Updated Management Strategy Evaluation for Eastern Jack and Blue Mackerel

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Executive Summary

The Management Strategy Evaluation (MSE) analyses for eastern jack mackerel and eastern blue mackerel are updated by refining the scenarios on which the MSE is based to account for the recommendations of the Small Pelagic Fishery Scientific Panel, as well as the results of the assessments of these two stocks. The projections are based on the harvest control rule developed for the Small Pelagic Fishery (SPF), which was designed to be robust to the frequency with which data are collected, as well as species biology and associated uncertainties. Results are shown for six sets of reference point choices given that final decisions have yet to be made regarding the target and limit reference points for the SPF. In addition, results are shown for three definitions of "probability of dropping below the limit reference point" (last 20 years of the projection period, all years, in 20-year blocks). Allowing for auto-correlation (ρ=0.707 for blue mackerel; ρ=0.9 for jack mackerel) leads to the conclusion that it is not possible to maintain stocks above the reference points considered with the pre-specified probability (10%) even without fishing, but this is not the case if deviations in recruitment about the stock-recruitment relationship are temporally uncorrelated (i.e. ρ=0). Thus, results are only shown for the case ρ=0. The Tier 1 exploitation rate is selected to achieve the target reference point on average (for the base-case analysis) and to achieve a probability of dropping below the limit reference point of no more than 10% (across all scenarios). The Tier 1 exploitation rate for eastern jack mackerel ranges between 0.051 (when a target reference point of $0.7B_0$ is chosen) to 0.090 (for a limit reference point of $0.2B_0$ evaluated over the last 20 years of the projection period). The Tier 1 exploitation rate for blue mackerel ranges from 0.061 to 0.119, depending on the definition of the probability of dropping below the limit reference point and is determined primarily by the scenario in which recruitment variation is assumed to be high.

1. Introduction

The use of harvest control rules (mathematical functions that determine scientific management advice as a function of monitoring data) is considered state-of-the-art in terms of achieving management goals, and their use has been widely supported by national and international management bodies. Most harvest control rules are functions that determine how the management actions depend on the results of monitoring. Figure 1 contrasts three harvest control rules, all of which set a target exploitation rate, have a minimum stock size below which the exploitation rate is set to zero, and have a maximum permissible exploitation rate. These three harvest control rules will achieve different trade-offs between the probability of the stock being driven to low levels, the average catch and the inter-annual variation in catch[1]. It is not straightforward to assess these trade-offs based solely on the form of the harvest control rule and the choice of values for its parameters. Methods based on Monte Carlo simulation (often referred to as Management Strategy Evaluation, MSE; Punt *et al*. [2016a]) have therefore been developed to assess these trade-offs.

[1] These are the three key dimensions of performance for single-stock management systems, but there are many ways to define mathematical summaries relative to them.

The performance of a management system depends not only on the form of the harvest control rule and the values for its parameters, but also on how well the inputs needed to apply the harvest control rule[2] can be estimated using monitoring data, and how well management actions are implemented. Thus, MSE involves evaluating "management strategies", which are combinations of specifications for monitoring systems, methods for analysing monitoring data, and harvest control rules (Punt *et al*., 2016a).

The Commonwealth Small Pelagic Fishery (SPF), managed by the Australian Fisheries Management Authority (AFMA), is a purse-seine and mid-water trawl fishery extending from southern Queensland to southern Western Australia (see Ward *et al*. [2012] for details). The target species are jack mackerel, *Trachurus declivis*, redbait *Emmelichthys nitidus*, blue mackerel *Scomber australasicus* and Australian sardine *Sardinops sagax* (off parts of the east coast only). Yellowtail Scad, *Trachurus novaezelandiae*, is taken as by-product. The SPF is managed using a combination of input and output controls that include limited entry, zoning, mesh size restrictions and total allowable catches. A new Management Plan was implemented in 2009 that established Eastern and Western management sub-areas (zones, hereafter east and west) rather than the previous four (AFMA, 2009), and introduced new controls such as Individual Transferable Quotas. There is a tiered harvest strategy in place where the tier depends on the amount of research, and in particular an estimate of absolute abundance (Figure 2).

Smith *et al.* (2015) conducted a management strategy evaluation to understand the consequences of alternative ways of applying the tiered harvest strategy framework. Analyses were undertaken for all of the stocks in the SPF, both in a single-species context and also using the end-to-end ecosystem model Atlantis. The analyses were updated inter alia by Smith and Punt (2015, 2016), which suggested that the values for key parameters depended on assumptions regarding the current depletion (the expected value of spawning stock biomass when the management strategy is first applied relative to the unfished equilibrium spawning stock biomass). This led to a request to conduct a stock assessment for eastern jack mackerel (and subsequently eastern blue mackerel) to provide information that could reduce the range of uncertainties considered in Smith *et al*. (2015) and Smith and Punt (2015, 2016). Punt *et al*. (2016b) document an assessment for eastern jack mackerel using Stochastic Stock Reduction Analysis (SSRA) and a state-space assessment method while Punt et al. (2016c) document an assessment for eastern blue mackerel using SSRA. These assessments provide information on current (2015) depletion, and (for eastern jack mackerel) selectivity for the purse-seine and mid-water trawl gears, and the extent of variation in recruitment about the stock-recruitment relationship.

This document first provides updated specifications for the MSE, as it is applied to eastern jack mackerel given the results of the assessment of Punt *et al*. (2016b) and as it is applied to eastern blue mackerel given the results of the assessment of Punt *et al*. (2016c). It then identifies a range of harvest strategy parameterizations given various possible ways to interpret the performance standard implied by the Commercial Harvest Strategy Policy.

