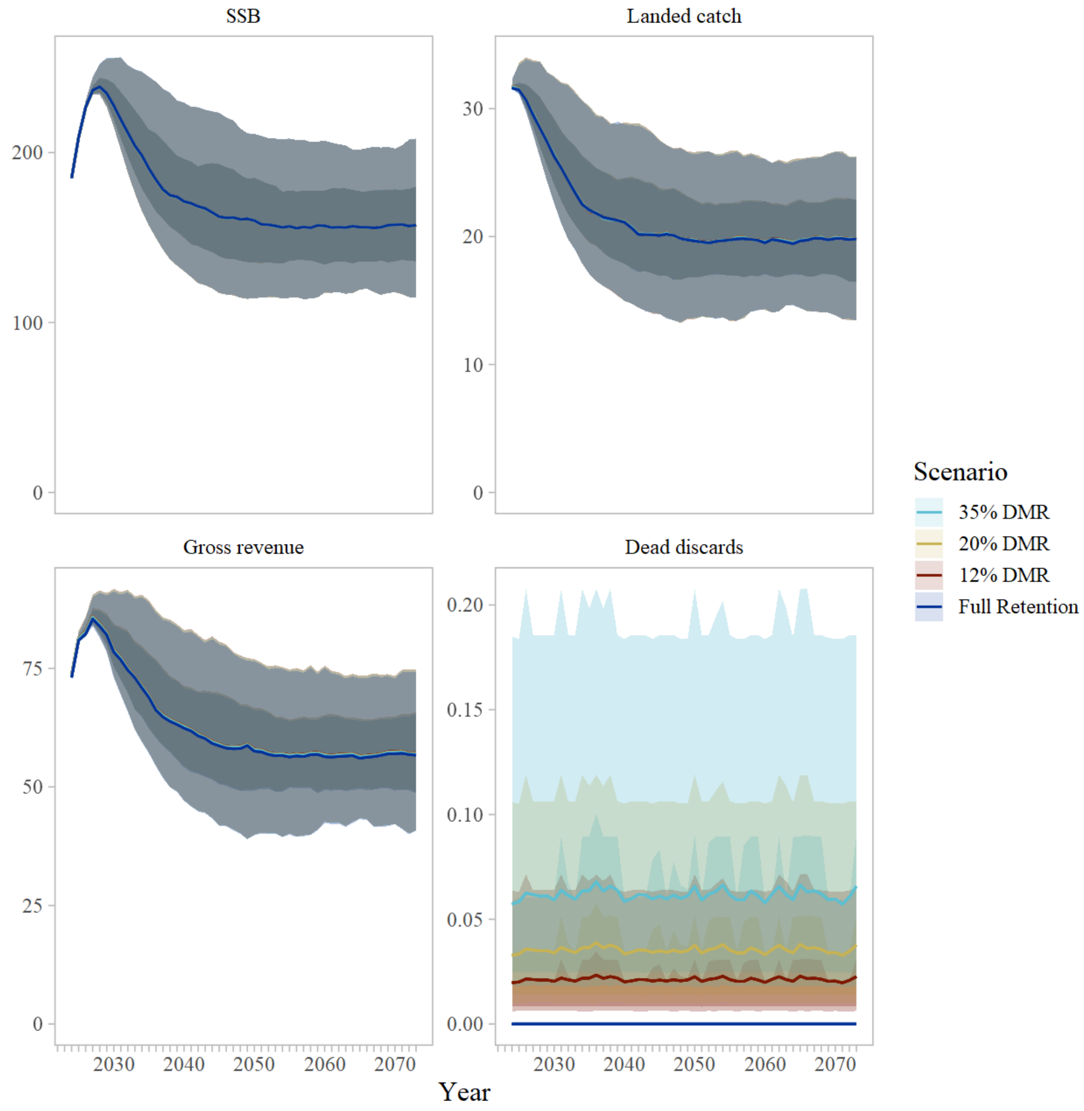
# Methods: Shiny App

- Ben Williams developed a user-friendly shiny app to illustrate impacts of retention and DMR options-- https://shinyfin.psmfc.org/small_sablefish/.
  - **Provides results in an interactive format to aid understanding and comparisons.**
- Includes full factorial combination of sensitivity runs and some alternate runs, which were not meant for review (provided to further aid understanding of model dynamics).
- Intended to enable interested parties to explore assumptions and consider impacts on their own and in a different format from a management document.



