NOAA FISHERIES

Improving the ABC Control rule for the GMFMC: A proposal for Tier 1.

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Gulf of Mexico Fishery Management Council SSC
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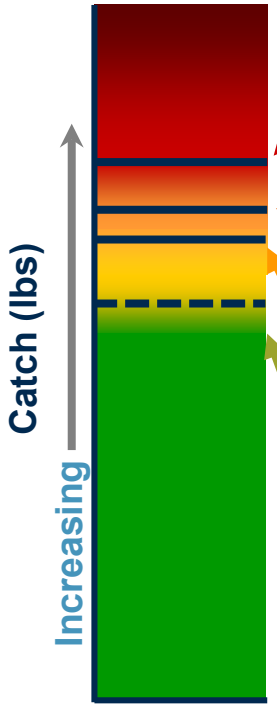
ABC Control Rule: Roles and Responsibilities



Overfishing Limit (OFL): Catch expected when fishing at MFMT (catch with a 50% probability of exceeding the true OFL as determined by the stock assessment)

Acceptable Biological Catch (ABC): Catch reduced below OFL to account for scientific uncertainty (catch with less than a 50% probability of exceeding the true OFL)

SSC ABC Control Rule

Annual Catch Limit (ACL): Catch that invokes accountability measures

Annual Catch Target (ACT): Catch reduced below ACL to account for management uncertainty or achieve optimum yield

Council

ABC Control Rule

- ABC control rule is an agreed procedure, adopted in the FMP, for setting the ABC for a stock or stock complex as a function of the scientific uncertainty in the estimate of OFL and any other scientific uncertainty
- Each Council must establish an ABC control rule based on scientific advice from its SSC.
- The SSC must recommend the ABC to the Council. An SSC may recommend an ABC that differs from the result of the ABC control rule, but must explain why.
- It can be data-limited in some circumstances and can involve complex drivers based on measured stock biomass, measured uncertainty, forecasts of environmental effects, etc.

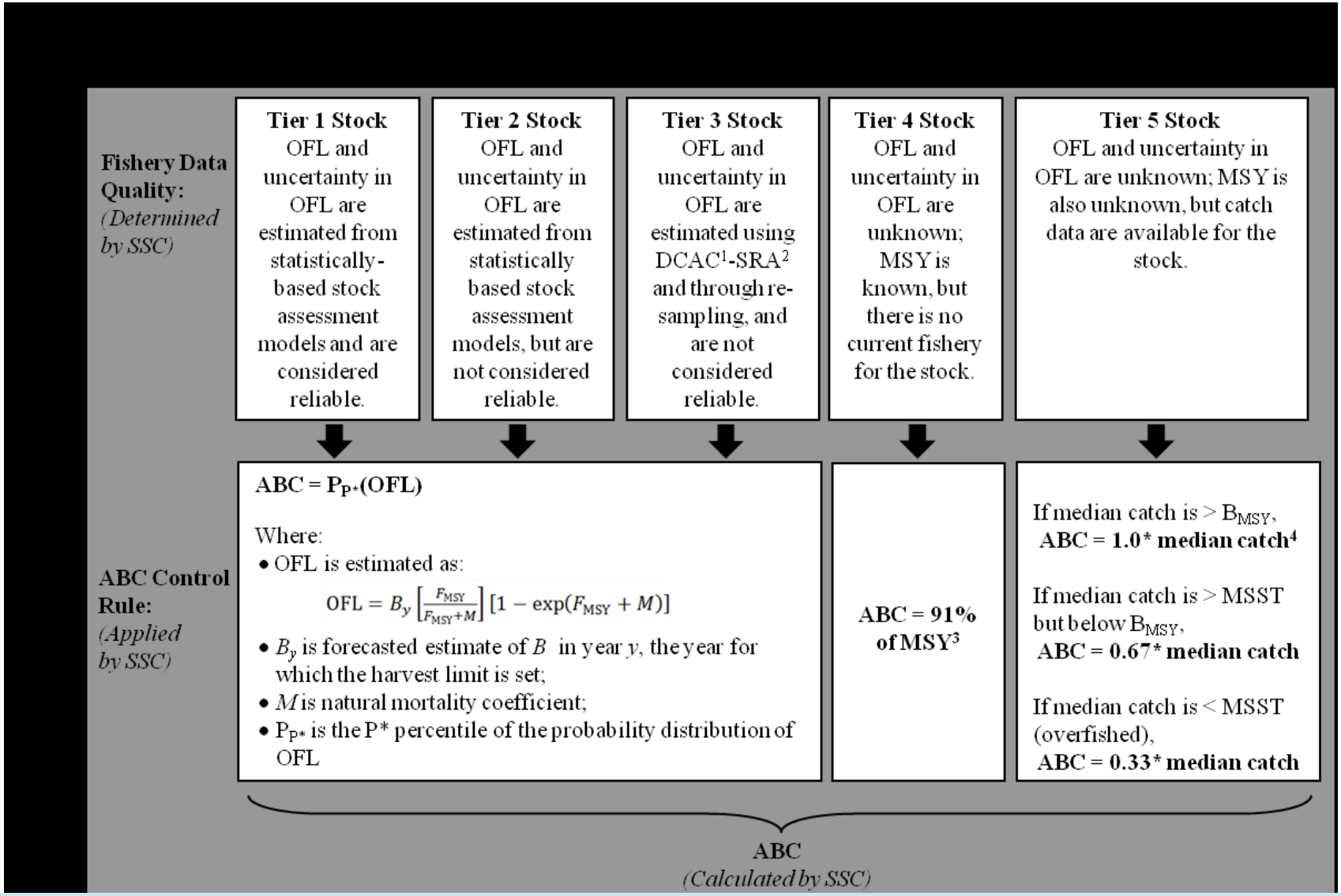
Actual ABC Control Rules Vary by Council