2. Methods

2.1 Operating model

The operating model is age-structured, and recruitment is driven by spawning stock biomass. The basic population dynamics are governed by the equation:

[2] In the case on Figure 1, current biomass and current biomass relative to unfished biomass.

$$N_{y,a} = \begin{cases} \dfrac{4hR_0\tilde{S}_y / \tilde{S}_0}{(1-h)+(5h-1)\tilde{S}_y / \tilde{S}_0} e^{\varepsilon_y - \sigma_R^2/2} & \text{if } a = 0 \\ N_{y-1,a-1} e^{-Z_{y-1,a-1}} & \text{if } 1 \le a < x \\ N_{y-1,x-1} e^{-Z_{y-1,x-1}} + N_{y-1,x} e^{-Z_{y-1,x}} & \text{if } a = x \end{cases} \tag{1}$$

where $N_{y,a}$ is the number of fish of age *a* at the start of year *y*, $Z_{y,a}$ is the total mortality on animals of age *a* during year *y*:

$$Z_{y,a} = M + S_a F_y \tag{2}$$

M is the instantaneous rate of natural mortality, S_a is the selectivity of the fishery on animals of age *a*, F_y is the fully-selected fishing mortality rate during year *y*, $\tilde{S}_y$ is the spawning stock biomass at the start of the year:

$$\tilde{S}_y = \sum_a w_a \, f_a \, N_{y,a} \tag{3}$$

$\tilde{S}_0$ is the average unfished spawning stock biomass, w_a is the weight of an animal of age *a* at the start of the year, f_a is the proportion of animals of age *a* that are mature, *h* is the “steepness” of the stock-recruit relationship (Francis, 1992), ε_y is the recruitment deviation for year *y* :

$$\varepsilon_y = \rho\varepsilon_{y-1} + \sqrt{1-\rho^2}\eta_y \;\; \eta_y \sim N(0;\sigma_R^2) \tag{4}$$

ρ is the extent of temporal autocorrelation in recruitment, σ_R is the standard deviation of the recruitment deviations in log-space, and *x* is the maximum age-class (assumed to be a plus-group).

The catches by age and year, $C_{y,a}$, are given by the Baranov equation:

$$C_{y,a} = \frac{S_a F_y}{Z_{y,a}} N_{y,a} (1 - e^{-Z_{y,a}}) \tag{5}$$

and the catches in weight by:

$$\tilde{C}_y = \sum_a w_{a+1/2} \, C_{y,a} \tag{6}$$

The projection period starts with a burn-in period of 75 years. The burn-in period involves a projection in which there is a constant level of fishing mortality, chosen so that deterministically, the population would be at a pre-specified level of depletion. The burn-in period is followed by a projection period in which catches are assumed to equal to the catch limits computed using the management strategies. The second projection period is 117 years for eastern jack mackerel and 50 years for eastern blue mackerel. The length of the second projection period is based on the projections under the management strategies having the same length in terms of generation time for all SPF stocks. Smith *et al*. (2015) conducted 50-year projections for all stocks, but this implies different numbers of generations given the differences in longevity and productivity among stocks. Recruitment variation occurs during the burn-in period so the spawning stock biomass at the start of the projection period for each of the 1,000 simulations is distributed about the pre-specified depletion level, with the extent of variation depending on σ_R, and ρ.

2.2 Data generation and management strategies

Estimates of spawning stock biomass are assumed to be available with a coefficient of variation (CV) of 0.5. The estimates are assumed to be unbiased for the bulk of the analyses, but three of sensitivity tests (see Section 2.3) explore the implications of bias in these estimates. The management strategy is based on the three-tier harvest control rule (Figure 2). This management strategy sets the recommended Biological Catch (RBC)[3] by multiplying the most recent estimate of spawning stock biomass[4] by an exploitation rate that depends on the time since the last survey was conducted. The premise of the analysis is that the future monitoring strategy is unknown, but could be any of: (a) a survey every 5 years, (b) a survey every 10 years (eastern blue mackerel) or 15 years (eastern jack mackerel), and (c) a survey once and then never again. Consequently, three sets of analyses are undertaken:

- The Tier 1 exploitation rate applies for 5 years and the RBC is constant over the 5 years (RBC = Tier 1 rate x most recent survey biomass estimate)[5]. Surveys are conducted every 5 years (Fig. 2; upper panels)
- If there is no survey in year 5, the Tier 2 exploitation rate (half of the Tier 1 exploitation rate) is applied for a further 10 years (jack mackerel; 5 years for blue mackerel) (so the initial catches are halved). Surveys are conducted every 15 years (jack mackerel; 10 years for blue mackerel).
- If there is no survey after 15 years (jack mackerel; 10 years for blue mackerel), the Tier 3 exploitation rate (half of the Tier 2 exploitation rate or a quarter of the Tier 1 exploitation rate) is applied. There is only one survey in the tests based on this Tier.

2.3 Scenarios (base-case and sensitivity)

Data for eastern jack and blue mackerel were taken from Ward *et al.* (2012) and Giannini *et al.,* (2010). For jack mackerel, the base-case value for steepness was 0.75 while it was 0.59 for blue mackerel (Giannini *et al.,* 2010). The base-case value for natural mortality was set at 0.26yr^{-1} for jack mackerel and 0.62yr^{-1} for blue mackerel. The estimates of growth and maturity are the same as those used by Smith *et al*. (2015) and Smith and Punt (2015, 2016), but selectivity for jack mackerel has been updated to the estimates for mid-water gear for the dome-shaped* model of Punt *et al*. (2016b). Other differences from the specifications on which the base-case analysis of this report is based compared to the base-case specifications of Smith *et al*. (2015) are:

- The extent of variation in recruitment for jack mackerel is increased from a CV of 0.6 to a CV based on the results of the state-space assessment method in Punt *et al*. (2016b).
- The CV for the estimate of spawning stock biomass from the DEPM is increased from 0.3 to 0.5 following a recommendation from the Small Pelagic Fishery Scientific Panel (AFMA, 2016).
- Initial depletion for jack mackerel is set to 1 based on the results of the state-space assessment method in Punt *et al*. (2016b).
- Initial depletion for blue mackerel is set to 0.93 based on the results of the Stochastic Stock Reduction Analysis in Punt *et al*. (2016c)

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[3] Assumed to be taken exactly.

[4] Given the fast dynamics of small pelagic fishes, the RBC is based on the most recent estimate only.

[5] For computational ease it is assumed that an estimate of abundance can be produced essentially immediately after data collections takes place.

