NOAA FISHERIES

Stock Assessment for canary rockfish

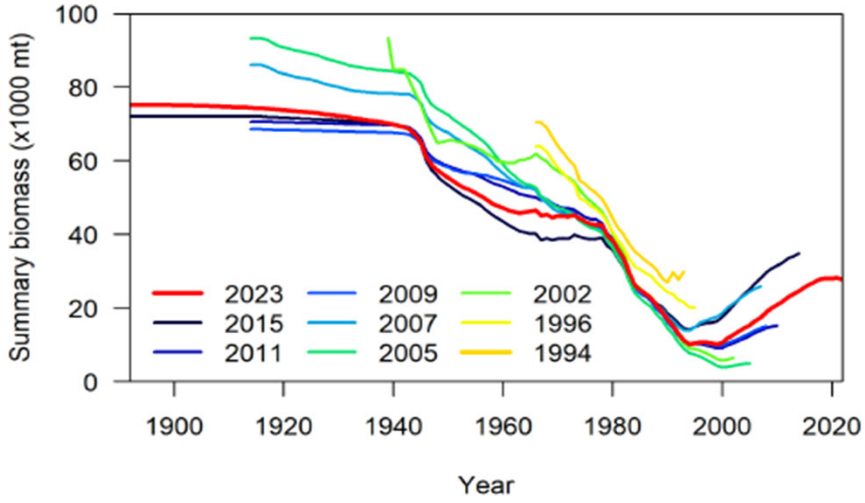
STAR Panel 24-28 July 2023

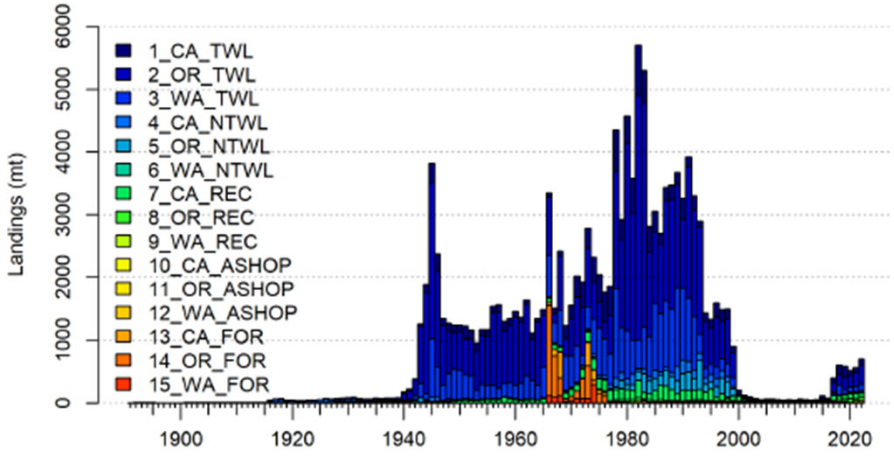
Stock assessment team: Brian Langseth, Kiva Oken, Alison Whitman, John Budrick and Tien-Shui Tsou

Review Panel: John Field (chair), Kristin Marshall, Joseph Powers, Martin Cryer, Whitney Roberts (GMT), Gerry Richter (GAP), Marlene Bellman (PFMC staff)

Assessment history

- Caught in a wide mix commercial and recreational fisheries, but greatest catches from trawl
- Last assessment was 2015 benchmark, which was a spatial model with distinct CA, OR and WA areas
- Assessed many times over last 30 years, declared overfished in 2000, declared rebuilt in 2015
- Catches (and fishery dependent data) were very low from 2000 through ~2016



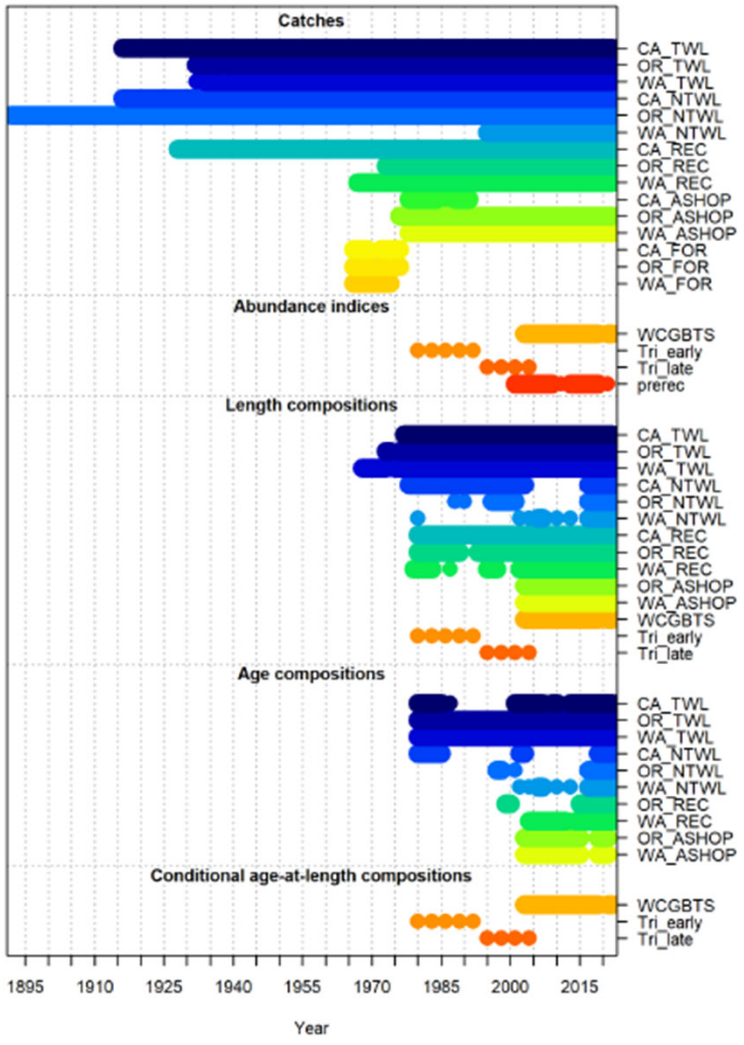


Data Sources

A high degree of complexity in fleet structure, but only three fishery-independent indices. A number of potential sources of information that were spatially constrained were considered but not included in the final model.

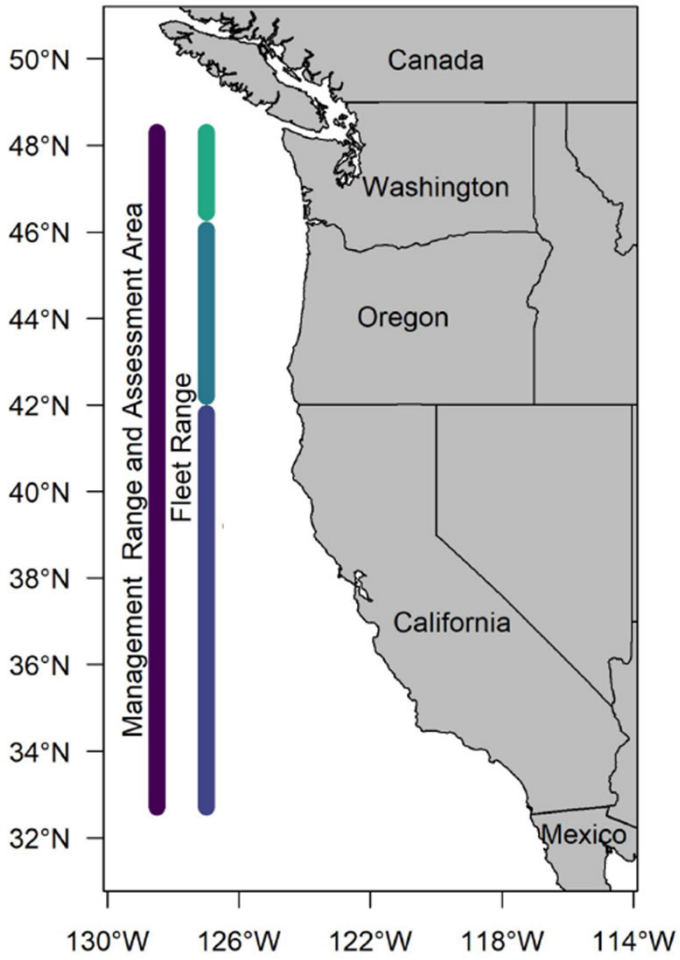
Considered but not used include:

- Lengths
  - CA Commercial Collection Report System
  - Historical CDFW Dockside Sampling
-
- Indices
  - California Collaborative Fisheries Research Program
  - CA Deb Wilson-Vandenberg CPFV index
  - CRFS onboard CPFV index
  - CA ROV survey
  - WA dockside interview data
  - WA nearshore rod and reel survey
  - OR onboard CPFV index
  - OR marine reserves hook and line survey
  - NOAA Washington Olympic coast YOY survey
  - NOAA hook and line survey
  - International Pacific Halibut Survey



Major changes from 2019 assessment

- The 2015 model was a spatial 3-area model (states were the basis for areas), STAT returned to a single coastwide model. Absence of evidence of stock structure from genetic (or other) analyses, and parsimony, were key drivers of this decision.
- Spatial aspects were addressed through geographic separation of data sources/fleets where possible
- The natural mortality (M) “ramp” for older females used in the 2015 (and most previous) assessments was revisited and revised to an age invariant M, male M was fixed at the prior and female M estimated.
- Fisheries and surveys had sex-specific selectivity curves (which the 2015 benchmark did not include) with time blocks as appropriate for each fleet.



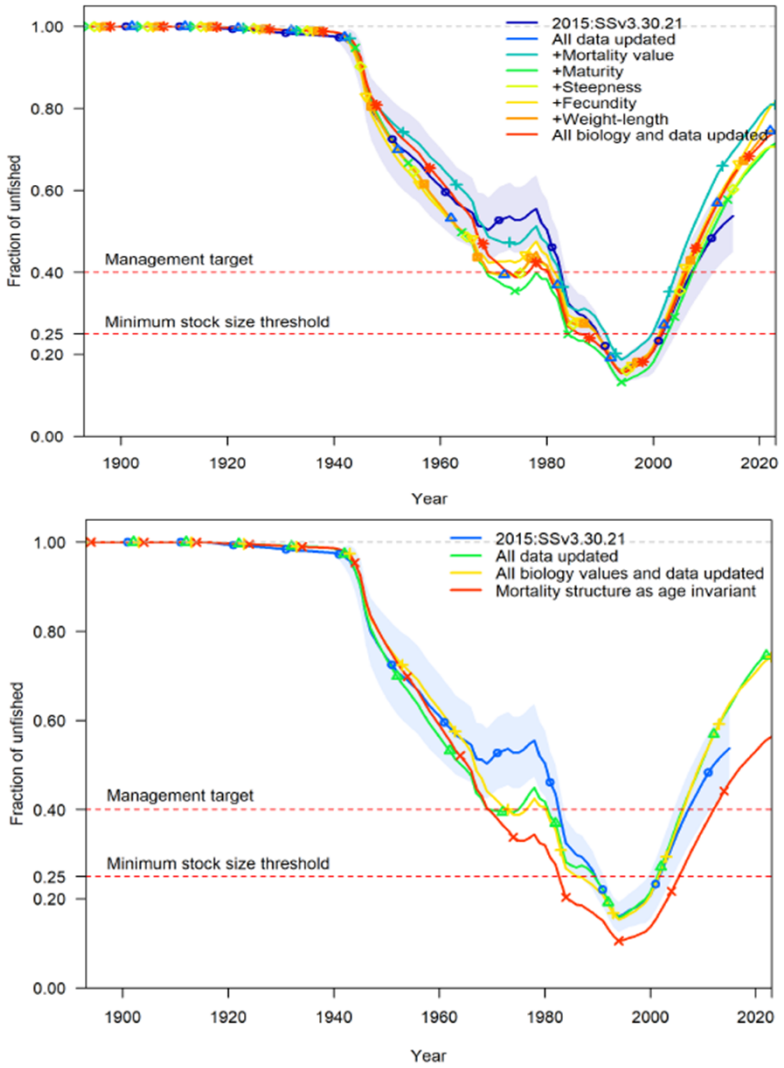
Key model details

- Stock synthesis version 3.30.21 (released February 2023)
- Modeling period begins in 1892, unfished equilibrium prior to that.
- 5 fleets x 3 states for fisheries, plus 3 surveys (triennial, WCGBTS, juvenile)
- Survey ages treated as conditionals
- Francis data weighting
- Sex-specific biology, growth estimated internally
- Male M fixed at median of the prior, Female M estimated
- Flexibility for dome shaped selectivity for all fleets, 3 parameter double normal with sex-specific descending limbs
- Sigma R fixed at 0.5

Bridging from 2019 to 2023 model

Bridging was a bit complicated. General sequence in bridging was to update data, then update biology (including changes to how natural mortality is treated).