Some Councils have adopted a single framework for all Fishery Management Plans and others have different frameworks for each FMP

Most attempt to various degrees to set ABCs below the OFL in a way that reflects uncertainty…

…but how they do it varies a great deal

Example: WPFMC ABC Control Rule



Existing GMFMC ABC Control Rule for Reef Fish

- Tier 1
  - ***Condition for Use***: Assessment estimates MSY reference points and produces PDF of OFL. Choice of ***P* based on level of uncertainty considered in the assessment using a risk determination table:***
    - Level of assessment and use of F_{MSY} proxies (e.g. F_{SPR30}, $F_{0.1}$).
    - Characterization of Uncertainty (e.g. fully integrated, sensitivity runs, none)
    - Severity of Retrospective Pattern
    - Use of Environmental Covariates
  - OFL = yield at MFMT
  - ABC = yield at P* percentile from projection of MFMT (or $F_{REBUILD}$)

$$P^* = \exp\left[-a - b \sum_{i\ \mathrm{dimension}} Dimension\ score_i\right]$$

P* = 0.446

S_{hi}= 3.998

Maximum Risk **0.50** a= 0.693

Minimum Risk **0.30** b= 0.1277703

$$a = -\ln(0.50) \qquad b = -\frac{a + \ln(0.30)}{S_{hi}} \qquad S_{hi} = highest\ possible\ score$$

Element scores are scaled from zero to a maximum. In this example the maximum is 2.00, but this can be changed