Table 2 lists the specifications for the sensitivity analyses. The sensitivity analyses match those used by Smith *et al*. (2015) with the following differences:

- Scenario 1 involves a CV for the DEPM estimate of abundance of 0.8. Smith *et al*. (2015) considered a sensitivity analysis in which this CV was set to 0.5, but that level of CV is now part of the base-case analysis; 0.8 reflects (approximately) the same proportional increase in CV that the original Scenario 1 considered.
- The sensitivity analysis that explored DEPM biases of 25% and 50% were dropped and replaced by a sensitivity analysis based on the recommendation of a 20% positive bias (AFMA, 2016).
- A sensitivity test for eastern jack mackerel based on the selectivity pattern assumed by Smith *et al.* (2015) has been added because this selectivity pattern forms the basis for the Stochastic Stock Reduction Analysis of Punt *et al*. (2016b).
- Sensitivity analyses (Scenarios 10 and 11) have been added to explore the implications of uncertainty regarding the extent of variation in recruitment about the stock-recruitment relationship.
- Sensitivity analyses (Scenarios 12 and 13) have been added to explore the implications of uncertainty regarding initial depletion. The values considered are based on the results of the Stochastic Stock Reduction Analysis (Punt *et al*., 2016b,c).
- Sensitivity analyses (Scenarios 14 and 15) have been added to explore the implications of uncertainty regarding natural mortality. The values considered are ±20% of the base-case values.

Results are shown the case in which recruitment is temporally uncorrelated (ρ=0) as well as when there is temporal auto-correlation in recruitment (ρ=0.707 for blue mackerel; ρ=0.9 for jack mackerel). Smith *et al*. (2015) only considered the case ρ=0, but the Small Pelagic Fishery Scientific Panel recommended that analyses with ρ estimated be conducted. The value of ρ selected for jack mackerel is based on the estimate from the state space assessment method of Punt *et al*. (2016). The value ρ=0.707 for blue mackerel was selected so that half of the variation in recruitment is attributed to auto-correlation (Punt *et al*., 2016c).

2.4 Performance metrics

The risk-related performance metrics are:

- The average spawning stock biomass over the last 20 years of the projection period divided by B_0[6] (denoted "Depletion").
- The proportion of simulations * years in which the spawning stock biomass is less than 0.5 B_0 over the last 20 years of the projection period (denoted "P(B<B_{50}).
- The proportion of simulations * years in which the spawning stock biomass is less than 0.7 B_0 over the last 20 years of the projection period (denoted "P(B<B_{70}) (Base-case; last 20)").
- The proportion of simulations * years in which the spawning stock biomass is less than 0.2 B_0 over the last 20 years of the projection period (denoted "P(B<B_{20}) (last 20 years)").
- The maximum over all years of the proportion of simulations in which the spawning stock biomass is less than 0.2 B_0 (denoted "P(B<B_{20}) (all years)").
- The maximum over blocks of 20-year periods of years of the proportion of simulations in which the spawning stock biomass is less than 0.2 B_0 (denoted "P(B<B_{20}) (blocks)").

[6] B_0 is the expected spawning stock biomass over the last 20 years of a 117/50 year projection period when there is no exploitation, but recruitment is stochastic.

- The proportion of simulations * years in which the spawning stock biomass is less than 0.3 B_0 over the last 20 years of the projection period (denoted "P(B<B_{30}) (last 20)").
- The maximum over all years of the proportion of simulations in which the spawning stock biomass is less than 0.3 B_0 (denoted "P(B<B_{30}) (all years)").
- The maximum over blocks of 20-year periods of years of the proportion of simulations in which the spawning stock biomass is less than 0.3 B_0 (denoted "P(B<B_{30}) (blocks)").

The first two performance metrics relate to achieving a target reference point of either 50% or 70% of the expected unfished spawning stock biomass while the last six performance metrics pertain to avoiding dropping the stock below the limit reference point.

The catch-related performance metric is:

- The average catch over the last 20 years of the projection period divided by MSY[7] for the base-case scenario (denoted "Catch/MSY (base-case)").

2.4.1 Tuning and Interpretation of results

The aim is to find a management strategy that maximizes yield subject to achieving adequate conservation performance. Specifically, given a choice for the target reference point and the limit reference point, simulations are conducted in which surveys are conducted (a) every 5 years, (b) every 15 years (jack mackerel) / 10 years (blue mackerel) or (c) only once, and finding the initial (Tier 1) harvest rate[8] that achieves **both** a probability of no more than 0.5 of being below the target reference point for the base-case analysis and 0.1 of being below the limit reference point for all scenarios are selected for each choice survey frequency (every 5 years; every 10/15 years; only once). The final (Tier 1) harvest rate is then the minimum of the three Tier 1 rates[9].

3. Results

3.1 Impact of auto-correlation in recruitment

Results are only shown for the case ρ=0 because there were no values for the Tier 1 exploitation rate that satisfied the performance standard (a probability of no more than 0.5 of being below the target reference point for the base-case analysis and of no more than 0.1 of being below the limit reference point for all scenarios). This occurs because the spawning stock biomass will be driven to low levels even in the absence of fishing given high temporal auto-correlation in recruitment (combined with high variation in recruitment). Figure 3 show the outputs of the SSRA for jack mackerel when ρ=0 (upper panels) and when ρ=0.9 (lower panels). The impact of temporal auto-correlation in recruitment is most evident in the distribution of current (2015) depletion, which indicates a substantial probability below 0.5, even though in expectation current depletion is close to 1.

3.2 Jack mackerel

As expected, the Tier 1 exploitation rates (and hence the Tier 2 and Tier 3 exploitation rates) that satisfy the performance standard depend on the choice of reference points (Table 3). The Tier 1 exploitation rate for jack mackerel ranges between 0.051 (when a target reference point of 0.7B_0 is chosen) and 0.090 (for a limit reference point of 0.2B_0 evaluated over the last 20 years of the projection period). As expected, evaluating the risk of dropping below the limit reference point by year leads to a lower Tier 1 exploitation rate (rows "all years" vs "last 20 years" and "20-year blocks"). The sensitivity tests that determine the Tier 1 rates depend on

[7] Maximum expected catch under a harvest strategy in which a constant exploitation rate is applied to true biomass when recruitment is stochastic.

