CCSBT-EC/1510/BGD01
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Commission for the Conservation of
Southern Bluefin Tuna

みなみまぐろ保存委員会

Informal Report from the MP Technical Group on the implications of cancellation of the aerial survey in 2015 and potentially beyond

July 2015

Background

The Commission has requested advice on the implications of cancellation of the aerial survey in 2015, and potentially beyond, for the management procedure (MP).

The informal ESC webinar noted that the MP can be operated in 2016 (even missing the 2015 aerial survey index) if there is a 2016 aerial survey index. If both the 2015 and 2016 aerial survey indices are missing, then (a) the MP cannot be used to set the 2018-2020 TAC, and (b) there is not sufficient time to carry out a proper management strategy evaluation (MSE) of alternatives.

In addition, the informal ESC webinar considered that it would be helpful to conduct an analysis of the implications of decreasing the sampling intensity and costs of the aerial survey, to inform deliberations at the coming meeting of the SFMWG.

A "reduced" aerial survey with less flight time (nautical miles flown) is expected to result in reduced precision of the survey estimates of abundance. While there is a negative relationship between the historical survey effort levels and the estimated variance of the index, the survey effort can only be defined approximately in advance of the survey because the total flight time will be affected by weather conditions.

The proposition of conducting the aerial survey every second year was considered logistically infeasible for reasons of continuity; spotter expertise and calibration/training of new spotters for future years is considered critical for providing a reliable index that is comparable over time (Attachment 1). It was also noted that changing the frequency of the survey would effectively represent a new MP and would require full MSE testing. This option was therefore excluded from further consideration.

A series of analyses and subsequent technical discussions were completed. The results, summarised in Attachment 2, indicate that the performance of the MP control rule is largely unaffected by a decrease in precision of the aerial survey within the range evaluated. Little difference in the projected spawning stock biomass and catch trajectories was observed when the aerial survey effort was reduced to values that are less than half the effort applied in 2010-2014.

Summary of the role of the aerial survey in the CCSBT Management Procedure, Operating Model and Assessment of Stock Status

- The MP is a central component of the SBT rebuilding plan.
- The aerial survey provides fishery-independent information on recruitment that has been critical in the CCSBT Operating Model, for development and testing of MPs and for periodic assessments of stock status. The aerial survey index, on its own, is also an important indicator of year class strength and trend in recruitment.
- Given that the SBT stock is estimated to be depleted, and a substantial proportion of the catch is taken from the juvenile and sub-adult components of the stock, continued recruitment monitoring is essential for early warning of possible low recruitments in the future.
- All other recruitment monitoring programs ceased in 2015 or earlier (i.e. trolling, SAPUE and the aerial survey were all cancelled in 2015). Although development of a potential recruitment index from Taiwanese and Korean longline CPUE is in progress, some technical issues remain and the time series are short.
- The tests of the reduced aerial survey, examined in the comparison runs of the MP, indicated that performance was unaffected for the range of survey precision examined. A reduced 2016 aerial survey, within the range of options considered adequate (outlined below), would allow continued operation of the MP and other uses of the survey (e.g., indicator and stock assessment).

- Without the 2016 aerial survey data, the MP could not operate and exceptional circumstances would likely be triggered.
- If the aerial survey is discontinued a new MP will need to be developed, which will take considerable time and funding to complete. In the interim, the CCSBT will be without a tested and agreed rebuilding plan.

Recommendations

The following recommendations can be made based on the numerical tests conducted, as well as the general considerations above.

1. The aerial survey for 2016 should proceed to allow the use of the MP for setting the 2018-2020 TAC in 2016.
2. Three alternative operational configurations of the aerial survey are provided in Table 1, which meet the following minimum requirements to be consistent with the testing conducted for the CCSBT MP: i) they are within the range of distance searched in previous surveys, and ii) they involve sufficient charter hours to allow for at least one replicate of the survey area in each survey month. The level of operational risk to achieving these requirements, and the likely error associated with the realised survey estimates, increase from Option 1 to Option 3.

Table 1. Three options for proceeding with the aerial survey in 2016 and beyond. Option 1 is the configuration of the 2014 aerial survey.

