

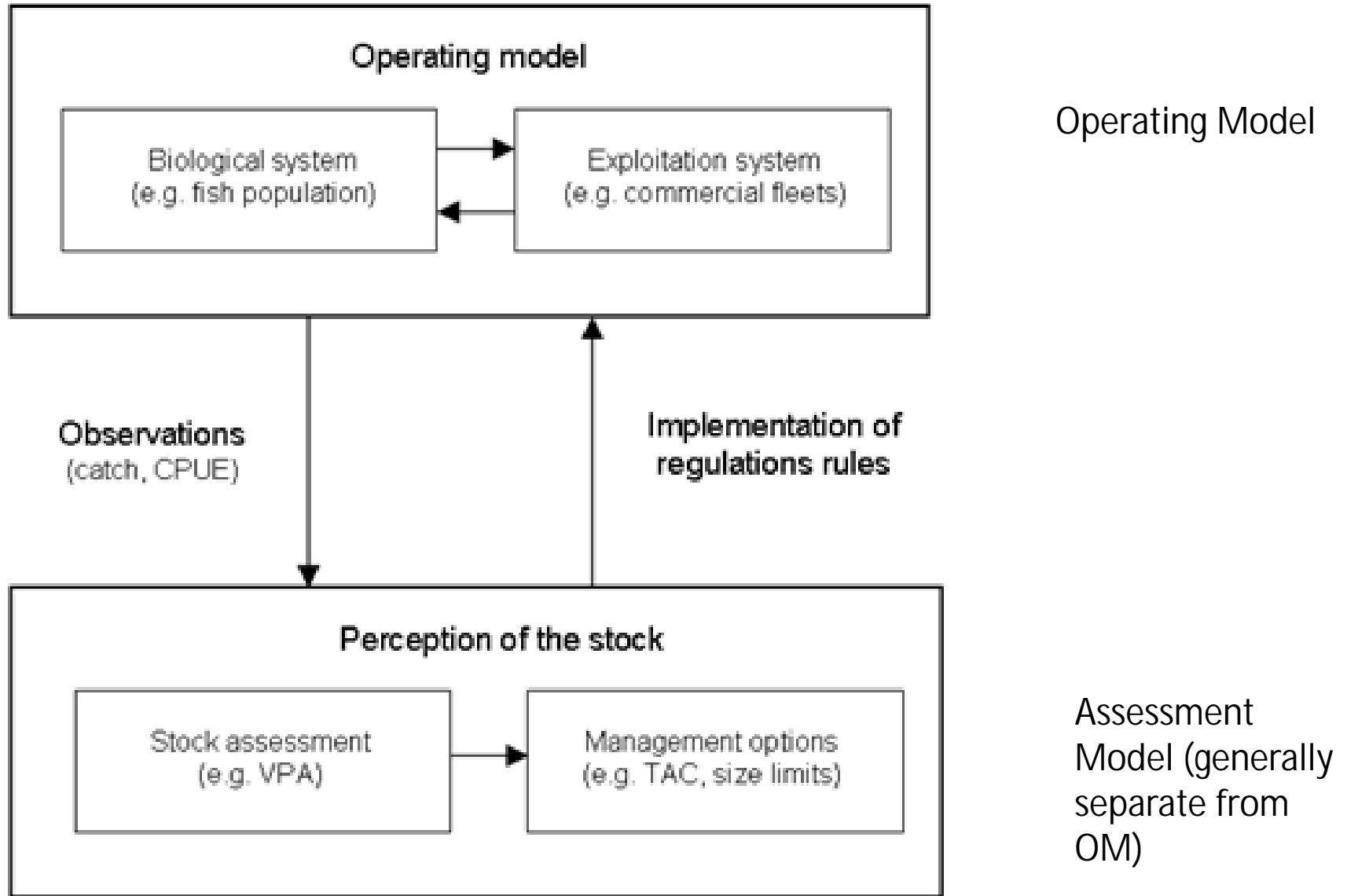
Management strategy evaluation
(MSE) implementation in Stock
Synthesis: application to Pacific
bluefin tuna

Mark Maunder

Management Strategy Evaluation (MSE)

- Complete management strategy
 - Data to collect
 - Method to analyze the data
 - Harvest control rule
- Evaluate the management strategy under different possible states of nature
 - States of nature represented by operating model assumptions and parameter values
 - Condition states of nature on data (i.e. use stock assessment)
 - Determine evaluation criteria (biomass level, catch, ...)