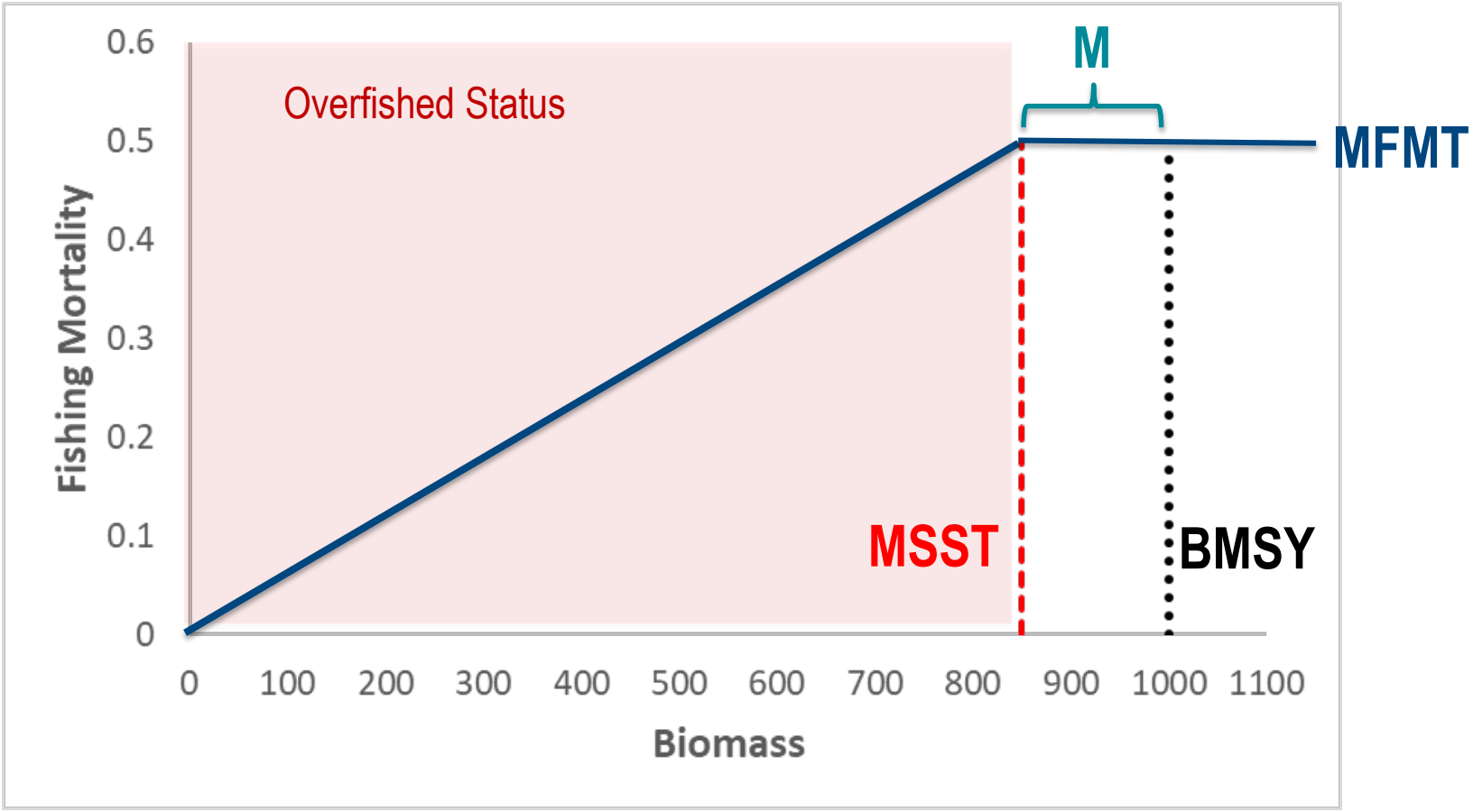
Dimension	Dimension Wt	Tier No.	Tier Wt	Element Score	Element	Score it	Element Result	Tier Result	Dimension Result
Assessment Information	**1**	1	1	0.00	Quantitative, age-structured assessment that provides estimates of exploitation and biomass; includes MSY-derived benchmarks.		0.67	0.67	0.67
				0.67	Quantitative, age-structured assessment provides estimates of either exploitation or biomass, but requires proxy reference points.	x			
				1.33	Quantitative, non-age-structured assessment. Reference points may be based on proxy.				
				2.00	Quantitative assessment that provides relative reference points (absolute measures of status are unavailable) and require proxies.				
Characterization of Uncertainty	**1**	1	.333	0.0	The OFL pdf provided by the assessment model includes an appropriate characterization of "within model" and "between model/model structure" error. The uncertainty in important inputs (such as natural mortality, discard rates, discard mortality, age and growth parameters, landings before consistent reporting) has been described with using Bayesian priors and/or bootstrapping and/or Monte Carlo simulation and the full uncertainty has been carried forward into the projections.		0.67	0.2231	0.22
				0.67	The OFL pdf provided by the assessment model includes an approximation of observation and process error. The uncertainty in important inputs (such as natural mortality, discard rates, discard mortality, age and growth parameters, landings before consistent reporting) has been described with ***SENSITIVITY RUNS*** and the full uncertainty has been carried forward into the projections.	x			
				1.33	The OFL pdf provided by the assessment model includes an incomplete approximation of observation and process error. The uncertainty in important inputs (such as natural mortality, discard rates, discard mortality, age and growth parameters, landings before consistent reporting) has been described with ***SENSITIVITY RUNS*** but the full uncertainty ***HAS NOT*** been carried forward into the projections.				
				2.0	The OFL provided by the assessment ***DOES NOT*** include uncertainty in important inputs and parameters.				
		2	.333	0.0	Retrospective patterns have been described, and are not significant.	X	0.0	0	
				1.0	Retrospective patterns have been described and are moderately significant.				
				2.0	Retrospective patterns ***have not*** been described ***or*** are large.				
		3	0				0	0	
					NOT USED				
						z			
		4	.333	0.0	Known environmental covariates are accounted for in the assessment.	x	0.0	0	
				1.0	Known environmental covariates are **partially** accounted for in the assessment.				
				2.0	Known environmental covariates ***are not*** accounted for in the assessment.				

SEFSC Proposal: Tier 1

- The ABC control rule should:
  - Reduce fishing mortality (MFMT) as stock size declines.
  - Impose a B_{CRIT} to reduce F to zero at some level of depletion. This would prevent stocks from reaching a level below which reproduction limitations become severe.
  - Divorce P* and σ. P* is a risk determination which is the prerogative of the Council. SSC should focus on characterizing scientific uncertainty (σ).
  - Impose a tiered system where as data quality/quantity declines σ increases, resulting in larger buffers between OFL and ABC for lower tiers.