Option	Number of planes	Plane 1	Plane 2	Charter hours	Distance searched(nm)[1,2]	Approx. Budget	Risks[3]
1	2	Jan - Mar	Jan, Feb	250	10,000-12,000	$830K	1
2	2	Jan - Mar	Mid-Jan - mid-Feb	200	6,000-8,000	$680K	1, 2, 3
3	1	Jan - Mar	-	150	4,500-8,000	$560K	1,4

Risks categorizations:

1. Decision to proceed with survey would be too late to secure experienced spotters;
2. One month for 2nd spotter would be insufficient/unworkable for other employment arrangements; likely results in failure to secure 2nd spotter;
3. Decreased availability of 2nd plane in Jan & Feb, combined with bad weather in either month, means additional distance would not be achieved during peak abundance months;
4. One plane for the duration combined with, for example, bad weather, operational difficulties, spotter availability would likely result in less than one replicate of GAB/month.

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[1] The distance that will be searched becomes more uncertain with the reduction in availability of the 2nd plane. This is a function of the added flexibility of being able to fly twice as much and in multiple "blocks" in the windows of weather that meet the strict environmental conditions under which the survey is conducted.

[2] Note, the coefficient of variation (CV) of the aerial survey is calculated based in the final number of transects actually flown per block per month. Hence, the actual CV for the survey will increase the fewer the transects flown each month of the survey.

[3] On average, the estimated relative abundance is highest in January, intermediate in February and lowest in March. Hence, to obtain a survey index that is consistent with previous surveys, and the tested MP, it is necessary to complete a minimum number of replicates per month. The costing for Option 3 is based on this premise, but carries an appreciable operational risk that this minimum outcome is not achieved.

Attachment 1

Contracting and logitics requirments for the SBT Scientific Aerial Survey

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23 March 2015

Background

The scientific aerial survey for Southern Bluefin Tuna (SBT) in the Great Australian Bight (GAB) was designed and initiated as part of the Recruitment Monitoring Program, a collaborative initiative between Japan and Australia. It is the only long-term, fisheries independent index of recruitment for the stock. It ran continuously between 1993 and 2000, when operations ceased while the design and initial results were reviewed. It resumed in 2005 and continue uninterrupted though to 2014. The re-instatement of the survey in 2005 was in response to serious concerns from the Scientific Committee over several historically low year classes in the early 2000's.

The scientific aerial survey is an input data series for both the CCSBT Operating Model, used for periodic assessments of stock status and testing and tuning Management Procedures, and the CCSBT Management Procedure, used to recommend the TAC for the international fishery in 3-year blocks.

There was no scientific aerial survey in the summer of 2015 due to lack of agreement on funding arrangements. In addition, neither of the other potential sources of recruitment information in the GAB (the commercial spotting index, or SAPUE , or the trolling index on 1+ yr old fish in Western Australia) were conducted for the 2015 season.

This paper provides a summary of the contracting and logistic arrangements associated with implementing the scientific aerial survey, with a particular focus of the timing of decisions required to re-instate the survey for the 2016 season (January-March, 2016).

Project Management

Historically, the aerial survey project has been funded by the Australian Fisheries Management Authority (incl. compulsory Industry funding), the Department of Agricuture, and CSIRO. Proportional contributions have varied over the years, but generally average ~ 40:40:20, respectively. More recently (2013, 2014), CCSBT members have also contributed to the cost of the survey.

The project is lead by CSIRO (Principal Investigator, Jessica Farley) and delivered by a large project team, with the following roles:

- Project management, contracting and field coordination: CSIRO (Farley)
- Light plane charter, pilots, aircraft management, safety, etc: Australian Fishing Enterprises (AFE)
- Experienced commercial tuna spotters: private contractors
- Field personnel for data recording and processing: Casual appointments to CSIRO for field season
- Data management, quality control, exploratory analysis, generation of the standardised index, reporting and presentation to CCSBT: CSIRO (Farley, Eveson, Bravington)

Logistics

The scientific aerial survey operates from 1 January until 30 March of the survey year (i.e. 2014 survey was 1 Jan-30 Mar 2014). Hence, it is necessary to have funding confirmed, contacts in place and field staff hired well in advance of this date. In the years since other CCSBT members have contributed to the cost of the survey, this has meant that the final funding arrangement has not been confirmed until after the Commission meeting. For practical purposes, this has meant early November. Given field preparations and contracting for planes etc has to commence well before the Commission meeting, the timing of confirmation of funding has resulted in CSIRO, AFE and the tuna spotters taking on substantial commercial risk (proceeding with preparations and charter plane bookings etc) to ensure the survey could proceed in these most recent two years.