MSE feedback loop



From Kell ICES MSE course

SS and MSE

- Use SS as operating model
 - Data simulated using the bootstrap option
 - Assessment conditioned on data
 - Use priors (to free up more parameters) and MCMC to represent alternatives states of nature
 - Add process error by extending the “estimation period”
- SS (simplified perhaps) can also be used as the assessment model

Determine states of nature: Run the SS stock assessment in MCMC mode to generate the states of nature

- Extend the modelling time frame to include the period over which the MSE will be conducted in .dat file and .ctl files.
- Add zero catches for all fisheries for the period of N years over which MSE will be conducted. Add N years of CPUE data to survey.
- Turn the forecast off and set forecast years to zero
- Modify control file so that recruitment bias correction is 1 for all years. Five lines: endNoBias,startFullBias,endFullBias,startNoBias,maxBiasAdj
- Make catchabilities parameters so that MCMC samples from them
- Make recruitment deviates not dev_var_vector (not sum to zero)
- Run the model using the MCMC mcsave option. e.g. SS -mcmc 1000000 -mcsave 1000 (you can also use the -noest option if the model has already been run with the hessian estimated).
- Run the model using the MCMC mceval option. e.g. SS -mceval
- The draws from the posterior of the estimated parameters will be in the file posteriors.sso

Evaluate the harvest rule under different states of nature

- a. Take a sample of the parameters from the posterior and insert them in the par file. This will require matching up the parameters in each file since the posteriors.sso only has the estimated parameters and the par file has all the parameters
- b. Change starter file to initiate the model parameters from the par file and do not estimate parameters
 - a. 1 # 0=use init values in control file; 1=use ss3.par
 - b. 0 # Turn off estimation for parameters entering after this phase
- c. Put in data where you would like the model to simulate data including the years, sample size/sd, and types.
- d. Add one data bootstrap in the starter file
 - a. 3 # Number of datafiles to produce: 1st is input, 2nd is estimates, 3rd and higher are bootstrap
- e. Run the model using the `-nohess` command line option
- f. Take the simulated data and apply the harvest control rule and calculate the quota.
- g. Put the quota in the data file as the catch for the appropriate year.
- h. Repeat e-g for each year of the MSE
- i. Store the appropriate information from the SS output files (e.g. ending biomass, average catch)
- j. Repeat a-i for each sample from the posterior