[8] The harvest rate that would be applied in the first year after a survey estimate becomes available.

[9] The minimum is taken because when a survey is next undertaken is unknown (or even whether another survey will be conducted).

survey frequency and the basis for calculating the risk of dropping below the limit reference point (1: high survey CV; 2: positively biased estimates of abundance; 6: low steepness 9: “original” selectivity; 11: high recruitment variation).

Table 4 shows the values for all of the performance statistics for each choice of survey interval and for the base-case analysis and each sensitivity test. The factor determining the choice of Tier 1 exploitation rate is highlighted in red shade. For example, for Table 4b, the Tier 1 exploitation rate is determined by keeping the probability of dropping below $0.2B_0$ less than 0.1 when surveys are conducted every 15 years and selectivity equals the ‘original’ form. The final depletions increase with decreasing survey frequency, but are always above the target reference point ($0.5B_0$ for Tables 4a-c and $0.7B_0$ for Tables 4d-f). Expected catch as a proportion of MSY[10] declines with decreasing survey frequency. It is less than 70% for 5-year surveys and declines to less than 30% for a single survey.

3.3 Blue mackerel

The results for blue mackerel are qualitatively the same as for jack mackerel (Tables 3 and 5). However, unlike the case for jack mackerel, risk (and hence the Tier 1 exploitation rate) is driven entirely by the sensitivity test in which the extent of recruitment variation is high (σ_R=1). This is not unexpected because, with a high rate of natural mortality, much of the population biomass consists of new recruits. In several cases (Table 5), the risk associated with sensitivity test 11 is several times larger than that associated with the other sensitivity tests.

4. Discussion

The MSE conducted here calculates Tier 1 exploitation rates that are robust to survey frequency and uncertainties related to survey bias, stock-recruitment steepness, selectivity, natural mortality, and current depletion. These rates are calculated separately for each choice of target and limit reference point, and for the definition for the probability of dropping below the limit reference point. The scenarios considered in this document expand on those considered by Smith *et al*. (2015) and reflect, to the extent possible, the outcomes from assessments.

The most important drivers of the Tier 1 exploitation rates are the extent of temporal auto-correlation in recruitment, combined with the extent of recruitment variation and the value for natural mortality. Specifically, the stocks will drop below the limit reference point with a greater than 10% probability even in the absence of exploitation if recruitment auto-correlation is 0.707 (blue mackerel) or 0.9 (jack mackerel) given the values for the other biological parameters.

The increase to the range of values tested for both recruitment variability and autocorrelation in this work were driven by the outcomes of the initial suite of integrated assessment models for Eastern Jack Mackerel. These models, by assuming constant fishery selectivity over time, interpret the catch age-composition data as strongly informative about the age structure of the population, which drove the recruitment trend and associated distributional parameters estimated. If the catch-at-age data are representative of the fish caught, but not necessarily of the wider population – due to time-varying selectivity (driven by operational shifts such as timing, location and depth of fishing) – one would expect different results. It seems likely that a less variable recruitment trend would arise if allowance was made for a temporally changing selectivity pattern. However, estimating time-varying selectivity would lose the ability to estimate the key distributional parameters of recruitment, so one form

[10] MSY depends on scenario and is consequently calculated separately for each scenario.

is not immediately preferable to another. Ideally both should be developed as alternative hypotheses.

The high variation of small pelagic fishes is well-known and this leads to the question of whether a single performance standard is appropriate to all species. For example, the performance standard for small pelagic fishes off South Africa is whether the probability of dropping below the limit reference point is increased by x% compared to the corresponding probability under zero exploitation rate. This definition would be equivalent to “the probability of dropping below the limit reference point should be no more than x%” for long-lived species such as pink ling because the probability of dropping below the limit reference point in the absence of exploitation would be close to zero due to relatively small effects of recruitment variation and autocorrelation on the age structure. Consequently “the probability of dropping below the limit reference point should be no more than x%” is the same as “the probability of dropping below the limit reference point should not be increased by more than 10% compared to the no-fishing scenario” for long-lived species. Implementing a similar approach to risk management for short-lived species in the context of auto-correlated recruitment is possible, but is the beyond the scope of the current analysis. It would require that the probability of dropping the limit reference point to be computed for each scenario (see Table 6 for an example) and a value of x% selected.

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Table 1. Values for the biological parameters for eastern jack and eastern blue mackerel (source: Smith *et al*., 2015; Punt *et al*. 2016b,c).

	Jack mackerel				Blue mackerel			
Age	**Weight**	**Proportion mature**	**Selectivity[1]**	**Original Selectivity[2]**	**Weight**	**Proportion mature**	**Selectivity**	**Knuckey selectivity**
0	5.3	0	0	0	34.5	0.01	0.01	0.3
1	41.3	0	0	0	142.6	0.17	0.17	1
2	107.0	0.04	0.043	0.680	278.2	0.69	0.69	1
3	187.0	0.22	0.149	0.860	402.6	0.91	0.91	1
4	267.9	0.56	0.512	1.000	501.3	0.97	0.97	1
5	341.9	0.80	0.953	1.000	573.7	0.98	0.98	1
6	405.4	0.90	1.000	1.000	643.9	0.99	0.99	1
7	457.9	0.95	1.000	1.000				
8	500.0	1.00	1.000	1.000				
9	533.2	1.00	1.000	1.000				
10	558.9	1.00	1.000	1.000				
11	578.8	1.00	1.000	1.000				
12	605.6	1.00	0.994	1.000				

1: Based on the results for mid-water trawl and estimating the extent of auto-correlation
2: Base-case in Smith *et al*. (2015)

Table 2. Specifications of the base-case analysis and the sensitivity tests.

