**Pacific Herring ISCAM-mseR Integration Update**

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# Summary

As it stands, we have a close reconstruction of the historical period and successful closed-loop simulations projecting into the near future (Fig. 1). Estimations using ISCAM in the mseR management procedures are stable, if a little slow, with successful convergence in every iteration. Replicates with 6 projection years take about 2 minutes to complete.

# Methods

## Operating Model

The operating model is a sex-aggregated, multi-fleet statistical catch-at-age model. Herring are simulated from age 1 to the plus group at age 10, and each year experience instantaneous fishing and natural mortality, are observed by spawn surveys, and spawn recruits for the following year. The historical period is conditioned using leading parameter estimates from the ADMB report files of the 2015 stock assessment model ISCAM. In this historical period, 1951 numbers-at-age are used to initialize the operating model, then ISCAM estimates of F and M are applied to update the numbers-at-age. Numbers are transformed to biomass (spawning and total) using fixed maturity and yearly historical weight-at-age observations used in the 2015 assessment.

During the projection, the simulation takes over the weight-at-age and natural mortality. Natural mortality returns to initial average mortality (Fig. 2), and weight-at-age uses the allometric length-weight relationship solved from the 1951 empirical weight-at-age observations and 2015 assessment length-at-age observations. I intend to switch this to time-series bootstraps or random walks continuing the historical trends.

The operating model is modified from the mseR-Sablefish operating model used in the 2016 MSE process. To do so, I removed the two-sex structure and reduced the discard probability to zero, though this might be useful in future for unreported catch modeling. I used a time-averaged mortality rate in the reference points calculations to accommodate time-varying natural mortality in the per-recruit quantities (as done by Martell in ISCAM) (Fig. 3).

The generic sableOpMod modification has not yet been started. As it stands, the current structure of the herring OM requires only minimal changes to the control file to use other stocks, but there is no multi-stock capability yet.

## Assessment Model

The assessment model is ISCAM, with the changes I made to allow for age-dependent M estimation in the Herring M sim-est paper. Model estimates of biomass and leading parameters are close to the simulated values in the closed loop simulation, but with a tendency to bias B0 high and R0 low. Retrospective fits to exploitable biomass are decent, if biased low in the later historical period (Fig. 4), while restrospective fits to spawning biomass are very good (Fig. 5)

## Management Procedure

The DFO management procedure is implemented as variable F harvest control rule, ramping from F = 0 at the lower stock reference to F = 0.22 at the upper stock reference. Upper and lower stock reference and maximum F values are calculated from yearly unfished spawning biomass estimates, which are provided by ISCAM, and the DFO management procedure’s cutoff of 25% and maximum harvest rate of 20%.

../mserproject/plots/BCF.pdf

Figure 1. Simulated spawning biomass, catch and fishing mortality for the historical period (1951-2015) and projection (2016 onwards).

../mserproject/plots/Mt.pdf

Figure 2: Simulated natural mortality rates for historical and projection periods.

../mserproject/plots/refPts.pdf

Figure 3: Reference points calculated from the 2015 herring stock assessment parameter estimates.

../mserproject/plots/retro.pdf

Figure 4: Retrospective assessment model estimates of exploitable biomass.

../mserproject/plots/retroSpawn.pdf

Figure 5: Retrospective assessment model estimates of spawning stock biomass.