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Potential forms of candidate management procedures and data generation methods

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CCSBT-OMMP/1706/5

Oceans and Atmosphere

Citation

Hillary RM, Preece AL and Davies CR (2017). Potential forms of candidate management procedures and data generation methods. CCSBT-OMMP/1706/5. CSIRO, Hobart, Australia.

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Acknowledgments

This work was funded by CSIRO and the Australian Department of Agriculture and Water Resources.

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Abstract

The work plan for development of a new Management Procedure (MP) was revised at the 2016 ESC, with candidate MP testing postponed until after the 2017 ESC. Three new data sources for potential inclusion in new candidate MPs were considered at the 2016 ESC: i) gene-tagging, as an absolute index of 2 year old recruits, ii) Parent-Offspring-Pairs (POPs), and iii) Half-Sibling Pairs from the Close-Kin Mark Recapture method as estimates of absolute estimates of spawning adult abundance. The Japanese longline CPUE series, used in the current MP, will also be considered for use in a new MP. Here we describe a range of indicators that can be derived from these data series and general functional forms of harvest control rules that could be used in candidate MPs based on these series are considered. Preliminary methods to combine some, or all, of the data and rules into candidate MPs are discussed.

1 Background

1.1 Timetable for MP development

The work plan for development of a new Management Procedure (MP) was revised at the 2016 ESC to focus the June OMMP meeting on the 2017 stock assessment and incorporation of the new data series into the operating models (OM). Further consideration of development and testing of candidate MPs was postponed until after the 2017 ESC. The incorporation of the new data series into the operating models for use in the 2017 stock assessment is, however, tightly linked to the MP development work as these data series, i.e. Parent-Offspring Pairs (POPs) and Half-Sibling Pairs (HSP) and gene-tagging for a recruitment index, are being considered for use as monitoring series in potential Candidate MPs (see Hillary et al., 2016a and Davies et al 2106). As the reconditioned OMs will also be used for Management Strategy Evaluation (MSE) of candidate MPs, it is necessary for these new data series to be incorporated into the OMs.

The development of a new MP for SBT was triggered by the decision to cease the scientific aerial survey, which provides the relative abundance index of juveniles (ages 2-4) used in the CCSBT MP (Anon 2013, Attachment 10). In the absence of a continuing aerial survey a new MP is required. Simulation tests in 2015 (Anon 2015a) indicated that inclusion of informative fishery independent recruitment data in the MP improved key performance measures (i.e. a decreased risk of further stock declines, earlier rebuilding and increased catches in the latter stages of the rebuilding period) compared with simulations without informative recruitment data. The ESC agreed that a juvenile abundance index was essential for inclusion in the MP (Anon 2015b). In 2015 the Extended Commission agreed to implement gene-tagging as a new recruitment-monitoring program, to estimate absolute abundance of 2 year olds, and requested that the ESC develop a new MP that would use gene-tagging data as the juvenile recruitment index in place of the current aerial survey.

1.2 The MSE process

The SBT Management Procedure (MP) specifies the monitoring data, analysis methods and harvest control rule for recommending TAC and is encompassed by an implementation framework which includes a schedule for TAC recommendations, evaluation of meta-rules and examination of exceptional circumstances, stock assessments and MP performance review (See ESC 2013, Attachment 10). The implementation framework serves to ensure, to the extent possible, that operation of the MP is consistent with the conditions and manner in which it was tested. These components of a new MP will need to be addressed during the design and testing period to specify the full MP.

The process of testing and selecting candidate MPs (known as Management Strategy Evaluation, MSE) involves reconditioning the CCSBT Operating Models with updated data and/or new data series, defining data generation methods for monitoring series for model projections for monitoring series to be used in candidate MPs, defining performance measures for evaluation of candidate MPs and tuning individual MPs to the rebuilding objective of the Commission (see

Davies et al 2016, and Anon 2009, 2010 and 2011 for most recent round of MP development, testing and selection).

The SBT OMs are being updated and "reconditioned" in 2017, to include new data series available. These OMs may be reconditioned again in 2018 when the first gene-tagging estimate of abundance of 2 year old is available, as part of the initial testing of the candidate MPs by MSE. An important step in the MSE process will be agreeing on a final set of reconditioned OMs for the tuning of the candidate MPs to the Commissions rebuilding objectives and their relative performance with respect to a range of performance criteria and robustness tests. The reconditioning of the OM's for the purposes of the 2017 stock assessment is addressed in Hillary et al (2017). Regular, iterative consultation and engagement with both the ESC and EC and members' stakeholders is an essential component of the MP development process. This needs to be included in the OMMP Technical group's consideration of the detailed work plan for MP development through 2017-2018 and, based on previous experience, likely 2019 to finalise MP selection and refinement of MP implementation arrangements.