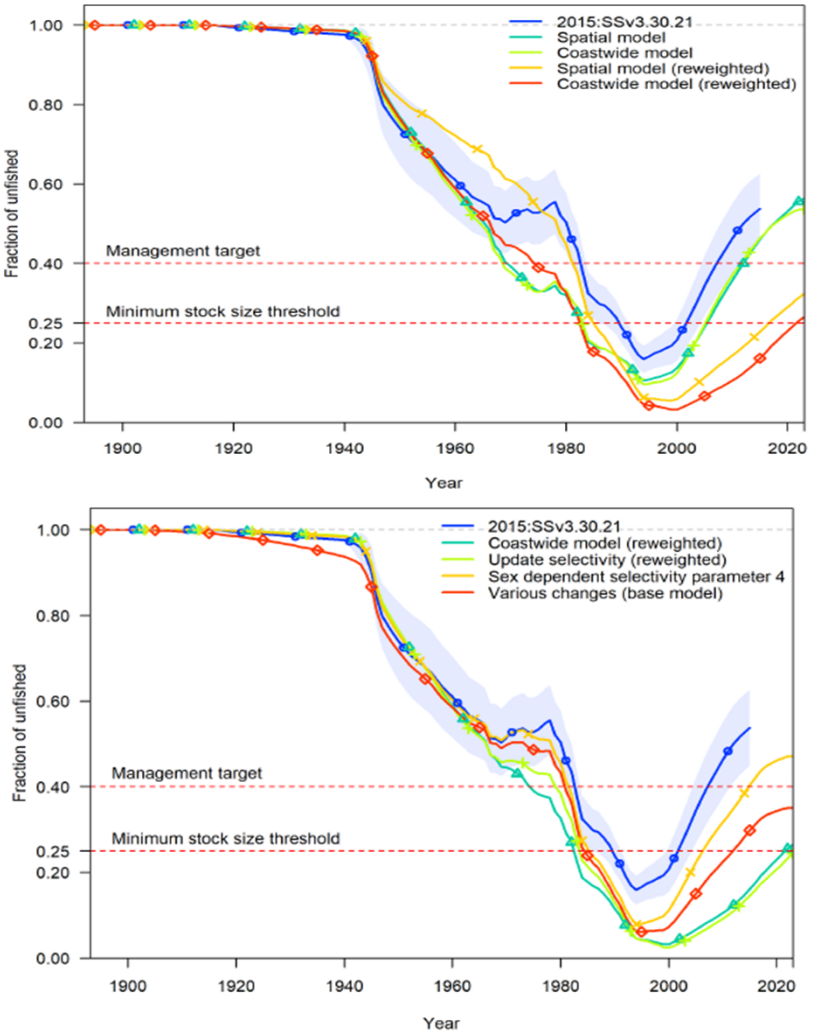
In general, the greatest change in model trend, perception of productivity and status was associated with modeling female natural mortality as age invariant in this section of the bridging.



Bridging from 2019 to 2023 model

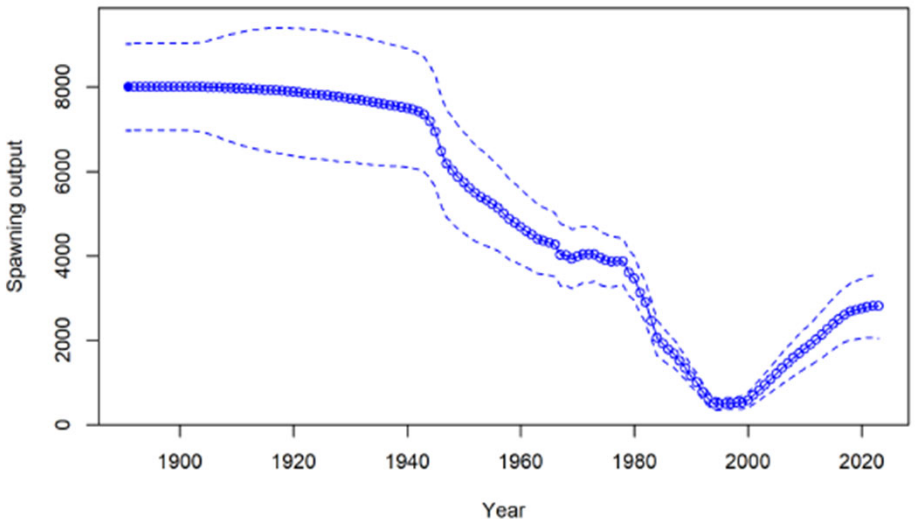
The change from a spatial to a coastwide model did not initially cause a substantial change in the perception of stock status, but subsequent retuning led to changes in the perception of stock status for both the spatial and the coastwide models.

Adding sex-specific selectivity was also quite influential, this was part of the approach for addressing the lack of larger, older females in the data.

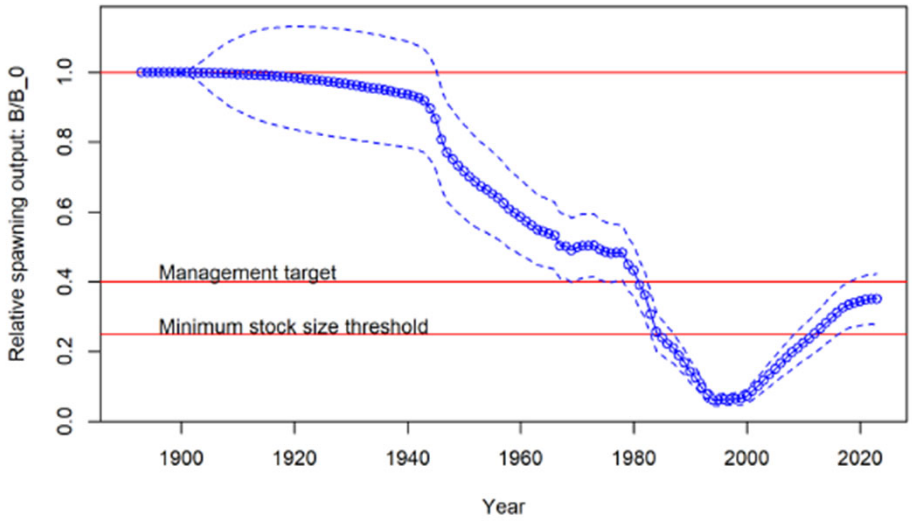


Base model results

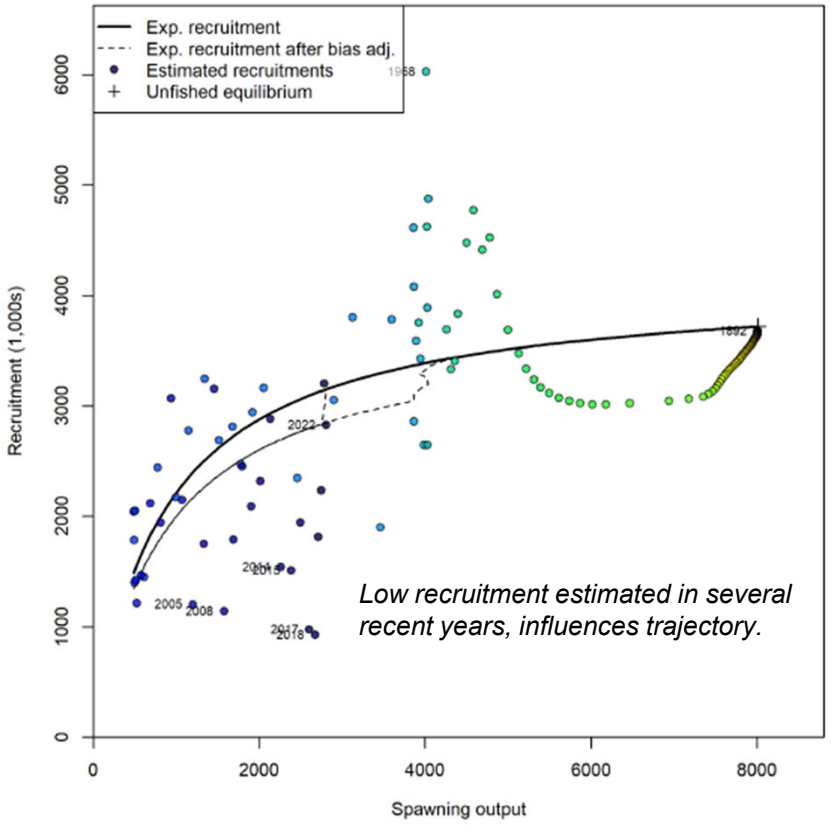
Spawning output



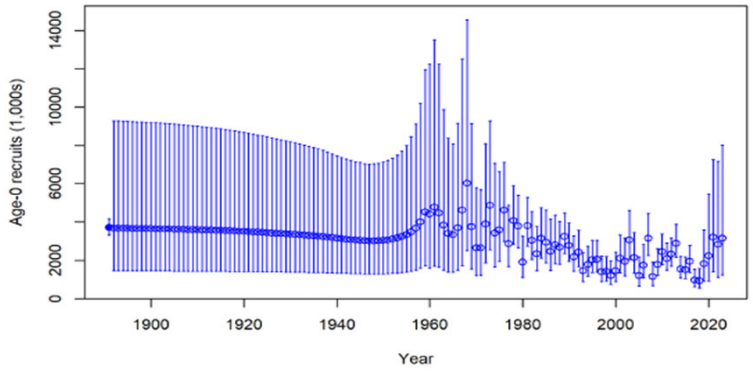
Relative spawning output (depletion)