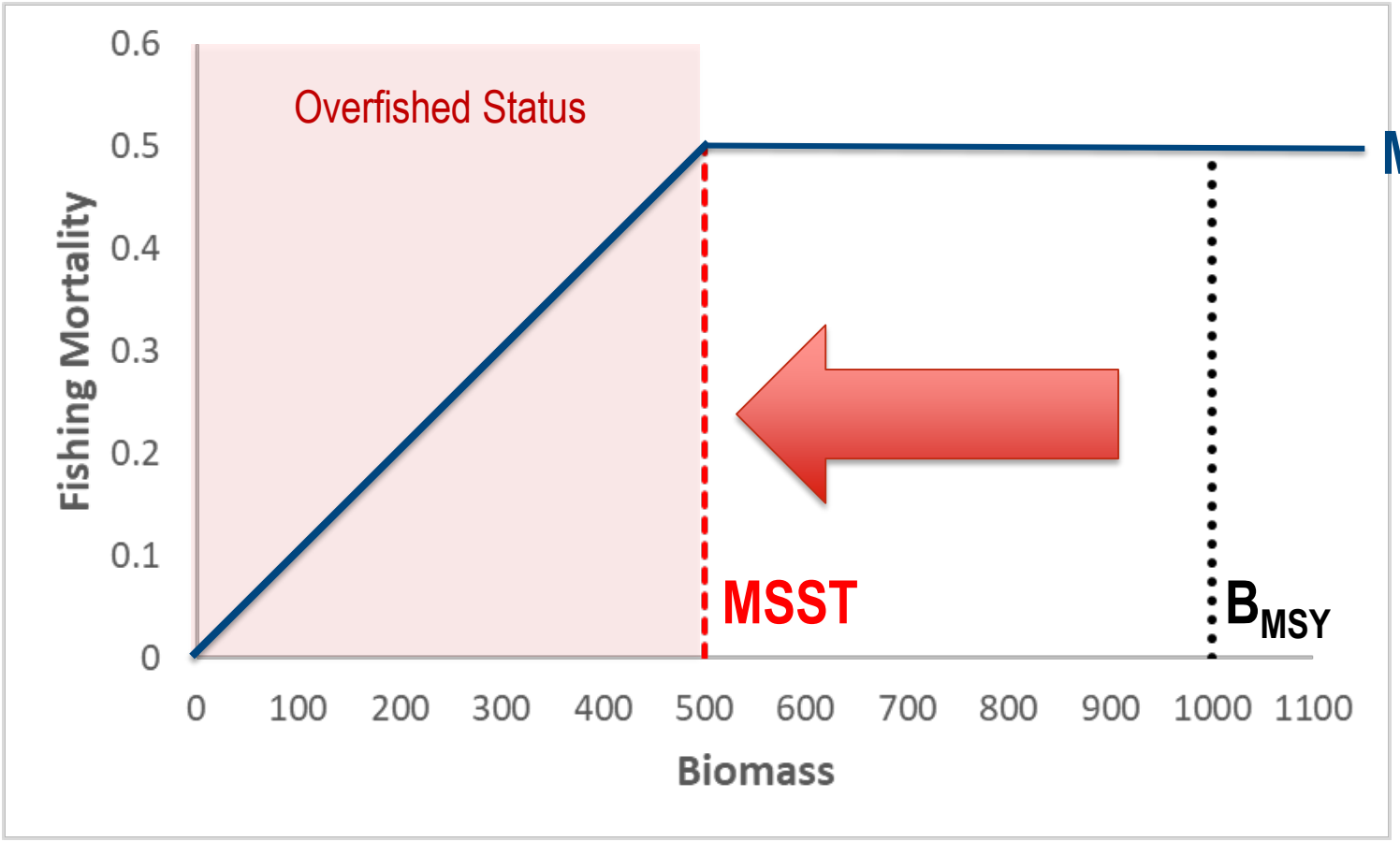
ABC Control Rule: General Guidance

- The ABC control rule should consider reducing fishing mortality (MFMT) as stock size declines. Previously, MSST was based on M. Rebuilding plans were required when $B < (1-M)*B_{MSY}$.