1.3 Current status of work program for new MP

One of the first steps in development of candidate MPs is consideration of the data sources available for use as monitoring series in the candidate MPs. Three new data sources were considered at the 2016 ESC for inclusion in new candidate MPs: i) gene-tagging as an absolute index of 2 year old recruits, ii) Parent-Offspring-Pairs (POPs), and iii) Half-Sibling Pairs data on adult abundance from the Close-Kin Mark Recapture method (Davies et al 2016). The Japanese longline CPUE series used in the current MP will also be considered for use in a new MP. The potential information content of each of these new series was examined in Hillary et al (2016a), and proposed methods for data generation were provided in Hillary et al (2016b).

These new data series are at varying stages of development as a regular monitoring time series for use as input data series for candidate MPs and integration in the SBT OM for stock assessment and MSE purposes. The new POP data (additional years to those already included in the OM) are available and will be included in reconditioning the operating models in June 2017 (Hillary et al 2017). The HSP data are available (Bravington et al 2017) for inclusion in the reconditioned OMs for 2017 assessment, but were not available in time for the OMMP meeting (Hillary et al 2017). The CCSBT has committed to ongoing collection and genotyping of samples of adults and juveniles to provide a time-series of POPs and HSPs into the future (Anon 2016). The first gene-tagging estimate of abundance of age 2 fish (age 2 cohort in 2016, from the gene-tagging pilot study) will not be available until early 2018, and therefore will not be included in the reconditioning of the OM's until 2018. The projections module of the reference set of operating models will generate simulated data with the same statistical properties as each of the monitoring data series, including these new sources, for use in candidate MPs as part of the MSE testing.

1.4 Forms of MP

As noted in Davies et al (2016) initial development of a wide variety of candidate MPs is useful to demonstrate contrasting performance and behaviours of different candidates that may be more or less attractive to CCSBT members and their stakeholders. Here we discuss the preliminary consideration of alternative forms of MPs and issues related to their likely performance. Full development and review of candidate MPs will occur after the ESC according to the revised ESC work plan (Anon 2016b, Att 10).

The 2016 ESC briefly discussed the rationale behind the use of model-based and empirical decision rules in MPs. The distinction between these types of MP is that an estimation model is used to transform the input data from the monitoring series into a population (i.e. spawning biomass) or fishery parameter (e.g. F) for use in the harvest control rule in a model-based MP, while an empirical rule does not include the explicit estimation of population or fishery parameters; using trends or targets in empirical indices derived from CPUE, catch composition or surveys etc. Neither type of MP is, a priori, considered likely to perform better than the other, as performance in any particular circumstance will depend on the interaction between the nature and quality of the monitoring series, estimation model and decision rule and the trend and current state of the stock and fishery. An advantage of an empirical MP is that it can be easier to explain and understand the mechanisms that underpin the TAC advice. As such, they can be more transparent to decision makers and stakeholders than a model based rule where a more complex population dynamics model is used in the MP. There is a growing body of examples that indicate that relatively simple empirical MPs can perform as effectively as those that include more complex models (see Carruthers et al, 2016; Geromont and Butterworth, 2015). The current SBT MP (the Bali Procedure) is a combination of a relatively simple statistical population model and an empirical rule, with the final recommended TAC being the average of the TACs recommended by the two. See Hillary et al 2016c for the most recent TAC calculation.

2 Candidate MPs: general functional forms, derived indicators and index combinations

The ESC has identified four potential monitoring series to be used in candidate MPs: abundance of 2 year olds from gene-tagging, longline CPUE, and parent-offspring (POP) and half-sibling (HSP) pair data from close-kin mark recapture. Below, we take each data source in turn and suggest indicators that could be derived from each monitoring series and general functional forms for the Harvest Control Rules (HCR)s that use these indicators. We then suggest some simple methods to combine some, or all, of the various indicators into candidate MPs.

2.1 Gene tagging

The gene tagging “data” will come in the form of pre-estimated absolute numbers of 2 year old fish for a given year: $N_{y,2}$ (see Hillary et al. 2016a for the details). The information content in these data is both absolute and relative – the absolute information is obvious, but as estimates accumulate over time they will also be informative on the trend and variation in mean recruitment. We propose that both features of the gene tagging data can be used in an MP context, thereby making use of this new data series from the start of the new MP (in the absolute sense) and more increasingly over time in the relative sense (trend and variation) as the data series increases in duration. We provide initial thoughts on how both forms of recruitment data (absolute and relative) from gene-tagging could be used in harvest control rules below.