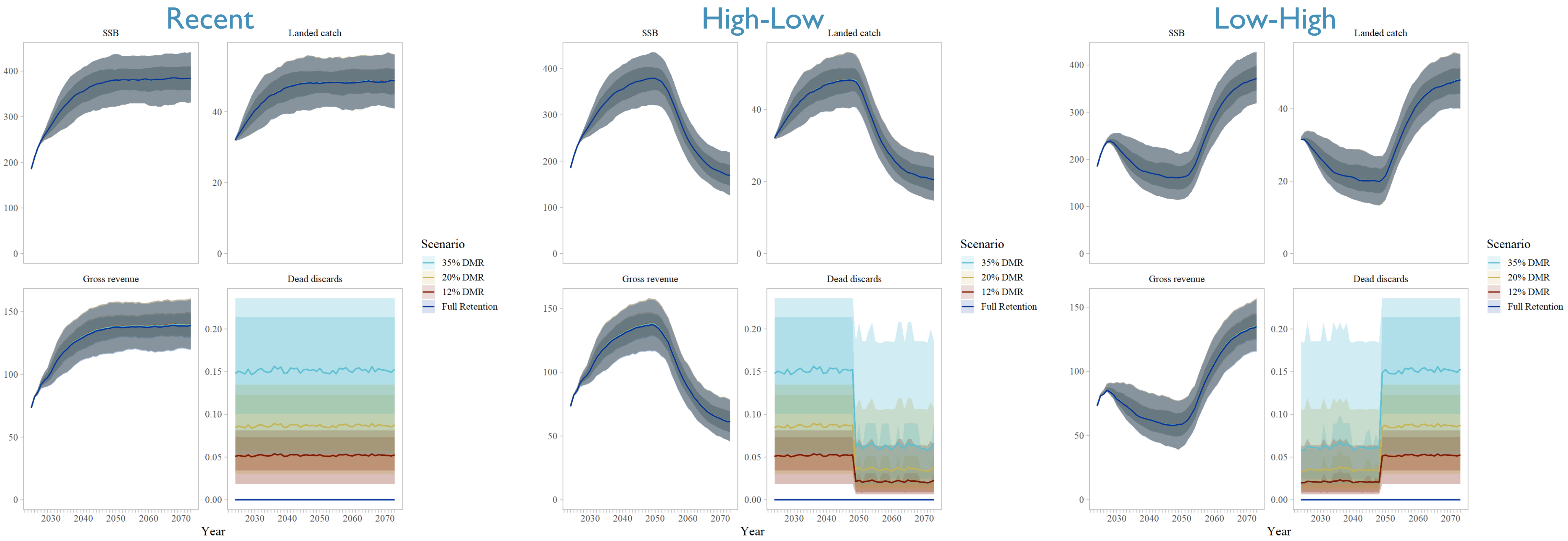
# Results: Historical Recruitment

- Dead discards are minimal under all discarding scenarios.
- Allowing discarding has extremely limited impact on most metrics.
  - **Slight improvement in gross revenue.**
- SSB and revenue lag max catch.
  - **Catch maximized when exploitable biomass is highest.**
  - **SSB and revenue maximized when older individual are present.**
- Long-term metrics reduced as recruitment returns to long-term average.
- Probability of entering an overfished state is independent of discarding assumption.
  - **< 7% of all years across all iterations were in an overfished state for a given retention and DMR.**



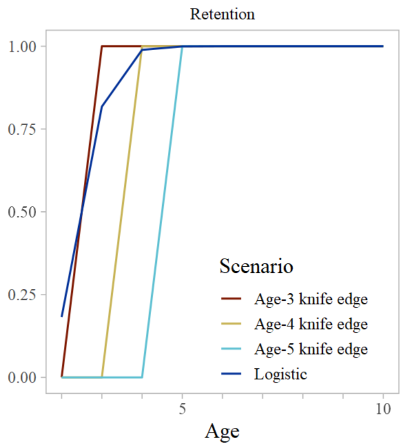
# Results: Alternate Recruitment Scenarios