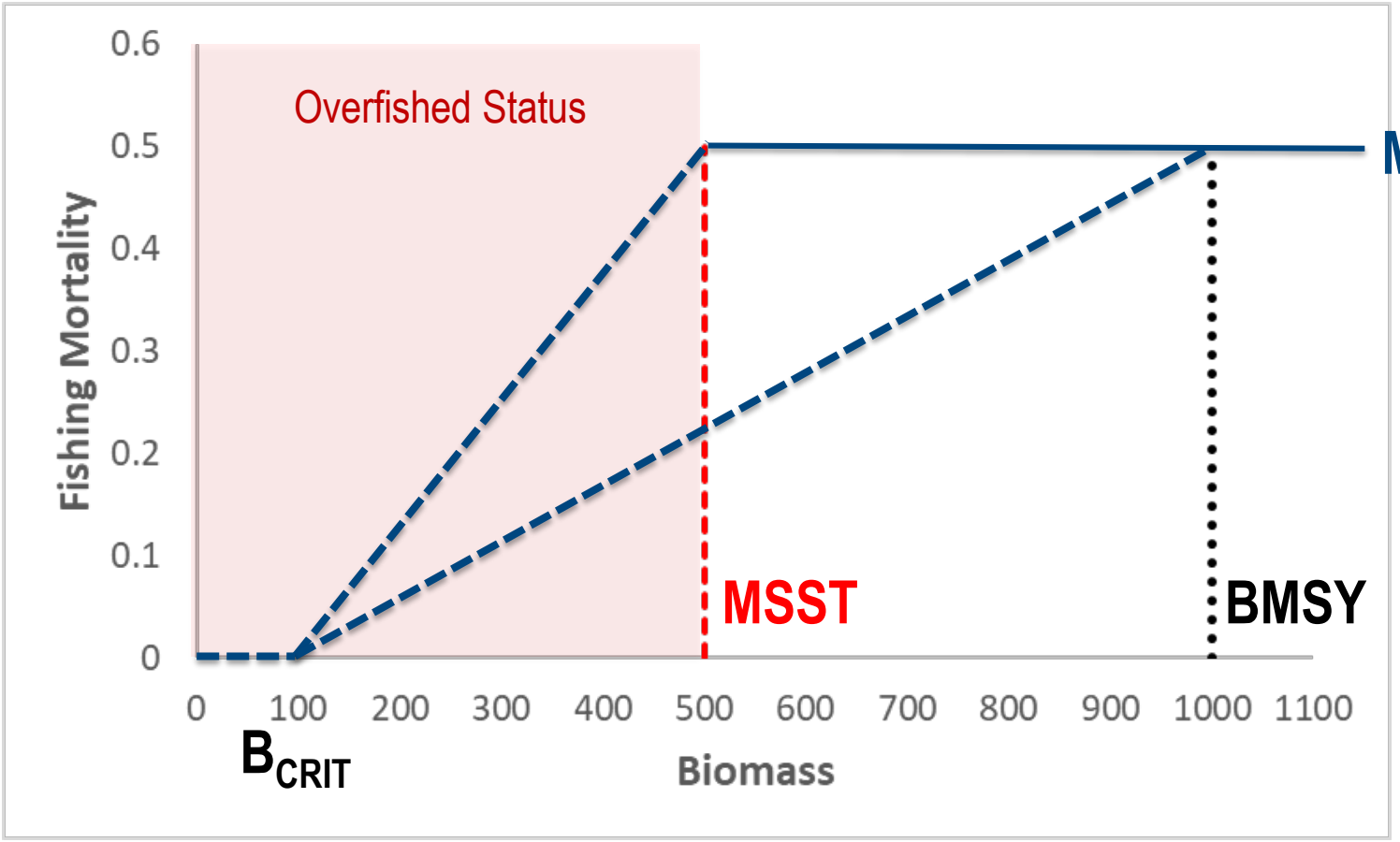
ABC Control Rule: General Guidance

- MSST now often set to 50%B_{MSY}. Stock is reduced well below the level that produces MSY before reducing F. Can require large reductions in F (and catch) and long rebuilding plans.



ABC Control Rule: General Guidance

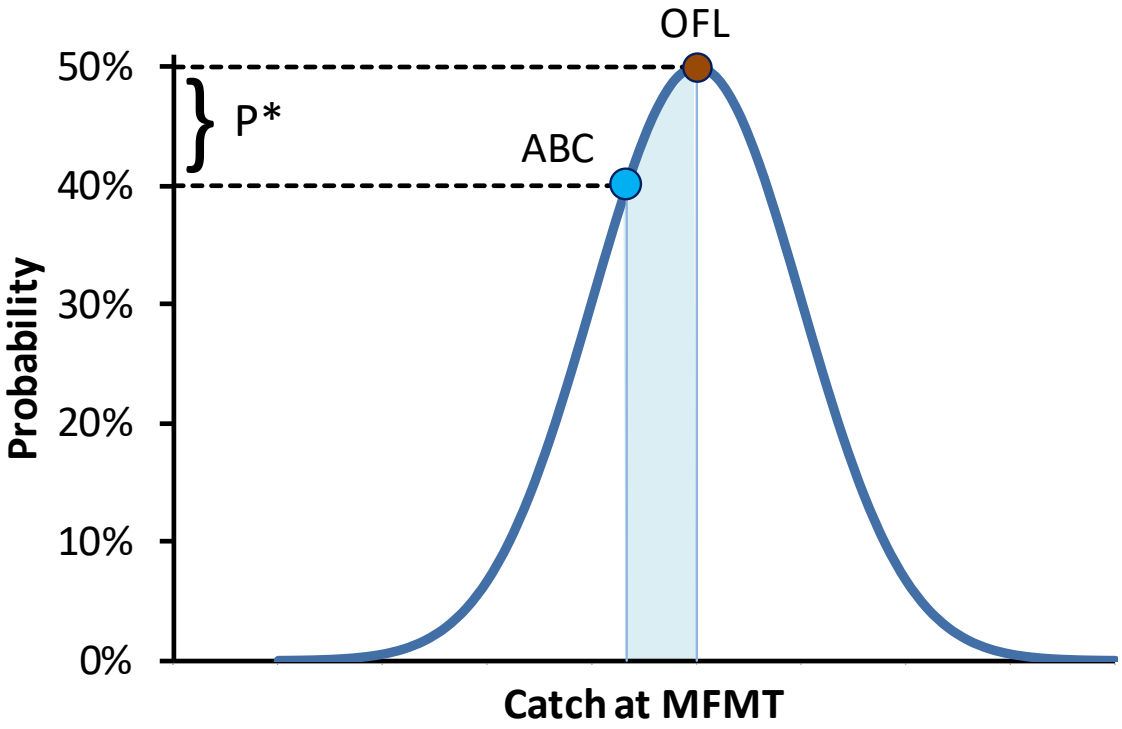
- To reduce the likelihood of long and/or harsh rebuilding plans The SSC could consider reducing F when B<BMSY. The SSC could also impose a B_{CRIT} to reduce F to zero at some level of depletion



ABC Control Rule: General Guidance

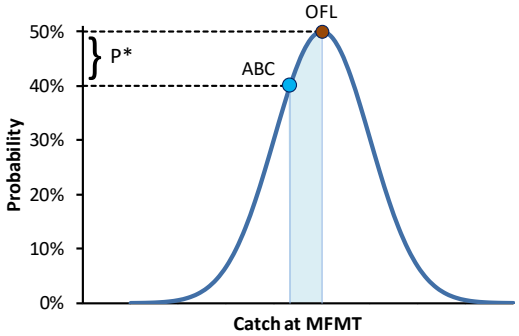
- The determination of ABC should be based, when possible, on the probability that a catch equal to the stock's ABC would result in overfishing (P*). The probability of overfishing cannot exceed 50% and should be a lower value.