The lowest estimates of recruitment for SBT – the signal of which has been observed consistently across a range of different data sets – were between 1999 and 2002. From the analyses of the CCSBT SRP tag data covering those years we have estimates of the absolute abundance of the 2 year old fish from those cohorts. We consider that these estimates could be used as “limit” levels of 2 year old abundance, with an associated HCR that takes recent mean 2 year old abundance from the GT program and compares it to the limit level, linearly reducing the TAC as this ratio decreases and leaving it unchanged above it (see Figure 1).

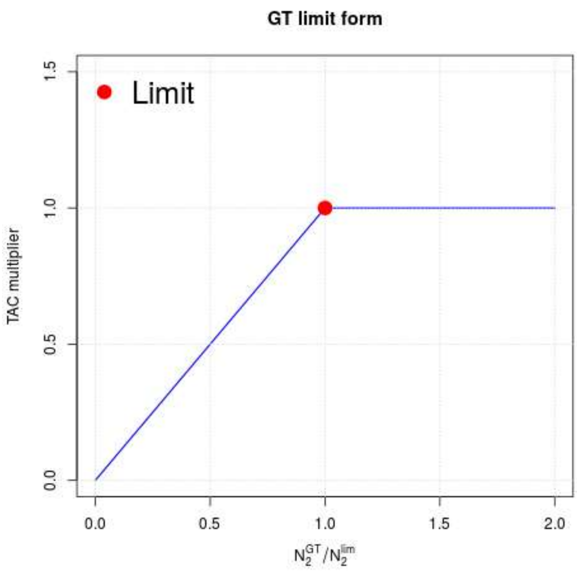

Figure 1: Suggested functional form for a limit-type approach to using the absolute abundance information on recruitment from the gene tagging estimates.

Once there are sufficient time series of estimates from the gene-tagging program we can also use the relative information on trend. This information can be used in a similar fashion to recruitment information from the aerial survey in the previous MP. For a given number of years (5 was the previous assumption) we can estimate the log-scale linear trend, λ_{GT}, in the estimates and have a TAC multiplier like $(1+k_{GT}\lambda_{GT})$, so the TAC is increased/decreased if the mean recruitment trend is positive/negative and we control the gain parameter, k_{GT}.

2.2 Longline CPUE

In the previous MP there were both target and trend elements to how the CPUE data were used. Given more recent work has shown how complex the CPUE-to-SSB relationship is (Hillary et al. 2016b) we suggest moving away from target-style approaches, and retaining only the trend-type functional forms. Similar to the trend approach for gene-tagging, we suggest initially exploring a log-scale linear trend, λ_{CPUE}, with associated time-frame (7 years was the previous MP timeframe) and gain parameter, k_{CPUE}, and a similar TAC multiplier: $(1+k_{CPUE}\lambda_{CPUE})$.

2.3 POP and HSP data

In Hillary et al. (2016b) we demonstrated how to construct indices from both forms of the close-kin mark recapture data. The POP and HSP data correlated well (given the sample sizes of the current close-kin sampling program) with spawner abundance – the key variable we are attempting to recover. These two data sources (POP and HSP) are independent, so we can simply combine their respective relative indices of spawner abundance into one 'close-kin' index, I_y. From the exploratory data generation work (Hillary et al. 2016b) it seemed that the close-kin indices seemed most appropriate for target/limit type HCR approaches, rather than those based on log-linear trend. So we suggest exploring functional forms of this style for the close-kin data. A target/limit functional form for the TAC multiplier used in a number of MSE contexts (Carruthers et al. 2016; Geromont and Butterworth, 2015) is defined as follows:

$$\zeta_{CK} = 0.5 * [1+(C^{targ}/TAC_y) * 0.5 * (1+(I_y-I_{lim}))/(I_{targ}-I_{lim}))], \quad \text{if } I_{ck} > I_{lim} \quad (1a)$$

$$\zeta_{CK} = 0.5 * [1+(C^{targ}/TAC_y) * 0.5 * (I_y/I_{lim})^2], \quad \text{if } I_{ck} \leq I_{lim} \quad (1b)$$

A graphical description is given in Figure 2 of the second part of the HCR (the target/limit ratios) for a target-to-limit ratio of 2. Another reason for adopting a target-type approach is that we can reasonably expect, given the good correlation properties of the indices relative to spawner abundance, there to be a very close to linear relationship between the close-kin index and the actual spawner abundance. This makes the setting of targets/limits relatively intuitive, and allows us to potentially tune the target catch level, C^{targ}, as with the previous MP.

