MSE Framework: Biological Reference Points

Biological reference points are the criteria by which we determine stock status and inform triggers for management actions in the context of harvest control rules. Both true and estimated reference points are estimated in the framework.

documentation/mprocOptions.md
-documentation on options for the management procedure, which includes biological reference points

modelParameters/mproc.csv
-options for the management procedure, which includes biological reference points

modelParameters/set_om_parameters_global.R
-includes options for management procedure
-BrefScalar- scalar for SSB reference point
-FrefScalar- scalar for F reference point

functions/managementProc/get_FBRP.R
-function to estimate F reference point

functions/managementProc/getBBRP.R
-function to estimate SSB reference point

functions/managementProc/get_proj.R
-function to project the population, used for some reference point calculations

functions/managementProc/get_BmsySim.R
-function to estimate SSB reference point assuming an F reference point and recruitment history, simulates SSB given an F value

Types of F reference points available in the framework:

1. **F_{MSY}:** FREF_TYP=FmsySim

Maximum Sustainable Yield (MSY) reference points are based on F that provides the highest long-term yield. Simulation is used to find the F that maximizes yield. A backward-looking projection or forecast can be used. If a forecast is used, temperature impacts can be incorporated. If a forecast is not used, recruitment is based on a set of previous recruitments.

F_{MSY} (the fishing mortality that produces MSY) and B_{MSY} (the long-term stock size expected from fishing at F_{MSY}) are the most common target reference points, although they may not be the most economically beneficial option (Punt, 2010). Reliable estimation of these reference points requires either an informative time series of catch and relative stock size indices (Hilborn and Walters, 1992) or information about the stock-recruitment relationship (Punt, 2010). MSY reference points can incorporate environmental effects if an environmental variable, such as sea surface temperature, is

included in the stock-recruitment relationship (Hill et al., 2011). In MSY-based HCRs, the target biomass reference point is typically B_{MSY} and the limit biomass reference point is typically (1-M)B_{MSY} or 50%B_{MSY}. The limit fishing mortality reference point is typically F_{MSY}, and the target fishing morality reference point is typically 0.75F_{MSY} (Restrepo et al., 1998; NPFMC, 2015). If there is only a target fishing mortality reference point and no limit reference point, then the target fishing mortality reference point is typically F_{MSY}. MSY-based HCRs have been applied in the management of the Pacific sardine fishery (Hill et al., 2011) and United States west coast groundfish fisheries by the North Pacific Fishery Management Council (PFMC, 2014).

Status in New England groundfish management: MSY-based reference points are used for Georges Bank winter flounder (NEFSC, 2019).

documentation/FmsyGridSim.md
-description on methodology for determining F_{MSY} based on maximizing yield over a grid search

2. F_{MED}: FREF_TYP=Fmed

Fishing mortality rate F corresponding to a SSB/R equal to the inverse of the 50th percentile of the observed R/SSB. This fishing level can be supported by observed survival rates from spawning to recruitment in 50% of years. This is an ICES approach that translates average recruitment-per-spawner to a value on the spawner biomass-per-recruit curve to determine the F reference point. This approach does not work well if mean recruitment is variable.

functions/managementProc/get_fmed.R
-function to estimate Fmed based F reference point

functions/managementProc/get_replacement.R
-function to get the slope of recruits versus SSB

3. Per Recruit: Yield per-recruit (YPR; FREF_TYP=YPR) or spawning potential ratio (SPR; FREF_TYP=SPR)

YPR provides an F estimate that maximizes yield given a growth rate, fishery selectivity, and natural mortality. Recruitment is assumed to be constant. The F reference point is based on x percent of the slope at the origin.

SPR reference points are based on the expected spawning-biomass-per-recruit, given a certain F, fishery selectivity, and other population dynamics parameters (Punt, 2010). SPR models take the levels of spawner-biomass-per-recruit and standardize them to the maximum (i.e., the level at F=0). This way the reference points that are developed are comparable among stocks that have different life histories. The F reference point is based on the desired quotient of spawning biomass-per-recruit at the reference point to spawning biomass-per-recruit at zero fishing.

In the United States, proxies for F_{MSY} based on a percentage of unfished spawning-biomass-per-recruit are suggested. Fx% is the long-term F that would result in the spawning-biomass-per-recruit to be x% of unfished spawning-biomass-per-recruit. SPR-based HCRs have been applied in the management of

United States west coast groundfish fisheries by the North Pacific Fishery Management Council (F40% or F50% and B40%; Punt, 2010; PFMC, 2014; Kvamsdal et al., 2016).

Status of SPR based reference points in New England groundfish management: Most groundfish stocks are managed using F40%SPR as a proxy for F_{MSY} (NEFSC, 2019).

functions/managementProc/get_perRecruit.R
-function to return yield-per-recruit, SSB per recruit, or spawning potential ratio

Types of SSB reference points available in the framework:

1. **Simulation-based:** BREF_TYP=SIM

This SSB reference point is developed via simulation. A backward-looking projection or forecast may be used.

2. **Per-recruit:** BREF_TYP=RSSBR

This SSB reference point is the level of spawning biomass-per-recruit at the F_{MSY} proxy multiplied by 'average' recruitment.