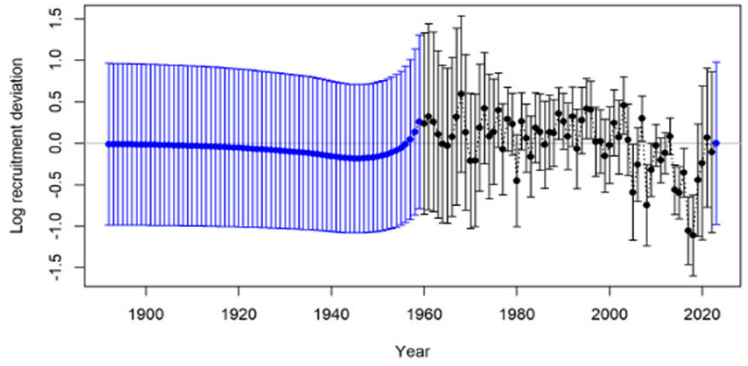
Recruitment



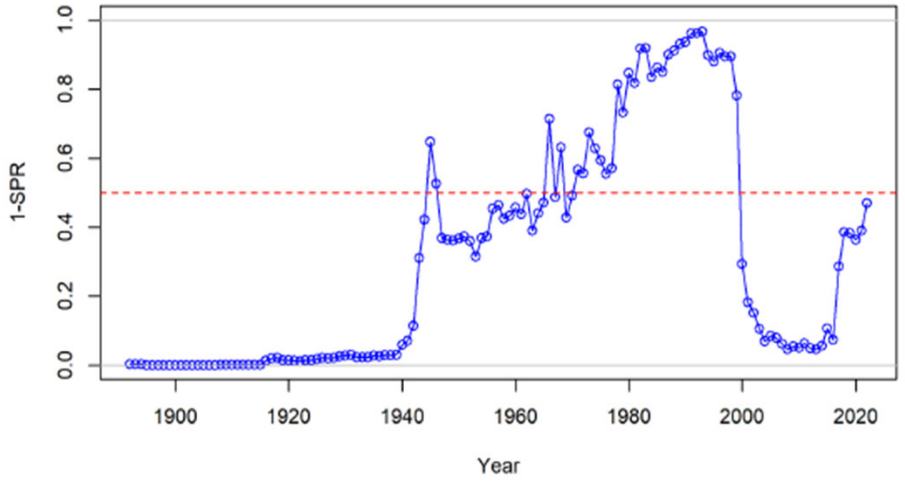
Recruitment

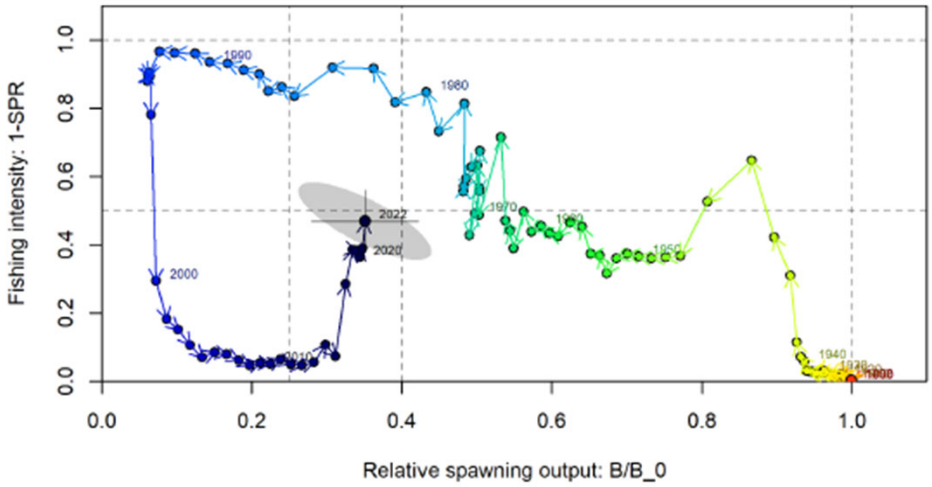


Recruitment deviations



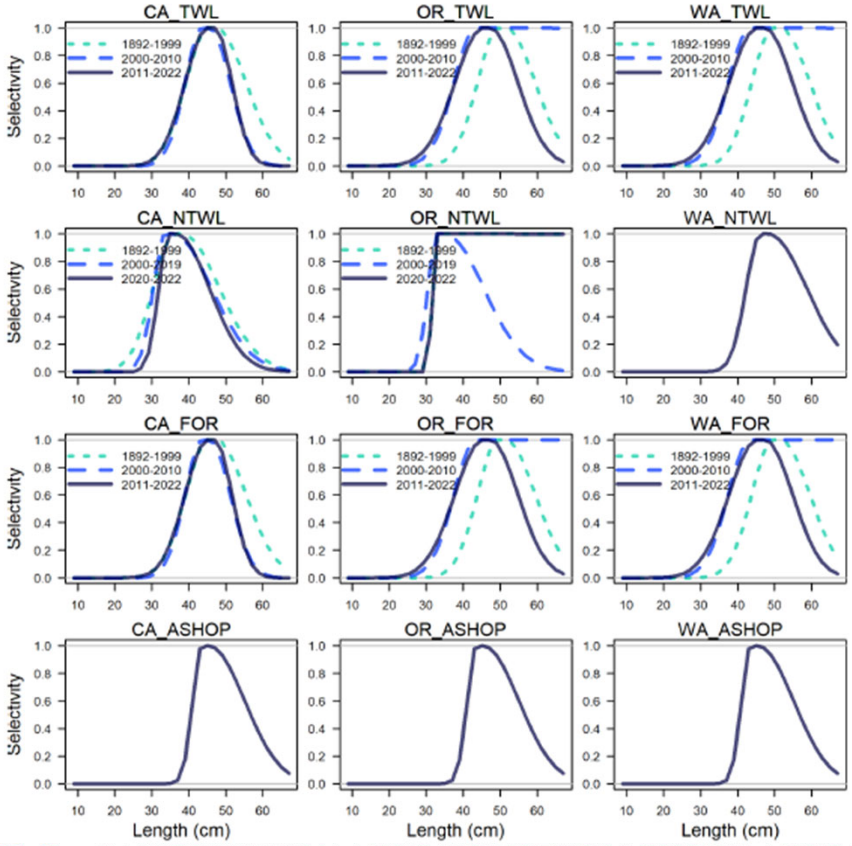
Impacts of Fishing



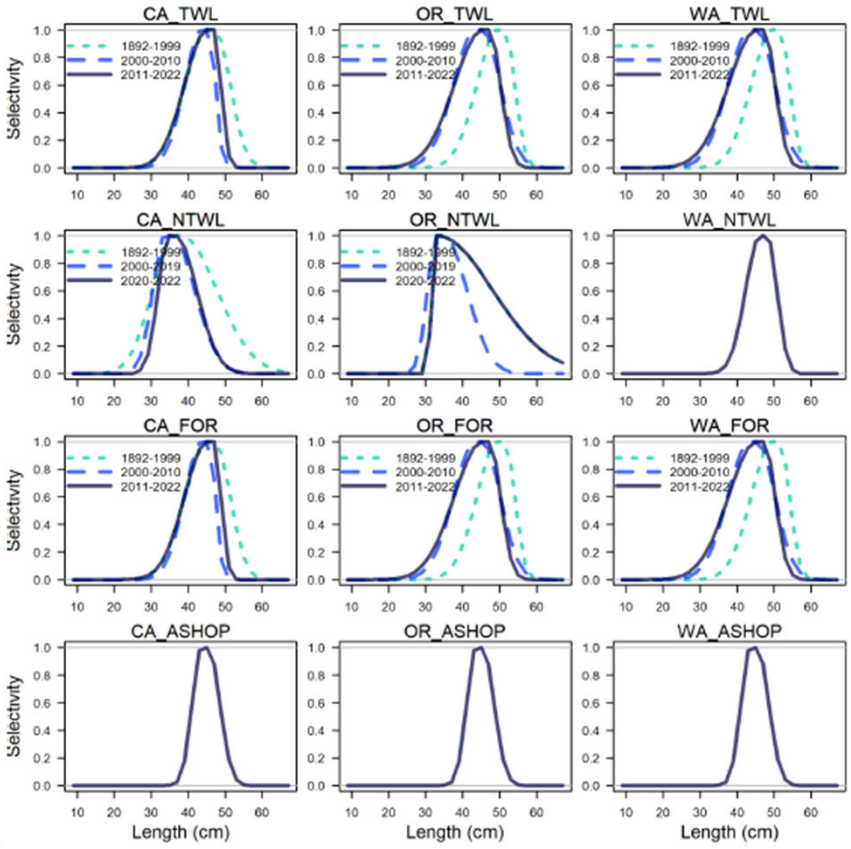


Selectivity patterns

Females



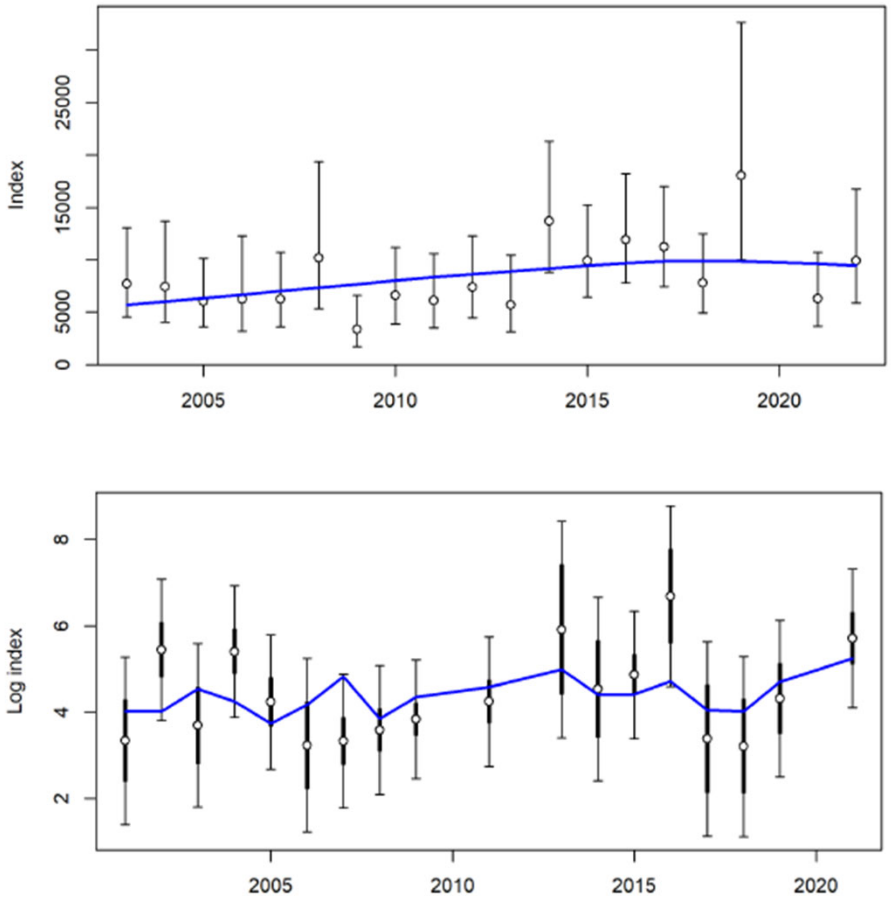
Males



Survey data fits

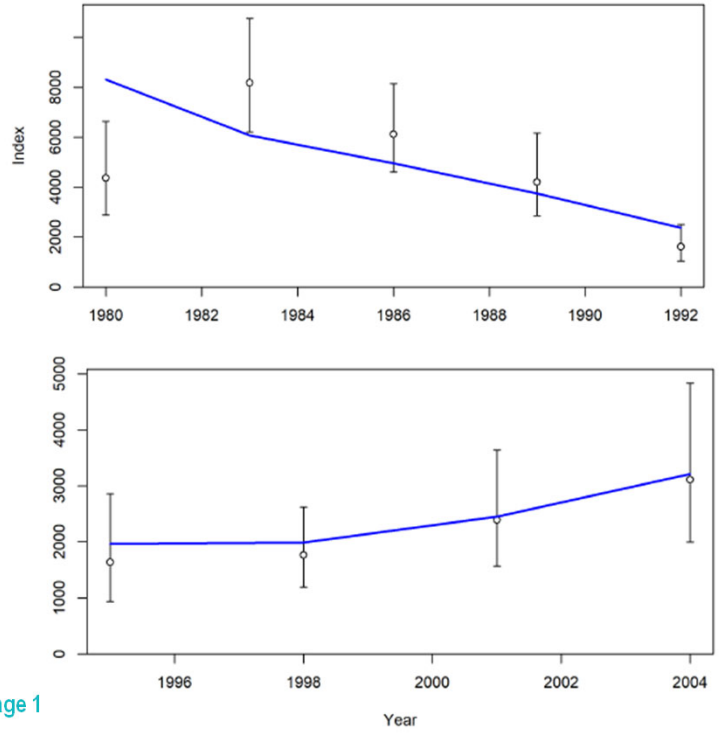
West Coast Groundfish Bottom Trawl Survey (top), Rockfish Recruitment/Pre-recruit survey (bottom).