(a) Eastern jack mackerel (ρ=0; with the values for ρ=0.9 in parenthesis)

Scenario	Survey CV	Survey bias	Steepness	Natural Mortality	Selectivity	σ_R	Initial depletion
Base-case	0.5	1	0.75	0.26	Table 1	1 (1.4)	1.00 (1.00)
1	0.8						
2		1.2					
3		0.5					
4		0.75					
5			0.9				
6			0.6				
7					One year to the left		
8					One year to the right		
9					Original		
10						0.6 (1)	
11						1.2 (1.6)	
12							0.77[a] (0.54[b])
13							0.94[a] (0.91[b])
14				0.208			
15				0.312			

a: Based on SSRA results with ρ=0; b: Based on SSRA results with ρ=0.9

(b) Eastern blue mackerel (ρ=0; with the values for ρ=0.707 in parenthesis)

Scenario	Survey CV	Survey bias	Steepness	Natural Mortality	Selectivity	σ_R	Initial depletion
Base-case	0.5	1	0.59	0.62	Table 1	0.6	0.93 (0.91)
1	0.8						
2		1.2					
3		0.5					
4		0.75					
5			0.71				
6			0.47				
7					One year to the left		
8					One year to the right		
9					Knuckey selectivity (Table 1)		
10						0.4	
11						1.0	
12							0.85[a] (0.74[b])
13							0.95[a] (0.94[b])
14				0.496			
15				0.744			

a: Based on SSRA results with ρ=0; b: Based on SSRA results with ρ=0.707

Table 3. Summary of the tier 1 rates based on projections in which (a) the tier 1 control rule is always applied, (b) the tier 2 control rule is always applied, and (c) in which the tier 3 control rule is applied (columns "Tier 1", "Tier 2", and "one survey only"). The final column indicates the lower of the three tier 1 rates (that which consequently satisfies risk irrespective of future survey interval). The values in parenthesis are the sensitivity tests for which risk is highest. Results are only shown in this table for the case in which ρ=0 because the results for ρ=0.9 (jack mackerel) and ρ=0.707 (blue mackerel) indicate that even a zero exploitation rate cannot satisfy the performance standard.

(a) Eastern jack mackerel (no auto-correlation in recruitment)

Target Reference point	Limit Reference point	Risk basis	Survey frequency			
			Tier 1	Tier 2	One survey only	Lowest rate
$0.5B_0$	$0.2B_0$	Last 20 years	0.111(11)	0.090(9)	0.092(6)	0.090
$0.5B_0$	$0.2B_0$	All years	0.093(1)	0.081(1)	0.086(2)	0.081
$0.5B_0$	$0.2B_0$	20-year blocks	0.105(11)	0.089(9)	0.092(6)	0.089
$0.7B_0$	$0.3B_0$	Last 20 years	0.051(0)	0.070(11)	0.087(6)	0.051
$0.7B_0$	$0.3B_0$	All years	0.051(0)	0.059(11)	0.067(11)	0.051
$0.7B_0$	$0.3B_0$	20-year blocks	0.051(0)	0.066(11)	0.080(11)	0.051

(b) Eastern blue mackerel (no auto-correlation in recruitment)

Target Reference point	Limit Reference point	Risk basis	Survey frequency			
			Tier 1	Tier 2	One survey only	Lowest rate
$0.5B_0$	$0.2B_0$	Last 20 years	0.122(11)	0.119(11)	0.135(11)	0.119
$0.5B_0$	$0.2B_0$	All years	0.105(11)	0.100(11)	0.105(11)	0.100
$0.5B_0$	$0.2B_0$	20-year blocks	0.122(11)	0.118(11)	0.128(11)	0.118
$0.7B_0$	$0.3B_0$	Last 20 years	0.073(11)	0.079(11)	0.111(11)	0.073
$0.7B_0$	$0.3B_0$	All years	0.061(11)	0.064(11)	0.066(11)	0.061
$0.7B_0$	$0.3B_0$	20-year block	0.073(11)	0.079(11)	0.091(11)	0.073

