

Reference Point Definitions

Biological Reference Points (BRPs) are the measures by which the status of a stock is determined. BRPs can be derived either empirically or analytically and are typically estimated under the assumption that population dynamics are constant and/or in equilibrium.

Empirical BRPs typically use stock biomass or exploitation levels during certain time periods as reference levels, with assumptions about the time periods to use to measure relative change. These assumptions vary across stocks, including a historical period where a stock is assumed responsive to management or had high, sustained productivity that may reflect Maximum Sustainable Yield (MSY), or a contemporary period of sustained recent conditions. Analytical reference points, meanwhile, are defined through the stock assessment modeling process.

The traditional approach to BRP calculation has typically integrated strong assumptions of stationary population dynamics. While there is some updating that occurs in recalculating reference points with updated data on certain vital rates (e.g., a five-year average of weight-at-age and maturity-at-age), in the case of stocks with an analytical assessment, there are usually stationary assumptions regarding recruitment and natural mortality. In both cases, BRPs are used as benchmarks to set status determination,¹ to inform management decisions according to Acceptable Biological Catch (ABC) control rules, and to define stock rebuilding targets.

A challenge in characterizing MSY and other BRPs is complying with the requirements of National Standard 1 (NS1) of the Magnuson-Stevens Act as conditions change over time. The NS1 Guidelines define MSY as “the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological, environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets.” However, as changing ocean and fishery conditions impact a stock’s productivity, the assumption of “prevailing conditions” may no longer hold, thereby necessitating revisiting that stock’s BRPs.

Dynamic [Biological] Reference Points (DRPs) are time-varying targets and thresholds that adjust for non-stationarity in stock productivity. DRPs can enable more responsive management by accounting for the impacts of broad and persistent ecosystem change or regime shifts to better reflect recent past and projected future stock conditions. As with conventional BRPs, DRPs can be biomass- and/or fishing mortality-based and may use proxies depending on data availability (e.g., spawning potential ratio [SPR]). In some cases, DRPs may include linkages with an environmental driver and/or productivity but this is not required.

Numerous approaches for developing DRPs have been explored, including but not limited to those described on the next page.

¹ Some, not all, empirical BRPs inform status determination.

Dynamic Reference Point Approach	Description	Citation/NEFMC Example
Time-Varying MSY Reference Points	Calculating reference points such as MSY, SSB_{MSY} , and F_{MSY} as a function of a time-varying stock-recruitment relationship	Collie, J. 2023. White hake recruitment assumptions: effects on biological reference points and rebuilding projections for white hake (white paper and presentation). (Not yet adopted by the NEFMC)
Dynamic B_0	Determines unfished biomass by predicting the abundance of the stock in the absence of fishing using the stock assessment estimated-parameters (non-equilibrium approach)	Bessell-Browne, P., A. E. Punt, G. N. Tuck, J. Day, N. Klaer, and A. Penney. 2022. The effects of implementing a “dynamic B_0 ” harvest control rule in Australia’s Southern and Eastern Scalefish and Shark Fishery. <i>Fisheries Research</i> 252: 106306. https://doi.org/10.1016/j.fishres.2022.106306 .
Environmental Covariate-Informed Dynamic Reference Points	State-space models can propagate environmental covariates into biological reference points by linking environmental variables to key biological processes (e.g., recruitment or mortality). These environmentally driven processes determine population dynamics, and reference points derived from those dynamics such as MSY, B_{MSY} , and F_{MSY} become functions of environmental conditions.	
Truncated Productivity or Moving Window Approach	Calculated using a truncated productivity (e.g., recruitment) time series or a moving average over a window of time	Adopted in the 2022 management track assessments for Atlantic herring and Southern New England/Mid-Atlantic winter flounder.
Regime-Based Reference Points	Regime or state-dependent reference points defined for a particular ecosystem regime or productivity state (i.e., separate reference points for high/low states)	Are examples of re-estimating reference points to account for a change in productivity—for instance, for the Bering Sea/Aleutian Islands Tanner Crab stock (see p. 63-64).
Environmentally Conditioned Reference Points	Ecosystem-based fishing mortality: reference point that adjusts fishing mortality based on ecosystem conditions (e.g., lower when conditions are poor, higher when good).	Bentley, J. W., M. G. Lundy, D. Howell, S. E. Beggs, A. Bundy, F. de Castro, C. J. Fox, J. J. Heymans, C. P. Lynam, D. Pedreschi, P. Schuchert, N. Serpetti, J. Woodlock, and D. G. Reid. 2021. Refining fisheries advice with stock-specific ecosystem information. <i>Frontiers in Marine Science</i> 8: 602072. https://doi.org/10.3389/fmars.2021.602072 .