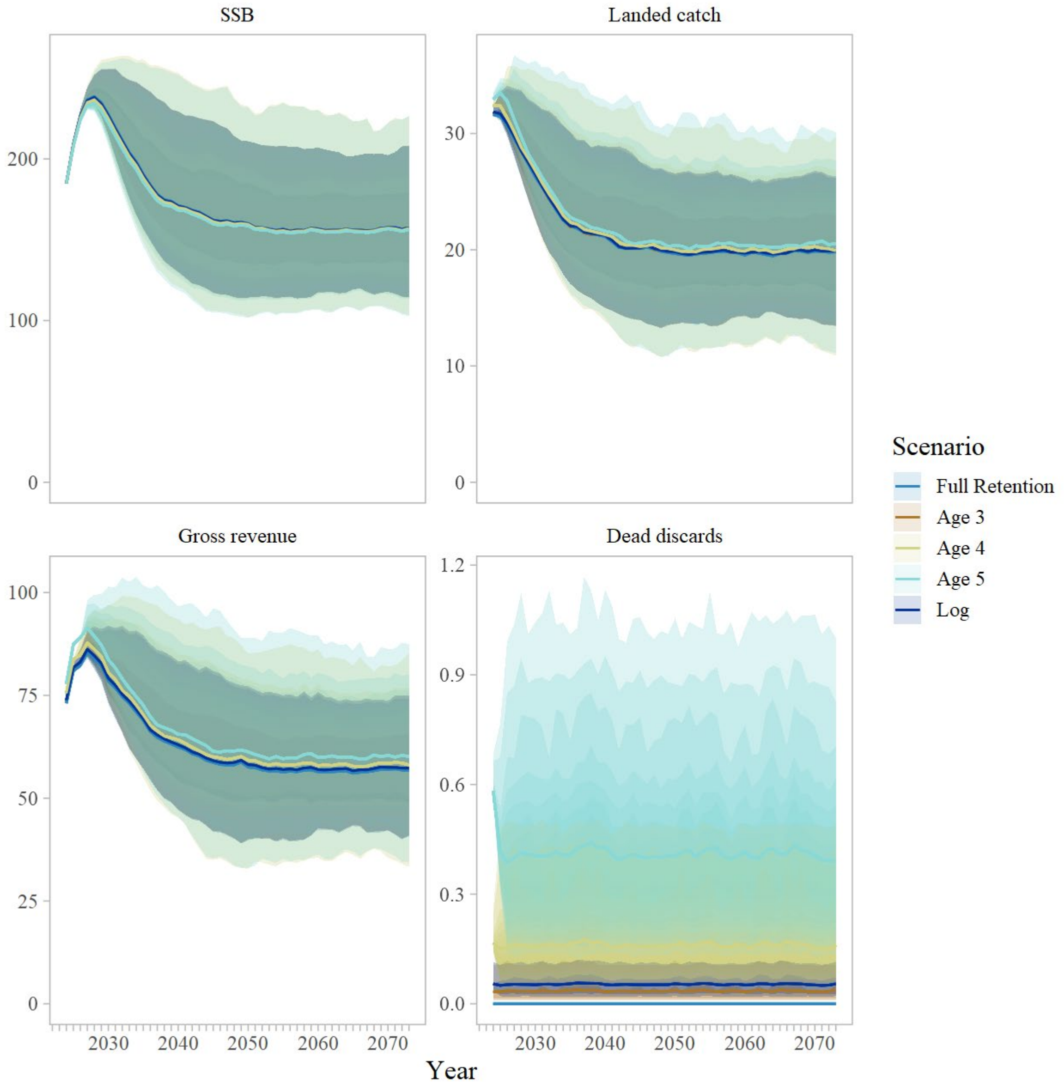
- Relative impacts of discarding independent of recruitment time series.
- Recruitment time series (not discarding assumption) had biggest impact on metrics.
  - **Higher SSB, catch, and gross revenue when recruitment transitions to higher average levels.**