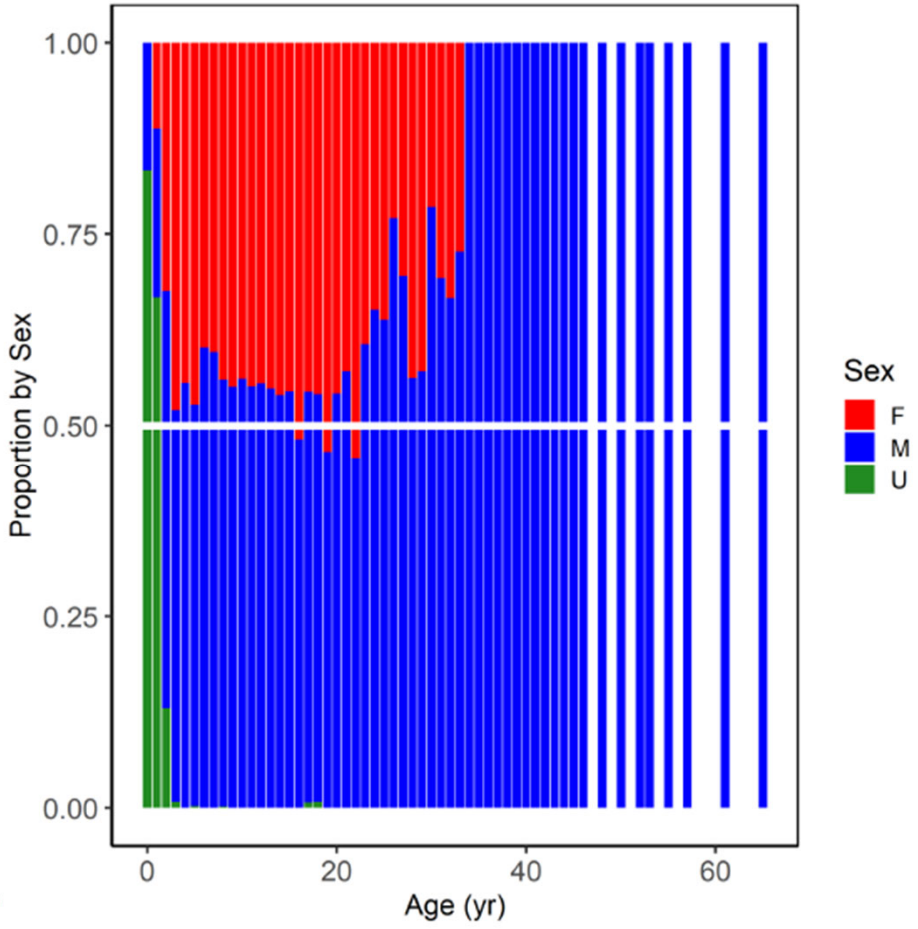
Not quite as nice a fit as petrale sole or many other species for WCGBTS, a much noisier signal, relatively flat since 2014-15 (last benchmark). Juvenile index is fairly noisy, historically hits some strong year classes, misses others, suggests low recruitment in 2017-19 period.



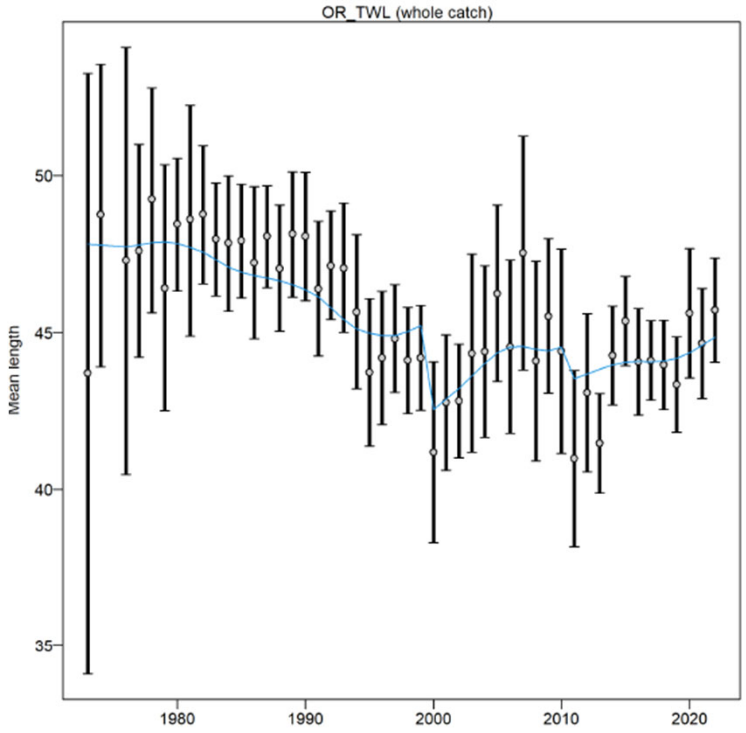
Triennial survey data

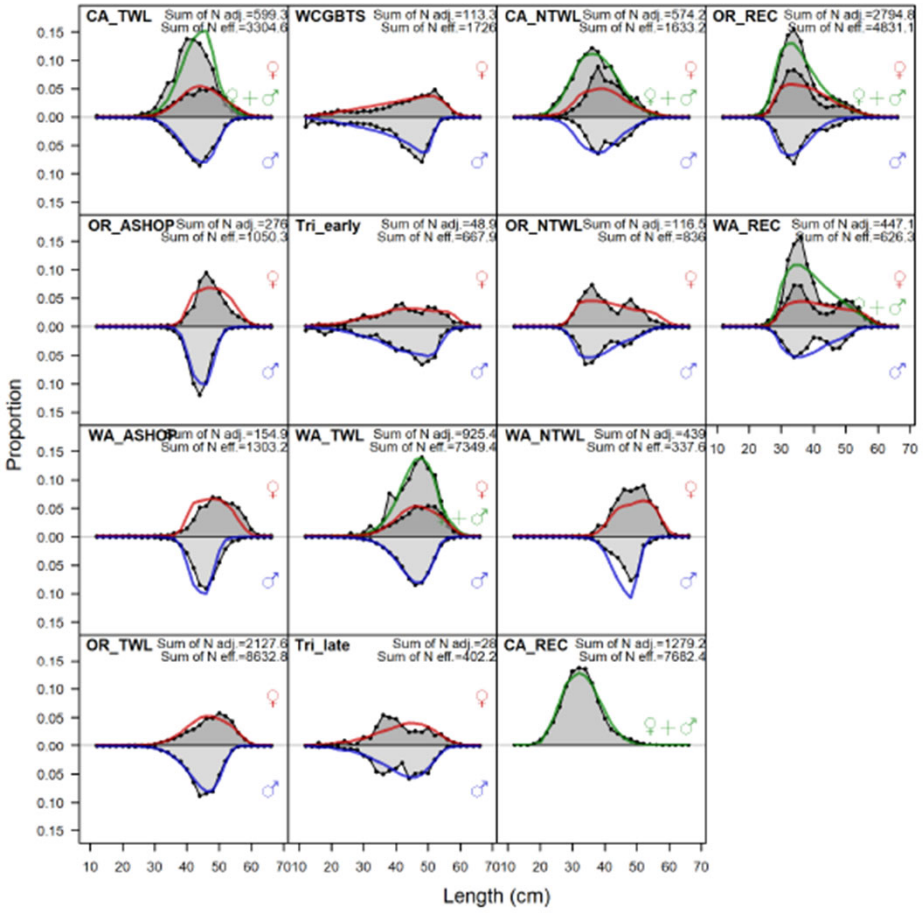
Fit to triennial survey index (bottom, note difference in y-axis!) and sex ratios (empirical) from triennial age data





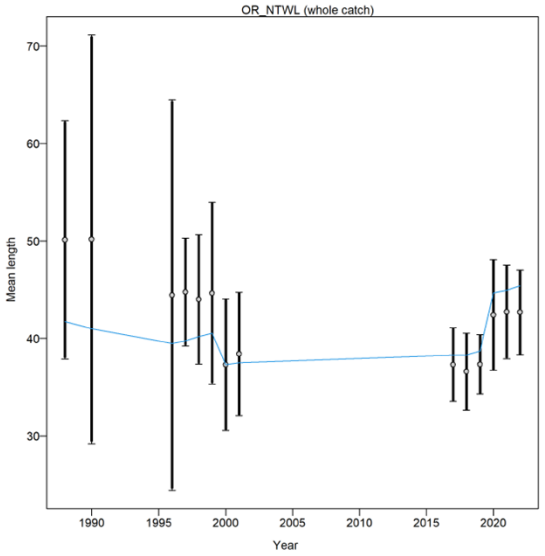
Length data generally well behaved, informative for well sampled fleets (trawl), but sparse for many others

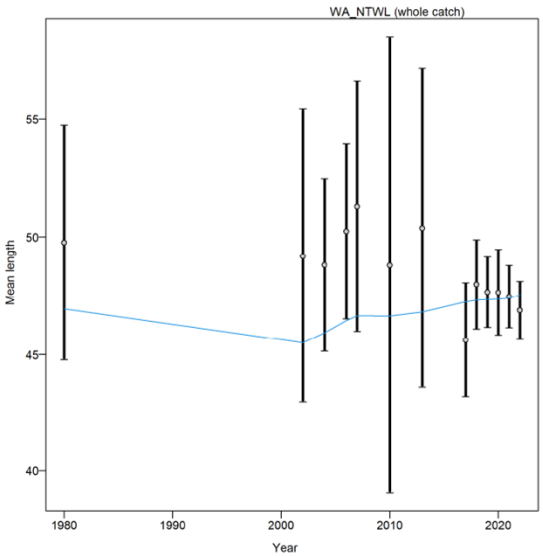




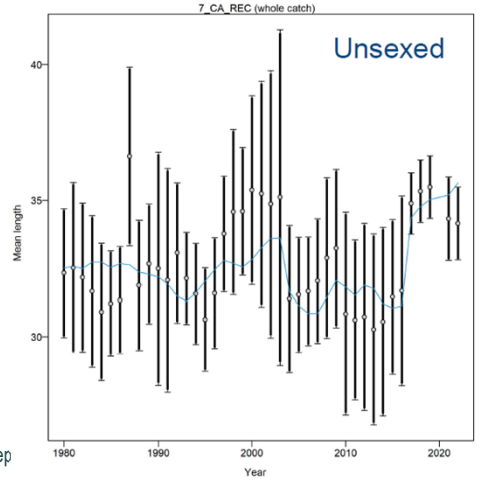
These are some of the "others," but note that some of these fleets might be important as they may encounter more older female canary than other fleets..

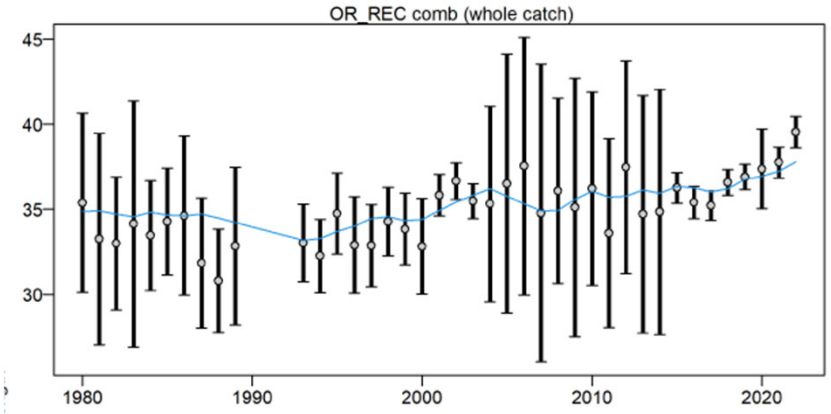
Selectivity time blocking in the model for most fisheries, typically limited to 2-3 time blocks