In the case of 2015, when the survey was cancelled due to lack of agreement on the funding, CSIRO had in principal agreements with AFE for the provision of charter plans, pilots and certified operation of the aircraft; AFE had formal bookings of the requisite aircraft and staff planned to particpate; one of the two calibrated tuna spotters had left contracted employment to return for the three months of the survey; and CSIRO had arrangements in place for casual contract field staff as well as substantial time allocations for existing staff. It was a matter of good fortune that substantial costs were not incurred by any of the parties due to the short notice cancellation. Nevertheless, as a result, the same parties will require substantial lead times and confirmed contractual arrangements, including penalty provisions for not proceeding, in order to particpate in the survey in 2016.

Contracting

As noted, CSIRO is contracted to manage and deliver the survey. CSIRO procurement policy requires that a sub-contract of the scale of the aircraft and pilot services is subject to competitive tender. Once a provider of the aircraft and pilot services is selected it is not necessary to go to tender for another 3-5 years.

The current preferred provider status expired in 2014 and it is not possible to extend this to include the 2016 survey. Hence, CSIRO will need to go to the open market for providers as soon as the decision is made on whether or not to proceed with a survey in 2016. The tender selection process takes a minimum of 6 weeks to complete. The selection process needs to be complete before CSIRO can enter into contracts with the preferred provider for the aircraft services.

For this reason, it is essential that a decision on whether or not to proceed with the 2016 survey and the nature of the funding arrangements is made well in advance of the annual Commission meeting. Given that the issue of funding arrangements for the scientific aerial survey has been the subject of considerable discussion amongst members at the 2014 EC meeting, and subsequently, and Commissoners are scheduled to meet at the Strategy and Fisheries Management Working Group meeting in Canberra (28-30 July 2015), it sems appropriate that this issue be considered at the SFMWG meeting. A decision at that meeting would provide sufficient time for CSIRO to complete tender and contracting processes by the end of September and advise the Commission of the outcome at its 22nd annual meeting in Korea in October 2015.

In addition to the need to conduct a tender process for the provision of aircraft and pilot services, the experienced commercial spotters, who are central to the quality and comparability of the index from the survey, have indicated that they will be prepared to particpate in the 2016 survey only if they have sufficient advance notice and contractual arrangements in place well in advance of commencement.

As participation in the survey means that they are not able to particpate in their normal work activities for a period of 3-4 months, they need to be able to make appropriate arrangements. Given the short notice of the cancellation of the 2015 survey, they have indicated they will not be prepared to particpate in 2016 unless contractual arrangements are confirmed 3 months in advance of commencement (i.e. 1 October 2015).

Proposed Schedule for 2016 Scientific Aerial Survey

1. 30 July 2015 - Decision on funding arrangements

2. 7 August 2015 - Formal advice on whether project will/will not proceed and contracting arrangements for project

3. 10 August 2015 - Initiate nitiate tender process for sub-contract for provision of aircraft services

4. 21 Septermber 2015 - Initiate contract arrangements for aircraft services, tuna spotters and field staff

5. 12 October 2015 - Advise CCSBT of outcomes of tender process and project status

6. 1 December 2015 - Preparatory activities for 2016 field season commence

7. 1 January 2016 - Survey commences
8. 30 March 2016 - Survey period finishes.
9. 30 May 2016 - Preliminary index available
10. 30 June 2016 - Index exchanged via CCSBT

Summary

The scientific aerial survey is the only long-term, fisheries independent index available for the SBT stock. It is a central input to the Management Procedure used for recommending the global TAC and an important index of recruitment in the Operating Models used to assess the status of the stock. In the absence of the 2016 index from the scientific aerial survey, it will not be possibe to run the current MP to recommend TACs for the 2018-2020 quota block.

This paper summarises the logistic and contractual issues that need to be managed in order to conduct the survey in 2016 and proposes a project schedule to achieve them. Central to achieving this schedule is that a decision on funding arrnagements for 2016 (and ideally beyond) is made at the July 2015 SFMWG meeting so that the necessary tender and contracting processes can be completed in time for the survey to proceed. In the absence of confirmation of funding arrangements by 30 July 2016, there is a substantial risk that the survey will not proceed due to logistic and contactual constraints.

Evaluation of effects of a reduced aerial survey on MP performance.