- **PROBLEM**: Width of PDF derived from stock assessment is an underestimate of the true scientific uncertainty. Buffers between OFL and ABC are too narrow.



The Hidden Details

Calculation of ABC (from PDF of OFL) requires quantifying uncertainty

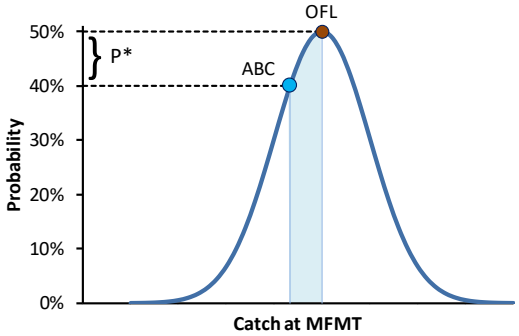


"there are known unknowns,... but there are also unknown unknowns – the ones we don't know we don't know. It is the latter category that tend to be the difficult ones."

Donald Rumsfeld, 2002

The Hidden Details

Calculation of ABC (from PDF of OFL) requires quantifying uncertainty

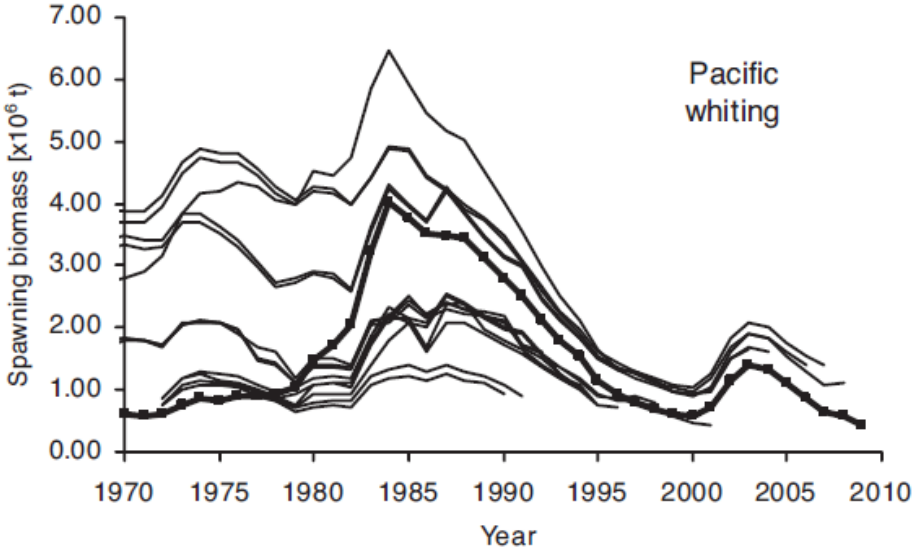


- Try to estimate variance of pdf as part of the assessment.

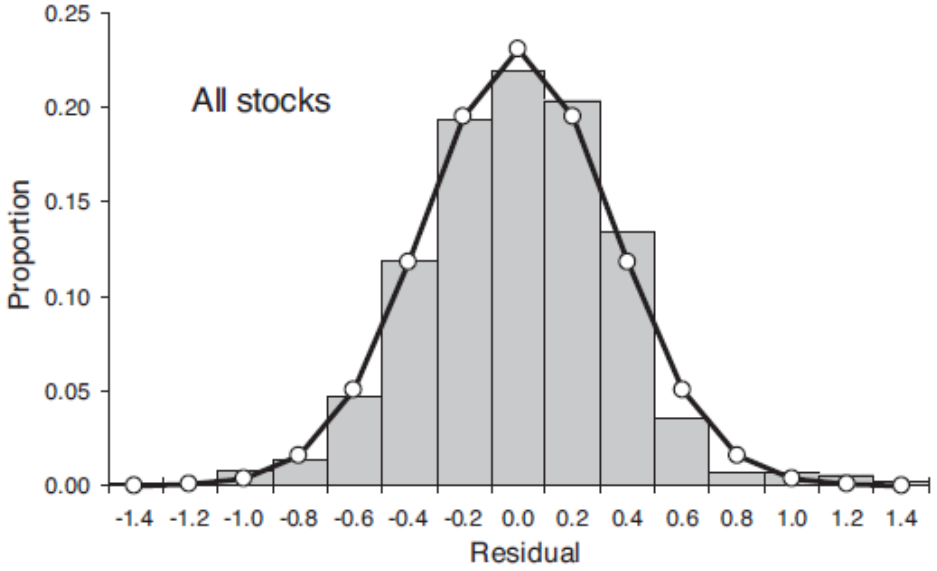
Current practice, often results in small buffers.

- Estimate variance external to assessment process
  - borrow from another assessment
  - compute from comparisons of estimates from multiple past assessments (Ralston et al. 2011)

Ralston et. al 2011: Meta-Analysis of Assessment Uncertainty



Examined uncertainty by calculating log-scale deviations from mean biomass from all historical assessments (17 stocks).