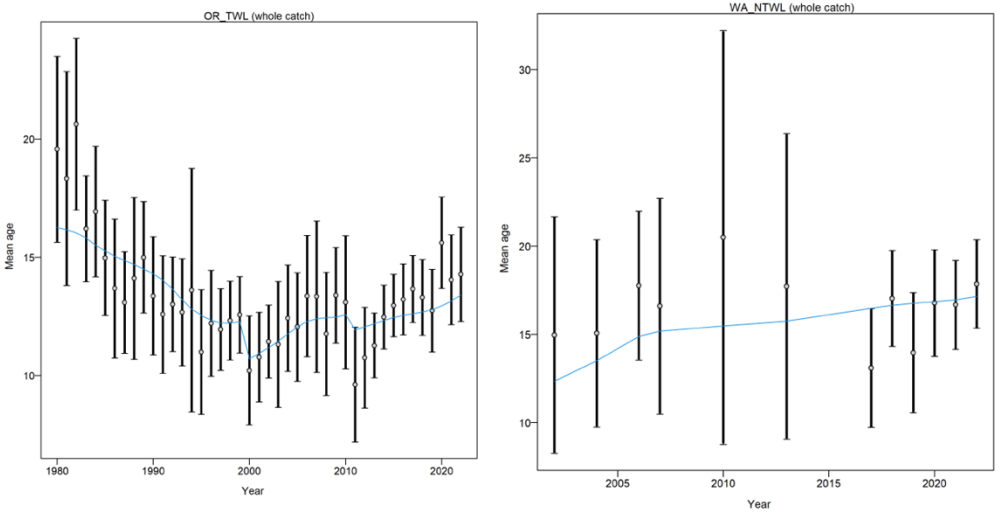


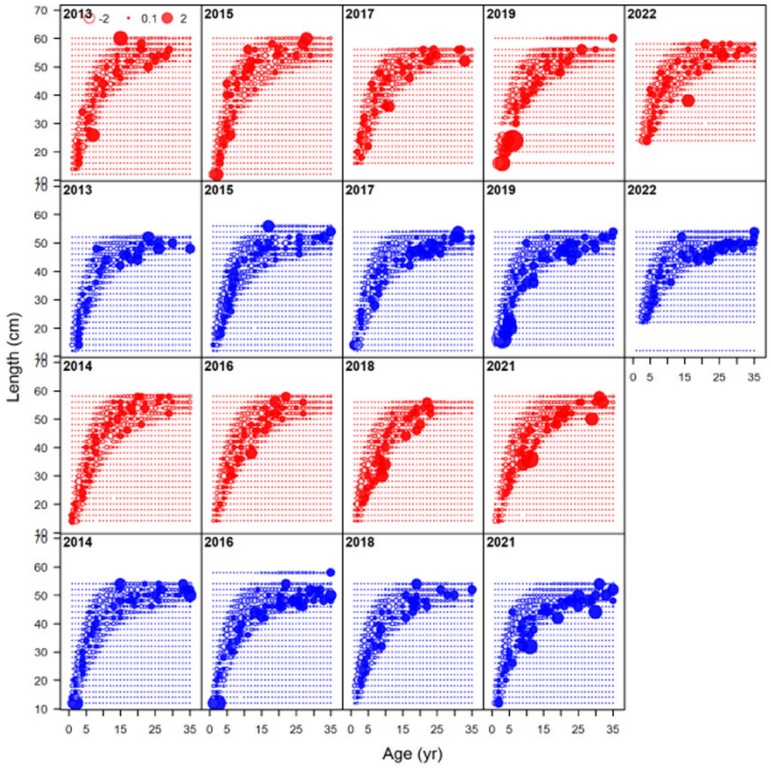
California



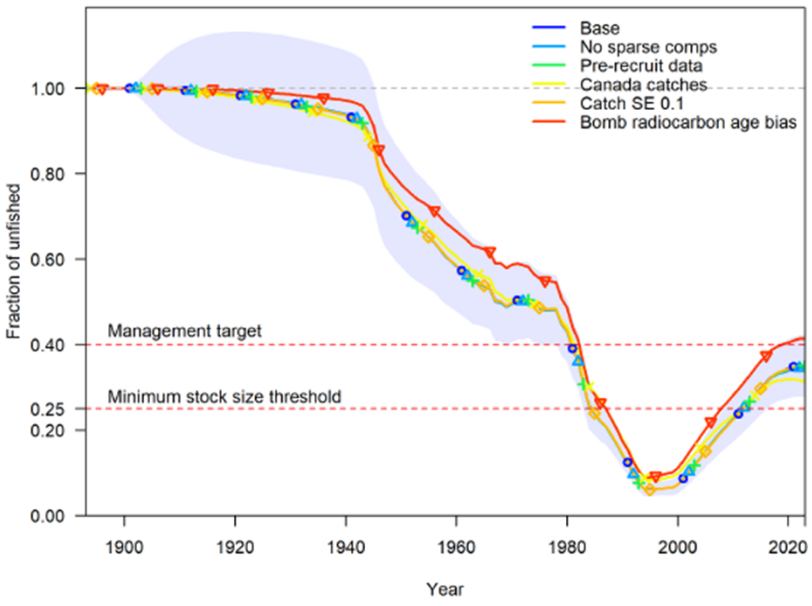


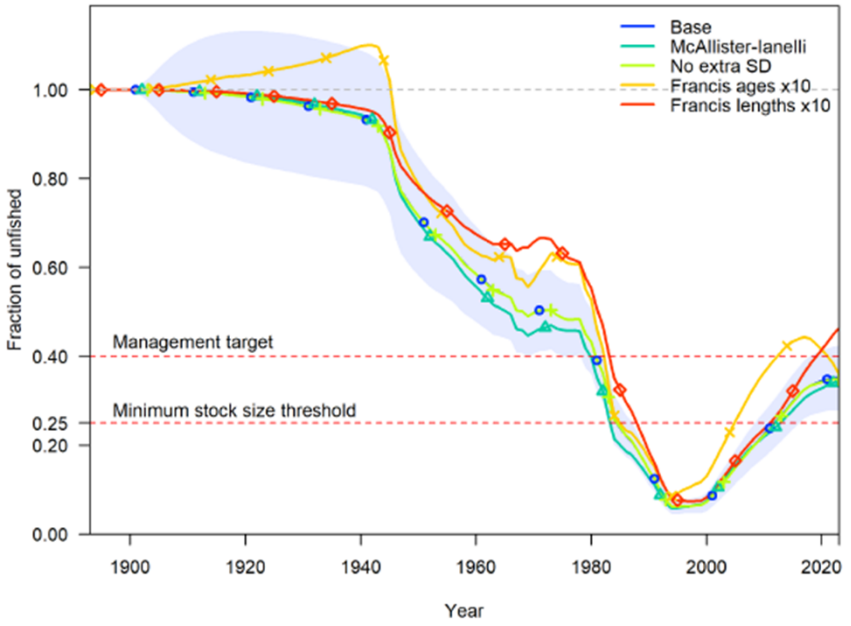
Cumulatively there is considerable amount of age data. Fishery data included as marginals, WCGBTS as conditional age at length (CAAL). Plenty of large females, fewer old ones but fits are generally reasonable.



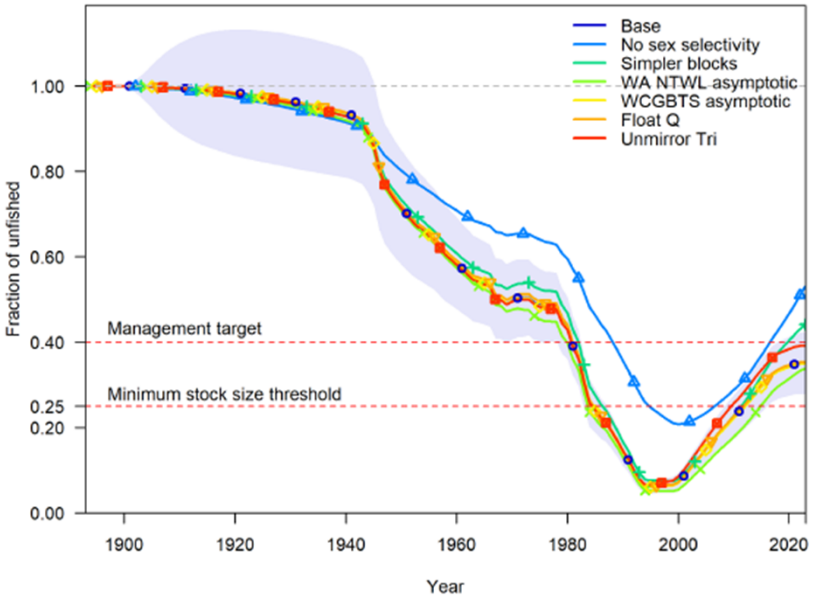


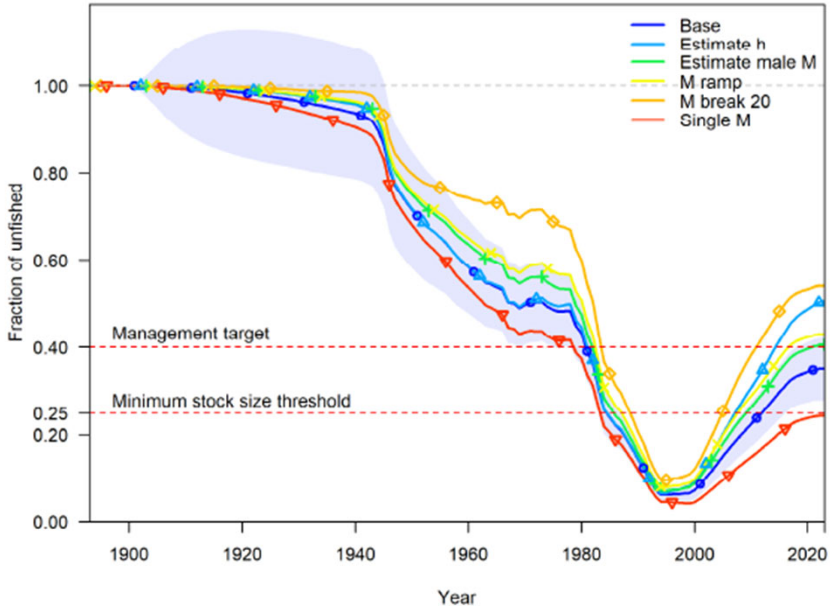
Considerable sensitivity analysis to different data sources, model assumptions, weightings..



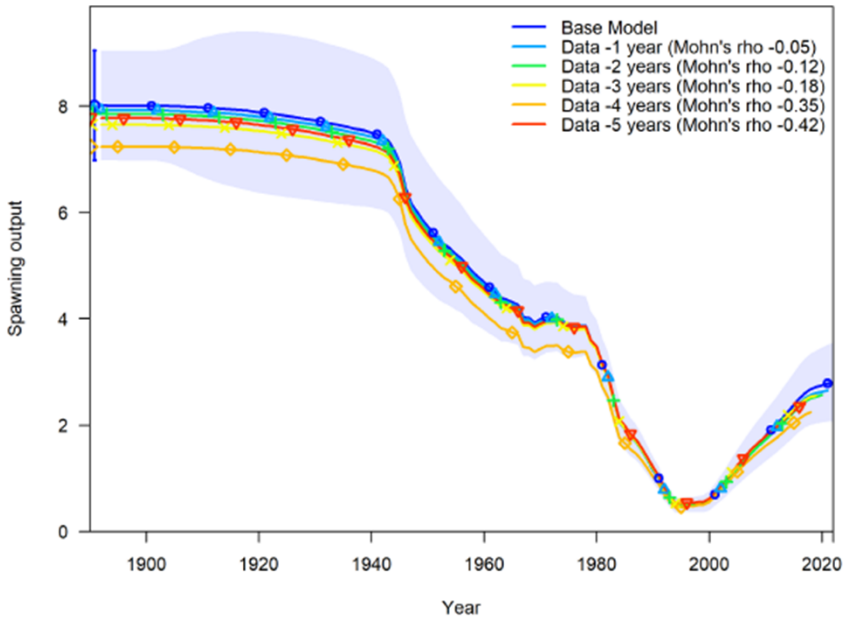


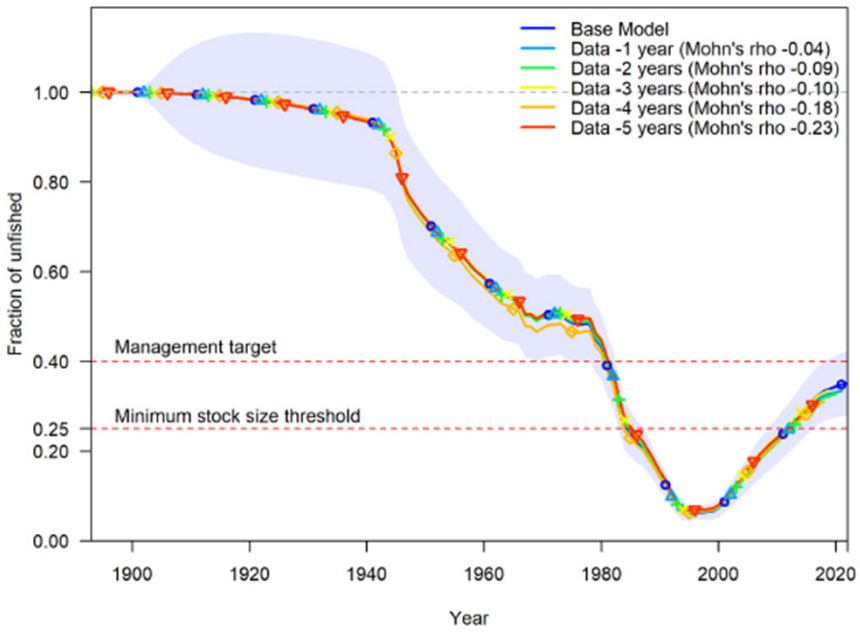
Model most responsive to structural assumptions related to resolving the lack of old females (selectivity and natural mortality parameterizations)