The analysis undertaken by Australia and Japan involved testing the impacts of increasing the variance of the simulated aerial survey data used to drive the MP in the projections. The increased CV on the aerial survey is intended to replicate a reduced annual aerial survey with less survey effort in each survey year. A modified MP was run with the different scenarios for aerial survey CV and calibrated to match the lower 5%ile of the spawning stock trajectory from the adopted MP (the Bali Procedure). Since there is no 2015 aerial survey point this was also excluded from the MP input data.

Selection of scenarios

Six scenarios were evaluated, spanning a range of survey effort from the average effort applied in 2010-2014 to the minimum value applied historically. The survey effort was maximum in 1994, with a total flight distance of 15,180 nm, it decreased to a minimum of 4,872 nm in 2007 and it increased again to more than 12,000 nm in 2013 and 2014 (Table A2.1). A reduced aerial survey was specified as one with a distance searched of 5,000 nm, less than half the effort applied since 2010 and close to the historical minimum. As an extreme scenario, a distance searched of 1,500 nm was also examined, even though such a distance would not be enough to complete even one replicate of the survey transects, thereby not allowing for the construction of a comparable single survey time-series as required for both the OM and the MP.

Table A2.1. Values of sampling effort (measured as flight distance searched) applied in the aerial surveys conducted since 1993, and corresponding observation errors (SDobs).

Year	Total distance flown (nm)	AS index	SDobs
1993	7603	337.6251	0.1814
1994	15180	223.0828	0.1587
1995	14573	303.8644	0.1489
1996	12284	287.7111	0.2070
1997	8813	150.7498	0.2223
1998	8550	185.1966	0.1924
1999	7555	69.8241	0.2758
2000	6775	122.9553	0.2362
2005	5968	127.9129	0.1938
2006	5150	128.4222	0.2559
2007	4872	110.7724	0.2483
2008	7462	167.3701	0.2134
2009	8101	96.7557	0.2236
2010	10559	188.6137	0.1508
2011	10148	334.491	0.1596
2012	10777	108.6969	0.2396
2013	12889	238.6325	0.1628
2014	12238	563.5327	0.1416

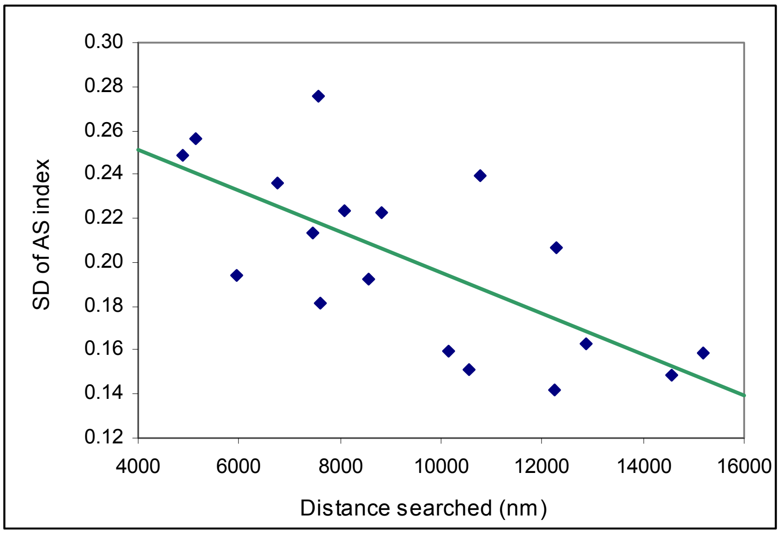

Figure A2.1. Standard deviation of the aerial survey index versus total flight distance searched during the survey together with the fitted least squares regression.

A negative relationship between the total distance searched and the standard error of the estimated aerial survey index (SDobs) was observed (Fig. A2.1), and the relationship was consistent with that predicted by sampling theory (i.e., SDobs decreased approximately in proportion to the square root of the sampling effort). A simple regression was fitted to SDobs versus total distance searched (Fig. A2.1) and used to predict the observation error of the survey index for decreasing values of distance searched, implying a decreased sampling effort. A reduction in distance flown from the average used in 2012-2014 (11,968 nm) to 5,000 nm resulted in an increase in predicted SDobs from 0.22 to 0.302.

In the current OM, the aerial survey data are simulated assuming a total error SDtotal = 0.30, which roughly corresponds to an average SDobs=0.20 and a process error with SDproc=0.22, assumed to be constant over time and independent of the observation error. There may be circumstances however under which process error could also increase with decreased survey effort. In order to incorporate this possibility three variations were considered: in the first case SDproc was kept fixed at 0.22; in the second SDproc was set at 1.25 the value of SDobs (0.302); in the third SDproc was set at twice the value of SDobs (0.483).