Table 4a. Risk summary for jack mackerel when the Tier 1 rate is selected based on a target reference point of $0.5B_0$ and a maximum risk (over all sensitivity tests) over the last 20 years of the projection period of dropping below $0.2B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey	Final	P(B<0.5B_0)	P(B<0.7B_0)	P(B<0.2B_0)			P(B<0.3B_0)			Catch /
	Frequency	Depletion			Last 20	All years	Blocks	Last 20	All years	Blocks	MSY
0	5	0.650	37.3	65.9	2.6	5.5	3.1	9.2	12.2	10.3	0.619
1	5	0.648	37.4	64.6	5.7	8.9	6.5	12.4	15.9	13.9	0.592
2	5	0.601	44.5	71.4	5.0	8.6	5.8	14.1	18.2	15.5	0.683
3	5	0.800	16.8	46.9	0.1	0.4	0.2	1.4	2.8	1.6	0.384
4	5	0.720	26.9	57.5	0.9	1.8	1.0	4.4	7.2	5.1	0.517
5	5	0.680	32.8	62.3	2.0	5.2	2.5	7.3	10.2	8.3	0.525
6	5	0.601	44.9	71.6	4.5	6.8	5.0	13.6	17.2	15.0	0.732
7	5	0.665	35.3	64.3	2.0	4.8	2.4	8.0	10.9	9.0	0.603
8	5	0.631	40.0	68.0	3.7	5.9	4.2	10.8	14.4	12.1	0.643
9	5	0.613	42.7	70.0	4.6	6.7	5.2	12.6	16.1	13.9	0.664
10	5	0.656	20.0	62.8	0.6	2.1	0.7	2.2	5.4	2.4	0.607
11	5	0.645	45.2	68.2	6.0	8.6	6.8	16.3	21.0	17.6	0.628
12	5	0.650	37.3	65.9	2.6	5.2	3.1	9.2	12.2	10.3	0.619
13	5	0.650	37.3	65.9	2.6	5.2	3.1	9.2	12.2	10.3	0.619
14	5	0.596	43.7	72.4	3.6	6.3	4.3	11.6	15.7	13.1	0.698
15	5	0.692	33.1	61.3	2.2	5.1	2.6	7.8	10.5	8.8	0.552
0	15	0.715	29.3	56.7	4.9	7.0	5.4	9.6	14.3	10.5	0.443
1	15	0.710	30.0	55.3	8.3	12.5	9.3	12.6	19.1	14.6	0.409
2	15	0.666	35.9	61.9	7.9	12.4	8.7	13.5	22.1	15.1	0.494
3	15	0.850	13.4	39.8	0.4	0.9	0.5	1.4	2.2	1.5	0.263
4	15	0.781	21.3	48.8	1.9	3.0	2.0	4.8	7.1	5.4	0.364
5	15	0.745	25.9	53.1	3.3	5.2	4.0	7.3	11.3	8.3	0.377
6	15	0.666	35.6	62.0	7.8	11.0	8.3	13.6	19.4	14.6	0.525
7	15	0.734	27.1	54.9	3.3	5.9	3.9	7.8	11.2	8.8	0.434
8	15	0.688	32.3	59.0	7.3	9.8	7.6	12.1	17.4	12.8	0.453
9	15	0.657	35.9	61.9	10.0	11.6	10.1	15.1	19.3	15.5	0.459
10	15	0.726	13.9	46.3	1.8	4.0	2.2	3.2	5.7	3.9	0.441
11	15	0.705	38.1	61.5	8.5	12.0	8.7	15.1	22.7	16.4	0.444
12	15	0.715	29.3	56.7	4.9	7.0	5.4	9.6	12.9	10.5	0.443
13	15	0.715	29.3	56.7	4.9	7.0	5.4	9.6	13.4	10.5	0.443
14	15	0.664	33.7	62.0	6.6	10.7	6.9	11.8	19.1	12.8	0.506
15	15	0.754	26.8	52.8	3.6	5.4	4.2	8.0	11.6	8.9	0.391
0	1 only	0.852	15.2	38.4	3.9	6.9	4.7	4.8	11.8	8.1	0.218
1	1 only	0.829	17.9	38.7	8.7	10.8	9.1	9.6	14.5	10.5	0.178
2	1 only	0.801	20.2	42.9	8.1	11.7	9.0	9.7	17.3	12.3	0.239
3	1 only	0.937	6.9	28.5	0.3	0.9	0.4	0.6	1.7	1.0	0.119
4	1 only	0.899	10.2	33.2	1.2	2.8	1.5	1.8	4.9	3.4	0.174
5	1 only	0.885	11.2	35.4	0.6	5.2	3.5	1.5	10.2	6.6	0.194
6	1 only	0.796	21.5	43.7	9.4	9.6	9.4	11.0	14.5	11.1	0.243
7	1 only	0.877	12.7	36.5	1.0	5.9	3.7	2.2	10.0	7.0	0.227
8	1 only	0.823	17.9	40.7	6.8	8.6	6.9	7.9	13.5	9.3	0.215
9	1 only	0.809	19.4	41.9	7.9	9.8	8.0	9.1	14.7	10.4	0.222
10	1 only	0.868	2.9	20.0	1.4	4.0	2.4	1.5	5.7	3.9	0.226
11	1 only	0.826	24.6	47.0	8.3	10.2	8.3	11.0	17.8	12.2	0.201
12	1 only	0.897	10.4	33.4	1.4	4.3	2.8	2.0	10.0	5.8	0.176
13	1 only	0.864	13.9	37.1	3.1	6.5	4.1	3.9	10.1	7.4	0.208
14	1 only	0.799	18.4	41.3	7.9	9.4	8.1	9.0	15.5	10.1	0.243
15	1 only	0.888	13.1	36.6	1.4	4.7	3.4	2.4	9.6	6.5	0.194