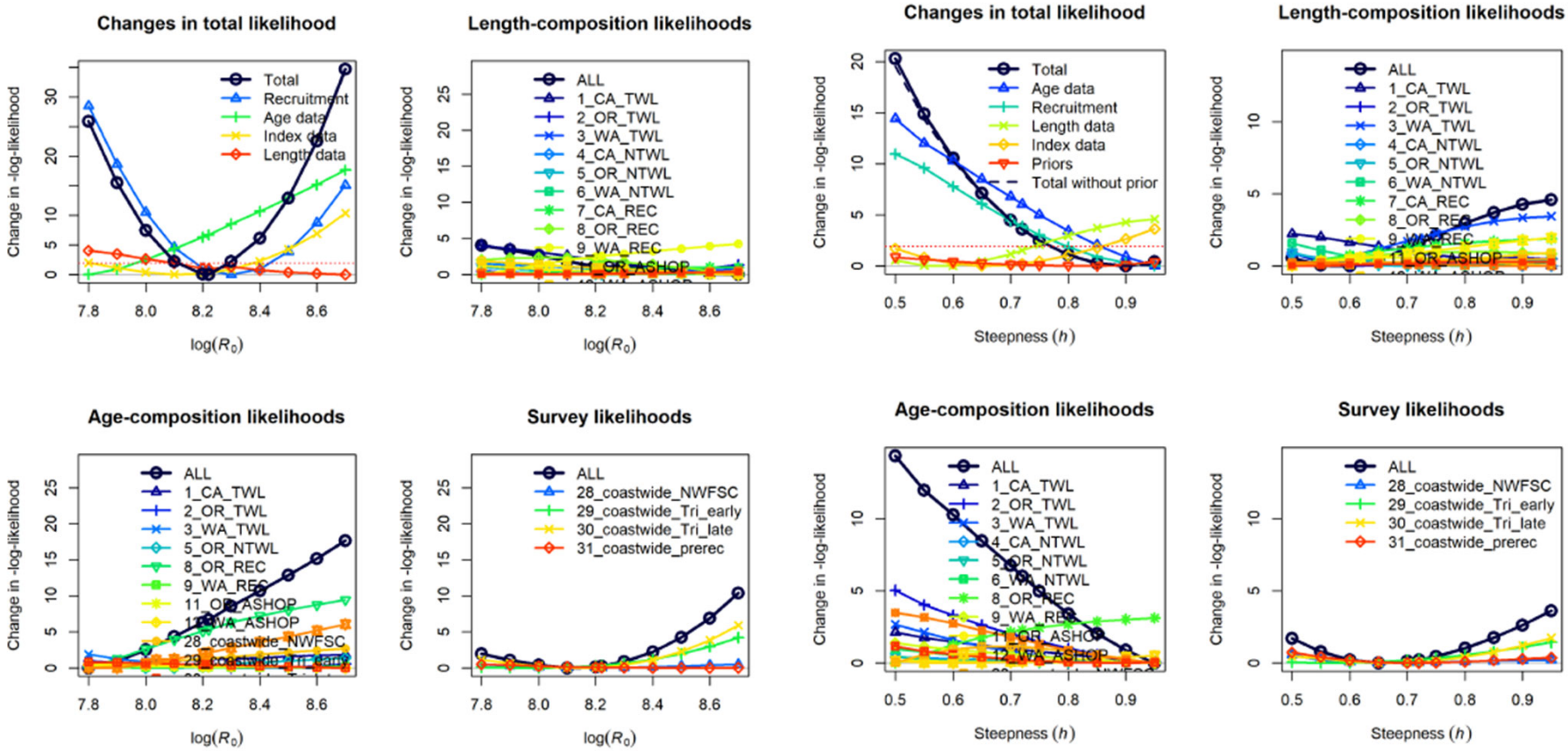


Retrospective analyses generally well behaved

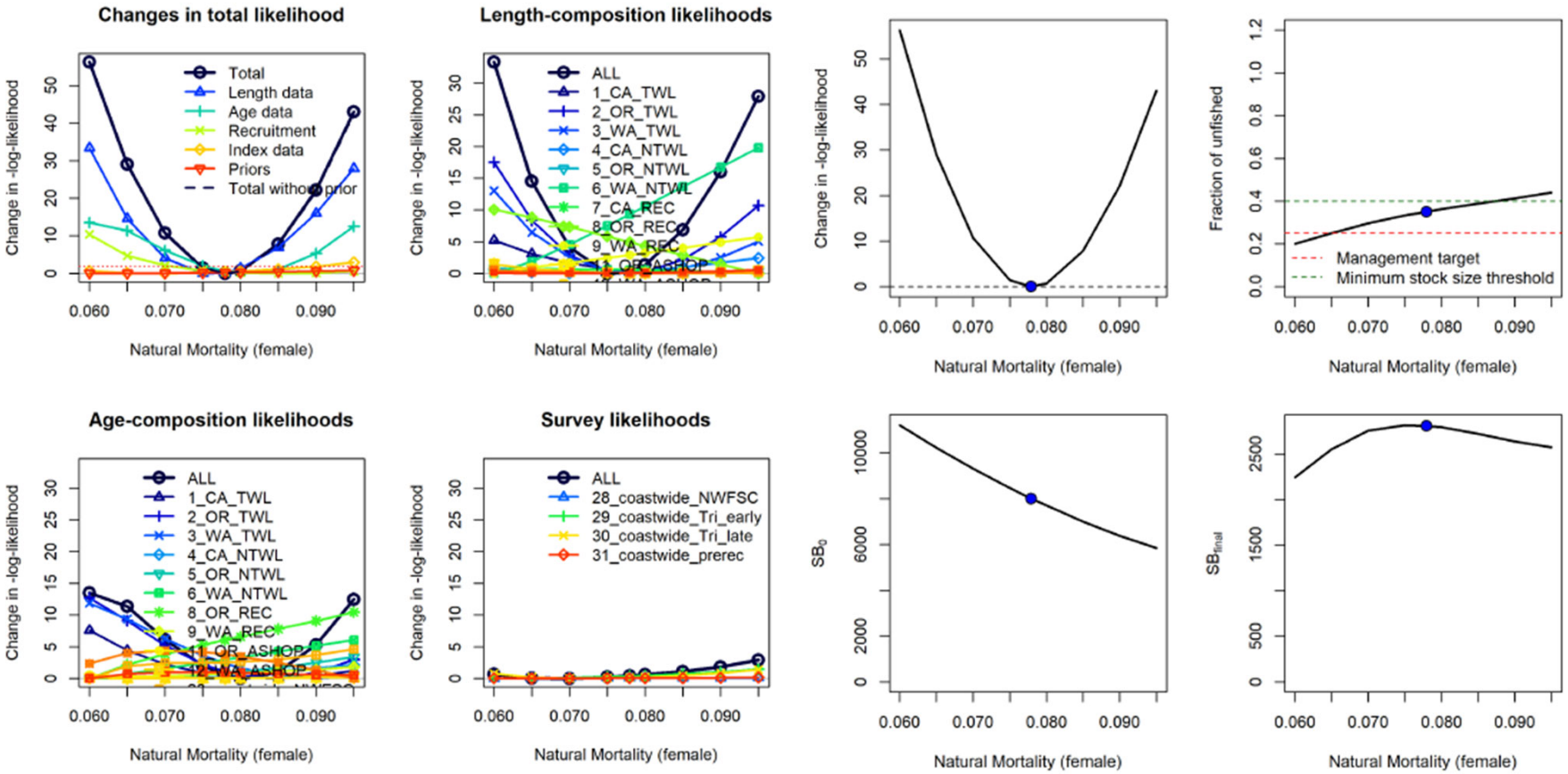




Likelihood profiles



Likelihood profiles

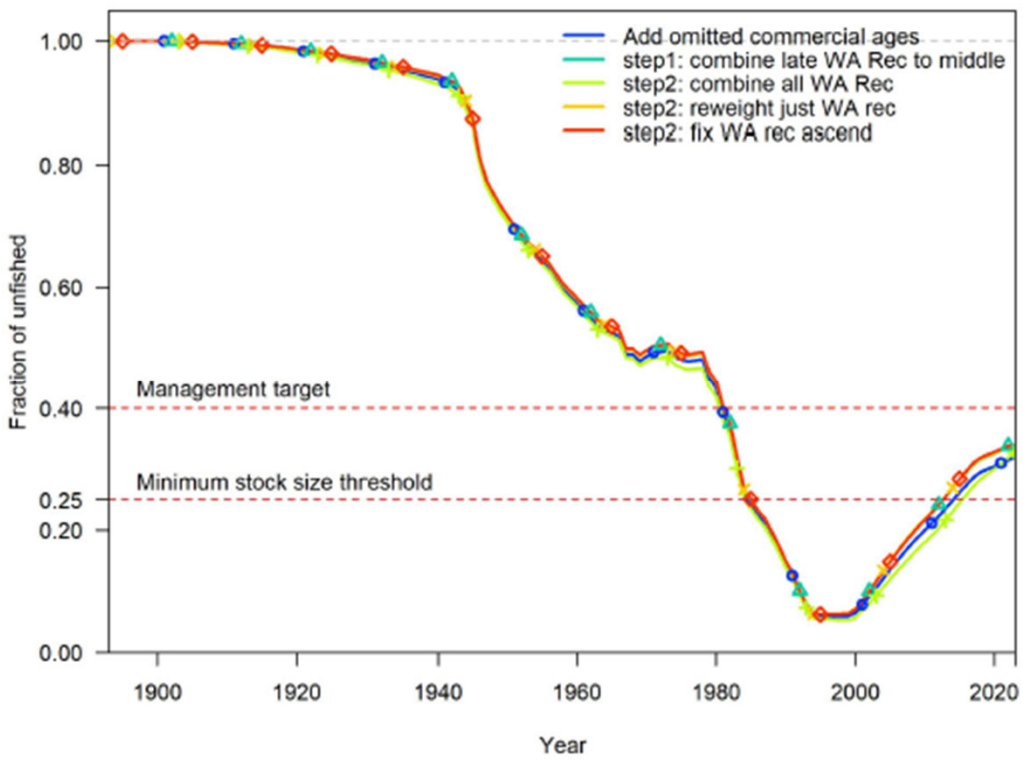


STAR Panel requests and responses

Request 1 (recommended by STAT) was to add a sizeable fraction of age data from recent years that were inadvertently omitted from the draft base model provided to the panel, and provide the fits to the updated model.

With the new age data, the model had high correlations among several of the selectivity parameters for the WA recreational fishery, thus the STAT also explored alternative time-blocking, mirroring and parameter fixing options.