Table A2.2. Standard deviation of observation error (SDobs), process error (SDproc) and total error assumed in the scenarios used to evaluate the effect of decreasing the aerial survey effort. In scenarios 1-5 the aerial survey of 2015 was excluded.

Scenario	Total distance searched (nm)	SDobs	SD proc	Total SD
Baseline (Bali MP)			0.22	0.30
1			0.22	0.30
2- Average 2012-2014	11968	0.177	0.22	0.28
3	5000	0.242	0.22	0.33
4	5000	0.242	0.302	0.39
5	1500	0.274	0.22	0.35
6	5000	0.242	0.483	0.54

Analyses conducted

Two sets of analyses were conducted:

1) The first used the Reference Set as the Operating Model (OM) and tested the Bali MP under the six scenarios specified earlier.
2) In the second set, a scenario with lower initial recruitment was evaluated, implemented through running the *lowR* scenario, in which the first *n* years of future recruitment (where *n* is set by the user) are half of what the OM would predict. As with previous robustness tests using this function, *n* = 4. Additional robustness tests that included CPUE scenarios were explored to see if the combination of a reduced aerial survey and previous CPUE robustness tests had any significant effect. The three main robustness tests for CPUE were:
   - *HighCPUECV*: CV in **future** CPUE is 0.3 not 0.2, to address the recent reduction in boats, general coverage, and increased variation in alternative CPUE indices.
   - *Upq*: From 2008 onwards the catchability of the LL CPUE series is increased by 35% based on previous estimates.
   - *Omega75*: non-linear CPUE to biomass relationship with the power exponent being set at 0.75, so increases/decreases in abundance result in lower magnitude increases/decreases in CPUE.

This is the first time we have combined robustness tests in this manner (i.e. *lowR* **and** CPUE-based scenarios used together) but this seemed sensible to do, given the implicit assumption that, by reducing the precision and information content of the survey, we would then be relying more on the CPUE to be informative.

For this second set of runs a subset of two scenarios was selected given that there was little contrast in the actual total standard deviation across all scenarios considered feasible:

1. Survey effort and process error as assumed in the Bali MP testing so total standard deviation is 0.3
2. Survey effort of 5,000nm with additional linkage to process error (so it also increases) so a total standard deviation of 0.39

The second scenario is arguably the most pessimistic in terms of survey effort that would likely result in at least the coverage of the transects to be comparable to the previously existing surveys, and in terms of the assumed inflation of process error resulting from the reduced survey effort.

In all cases the Bali MP settings were used – no recalibration was undertaken. In terms of summary statistics five were calculated:

1. Average annual future catch
2. Average inter-annual variability in catches (AAV) (%)
3. Probability of attaining the rebuilding target of 20% B_0 by 2022
4. Probability of attaining the rebuilding target of 20% B_0 by 2035
5. Probability that future SSB falls below 2014 levels

Results of first set of tests

The first set of tests conducted using the Reference Set as the OM and the full range of CV scenarios indicated that the decrease in precision of the simulated aerial survey data had very little impact on the catch and spawning biomass trajectories (Tables A2.2-A2.4, Figs. A2.2-A2.3).

Table A2.2. TAC in the first 4 years.

Scenario	Lower bound (5%)	median	Upper bound (95%)
Bali MP	14379.4	14807.4	14807.4
1	14331.3	14807.4	14807.4
2	14342.6	14807.4	14807.4
3	14309.6	14807.4	14807.4
4	14267.4	14807.4	14807.4
5	14297.3	14807.4	14807.4
6	14161.1	14807.4	14807.4

Table A2.3. Average TAC, and upper and lower bounds, over 19 years.

Scenario	5%	median	95%
Bali MP	14017.0	19819.7	22187.1
1	13968.6	19859.7	22187.1
2	13963.9	19900.2	22187.1
3	13917.5	19747.1	22187.1
4	13825.4	19673.4	22187.1
5	13911.4	19711.3	22187.1
6	13619.4	19257.7	22187.1

Table A2.4. Average annual variation in catch.