2.4 Combinations of data sets in candidate MPs and tuning considerations

It makes sense to – initially at least – explore a range of possible candidate MPs incorporating different combinations of data sets and HCRs, as well as alternative settings for HCR parameters and choices about tuning parameters. Initially, we can consider a 'generic' form for the HCR:

$$TAC_{y+1} = TAC_y * (\omega_{GT}\zeta_{GT} + \omega_{CPUE}\zeta_{CPUE} + \omega_{CK}\zeta_{CK}), \quad (2)$$

where the ζ_i are the TAC multipliers from the data-specific HCRs and the ω_i are their associated weights (that sum to 1). To exclude a particular data set (or sets) simply set its (their) weight(s) to zero.

In considering what HCR parameters to tune, this will obviously depend on the combination of indices in the candidate MP under consideration. We can, perhaps, also learn some lessons from the previous MP. Recall, that to reach the previous rebuilding objectives (20% of the unfished level by 2035 with a probability of 0.7) required – for the CPUE trend driven MPs – high levels of the gain parameter k_{CPUE} = 3 for positive signals (i.e. $\lambda_{CPUE} > 0$). This meant logarithmic increases in the TAC at three times the level seen in the CPUE index. Obviously, we should be cautious with tuning gain parameters (regardless of the index combination) to avoid strange values like the previous one, because it leads to certain parts of the candidate MP dominating the behaviour of the overall TAC setting dynamics.

If the CK data are included, one option is to tune the target catch parameter, C^{targ}, much as we did in the previous MP. If the CK data are not used, but the GT data are, then perhaps tune the limit level of the index for a given suite of potential gain parameters (for both data sets both CPUE and GT).

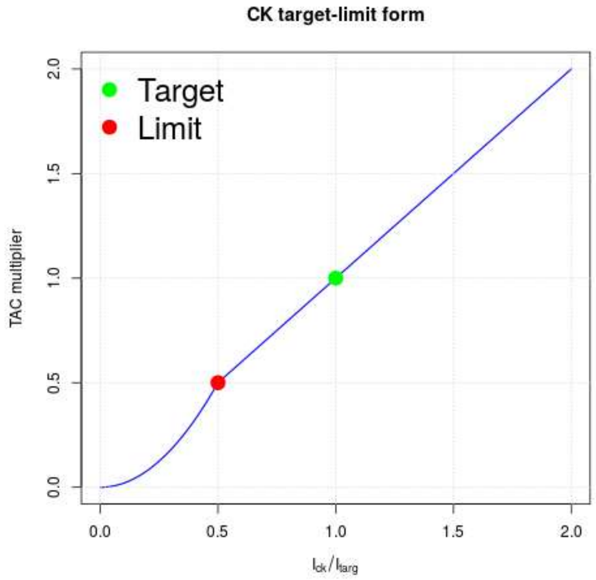

Figure 2: Suggested functional form for the target-limit type approach to using the close-kin index of spawner abundance.

2.5 Objectives and implementation framework

The objective of the current (Bali Procedure) MP is to rebuild the spawning stock to 20% of the initial spawning stock size by 2035. Given the estimated level of the stock, uncertainties in the models and future projections, the current MP was tuned to meet this objective with a 70% probability. The reconditioned operating models and performance of new MPs may change our understanding of the status of the stock and the potential speed and probability of rebuilding (Davies et al 2016). The harvest control rule of the current MP also has “hard-wired” constraints on minimum and maximum TAC changes (minimum change of 100t and a maximum change of 3,000t). Managers will need to provide advice on their preferred objectives; industry advice is required on the operational feasibility and desirability of likely MP behaviour (e.g. scale and frequency of TAC changes), and scientists will need to communicate the subtleties in performance and implications of choices between final candidate MPs that will be presented to the EC for initial consideration and final decisions (Davies et al, 2016).

The implementation framework for the Bali Procedure includes annual review of fishery and stock indicators and examination of evidence of exceptional circumstances and processes for action via the meta-rules. The MP TAC recommendations are used to set 3 year TAC blocks with a 1 year lag between calculation and implementation. A stock assessment is scheduled to be conducted every 3 years to provide updated advice on current stock status, and this is off-set from the TAC recommendation year. A review of the MP is scheduled to occur every 6 years to review performance of the MP. The rationale for the above decisions and any recommendations to change these in developing a new MP will need to be considered and revised to reflect the current circumstances and those that can be reasonably expected to arise in the near-medium term.

