Biological Reference Point Table

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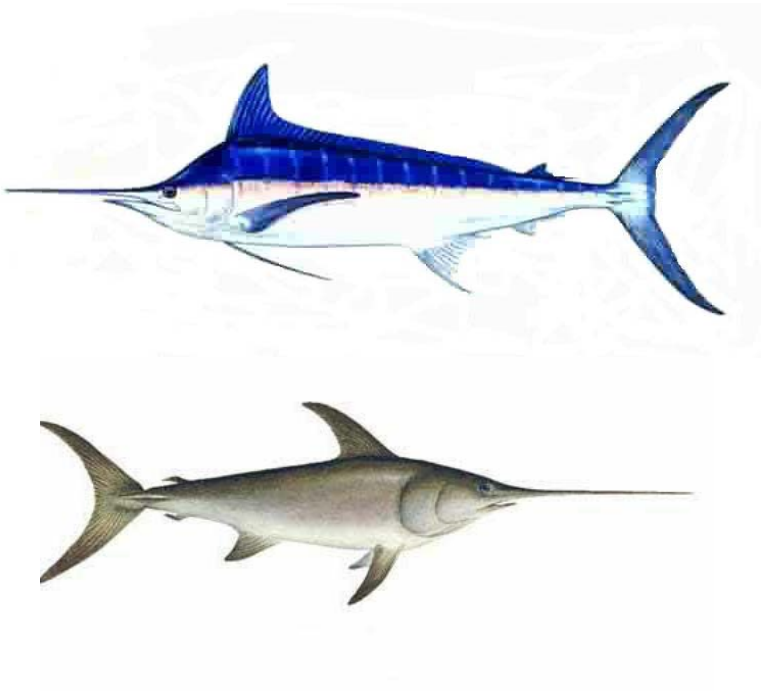

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Biological Reference Point	Definition and Management Purpose	Model Structure[1]	Data Needs[2]	Limit or Target Reference Point	Type of overfishing	Pros/Cons and Special Comments
F based Reference Points						
FMSY	Fishing mortality that maximizes yield under existing environmental conditions and fishery selectivity pattern	Age-structured or size-structured model for one or two sexes	Fishery catch, fishery catch per unit effort or other relative abundance indices, life history parameters	Has been used as limit and target reference point in various RFMOs	recruitment	FMSY is difficult to estimate if stock-recruitment relationship is not known. This BRP may be easy to implement but also entails high risk of recruitment overfishing. Can be estimated with biomass dynamics modeling.
F_{MAX}	Fishing mortality that maximizes yield per recruit	Age-structured yield per recruit model	Life history parameters	Has been used as a limit and a target BRP	growth	F_{MAX} may be appropriate if recruitment is relatively constant over a range of fishing effort. This BRP may be very risky for some rapidly-growing species because it may cause recruitment overfishing
$F_{0.1}$	The fishing mortality rate corresponding to 10% of the slope of the Y/R curve at the origin	Age-structured yield per recruit model	Life history parameters	Has been used as a limit and a target BRP	growth	A more precautionary exploitation level relative to F_{MAX}. Often thought to minimize potential recruitment overfishing without a substantial loss in yield.
F_{MED}	The fishing mortality rate corresponding to the median	Estimates of Spawners and Recruits	Estimates of Spawners and Recruits. Typically drawn from an age	Target or Limit	Recruitment	Not appropriate for assessments that assume no relation between spawners and recruits (ie. BH h=1.0).

	S/R ratio in the relationship of S/R against F.		structured assessment model.			Value dependent on the range of SSB used in the calculations. Typically not appropriate if estimates of recruitment taken from a narrow range of spawning biomass.
F_{τ}	Fishing mortality rate corresponding to the slope of the S/R function at the origin.	A S/R curve and a relationship of SSB/R and F	Estimates of Spawner and Recruits. Typically drawn from an age structured assessment model.	Limit	Recruitment	Fishing at F_{τ} leads to extinction. Can only be interpreted as a Limit.
$F_{X\%SPR}$	Fishing mortality rate that produces X% of the spawning potential without fishing under equilibrium conditions.	Age-structured Spawner per recruit model	Life history parameters	Has been used as a limit and a target BRP	Recruitment	Although a recruitment based BRP, it is a per-recruit calculation and thus does not depend on estimating the S/R relation. The appropriate level (X%) can be difficult to determine.
$F_{SSB\text{-}ATHL}$	Fishing mortality rate that produces no more than a determined probability of SSB falling below the 10th percentile of	Age or length structured assessment	Fishery catch, fishery catch per unit effort or other relative abundance indices. May use additional data such as, life history parameters, biological samples etc.	Target or Limit	Recruitment	Used by the ALBWG and assumes that specified level of spawning biomass is sufficient to insure recruitment success. ALB WG interprets this percentile as a limit BRP. Note this type of simulation based BRP can use any percentile or observed value of SSB.

	observed SSB levels in at least one year during a 25 year projection					
F_{lim}	ky					
F_{pa}	ky					
F_{loss}	ky					
Biomass based reference points						
B_{MSY}	The average biomass resulting from fishing at F_{MSY}	Age-structured or size-structured model for one or two sexes	Fishery catch, fishery catch per unit effort or other relative abundance indices, life history parameters (including natural mortality at age, size at age, weight-length relationships, fishery selectivity pattern, sex ratio in catch if two-sex model)	Has been used as limit and target reference point in various RFMOs	recruitment	BMSY is difficult to estimate if stock-recruitment relationship is not known. Can be estimated with biomass dynamics modeling. This BRP may be easy to implement but also entails high risk of recruitment overfishing
B_{MAX}	The average biomass resulting from a fishing mortality that maximizes yield per recruit	Age-structured yield per recruit model	Life history parameters	Has been used as a limit and a target BRP	growth	BMAX may be appropriate if recruitment is relatively constant over a range of fishing effort. This BRP may be very risky for some rapidly-growing species because it may cause recruitment overfishing

$B_{0.1}$	The average biomass level associated with fishing at $F_{0.1}$	Age-structured or size-structured model for one or two sexes	Fishery catch, fishery catch per unit effort or other relative abundance indices, life history parameters	Has been used as limit and target reference	growth	
$B_{X\%}$ (depletion)	A biomass level that is some specified fraction of the estimated unfished biomass level	Age-structured or size-structured model for one or two sexes	Fishery catch, fishery catch per unit effort or other relative abundance indices, life history	Has been used as limit and target reference	recruitment	Must use additional analysis to determine the appropriate depletion level. Usually a proxy for BMSY. Depletion is typically calculated relative to unfished level, however calculations of unfished state is controversial.
B_{lim}	ky					
B_{pa}	ky					
B_{loss}	ky					

[1]Model structure applies to calculation of reference point only. Additional model complexity may be needed to calculated observed metric (F, SSB etc) for comparison.

[2]Data needs are for calculation of reference point only. Additional data may be needed to calculated observed metric (F, SSB etc) for comparison.