Potential Robustness Trials for the Pacific Bluefin Management Strategy Evaluation

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Summary

To facilitate the process of deciding on a final set of uncertainties for the Pacific Bluefin tuna (PBF) management strategy evaluation (MSE), a list of potential uncertainties to be considered for the PBF MSE robustness tests was compiled by reviewing best practices from the literature, those considered in MSEs of other bluefin tuna stocks, and relevant discussions in past PBF working group (WG) reports.

Introduction

Management strategy evaluation (MSE) highlights trade-offs between management objectives and assesses performance of a set of candidate management strategies under a range of uncertainty using computer simulations. This uncertainty can be thought of as "what if scenarios" of stock productivity, fishery dynamics, data availability, stock assessment error, or management implementation. Candidate management strategies are tested under a range of "what if" scenarios to make sure that they can meet management goals in the real world, whose dynamics are uncertain. In an MSE, the operating model (OM) reflects what the simulation considers as the "true" dynamics of the system, thus consideration of a range of uncertainties in stock or fisheries dynamics requires development of different OMs and testing of performance of management strategies across the range of OMs.

Uncertainties considered in MSE are generally separated into the following types: 1) process uncertainty, 2) parameter uncertainty, 3) model uncertainty, 4) estimation uncertainty, and 5) implementation uncertainty (Punt et al. 2016). Process uncertainty refers to random temporal variation in parameters, such as future recruitment or time-varying selectivity. Parameter uncertainty reflects uncertainty in the fixed parameters of the OM (e.g., is steepness 0.99 or 0.89). Model uncertainty is associated with uncertainty in the structure of an OM (e.g., whether fishery selectivity is asymptotic or dome-shaped). Estimation uncertainty arises from errors in data collection or stock status estimation methods (e.g. simulated stock assessment misspecification). Implementation uncertainty reflects errors in the implementation of the management controls (e.g. actual catch exceeds the TAC because of discards).

According to Punt et al. 2016's MSE best practices, minimally an MSE should consider uncertainty in 1) process uncertainty, in particular variation in recruitment about the stock-recruitment relationship; 2) parameter uncertainty relating to the productivity and the overall size of the resource, and 3) observation error in the data used when applying the management strategies. The PBF MSE has already the capability to include all of the above uncertainties. Many iterations are run to account for process uncertainty in recruitment, with recruitment deviations in the OM being sampled from a normal distribution with mean 0 and standard deviation of 0.6, the σ_R used in the 2022 PBF stock assessment (Tommasi and Lee 2022). The PBF MSE software also accounts for observation error by feeding into the EM data generated with error (Tommasi and Lee 2022). The PBF MSE data generation routine creates a new data set of observations with error using the same variance properties (standard error of fleet specific catch, standard error of the CPUE indices, and effective sample size of the size composition data) and error structure (lognormal for catch and CPUE, multinomial for the size composition data) assumed during the conditioning phase. Catch data is assigned a CV of 0.1, abundance index data a CV of 0.2, and the effective sample size for the size frequency data is set to the fleet-specific average of the conditioning period (Tommasi and Lee 2022). The values can be changed to examine scenarios with higher or lower observation uncertainty. Finally, the PBF MSE code can be run for a range of different OMs with different parameter specifications to account for parameter uncertainty. Lee and Tommasi (2023) proposed a parameter uncertainty grid spanning different ranges of the most influential PBF productivity parameters: natural mortality for age 2 and older, steepness, and length at age 3. Different model diagnostics were presented to select a set of equally plausible OMs to potentially be used in the MSE reference set to capture parameter uncertainty (Lee and Tommasi 2023).

Punt et al. 2016 stress that the uncertainties to consider in addition to the minimal ones highlighted above will be case specific. Indeed, one of the first steps in an MSE process is to identify those factors that contribute to most of the uncertainty for the specific stock being evaluated (Punt et al. 2016). It is also best practice to separate uncertainties into reference or robustness trials (Rademeyer et al. 2007). The reference set captures the most likely plausible range of stock and fishery dynamics, while robustness trials are still plausible but unlikely (Punt et al. 2016). Identification of the best management strategy is generally based on evaluation of performance across the key uncertainties in the reference trials, but the robustness trials allow for a check that the management strategies still behave as intended even in an unlikely, but still plausible, scenario (Punt et al. 2016). As time and resources are limited not all potential uncertainty trials can be included in an MSE, and there is some arbitrariness related to which ones are selected as the key trials to run, either as part of the reference or robustness set (Punt et al. 2016). Indeed, part of the MSE process involves the lead technical group compiling a list of uncertainties, and then prioritizing them to aid in the selection of the final set. For instance, the North Pacific albacore tuna MSE and Southern bluefin tuna MSE assigned potential uncertainties as high, medium, or low priority to aid final selection of uncertainties to consider (ISC 2021, Anon 2019). To facilitate the process of deciding on a final set of uncertainties to consider for the PBF MSE, we compile here a list of potential uncertainties, in addition to the process, observation, and parameter uncertainties that the PBF WG is already planning on considering, for the PBF WG to prioritize that could serve as robustness trials for the PBF MSE.