# Results: Alternate Retention Scenarios

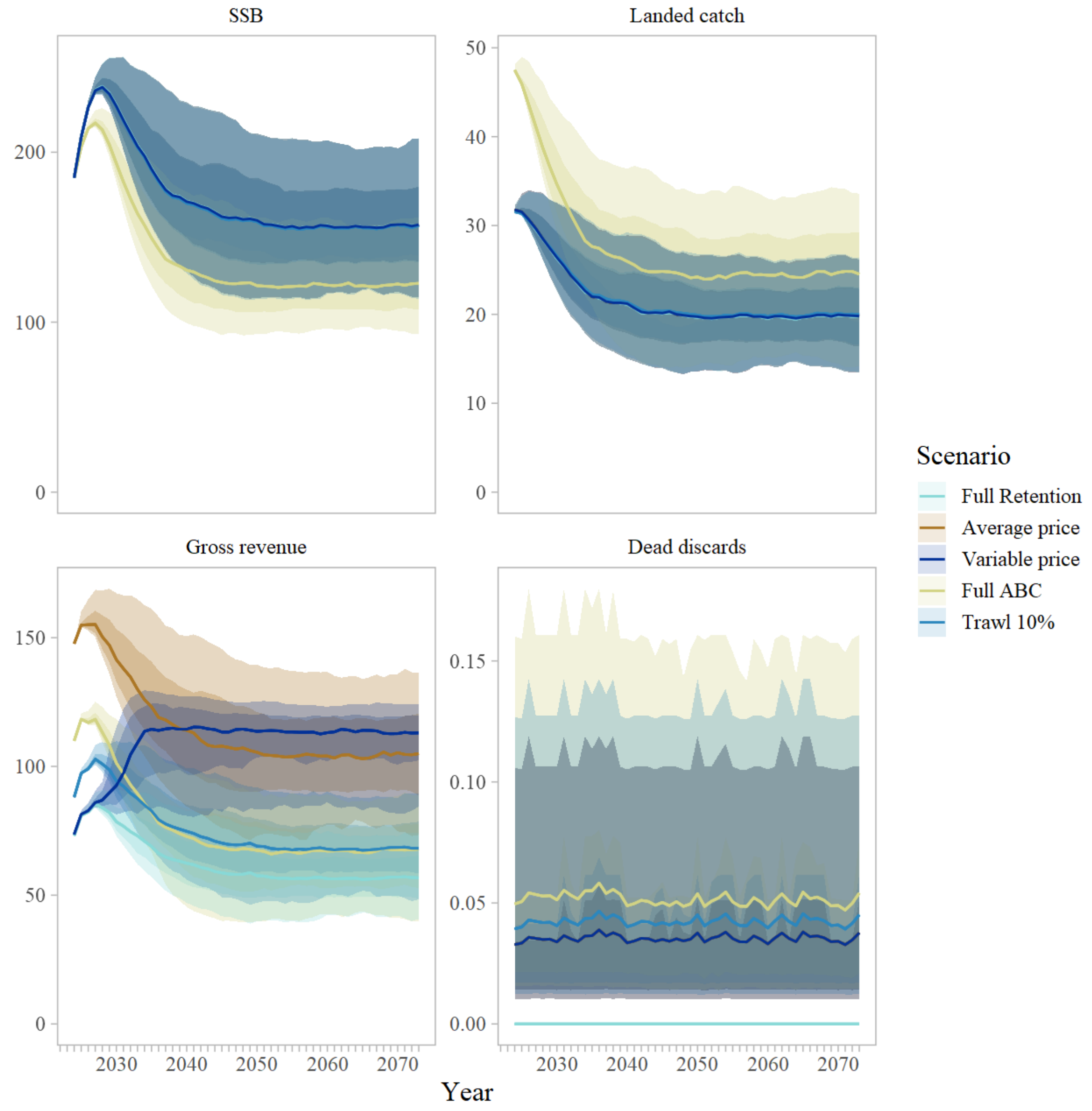
- Age of retention has moderate impact on output metrics.
  - **As age of retention is increased:**
    - **Dead discards increase.**
    - **SSB declines.**
    - **Landed catch and gross revenue increase.**
  - **Probability of entering an overfished state increased only slightly.**
- The logistic selectivity scenario represented an intermediary between age-3 retention and increased age of retention scenarios.