Apply the harvest control rule

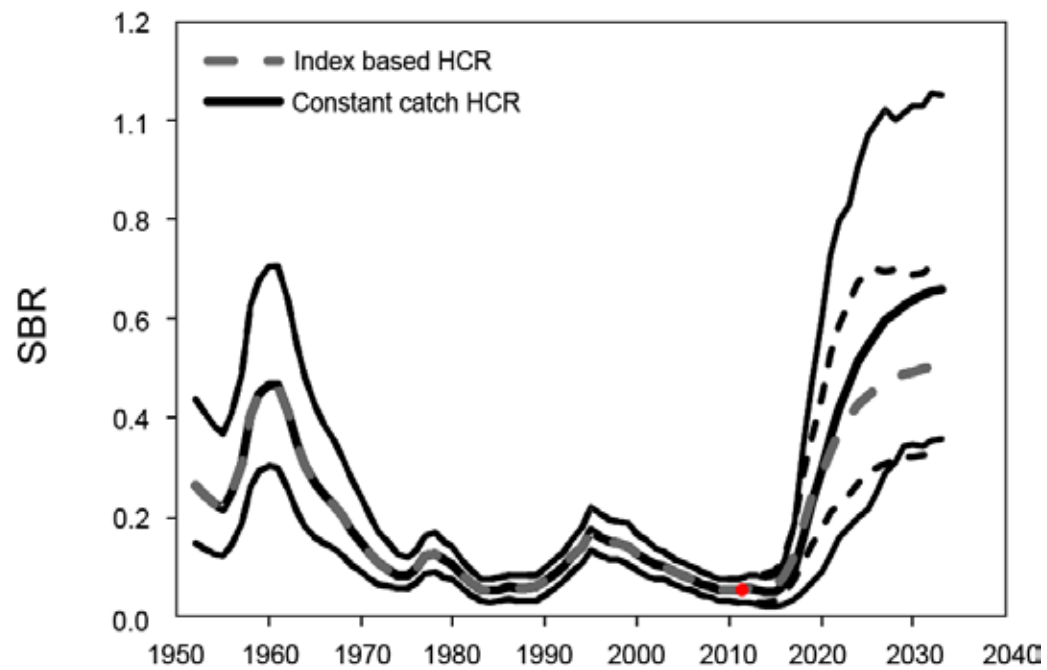
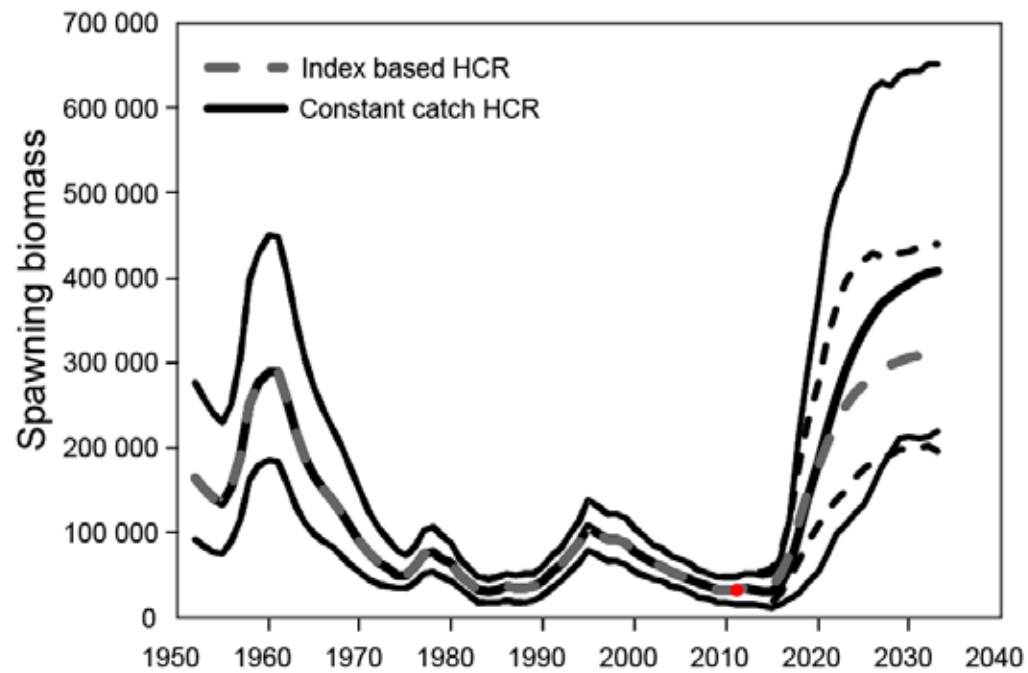
- Take the historical observed data (or the simulated data for this period) and add the simulated data for the future years if appropriate (from `data.ss_new`) and conduct the assessment and apply the control rule to determine the quota.
- Only take the newly created data point each year because all data points, including the ones that have already been used in the decision rule for previous years, are randomly generated.
- Make sure you take the value for the third data set, which is the one that is randomly generated.
- If you are using the catch in the decision rule (e.g. if the assessment model for your decision rule is based on a surplus production model) make sure you take the catch from SS and not from the previous assigned quota because if the quota is too high the setting for maximum F in SS may cause the catch used in SS to be lower than the quota.