Scenario	5%	median	95%
Bali MP	0.0352419	0.0436865	0.0610726
1	0.0352061	0.0437293	0.0607599
2	0.0351021	0.0436935	0.0607634
3	0.0352973	0.0436882	0.0609073
4	0.0355282	0.0437130	0.0612349
5	0.0353538	0.0437564	0.0613622
6	0.0353788	0.0437815	0.0619903

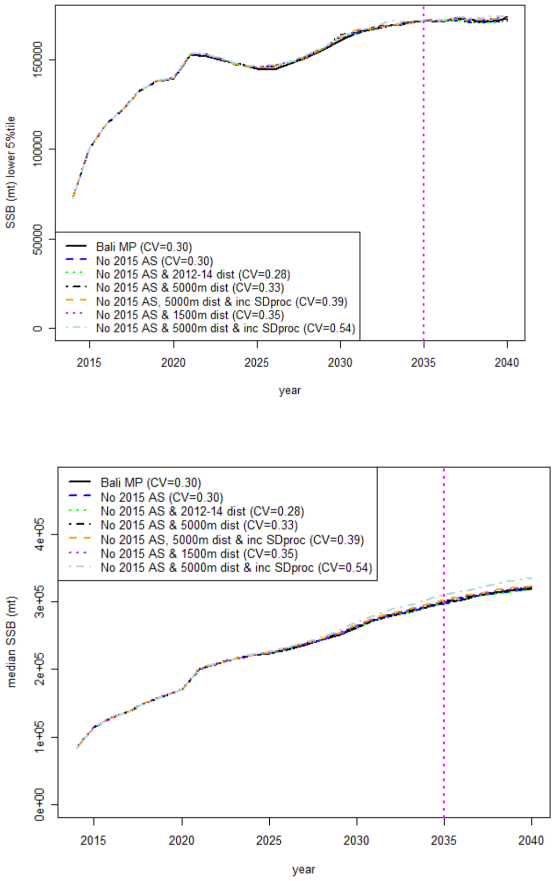

Figure A2.2. SSB trajectories for the scenarios. The scenarios were calibrated to the lower 5% level of the SSB in the Bali Procedure (top). Median SSB trajectories for these scenarios (bottom).

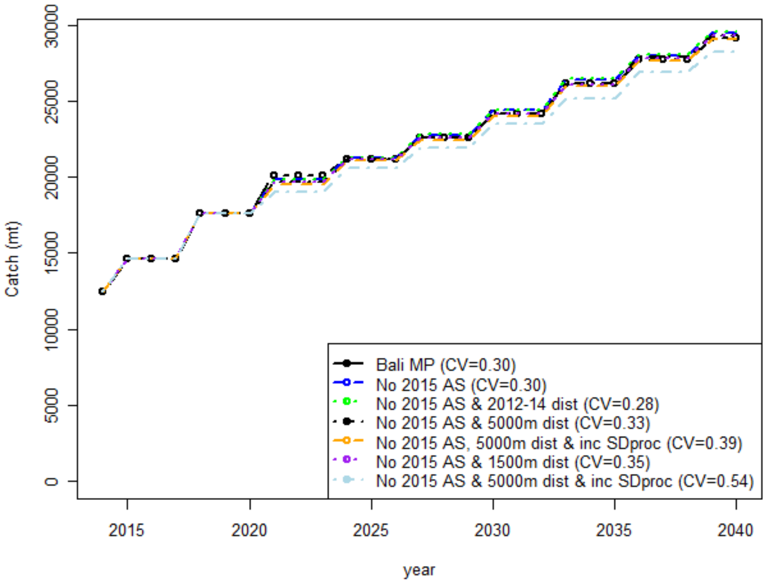

Figure A2.3. Future catch trajectories for the reduced-precision aerial survey scenarios.

Results of second set of tests

The results of the second set of tests indicate that for a range of future unanticipated low recruitments, CPUE-to-biomass scenarios, and alternative aerial survey precision estimates (conditional on what is minimally required to provide an aerial survey index) there seems to be little MP performance loss for a reduced-precision aerial survey.

The *lowR* scenario results in a reduction in rebuilding performance, slightly lower average catches and higher inter-annual variability than in the Reference Set (Table A2.5). There is zero probability across all scenarios of observing future declines in SSB from the present (or indeed minimum) estimated levels. There is also no discernible performance difference observed in terms of the both catch statistics and rebuilding probability by both 2022 and 2035 for the two aerial survey variance scenarios.

Table A2.5. Performance summary for low recruitment (*lowR)* only robustness tests for two aerial survey precision scenarios. Brackets denote the 80% PI.