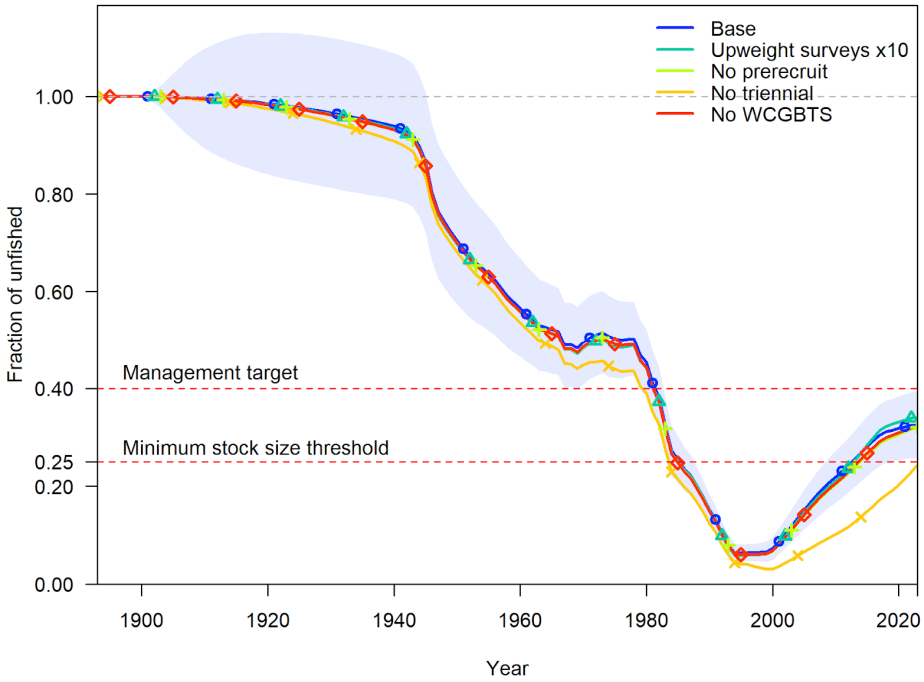
This began a bit of a "whack-a-mole" evaluation of modest but non-trivial revisions to model structure and selectivity parameterizations that continued through several more requests (namely requests 5, 6, 9, 10 and 11) while the revised base model was evaluated.



STAR Panel requests and responses

Request #2 was to drop or upweight the indices to examine the influence of data weighting choices on estimates of depletion. Specifically, there was interesting in assuring that there are no plausible data weighting scenarios that would lead to very low estimates of depletion, as well as to understand the influence of the early triennial index data.

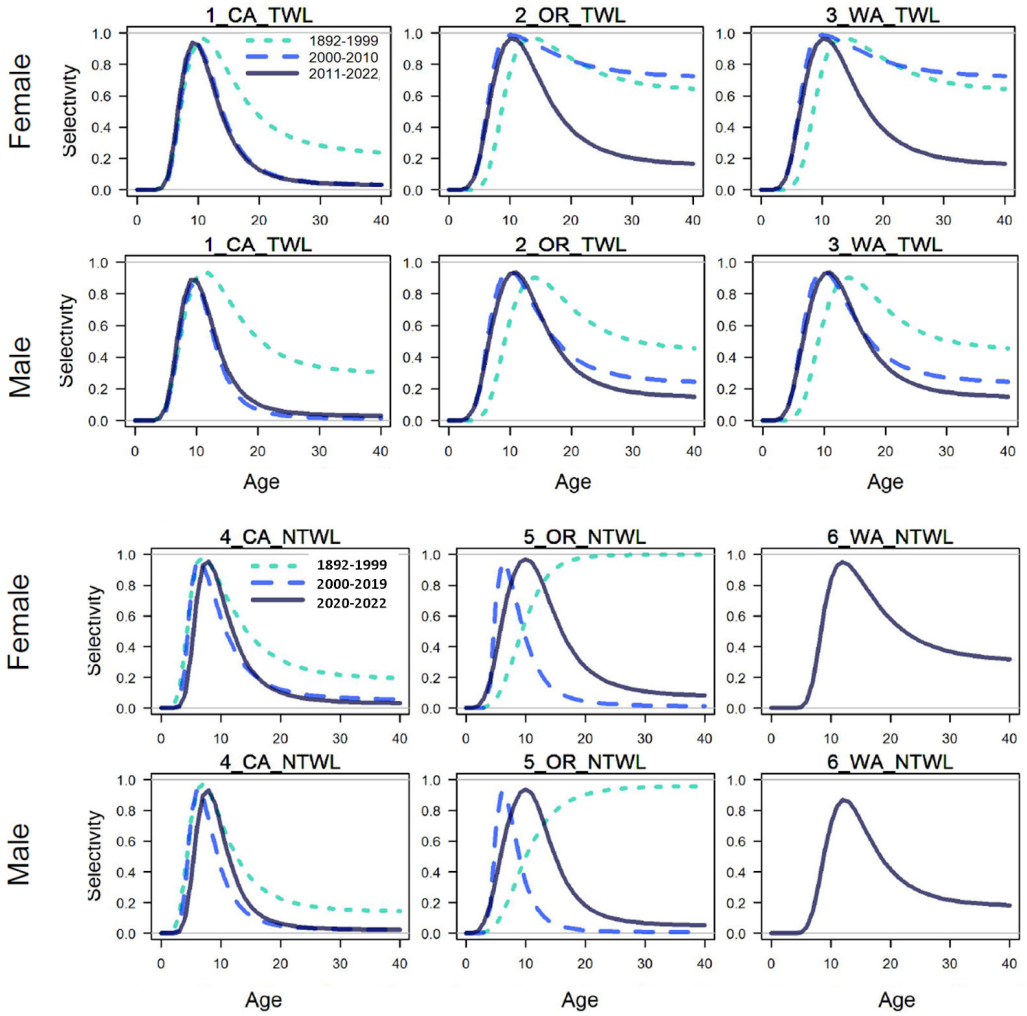
Excluding the triennial survey was very influential, and considerably more pessimistic. Excluding other survey indices was less influential, as was upweighting all abundance indices (lambda = 10).



STAR Panel requests and responses

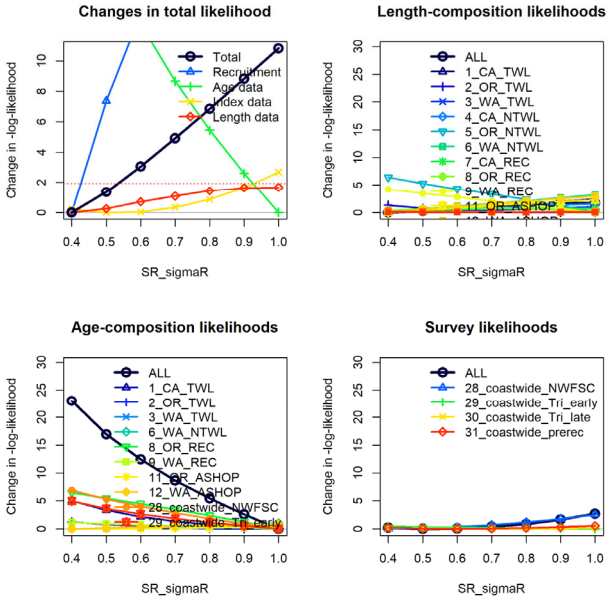
Request was to evaluate the estimated selectivity curves when M is fixed at the same value for the two sexes by both length and age. Rationale was that the Panel had seen selectivity curves by length but not by age, and the Panel was trying to understand the trade-offs between M for males and females and counterintuitive patterns in selectivity shapes for males and females (males were more domed).

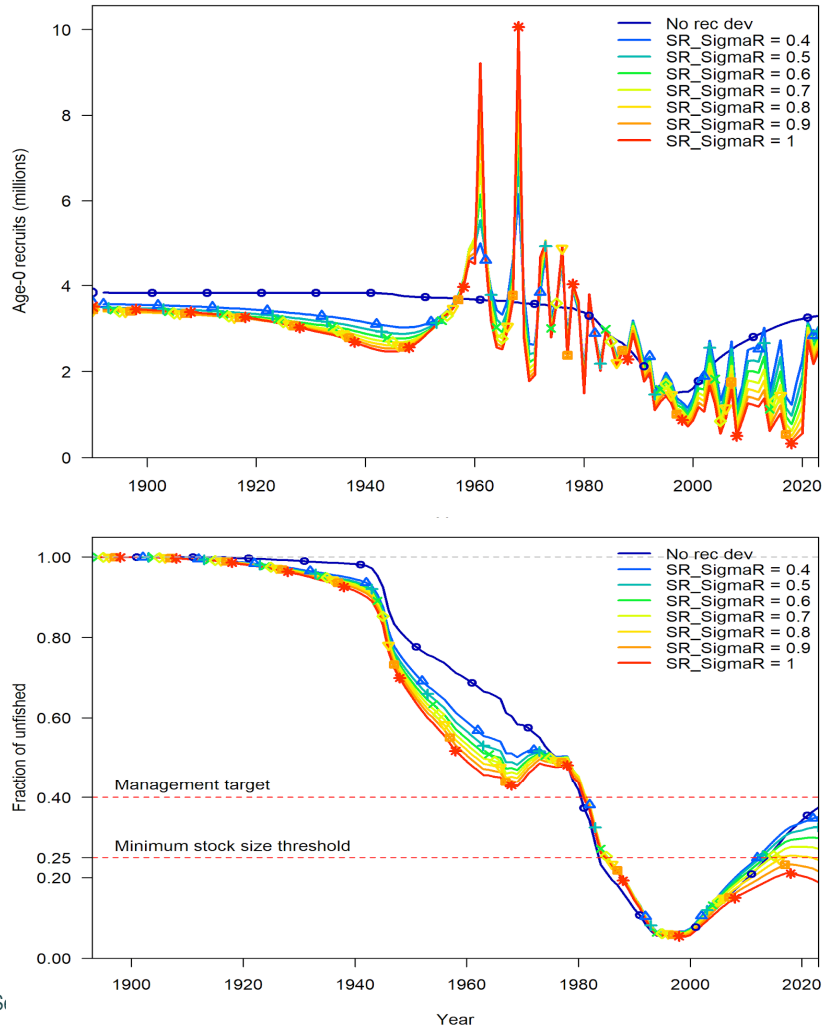
Even when males and females had the same (fixed) M, male selectivity was still more domed than female selectivity. The more dome-shaped nature of male age-selectivity was derived from length data and length selectivity patterns. Female selectivity became slightly more domed when M was fixed than when M was estimated. The panel agreed that no changes to the treatment of natural mortality in the model were warranted.



STAR Panel requests and responses

Request 5 was to profile over sigma R, including a model with no rec devs. This was done on the pre-STAR panel base model. Increasing sigma R substantially affected the model, especially recruitment since ~2003 and estimates of current spawning output. Very high values of sigma R suggested very low recent recruitment and more pessimistic stock status.

