MSE Framework: Harvest Control Rules (HCRs)

Harvest control rules (HCRs) define management actions and are oftentimes based on the status of a stock relative to its reference point. Five different HCR forms are available in the framework: constant F, threshold, ramp, P*, and F-step. There is an option to include a constraint on catch advice so that it would not be higher than the estimated catch that corresponds to the estimated overfishing limit (OFL) from the stock assessment to emulate the current in-season quota monitoring system. However, in misspecified scenarios, the true catch can be larger than the catch that corresponds to the true OFL in the OM when there is biased estimation from the stock assessment. There is also an option for a minimum catch limit (i.e., the minimum bycatch of the last ten years in the historical period), which would prevent F from declining to zero.

HCR Forms :

1. Constant fishing mortality (Caddy and Mahon, 1995 ; Restrepo et al., 1998; Mace, 2001; Goodman et al., 2002; Punt, 2010; Doonan et al., 2014 ; Dichmont et al., 2016 ; Fig. 1)

A 'constant fishing mortality' HCR harvests the same fraction of the stock regardless of biomass, and consequently catch increases linearly with abundance (e.g., 75% F_{MSY}; Restrepo et al., 1998; Goodman et al., 2002). The catch is set equal to a fixed proportion of the estimate of the population size. This option provides a balance between constant catch and constant escapement HCRs, as this option responds to stock size (Punt, 2010). Variants of this HCR could be based on different precautionary buffers (Restrepo et al., 1998). Constant F HCRs have been applied in the management of the U.S. west coast groundfish fishery (Dichmont et al., 2016) and the New Zealand orange roughy fisheries (Doonan et al., 2014).

Status in New England groundfish management: This option (75% F_{MSY}) is the Acceptable Biological Catch (ABC) control rule for many stocks that had not rebuilt on the expected schedule.

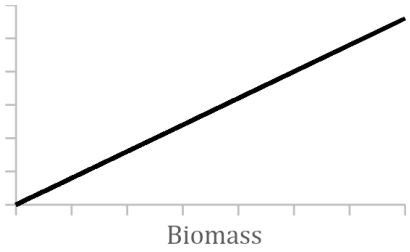

Figure 1. Constant fishing mortality harvest control rule.

2. Threshold (Butterworth and Best, 1994; Caddy and Mahon, 1995; Smith et al., 2008; Punt, 2010; Deroba et al., 2019; Feeney et al., 2019; Fig. 2)

A 'threshold' HCR harvest changes target F as a simple step function of stock biomass, with F set to zero at a level of abundance (e.g., 50%$SSB_{MSY;}$ Punt, 2010). Variants of this HCR could be based on different biomass thresholds (Deroba et al., 2019; Feeney et al., 2019). Threshold HCRs have been applied in management of whales by the International Whaling Commission (Butterworth and Best, 1994).

Status in New England groundfish management: This option has not been implemented.

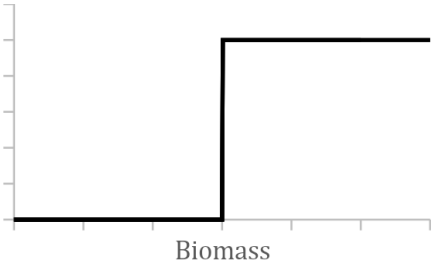

Figure 2. Threshold harvest control rule.

3. Ramp (Duplisea et al., 2012 ; Eikeset et al., 2013; Wetzel and Punt, 2015; Dichmont et al., 2016; FAO, 2016; Kvamsdal et al., 2016; PEW, 2016; Forrest et al., 2018 ; Deroba et al., 2019; Feeney et al., 2019; Fig. 3)

A 'ramp' HCR changes catch as a more complex function of stock biomass, typically with F increasing as biomass increases to some maximum rate. F is set at a constant level when the biomass is above the target biomass reference point and decreases when biomass is less than target level (e.g. 0.5Bmsy). The change in F can differ in steepness, and F does not need to be zero at a certain biomass. Variants of this HCR could be based on different ramp steepness and biomass thresholds (Deroba et al., 2019; Feeney et al., 2019). Ramp HCRs have been applied in management of Alaska crab fisheries, the Norwegian spring spawning herring fishery, the North sea cod fishery (Kvamsdal et al. 2016), the Northeast Arctic cod fishery (Eikeset et al. 2013), groundfish fisheries managed by the Pacific Fishery Management Council (Wetzel and Punt 2015), tuna fisheries managed by regional fisheries management organizations (FAO, 2016; PEW, 2016), and the Atlantic Canadian redfish fishery (Duplisea et al., 2012).

Status in New England groundfish management: This option has not been implemented but has been recommended to incorporate rebuilding plans into ABC control rules.

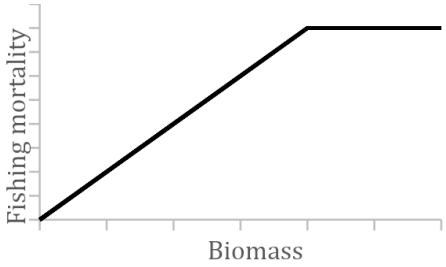

Figure 3. Ramp harvest control rule.

4. P* approach (Prager and Shertzer, 2010; Fig. 4)
   The P* approach avoids overfishing by accounting for scientific uncertainty with a probabilistic approach (Prager and Shertzer, 2010). The P* method derives target catch as a low percentile of projected catch at the overfishing limit. The level of P* can depend on the level of stock biomass.
   Status in New England groundfish management: The P* approach is currently used in the Council's Small Mesh Multispecies FMP.

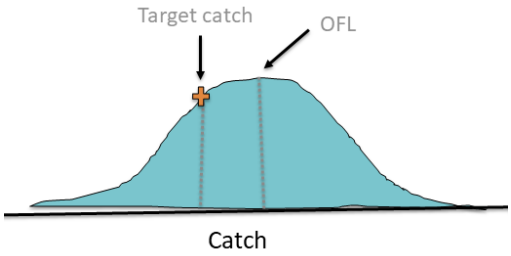

Figure 4. P* approach

5. F-step (Fig. 5)

If the SSB decreased below the biomass threshold (50% SSB_{MSY}), this HCR used a target F of 70% F_{MSY} that has recently been applied to some New England groundfish, such as SNE/MA yellowtail flounder and GB winter flounder, as the $F_{rebuild}$. If the SSB never decreased below the biomass threshold or increased to over SSB_{MSY} (rebuilt) after dropping below the biomass threshold, this HCR used a target F of 75% F_{MSY}. National Standard Guidelines were amended in 2016. These revisions reduced the need to identify an incidental bycatch ABC and indicated that $F_{rebuild}$ need not be recalculated after every assessment, making it less likely that $F_{rebuild}$ will be set to zero in response to short-term lags in rebuilding.

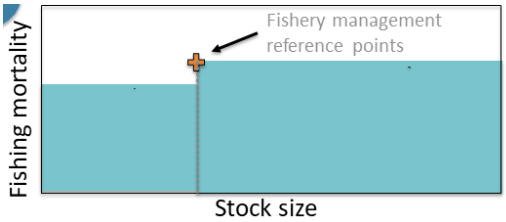

Figure 4. Step in fishing mortality HCR

documentation/mprocOptions.md
-documentation on options for management procedure, which includes HCRs

modelParameters/mproc.csv
-options for management procedure, which include HCRs

functions/get_nextF.R
-function that determines F based on HCR

functions/managementProc/get_slideHCR.R
-function that determines F based on the ramp or slide HCR