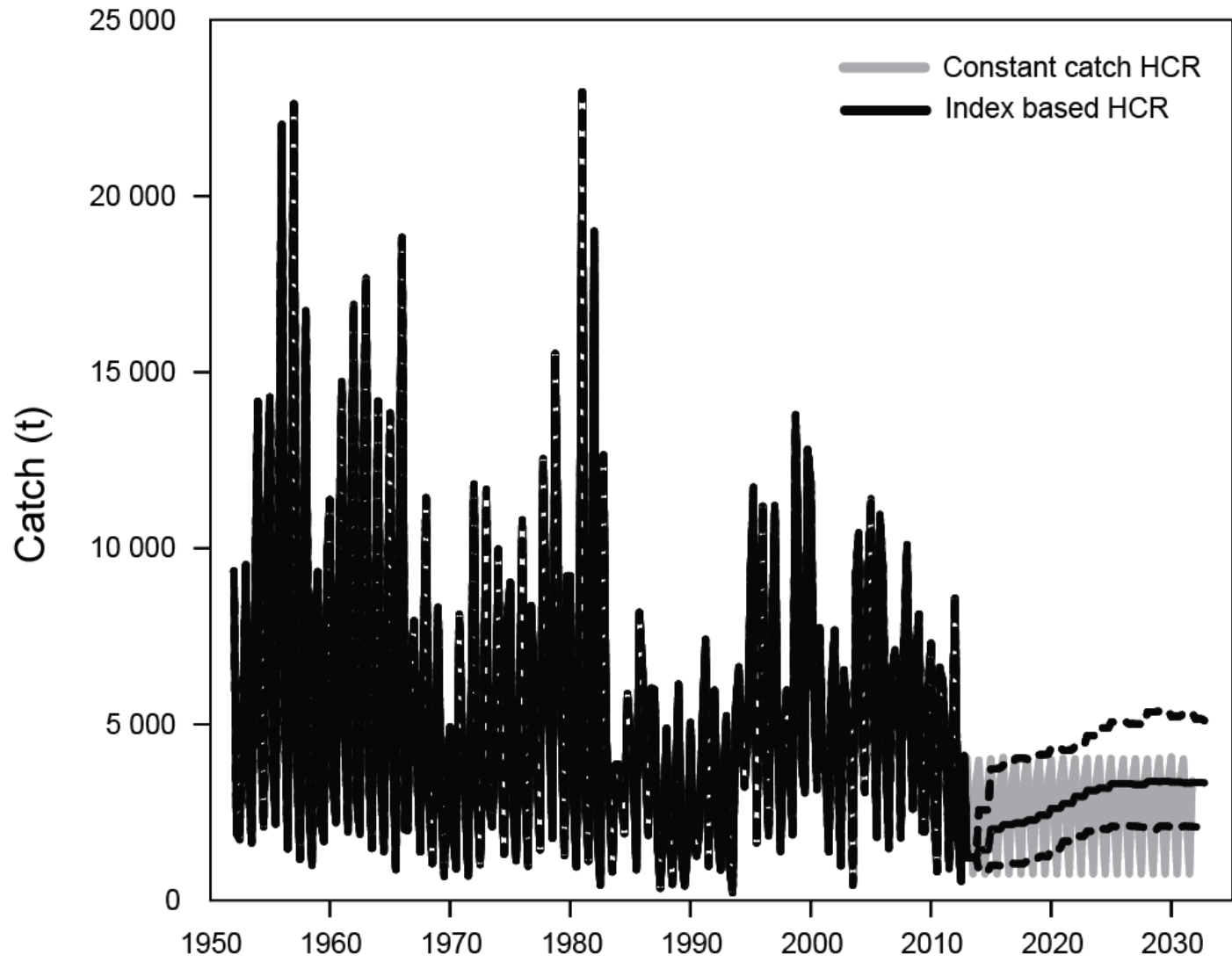
Pacific bluefin application

- Use the ISC SS-based stock assessment as an operating model.
- Control rule 1
 - All fisheries that catch juvenile bluefin have their catch set at 50% of the average catch from 2002-2004, by quarter.
 - Other fisheries have their catch set at the average catch from 2010-2012.
- Control rule 2
 - Based on two CPUE-based indices of abundance: an index of spawning biomass based on Japanese longline CPUE, and an index of recruitment (one-year-olds) based on Japanese troll CPUE.
 - The catch for each fishery is a harvest rate times the current index of abundance averaged and lagged appropriately.
 - The index used differs by fishery, and is related to the ages selected by the fishery.
 - An average of the index over one or more years is used to correspond to the ages caught by the fishery.
 - The harvest rate is calculated as the average catch in the past three years (2010-2012) divided by the average index in the past three years, averaged and lagged appropriately.
 - This “current” harvest rate is then multiplied by 0.5 to approximate the first harvest control rule and allow for rebuilding.