Aggregate distribution of log-deviations pooled over all 17 stocks with the fit of a normal distribution shown as the line with symbols (s =0.36).

Ralston et. al 2011: Meta-Analysis of Assessment Uncertainty

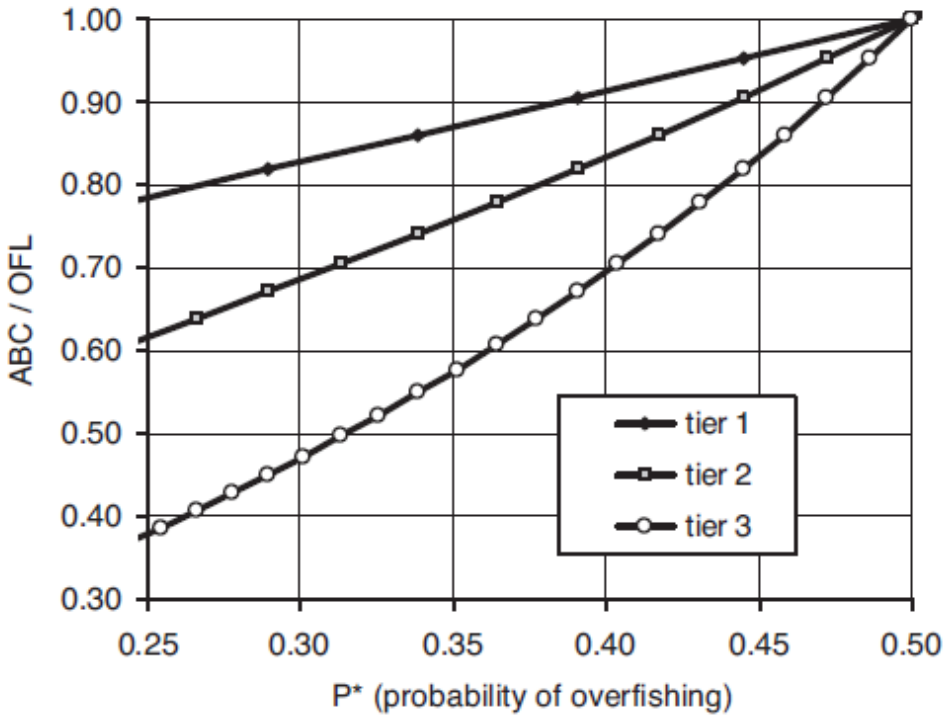


Figure 7

Relationship between the probability of overfishing (P^*) and an appropriate buffer between the allowable biological catch (ABC) and the overfishing level (OFL), based on varying amounts of uncertainty (σ=0.36, 0.72, and 1.44) assigned to different stock assessment tiers (1=data-rich, 2=data-moderate, and 3=data-poor), respectively.

SEFSC Proposal – Tier 1

Tier 1 "Data Rich"

- ***Condition for Use***: Full stage-structured assessment where reliable time series on catch, stage composition and index of abundance are available and the assessment provides estimates of MSST, MFMT, and PDF of OFL
- Maximum Fishing Mortality Threshold (MFMT) = $F_{MSY\ (or\ proxy)}$
- Minimum Stock Size Threshold (MSST) = $0.75*B_{MFMT\ (MSY\ or\ proxy)}$ [1]
- MSY = Long-term Yield at MFMT[2]
- OFL = Yield at MFMT
- ABC = *dX* where*

σ_{min} could be specified using Ralston approach or some minimum acceptable CV

*X** the yield that is produced at the percentile of the PDF of OFL corresponding to the acceptable probability of overfishing (P*) determined by the council and the PDF is determined from the assessment (subject to $\sigma > \sigma_{min}$) [3]

$$d = \begin{cases} \text{Scalar} & \text{if } B \geq Bmsy \\ \text{Scalar}*(B-B_{critical})/(B_{MFMT}-B_{critical}) & \text{if } B < B\ msy \end{cases}$$