Table 4b. Risk summary for jack mackerel when the Tier 1 rate is selected based on a target reference point of $0.5B_0$ and a maximum risk (over all sensitivity tests) over the all years of the projection period of dropping below $0.2B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey Frequency	Final Depletion	$P(B<0.5B_0)$	$P(B<0.7B_0)$	$P(B<0.2B_0)$			$P(B<0.3B_0)$			Catch / MSY
					Last 20	All years	Blocks	Last 20	All years	Blocks	
0	5	0.677	33.3	62.7	1.8	3.7	2.2	7.1	9.8	8.1	0.581
1	5	0.675	33.7	61.4	4.5	7.8	5.1	10.2	14.0	11.6	0.558
2	5	0.630	40.3	68.3	3.5	6.4	4.1	11.0	14.7	12.3	0.646
3	5	0.817	14.9	44.6	0.0	0.3	0.1	1.1	2.0	1.2	0.353
4	5	0.743	23.8	54.5	0.6	1.4	0.6	3.2	5.6	3.8	0.480
5	5	0.704	29.2	59.5	1.4	3.3	1.7	5.6	8.6	6.5	0.490
6	5	0.632	40.4	68.2	3.1	5.4	3.5	10.5	13.3	11.7	0.694
7	5	0.691	31.3	61.2	1.4	3.2	1.7	6.2	8.9	7.1	0.565
8	5	0.660	35.7	64.9	2.4	4.6	2.8	8.4	11.3	9.4	0.606
9	5	0.643	38.0	66.7	3.3	5.2	3.7	9.7	12.6	10.8	0.627
10	5	0.683	15.8	57.3	0.4	1.2	0.4	1.4	3.3	1.4	0.568
11	5	0.672	41.8	65.8	4.5	7.2	5.2	13.4	17.8	14.8	0.591
12	5	0.677	33.3	62.7	1.8	3.7	2.2	7.1	9.8	8.1	0.581
13	5	0.677	33.3	62.7	1.8	3.7	2.2	7.1	9.8	8.1	0.581
14	5	0.626	39.0	69.1	2.4	4.6	2.8	8.9	11.9	10.0	0.660
15	5	0.717	29.6	58.3	1.5	3.2	1.8	6.1	8.9	7.0	0.515
0	15	0.741	26.1	53.8	3.6	5.2	3.8	7.6	10.7	8.4	0.414
1	15	0.735	27.1	52.6	6.8	10.0	7.6	10.7	15.6	12.3	0.384
2	15	0.695	31.9	58.8	6.0	8.9	6.6	11.0	17.3	12.2	0.464
3	15	0.865	12.0	37.9	0.3	0.6	0.4	1.1	1.7	1.2	0.240
4	15	0.802	18.9	46.3	1.2	2.0	1.3	3.6	5.2	4.1	0.336
5	15	0.767	23.1	50.5	2.4	3.8	2.7	5.6	8.8	6.6	0.349
6	15	0.698	31.6	58.6	5.8	7.4	5.9	10.9	14.8	11.5	0.496
7	15	0.757	24.2	52.1	2.3	3.9	2.7	6.1	9.2	6.9	0.403
8	15	0.717	28.6	55.9	5.4	6.8	5.6	9.6	12.6	10.3	0.427
9	15	0.691	31.6	58.3	7.4	8.9	7.4	12.2	14.5	12.4	0.436
10	15	0.751	10.6	41.7	1.2	1.8	1.2	2.2	3.7	2.5	0.410
11	15	0.732	34.9	59.1	6.7	8.7	7.1	12.9	18.2	13.7	0.416
12	15	0.741	26.1	53.8	3.6	5.2	3.8	7.6	10.7	8.4	0.414
13	15	0.741	26.1	53.8	3.6	5.2	3.8	7.6	10.7	8.4	0.414
14	15	0.693	29.5	58.7	4.8	7.6	5.1	9.4	13.6	10.1	0.477
15	15	0.777	24.0	50.2	2.6	4.2	2.9	6.3	9.6	7.2	0.363
0	1 only	0.874	12.8	36.1	2.3	5.0	3.2	3.0	8.2	5.9	0.203
1	1 only	0.851	15.9	36.7	6.7	8.7	7.5	7.5	12.4	8.9	0.169
2	1 only	0.830	17.3	40.3	5.7	8.9	6.5	7.0	13.8	9.8	0.226
3	1 only	0.944	6.4	27.6	0.1	0.5	0.2	0.3	1.4	0.7	0.108
4	1 only	0.911	9.0	31.8	0.9	2.0	1.1	1.3	3.6	2.4	0.158
5	1 only	0.897	9.9	33.6	0.4	3.8	2.4	1.1	7.8	4.8	0.175
6	1 only	0.831	18.2	40.7	6.1	7.2	6.1	7.6	12.1	8.4	0.235
7	1 only	0.891	11.1	34.8	0.7	3.9	2.5	1.5	7.9	5.2	0.205
8	1 only	0.853	14.9	38.0	4.2	6.3	4.3	5.0	10.2	6.9	0.205
9	1 only	0.840	16.3	39.3	5.2	7.3	5.4	6.1	11.8	7.9	0.212
10	1 only	0.884	2.0	17.7	0.9	1.8	1.1	1.0	3.7	2.4	0.206
11	1 only	0.855	21.8	44.9	5.7	8.0	5.7	8.1	14.8	10.2	0.191
12	1 only	0.910	9.2	32.0	0.9	2.8	1.8	1.4	8.7	4.4	0.160
13	1 only	0.883	11.9	35.0	2.0	4.2	2.8	2.7	8.4	5.5	0.192
14	1 only	0.832	15.2	38.5	4.9	7.6	5.5	5.8	11.8	7.7	0.235
15	1 only	0.901	11.8	35.1	1.0	3.8	2.3	1.9	7.7	4.8	0.176

Table 4c. Risk summary for jack mackerel when the Tier 1 rate is selected based on a target reference point of $0.5B_0$ and a maximum risk (over all sensitivity tests) over 20-year blocks of years over the projection period of dropping below $0.2B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey Frequency	Final Depletion	P(B<0.5B_0)	P(B<0.7B_0)	P(B<0.2B_0) Last 20	P(B<0.2B_0) All years	P(B<0.2B_0) Blocks	P(B<0.3B_0) Last 20	P(B<0.3B_0) All years	P(B<0.3B_0) Blocks	Catch / MSY
0	5	0.651	37.2	65.9	2.6	5.3	3.0	9.2	12.1	10.2	0.618
1	5	0.649	37.3	64.5	5.7	8.9	6.5	12.3	15.9	13.8	0.591
2	5	0.602	44.4	71.3	5.0	8.5	5.8	14.0	18.0	15.4	0.682
3	5	0.800	16.8	46.8	0.1	0.4	0.2	1.4	2.8	1.5	0.383
4	5	0.721	26.9	57.4	0.9	1.8	1.0	4.4	7.2	5.1	0.516
5	5	0.680	32.8	62.3	2.0	5.2	2.5	7.2	10.2	8.2	0.525
6	5	0.602	44.8	71.5	4.4	6.8	5.0	13.5	17.1	14.9	0.731
7	5	0.666	35.2	64.3	2.0	4.8	2.4	8.0	10.6	8.9	0.602
8	5	0.632	39.8	68.0	3.7	5.9	4.1	10.8	14.4	12.1	0.642
9	5	0.614	42.5	69.9	4.5	6.7	5.2	12.5	16.1	13.9	0.663
10	5	0.657	19.9	62.7	0.6	1.9	0.7	2.2	5.2	2.4	0.606
11	5	0.645	45.2	68.2	5.9	8.5	6.7	16.2	20.9	17.6	0.627
12	5	0.651	37.2	65.9	2.6	5.0	3.0	9.2	12.1	10.2	0.618
13	5	0.651	37.2	65.9	2.6	5.2	3.0	9.2	12.1	10.2	0.618
14	5	0.597	43.6	72.3	3.6	6.2	4.3	11.6	15.7	13.0	0.697
15	5	0.693	33.1	61.2	2.2	4.9	2.6	7.7	10.5	8.8	0.551
0	15	0.715	29.2	56.7	4.8	7.0	5.4	9.6	14.0	10.5	0.443
1	15	0.711	30.0	55.3	8.2	12.5	9.3	12.5	18.9	14.6	0.408
2	15	0.667	35.8	61.8	7.8	12.3	8.6	13.5	22.1	15.0	0.493
3	15	0.851	13.3	39.7	0.4	0.9	0.5	1.4	2.1	1.5	0.262
4	15	0.781	21.3	48.7	1.8	3.0	1.9	4.8	6.9	5.3	0.364
5	15	0.745	25.8	53.0	3.3	5.2	3.9	7.3	11.2	8.3	0.376
6	15	0.667	35.5	61.9	7.7	10.9	8.2	13.5	19.3	14.5	0.524
7	15	0.734	27.1	54.8	3.2	5.8	3.8	7.7	11.2	8.8	0.433
8	15	0.688	32.2	58.9	7.3	9.7	7.6	12.0	17.3	12.8	0.452
9	15	0.658	35.8	61.8	9.9	11.6	10.0	15.0	19.3	15.4	0.458
10	15	0.727	13.9	46.2	1.8	3.9	2.2	3.1	5.7	3.9	0.441
11	15	0.706	38.0	61.4	8.4	12.0	8.7	15.1	22.6	16.3	0.443
12	15	0.715	29.2	56.7	4.8	7.0	5.4	9.6	12.9	10.5	0.443
13	15	0.715	29.2	56.7	4.8	7.0	5.4	9.6	13.3	10.5	0.443
14	15	0.664	33.6	61.9	6.5	10.4	6.9	11.7	19.1	12.7	0.506
15	15	0.755	26.7	52.7	3.5	5.4	4.2	7.9	11.6	8.8	0.390
0	1 only	0.853	15.1	38.3	3.8	6.9	4.7	4.7	11.8	8.1	0.217
1	1 only	0.831	17.8	38.6	8.5	10.8	9.1	9.4	14.5	10.4	0.178
2	1 only	0.801	20.1	42.8	8.1	11.5	8.9	9.6	17.3	12.2	0.239
3	1 only	0.937	6.9	28.4	0.3	0.9	0.4	0.5	1.7	1.0	0.118
4	1 only	0.900	10.2	33.2	1.2	2.8	1.5	1.8	4.9	3.4	0.174
5	1 only	0.885	11.2	35.3	0.6	5.2	3.5	1.5	10.2	6.6	0.194
6	1 only	0.798	21.3	43.6	9.2	9.4	9.2	10.8	14.5	11.0	0.244
7	1 only	0.877	12.7	36.4	1.0	5.8	3.7	2.1	10.0	6.9	0.227
8	1 only	0.825	17.7	40.6	6.6	8.5	6.8	7.7	13.4	9.2	0.215
9	1 only	0.810	19.3	41.8	7.7	9.7	8.0	9.0	14.6	10.3	0.222
10	1 only	0.869	2.9	19.9	1.4	3.9	2.3	1.5	5.7	3.9	0.226
11	1 only	0.826	24.6	47.0	8.3	10.2	8.3	10.9	17.7	12.2	0.201
12	1 only	0.898	10.4	33.3	1.4	4.3	2.7	2.0	10.0	5.8	0.175
13	1 only	0.864	13.8	37.0	3.1	6.5	4.1	3.9	10.1	7.3	0.208
14	1 only	0.800	18.4	41.3	7.9	9.3	8.1	9.0	15.5	10.0	0.243
15	1 only	0.888	13.1	36.6	1.4	4.7	3.4	2.4	9.6	6.5	0.194

