

Part I: Moving towards a sustainable fisheries
framework for BC herring: data, models &
alternative assumptions.

Part II: Stock assessment and management
advice for BC Herring stocks (2011/2012)

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Moving towards the sustainable fisheries framework.

Overview

- ▶ Review of the HCAM model in June 17-18, 2010.
 - ▶ Model parameterization of q .
 - ▶ Parametrization of q , M , and selectivity is confounded.
- ▶ Development of a new integrated Statistical Catch Age Model ($iSCA_M$).
- ▶ Data, assumptions and Analytical methods.
- ▶ Outstanding issues.



Introduction

- ▶ Current harvest control rule for BC herring:
 - ▶ Cutoffs set at $0.25 B_0$
 - ▶ 20% exploitation rate
 - ▶ Estimates of B_0 were last updated in 1996.
- ▶ HCAM model assumed $q = 1$ for the dive survey data.
- ▶ Natural mortality is modelled as a random-walk.
- ▶ Gill net selectivity is a function of weight-at-age.



Harvest Strategy Compliant with Precautionary Approach

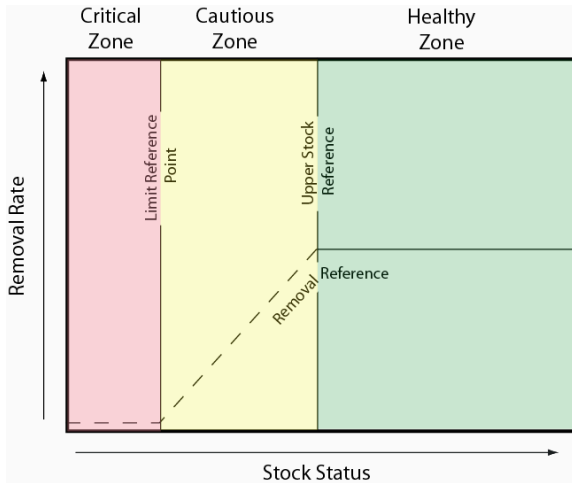


Figure: Fisheries management framework consistent with a precautionary approach.



Key elements for the new framework I

Reference points

- ▶ Limit Reference Point (LRP) & Upper Stock Reference (USR) requires knowledge of stock productivity and population scale.
- ▶ Removal Rate requires knowledge of stock productivity.
- ▶ MSY-based reference points require *a priori* allocation to different gears.

Risk & Decision making

- ▶ Onus on being able to reliably determine stock status (informative data).



Herring Stock Assessment Model Review I

Summary of Panel Recommendations



Herring Stock Assessment Model Review II

- ▶ Panel concluded that $q_2 = 1$ was inappropriate.
- ▶ CUTOFFS can be fixed or annually estimated (should be updated if management objective is 25% B_0)
- ▶ A model based approach to estimating B_0 and B_{MSY} is appropriate.
- ▶ Recruitment variation should be estimated within the model rather than fixing it at a pre-specified level.
- ▶ Issues regarding estimating selectivity vs. availability should be explored (data is limited to estimate availability).
- ▶ Science advice should be risk neutral.
- ▶ MSE should explore elements of the Sustainable Fisheries Framework (i.e., ensure that $B_t > 0.4B_{MSY}$ with 95% certainty over two generations.)
- ▶ ...



Input data

The input data for $i\text{SCA}_M$ is the same as HCAM:

- ▶ Catch by gear,
- ▶ Spawn survey index,
- ▶ Age-composition data for all gears,
- ▶ Empirical weight-at-age data.



Analytical methods

Integrated Statistical Catch Age Model (*i*SCA_M)

- ▶ The model is based on a statistical catch-age framework first developed by Fournier and Archibald (1982).
- ▶ Flexible options for modelling selectivity, natural mortality, & survey catchability.
- ▶ Integrated framework: joint estimation of policy parameters (e.g., reference points).
- ▶ Bayesian implementation...



Assumptions I

Error distributions

- ▶ Observation errors in catch are lognormal & σ is known.
- ▶ Errors in spawn survey are lognormal & σ is unknown.
- ▶ Recruitment deviations are lognormal & σ is unknown.
- ▶ Age-composition residuals follow a multivariate-logistic distribution.

Selectivity

- ▶ Seine gears: asymptotic and time invariant.
- ▶ Gillnet gear: parametric logistic function with weight anomalies as a covariate.



Assumptions II

Structural assumptions

- ▶ Age-2 recruitment with a Beverton-Holt model.
- ▶ Fishing & natural mortality occur simultaneously (Baranov catch equation).
- ▶ Natural mortality is age-independent.
- ▶ Natural mortality can vary over time (random walk, $\sigma = 0.1$).
- ▶ 100% of the total mortality occurs before spawning.
- ▶ Fecundity is proportional to mature biomass.

Equilibrium & MSY-based reference points

- ▶ B_o is based on average M and average fecundity-at-age.
- ▶ B_{MSY} is based on average (M) and fecundity in terminal year.



Objective function I

Major components of the objective function

- ▶ Likelihoods for data.
- ▶ Likelihoods for structural assumptions.
- ▶ Phased penalties to ensure regular solution.
- ▶ Prior densities for model parameters.



Objective function II

Likelihoods for data

- ▶ Normal density functions for:
 - ▶ catch residuals (log-scale) with fixed σ^2 ,
 - ▶ spawn survey residuals (log-scale) with estimated σ^2 .
- ▶ Multivariate logistic function for age-composition evaluated at the conditional MLE of σ^2 .



Bibliography

Fournier, D. and Archibald, C. (1982). A general theory for analyzing catch at age data. *Canadian Journal of Fisheries and Aquatic Sciences*, 39(8):1195–1207.