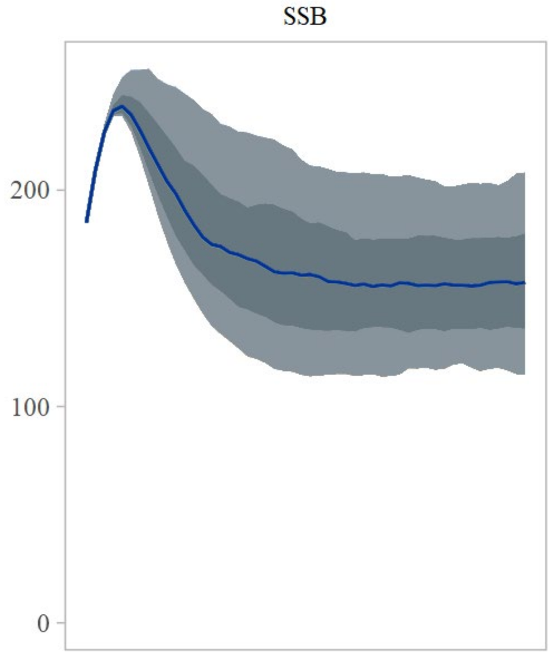
# Results: Sensitivity Scenarios

- Assumption regarding % utilization of the ABC had largest impact on probability of entering an overfished state.
  - **33% probability vs. 7% (for 66% ABC utilization).**
  - **Independent of discarding assumption.**
  - **Indicative that the $F_{40\%}$ HCR may not be robust to spasmodic recruitment.**
- Decreasing the % harvested by the trawl fleet had minimal impacts.
  - **Slight reduction in SSB due to increased selectivity of older fish.**
  - **Increase in revenue for fixed gear fleet.**
- When price is inversely proportional to landings, long-term gross revenue actually increases as landing return to ~2017 conditions (e.g., implicitly assuming market saturation dissipates).



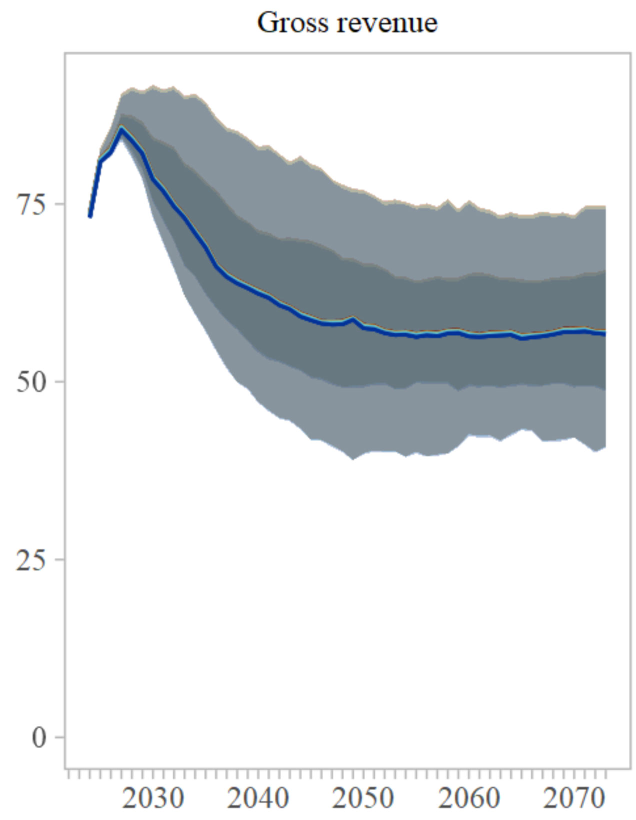
# Implications: Biological

- No conservation benefit, but no negative consequences from a simulation standpoint.
- Generally low probability of entering an overfished state.
  - **Independent of whether discarding is allowed or not.**
- Why does discarding not have more of an impact?
  - **Low selectivity at age-2, so very few fish being released.**
  - **Low fishing mortality, so limited harvest at age-2.**
  - **Comparatively high natural mortality (10%), which negates benefits of release.**
- Discarding with lowest DMR (12%) reduces age-2 mortality by 1%.
  - **Declines from 12% (full retention) to 11% (discarding with 12% DMR).**
- Released fish in first projection year add ~0.5kt to SSB over the lifespan of the cohort (~0.3% increase in SSB).



# Implications: Fishery

- Gross revenue increases slightly.
- Effort increases under discarding, likely with associated costs.
- Given tradeoff in size/weight of fish between age-2 and larger ages, likely to be limited opportunity to high-grade.
  - **For example, one grade 3/4 fish can be kept for every 3 age-2 fish released.**
- Age of retention has biggest impact on results.
  - **As retention age is delayed, more fish are released.**
  - **Catch and revenue increase, while SSB declines (increased harvest of older/larger fish).**
  - **Effort increases rapidly (age-5 retention associated with 12% increase in F).**



# Caveats: Model and Assumptions

- Predicting the future impossible, but…
  - **Projected impacts of discarding appear robust to alternate future recruitment dynamics.**
- Probability of entering an overfished state independent of discarding assumptions.
  - **More of an issue for the $F_{40\%}$ HCR as applied to long-lived, spasmodically recruiting species.**
- Incorrect parameter values/assumptions could impact results (see doc).
- A more sophisticated bioeconomic modeling framework would be warranted to adequately understand economic implications.
  - **Requires better economic data in the long-term.**
- Addressing behavioral changes when moving from full retention to legal discarding would necessitate a fishery behavior or agent-based model.
  - **The current biological model is not equipped to integrate complex behavioral changes, except implicitly by changing % ABC harvested, selectivity, retention, etc.**