3 Data generation

For the three data sets considered here (gene-tagging, CPUE and the close-kin data) the specifics of the data generation methods were previously outlined in Hillary et al. (2016b), along with the OM-specific changes required to do so in Hillary et al. (2016a). We do not expect large changes in either of these general approaches, but there will likely be some minor changes required once the various data sets (specifically the new ones: gene-tagging and the new POP and HSP data) have been incorporated into the OM. Given two out of the three new data sources are sample driven (GT and CK data) the OMMP group will have to explore options on future sample sizes (and perhaps even adaptive ones) to simulate these data into the future in the MP testing phase.

4 Robustness tests

Robustness tests are intended to test that Candidate MPs are robust to potential future scenarios that are plausible but not considered as part of the reference set of models. More pessimistic tests for the MP consider performance under conditions such as a series of very low recruitment, or uncertainty in interpretation of the CPUE abundance index. Variation in performance measures between MPs under these tests conditions can show contrasts that assist with selection of a final MP from a small set of candidates with similar performance against the reference set of OMs.

The following table of sensitivity tests was considered for reconditioning operating models for the 2017 stock assessment and were agreed at the OMMP meeting prior to the 2016 ESC. They should also form a sound starting point for robustness tests for testing of candidate MPs. The key tests in the final rounds of MP testing in 2011 were the more pessimistic tests, i.e. plausible worst case scenarios against which the candidate MPs would need to be able to respond.

Some of these tests are likely to still be relevant for testing new candidate MPs, although they will likely need some refinement following the reconditioning of the OMs to retain the original intent. When the OMs are reconditioned with new data, it is possible that the population dynamics may shift and new or adjusted robustness test may be required. This will be reviewed after reconditioning of the operating model.

Table 1. Preliminary candidate list of sensitivity runs to be conducted for the 2017 OMMP 8 reconditioning. Note that these are in addition to factors considered in the reference set of OMs. (Source: Table 2 Anon 2016a)

RUN	DESCRIPTION
Added catch (TBD)	Unaccounted catch mortality (see below)
SV_OverC	Continue 20% overcatch from Australian fishery as if the stereo video (SV) system was not implemented
LL1 Case 2 of MR	LL1 overcatch based on Case 2 of the 2006 Market Report
IS20	Indonesian selectivity flat from age 20+
High_aerialCV	In conditioning (set process CV to 0.4)
Aerial2014/2016	Sensitivity to 2014 and 2016 aerial survey data
Upq2008	CPUE q increase to be estimated (permanent from 2008)
Omega=0.75	A power function for the relationship between biomass and CPUE with power = 0.75 (or alternative based on diagnostics)
CPUE_alternatives	Based on input from CPUE working group
Taiwanese CPUE	
Korean CPUE	
CPUE S=0	Overcatch had no impact on CPUE
CPUE S=0.50	50% of LL1 overcatch associated with reported effort
updownq	increase in catchability (0.5) in 2009 then returns to normal after 5 years
CPUE S=0.75	75% of LL1 overcatch associated with reported effort [check diagnostics]
CPUE CV=0.3	Increases the specified CV of the CPUE series to have a lower bound of 0.3
Include 2007-08 CPUE Upper	Uses most optimistic CPUE series (Laslett)
Include 2007-08 CPUE Lower	Uses most pessimistic CPUE series (ST Window)
Piston line	Includes the piston-line troll survey index
Grid-type trolling index	Troll survey index alternative
Tag F / Mixing	Account for potential incomplete mixing of tagged fish. (new information may inform on treatment of tag data)

5 Summary

The experience from two previous rounds of MP development and testing and the benefits from investments in strategic science via the CCSBT Scientific Research Program mean we are well placed to develop a range of candidate MPs based on some or all of the available monitoring series. The availability of the close-kin data means, for the first time, we have a monitoring series that directly reflects the status of the spawning stock; the object of the Commission's rebuilding plan. It is also possible, if previous indications of stock status and productivity are supported by the results of the 2017 stock assessment, that the range of performance and behaviour of candidate MPs will not be as tightly constrained as was the case in the 2009-2011 process. Hence, it will be important that there are sufficient levels i) of participation by a range of MP developers in the technical process to ensure a wide variety of candidate MPs are developed and compared, and ii) of time and appropriate forums for informal and formal consultation between the technical, ESC and Commission processes to ensure effective communication of the potential performance and implications of alternative MPs.

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