Operating Model	Ave. Catch (kt)	AAV	Target @ 2022	Target @ 2035	Future declines
Reference set	21 (16-25)	4.5 (3.9-5.5)	0.23	0.71	0
lowR	19 (14-24)	5.1 (4.2-6.4)	0.15	0.64	0
lowR_asB	19 (14-24)	5.1 (4.2-6.4)	0.15	0.63	0

Tables A2.6-A2.8 provide similar performance summaries, all with *lowR* and alternative aerial survey precision scenarios, for the *highCPUECV*, *upq*, and *omega75* robustness tests, respectively. The additional variation in future CPUE (Table A2.6) and the *omega75* scenario (Table A2.6) appears to make no difference to the scenarios detailed in Table A2.5. While the *upq* scenario (Table A2.8) results in decreased rebuilding performance (by both 2022 and 2035), and the inclusion of the *lowR* scenario accentuates that performance reduction, there is nothing pathological in the results and the reduced aerial survey precision seems not to have any real effect either.

Table A2.6. Performance summary for the *highCPUECV* robustness test, by itself or in combination with *lowR* robustness tests for two aerial survey precision scenarios. Brackets denote the 80% PI.

	Ave. Catch (kt)	AAV	Target @ 2022	Target @ 2035	Future declines
highCPUECV	22 (16-25)	4.5 (3.9-5.5)	0.23	0.71	0
highCPUECV + lowR	18 (14-23)	5.1 (4.2-6.5)	0.15	0.63	0
highCPUECV + lowR_asB	19 (14-23)	5.1 (4.2-6.5)	0.15	0.63	0

Table A2.7. Performance summary for the *upq* robustness test, by itself or in combination with *lowR* robustness tests for two aerial survey precision scenarios. Brackets denote the 80% PI.

	Ave. Catch (kt)	AAV	Target @ 2022	Target @ 2035	Future declines
Upq	22 (16-26)	4.6 (4-5.6)	0.16	0.59	0
Upq + lowR	19 (14-24)	5.1 (4.3-6.5)	0.1	0.52	0
Upq + lowR_asB	19 (14-24)	5.1 (4.2-6.5)	0.1	0.51	0

Table A2.8. Performance summary for the *omega75* robustness test, by itself or in combination with *lowR* robustness tests for two aerial survey precision scenarios. Brackets denote the 80% PI.

	Ave. Catch (kt)	AAV	Target @ 2022	Target @ 2035	Future declines
omega75	21 (16-25)	4.5 (4-5.5)	0.24	0.71	0
Omega75 + lowR	18 (14-23)	5.2 (4.2-6.5)	0.16	0.64	0
Omega75 + lowR_asB	19 (14-23)	5.1 (4.2-6.5)	0.15	0.63	0

Discussion

Results indicate that a reduced aerial survey, with a lower sampling intensity than has been applied in recent years, may still result in adequate MP performance, with no large economic impacts, e.g. catch losses, for the scenarios considered.

There are several reasons why the performance of the MP control rule is not strongly affected by the increased variance of the aerial survey. These include that the MP is designed to provide relatively stable TACs (i.e. not to jump around too much), as there is a restrictive hard–wired limit to variability built in the MP “mini-assessment” model, and the MP has already been shown to be robust to an aerial survey CV of 0.5 (2011 robustness tests). In particular, for the aerial survey part of the MP a 5-year moving average is applied, and the relative recruitment is estimated and compared with the historically lowest estimates (acting as a kind of limit level). As a result, the increase in the CV of the aerial survey does not equate to a proportional increase in the variance of the average recruitment used by the MP decision rule. Even for the lowest levels of survey effort considered here, the standard CV in that moving average will be less than 20%. This is why it works quite well: the 5-year average and penalties against over-fitting the data still produce an informative mean relative recruitment to be used in the MP.

The aerial survey data are also used to estimate the sub-adult (=harvested) biomass in the MP model, which is also strongly informed by the CPUE data. This is an explicit design feature of the MP and means that the aerial survey signal can offset issues with the CPUE series when the two provide conflicting information.

An additional reason for the little difference in performance, even when combining the low recruitment runs with the CPUE scenarios, is how different the current reference set of OMs is relative to what the Bali MP was tuned to in 2011. Given the inclusion of the close-kin data and the more recent positive aerial survey points, the recovery projections and recent recruitment levels are notably better than in 2011, all of which contribute strongly to the robustness of the MP on tests that, in the past, had proved problematic.