# Scientific Uncertainty

- Increases in scientific uncertainty under this motion due to:
  - **Loss of data on age-2 recruitment (fewer age/length samples).**
  - **Limited data on discarding.**
    - **Need data on:**
      - **Magnitude of discards.**
      - **Size/age composition of discards.**
      - **Discard mortality rate.**
    - **Availability and precision of each data type will impact assessment uncertainty.**
- If data limited, would need to fix discard parameters (DMR, retention) or start the model at age-3 (since no data on age-2 dynamics).
- Likely to be author proposed risk table reductions from max ABC to address increased assessment uncertainty.

*Increasing stock assessment uncertainty*

| Scenarios | Data used in stock assessment | Ability to estimate: | | | Example |
|---|---|---|---|---|---|
| | | *Gear selectivity* | *Retention selectivity* | *Discard mortality rate (DMR)* | |
| **Mandatory retention with at-sea observers** | Age or length compositions from the total catch | Yes | *Not needed* | *Not needed* | Status quo |
| **Voluntary discarding with at-sea observers paired with shoreside sampling** | Age or length compositions from the retained catch *and* the total catch (retained + discarded) | Yes | Yes | No | BSAI king, snow, and tanner crabs |
| **Minimum size limit with at-sea observers** | Age or length compositions from the total catch (retained + discarded) | Yes | Assume full retention at minimum size limit | No | -- |
| **Voluntary discards with at-sea observers only** | Age or length compositions from the total catch (retained and discarded) | Yes (but may increase uncertainty) | No | No | -- |
| **Voluntary discards with shoreside sampling only** | Age or length compositions from the retained catch | No | No | No | Chatham Strait sablefish |

NPFMC (2021)

# Conclusions

- Given the proposed 'optional release' size, corresponding essentially to an average age-2 fish, the simulation does not indicate any negative consequences of allowing discarding.
- However, this is NOT a conservation based release motion.
  - **There are no biological benefits for enacting a minimum size limit for Alaska sablefish.**
  - **Likely to be some economic benefits, but costs associated with increased effort will also likely increase.**
- More extreme impacts were not observed due to the limited selectivity of age-2 fish and the comparatively high natural mortality compared to fishing mortality at this age.
- Scientific uncertainty associated with the stock assessment and resulting ABC projections will likely increase due to limited data available to model the discarding process.
- Interactive app available to further explore results of this work: https://shinyfin.psmfc.org/small_sablefish/.

# Sablefish MSE Informational Meeting

We'd like to provide an overview of the sablefish MSE work and engage stakeholders on some alternative management scenarios that could be explored.

**Meeting Information**
When: Tuesday, June 4th 5:30pm – 6:45pm AK time
Where: KANA Marketplace Convention Center boardroom, Kodiak AK

**Zoom Meeting Information**
https://alaska.zoom.us/j/87249317700
Meeting ID: 872 4931 7700
Dial by your location
• +1 253 205 0468 US

This is not a part of the Council meeting but we are hoping we will increase in-person attendance by trying to do this concurrent with the Council meeting.

A couple of the topics we'd like to discuss are:

1. Provide a general overview of the simulation framework and operating/assessment models being developed.
2. Engage the audience on alternative management scenarios of interest to stakeholders (e.g., max % change in ABC among years).
3. Engage the audience on performance metrics that could be used to define a robust commercial fishery (e.g., an acceptable range in variability of catch from year to year).
4. Discuss realistic future recruitment scenarios that could be simulated to emulate likely future population trajectories based on stakeholders' experience of historic and recent dynamics.

# Questions?

# Results: Per-Recruit Analysis

- Discarding had minimal impact on SSB-per-recruit and yield-pre-recruit
- Increased revenue-per-recruit minimally
- Fishing mortality to maximize yield (0.45) >> F to maximize revenue (0.15) > $F_{40\%}$ (0.086)
  - **Yield maximized at much higher effort than revenue (and reduces stock below $SSB_{40\%}$)**
- Results generally align with previous analyses (Lowe et al., 1991; NPFMC, 2021)