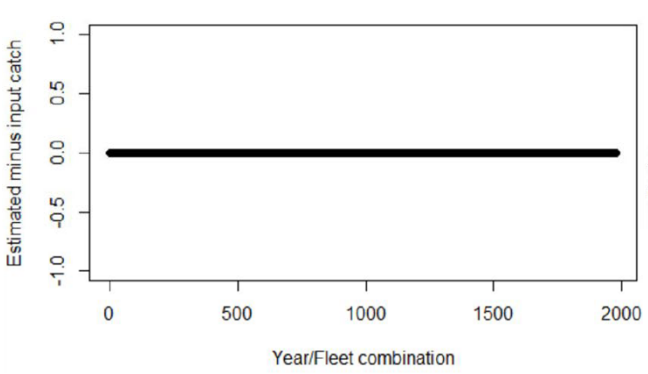


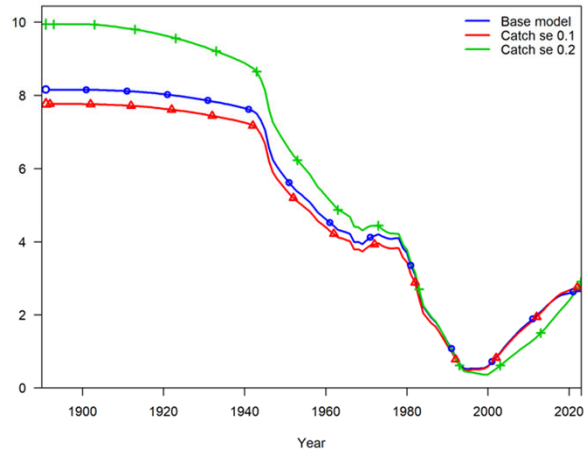


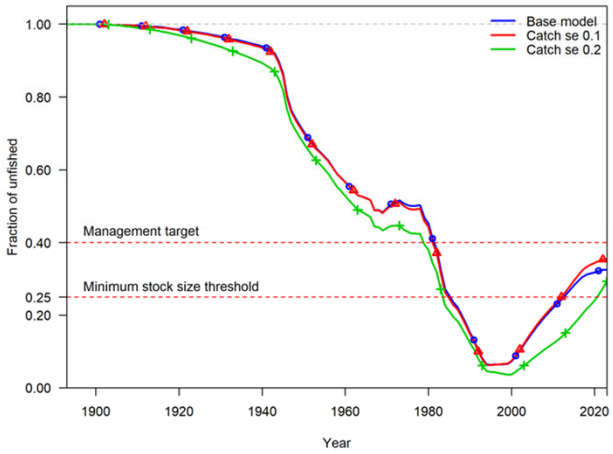
STAR Panel requests and responses

Request #8 was to provide a time series of estimated catches against input catch values for the model sensitivity run that included greater uncertainty in historical catches, as well as to run a model with uncertainty increased to 0.2 for years before 1980 to assess model behavior and provide similar plots. The rationale was that catch histories are uncertain, but this uncertainty is rarely evaluated within models.

The model estimates catch to be the same as the input catch whether the standard error (SE) is 0.1 or 0.2. However, models with different SEs on catch had different trajectories and different likelihoods, suggesting increasing catch SE leads to numerical instability. The panel agreed that the catch SE feature in Stock Synthesis and its impact on models is not well-understood, further exploration would be helpful, but this was beyond the scope of the assessment review.

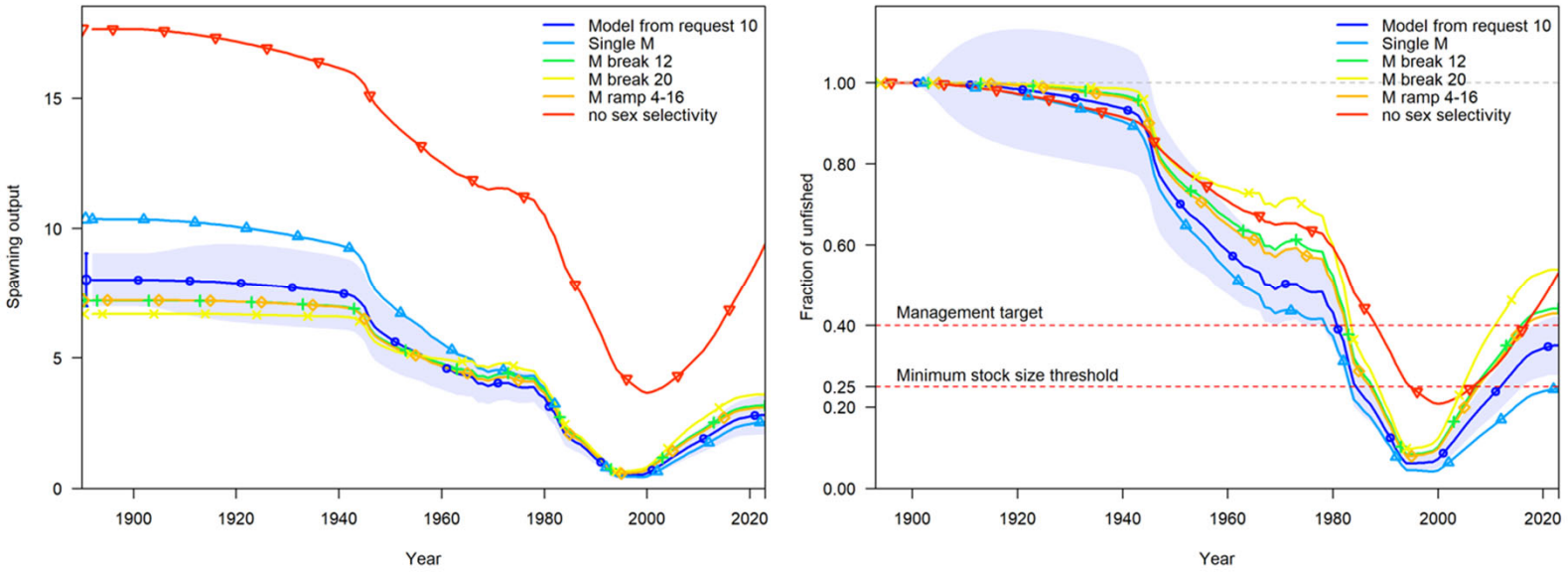






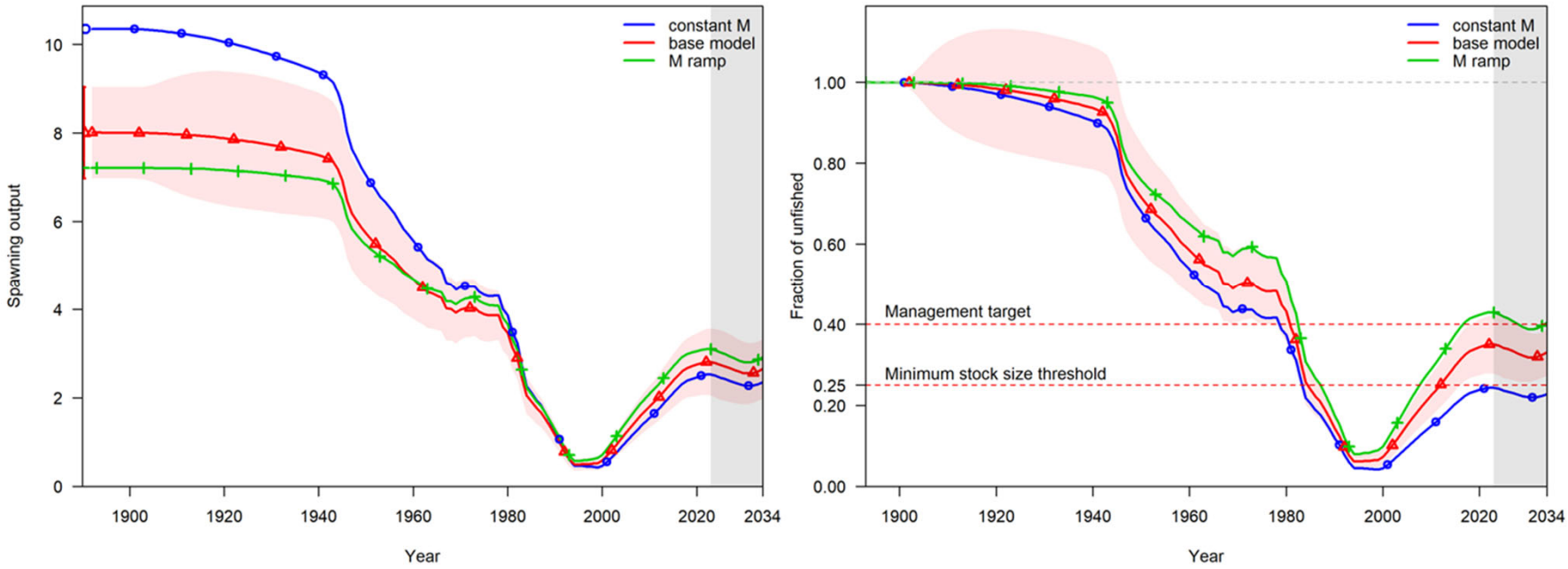
STAR Panel requests and responses

The Panel continued to explore sensitivity runs with different structural assumptions for M (now including the new age data and revised selectivity patterns), particularly as appropriate for a decision table (as in 2015 assessment). Sensitivity runs showed similar dynamics to the pre-STAR base model with the exception of the model without sex-dependent selectivity, which diverged considerably from the base model (particularly with respect to spawning output).



Decision table uncertainty

The assessment team and the panel agreed on a decision table in which the low state of nature reflected a single M scenario, and the high state of nature was represented by the "M ramp" scenario for females, with default harvest control rules, assuming a P* = 0.45.



Other review highlights

- The draft base model was improved by adding age data that was inadvertently omitted from the draft, after mirroring recent OR Non-Trawl & WA Recreational selectivity curves to the early time period, and reweighting the model
- The STAT team provided a robust rationale for the decision to move from a spatially explicit model to a single area model, developed a comprehensive bridging analysis, and explored many alternative models that addressed the rarity of old female canary rockfish in different ways.
- All coastwide index data were used, several data sources were not included as they were too localized in space (e.g, state-specific or finer spatial scale).
- The assessment is fairly deficient in data, particularly as only catch and some length data exist to inform the model prior to the 1980s when the stock declined steeply (close to target level when triennial index begins!). Relative to the exploitation history, abundance indices are short term. Thus, the assessment results rely heavily on fixed steepness and recent length and age data.

Major uncertainties

- As with many rockfish assessments, the canary rockfish natural mortality rate and the stock-recruitment relationship remain the major uncertainty in understanding the stock's current and potential productivity.
- There is limited information on rockfish stock structure beyond the US West Coast (e.g., Canada).
- The abundance indices are of insufficient precision to provide much information on trends in abundance in recent years.
- Further research is needed to understand the skewed sex ratios in the population, specifically, the apparent absence of older females in any data sets.
- Despite considerable improvement of the parameterization of selectivity, there are some remaining high correlations among selectivity parameters. Simplification of fleet structure and selectivity should be considered in the next full assessment.

Assessment team research recommendations

- Continued research into the mechanism leading to skewed sex ratios and empirical studies to estimate natural mortality rates.
- There is a need for non-trawl coast-wide fishery-independent surveys to improve abundance indices, this would also have the potential to provide biological data in a variety of habitats and across latitudinal gradients.
- Other biological relationships could be updated to better understand dynamics for canary rockfish (e.g., fecundity).
- Additional research into ecosystem or climate considerations (e.g, environmental drivers of canary rockfish productivity).

More assessment team research recommendations

- Further exploration of differences in spatial and non-spatial modeling structure, stability, and results. Consider establishing a process by which research-based assessments can be done to explore these issues
- Research to inform understanding of movement rates for a spatial model, as well as improve estimates of natural mortality.
- Revision of the ageing error matrices, incorporating the new aged canary rockfish data and utilizing new analytical methods (e.g., potential bias in ageing of old canary rockfish based on bomb-radiocarbon).

STAR Panel research recommendations

- Explore selectivity parameterization using asymptotic selectivity at length and domed selectivity at age.
- Consider potential changes over time in predation mortality, given large changes in known or likely predators (e.g., lingcod, hake).
- With respect to skewed age distributions, consider a comprehensive literature review and/or additional development of models to explore the potential mechanisms for greater mortality with age. Also consider cooperative research with Washington or Oregon fixed gear fleets to better sample age structure.
- Evaluate and explore additional sources of relative abundance information from either fixed gear fisheries or other fixed gear surveys in the California Current.
- If available, historical age structures (otoliths) that were surface read and not used in this assessment should be read using contemporary methods
- Given the uncertainty and apparent declines in Canary recruitment in recent years, monitor pre-recruit survey index closely between assessments.

Panel recommendations

- The Panel recommends that this be considered a Category 1b assessment, as there are compositional data to inform year class strength and growth, and there is trend information (albeit fairly uncertain) from surveys.
- Panel recommends using the default sigma value of 0.5 for category 1 assessments.
- The Panel recommends that the next assessment should be an update, unless new data or research indicate a need to reconsider the treatment of natural mortality or steepness in this model.