Reduces MFMT as B declines

$B_{critical}$ = minimum level of depletion at which fishing would be allowed

Scalar = 1 if *P** < 50% specified by council, <1 otherwise

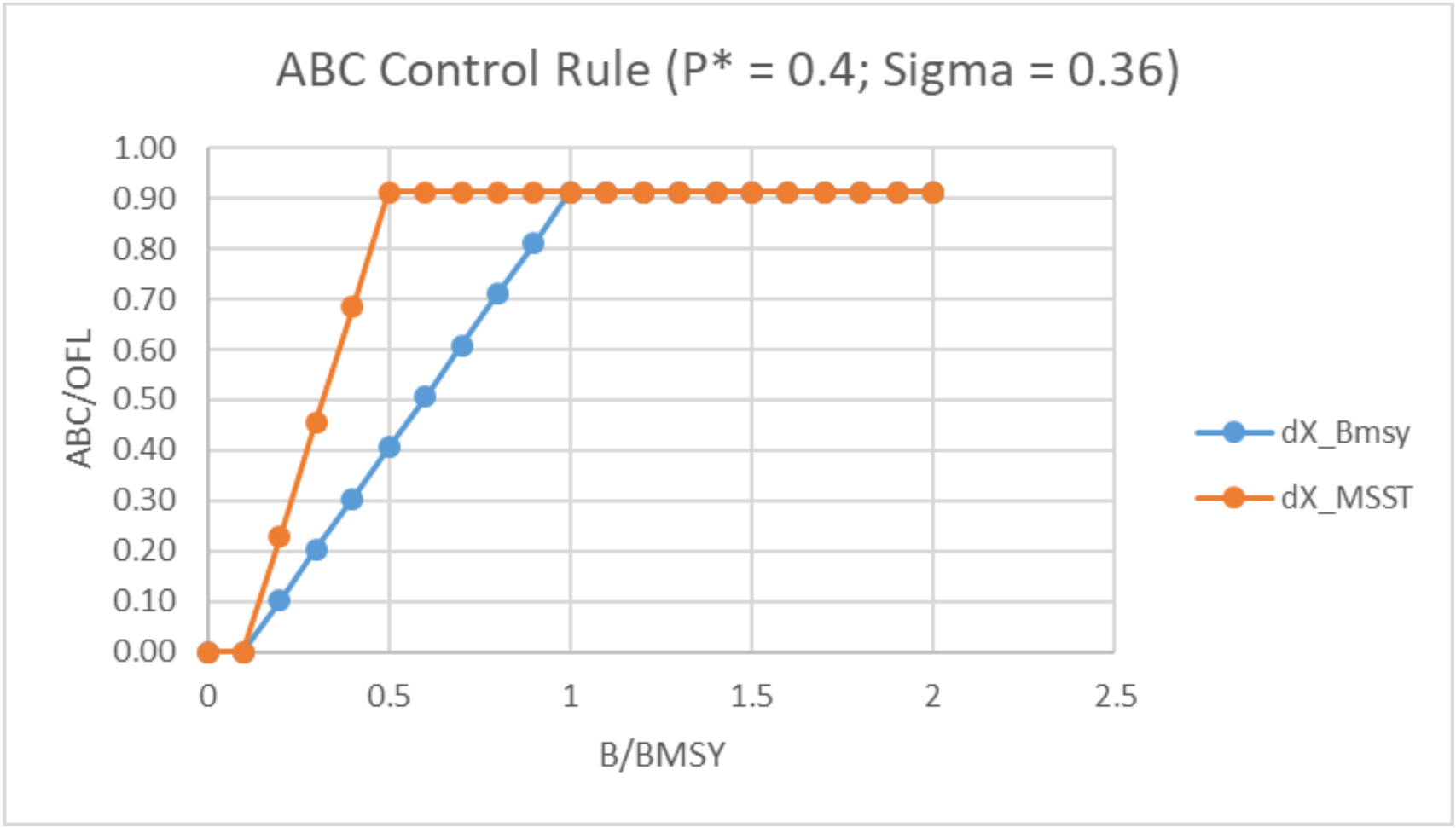
[1] Can use F_{MSY} proxies, such as %SPR (e.g. due to poor/unknown stock recruitment relationship), as appropriate with the level commensurate with the species life history and ecological function.

[2] Assuming the spawner-recruit relationship is well estimated, otherwise undefined.

[3] σ_{min} is the minimum acceptable standard deviation or coefficient of variation set by the SSC

Demonstration

- See GMFMC_ABC RULE DEMO_Tier 1.xlsx



Comparison to Current ABC Control Rule

- See GMFMC_ABC RULE DEMO_Tier 1.xlsx

- We'll take a look at how the ABC control rule functions for recently assessed stocks that are:
  - Above BMSY (i.e. Vermilion Snapper)
  - Below BMSY, above MSST (i.e. King Mackerel)
  - Below MSST (i.e. Greater Amberjack)

EXTRA SLIDES

National Standard 1 Guidelines

For all stocks and stock complexes that are "in the fishery"… the Councils must evaluate and describe the following items in their FMPs and amend the FMPs, if necessary, to align their management objectives to end or prevent overfishing:

(1) Maximum sustainable yield (MSY) and status determination criteria (SDC)

(2) Optimum Yield (OY)

(3) ABC control rule

(4) Mechanisms for specifying ACLs and ACTs

Maximum Sustainable Yield

MSY is 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.

F_{MSY} = fishing mortality rate that, if applied over the long term, would result in *MSY*.

B_{MSY} = long-term average size of the stock, measured in terms of the stock's reproductive potential that would be achieved by fishing at F_{MSY}

Status determination criteria (SDC)

MFMT (Maximum fishing mortality threshold) = level of fishing mortality F above which overfishing is occurring (typically = F_{MSY} or proxy)

OFL (Overfishing limit OFL) = annual amount of catch that corresponds to fishing at MFMT. The OFL is an estimate of the catch level above which overfishing is occurring.

MSST (Minimum stock size threshold) = the stock size below which the stock or stock complex is considered to be overfished (typically = cB_{MSY}, where $c \geq 0.5$).

Optimum Yield (OY) in the MSRA

(28) The term "optimum", with respect to the yield from a fishery, means the amount of fish which--

(A) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;

(B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, ***as reduced*** by any relevant economic, social, or ecological factor; and

(C) in the case of an overfished fishery, provides for ***rebuilding to a level consistent with producing the maximum sustainable yield*** in such fishery.