Methods

We compiled a list of potential uncertainties to be considered by the PBF WG by reviewing PBF WG reports, the Punt et al. 2016 MSE best practices paper, as well as working papers from the Southern Pacific bluefin tuna MSE (Anon, 2019) and the Atlantic bluefin tuna MSE (Anon, 2020). These uncertainties were all listed in Table 1. Note we did not include those uncertainties related to steepness, growth, or natural mortality as those have been considered as part of the PBF MSE reference set in Lee and Tommasi (2023).

Results

Table 1 shows the potential set of uncertainties that we compiled from the sources outlined in the methods. Most potential uncertainties relate to uncertainty with data or biological processes.

Table 1. Potential uncertainties to be considered in PBF MSE robustness trials compiled from the sources outlined in the methods. Highlighted in orange are the ones from past PBF WG reports.

Uncertainty Type	Uncertainty	Description	Source	Priority
Data related	No recruitment index	No recruitment index in EM. Due to changes in fisheries operations following changes in management, it has become difficult to generate a recruitment index from the JP troll data.	PBF WG	
	Only Taiwan CPUE index	No recruitment or JPLL index in EM. Above described changes in management may affect also JPLL index.	PBF WG	
	Exclusion of particular years of data	CPUE index does not contain specific years	CCSBT	
	Alternate CPUE method	Use CPUE from the same dataset as base case but computed with a slightly different methodology	CCSBT (actually part of reference set)	
	Catchability	Change in the relationship between catchability and abundance	Punt et al. 2016, CCSBT	
	Sampling frequency	Change in the frequency data is provided	Punt et al. 2016	
	Data weighting	Different likelihood weight for specific length composition data	ICATT (part of reference set)	

	Errors in catch	Use of different historical catches	ICATT	
	Ageing error		Punt et al. 2016	
Implementation	Implementation Error	Realized catches differ from total allowable catches due to misreporting, black, market catches, discards, etc. for PBF, can be an overcatch for the discard fleets higher than the current 5/6% Constant or increasing over time? Discard less if TAC is high?	Punt et al. 2016, PBF WG, CCSBT (uses a 20% overcatch for surface fleets (robustness), and 14% for longlines until 2006 in reference set, and also unreported non-members catch of 10% TAC)	
Biology	Occasional catastrophic mortality or recruitment events	For PBF, a 10-yr long drop in recruitment.	Punt et al. 2016, PBF WG, CCBST (used 5 years low recruitment period), ICATT used different recruitment regimes by changing R0 over time	
	Stock-recruitment	Form of stock recruitment relationship	Punt et al. 2016	
	Correlation in	CCSBT used AR-1 process for all recruitment deviations.	Punt et al. 2016,	

	recruitment	*Note PBF WG checked historical recruitment deviations and found no autocorrelation.	CCSBT	
	Reproduction by age	CCSBT used different parameter values for the reproductive contribution by age, ICATT had two different maturity at age scenarios associated with different natural mortalities (i.e. older age of maturity with low M and younger age of maturity with high M)	CCSBT (as part of reference set), ICATT (as part of reference set)	
	Senescence	Increase in M for older individuals	ICATT	
	Presence of depensation		Punt et al 2016	
	Time varying natural mortality, growth, or R0		Punt et al 2016	
Other factors	Different selectivity form	For PBF could be different selectivity shape for the main TWLL and JPLL fleets or other. CCSBT used a scenario with a different selectivity curve for one fleet	PBF WG, Punt et al. 2016, CCSBT	
	Time varying selectivity	Change in selectivity over time	PBF WG, Punt et al. 2016	
	Spatial and stock structure	ICATT had different east/west mixing proportions in their multiple strata operating model	Punt et al. 2016, ICATT	
	Initial stock size (unless it is		Punt et al. 2016	

	estimated reliably when conditioning the OM)			

Discussion

We have compiled at table of potential uncertainties that could be considered by the PBF as potential robustness tests. As many were derived from other Bluefin tuna stocks, they may be of low priority for PBF. It would be useful for experts in the PBF WG to use this table as a starting point to discuss and refine potential robustness trials for PBF.

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