Indices and lags

Fishery	Main ages selected	Index used	Lags used
1	Spawners	LL	-1
2		Troll	-1
3	3 to 6	LL	-2 to -5
4	2 to 6	LL	-1 to -5
5	1	Troll	-1
6	1	Troll	-1
7	1 to 3	Troll	-1 to -2
8	1 to 3	Troll	-1 to -2
9	1 to 2	Troll	-1
10	1 to 4	Troll	-1 to -3
11	Spawners	LL	-1
12	2 to 3	Troll	-1 to -2
13	2 to 3	Troll	-1 to -2
14	1+	LL	-1





MSY seeking HCR

$$\text{if } \begin{cases} \frac{I_{t+1}}{I_t} \leq \alpha_{LB} & C_t = \beta_{LB} C_{t-1} \\ \alpha_{LB} < \frac{I_{t+1}}{I_t} < \alpha_{UB} & C_t = C_{t-1} \\ \frac{I_{t+1}}{I_t} \geq \alpha_{UB} & C_t = \beta_{UB} P_{t-1} \end{cases}$$

where

$$P_t = B_{t+1} - B_t + C_t$$

B_t is biomass at the start of year t and is equal to the index (I) times catchability (q).

C_t is the catch in year t

$\alpha_{LB} < 1$, $\alpha_{UB} > 1$, $\beta_{LB} \leq 1$, $\beta_{UB} \leq 1$ are the control parameters

Improved HCR

$$\text{if } \left\{ \begin{array}{l} \frac{\hat{I}_t}{\hat{I}_{last}} \leq \alpha_{LB} \\ \alpha_{LB} < \frac{\hat{I}_t}{\hat{I}_{last}} < \alpha_{UB} \\ \frac{\hat{I}_t}{\hat{I}_{last}} \geq \alpha_{UB} \end{array} \right. \quad \begin{array}{l} C_t = \left[1 - \frac{\hat{I}_{last} - \hat{I}_t}{\hat{I}_{last}} \beta_{LB} \right] C_{t-1} \\ C_t = C_{t-1} \\ C_t = \beta_{UB} P_{t-1} \end{array}$$

Where \hat{I}_t is the index value predicted from a linear regression on the index values, including the year of the last change (I_{last}) to the current year (t), with a minimum of three years (or a smoother such as a moving average).

Suggested parameter values

$$\alpha_{LB} = 0.9$$

$$\beta_{LB} = 1.5$$

$$\alpha_{UB} = 1.1$$

$$\beta_{UB} = 0.9$$

Advantages

- You do not need to know the production function (i.e. you do not need to know natural mortality or the stock-recruitment relationship, which are both typically highly uncertain)
- It adjusts for changes in productivity
- Basing the reduction (when the index decreases) on the catch rather than the productivity reduces the risk of stock collapse if catchability is misspecified.

Issues

- A non-linear relationship between the index and abundance
- High variability in the index due to observation or process error
- Uncertainty in the estimate of catchability
- Application of the harvest control rule might be complicated when there are multiple fisheries with different age-structured selectivities and when these selectivities differ from the selectivity of the index of abundance and/or the measure of surplus production.
- Not clear if it finds MSY if biomass is above B_{MSY}

Future work

- Improve the stock assessment model used for the operating model
- Include more uncertainty
 - Stock-recruitment
 - Natural Mortality
 - Growth
 - Nonlinear relationship between CPUE and abundance
- Identify other candidate management procedures
- Identify performance criteria

Acknowledgments

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