Table 4d. Risk summary for jack mackerel when the Tier 1 rate is selected based on a target reference point of $0.7B_0$ and a maximum risk (over all sensitivity tests) over the last 20 years of the projection period of dropping below $0.3B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey	Final	P(B<0.5B_0)	P(B<0.7B_0)	P(B<0.2B_0)			P(B<0.3B_0)			Catch /
	Frequency	Depletion			Last 20	All years	Blocks	Last 20	All years	Blocks	MSY
0	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
1	5	0.772	20.8	49.8	1.4	2.7	1.5	4.1	5.9	4.7	0.416
2	5	0.740	24.2	54.9	0.6	1.5	0.7	3.3	5.8	4.0	0.485
3	5	0.878	9.6	35.7	0.0	0.1	0.0	0.3	0.6	0.3	0.241
4	5	0.825	14.2	43.4	0.0	0.3	0.1	0.9	1.8	1.0	0.339
5	5	0.794	17.4	47.5	0.2	0.7	0.2	1.5	3.0	1.8	0.352
6	5	0.746	23.8	54.2	0.4	1.1	0.6	3.2	5.2	3.6	0.522
7	5	0.786	18.5	48.7	0.2	0.8	0.2	1.7	3.1	2.0	0.410
8	5	0.764	21.0	51.6	0.4	1.0	0.4	2.4	4.0	2.9	0.447
9	5	0.752	22.5	53.3	0.5	1.2	0.5	2.9	4.9	3.3	0.467
10	5	0.779	4.7	36.5	0.0	0.3	0.1	0.1	0.7	0.2	0.413
11	5	0.774	28.7	55.6	1.1	2.3	1.3	5.6	7.9	6.3	0.434
12	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
13	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
14	5	0.736	21.8	54.6	0.3	0.9	0.3	2.3	3.7	2.6	0.496
15	5	0.806	18.7	47.0	0.2	0.8	0.3	1.9	3.3	2.3	0.369
0	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
1	15	0.824	17.2	42.3	2.5	3.4	2.5	4.5	6.5	5.0	0.282
2	15	0.799	19.2	46.6	1.3	2.0	1.4	3.8	5.5	4.3	0.340
3	15	0.912	7.8	31.4	0.0	0.2	0.1	0.4	0.7	0.4	0.159
4	15	0.871	11.4	37.1	0.3	0.5	0.3	1.0	1.4	1.1	0.230
5	15	0.845	13.7	40.3	0.4	1.0	0.5	1.7	2.5	1.8	0.243
6	15	0.806	18.7	46.4	1.0	1.7	1.2	3.2	4.6	3.8	0.364
7	15	0.839	14.7	41.2	0.5	1.0	0.5	1.8	2.8	2.0	0.283
8	15	0.819	16.8	44.0	1.0	1.4	1.0	2.7	3.9	2.9	0.310
9	15	0.807	18.1	45.4	1.3	1.9	1.3	3.3	4.4	3.5	0.324
10	15	0.835	3.4	25.7	0.1	0.4	0.2	0.4	0.7	0.4	0.286
11	15	0.827	24.2	50.0	1.7	3.0	2.0	5.4	7.5	6.2	0.299
12	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
13	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
14	15	0.797	16.6	45.5	0.8	1.5	0.8	2.5	3.5	2.7	0.348
15	15	0.855	15.2	40.7	0.5	1.0	0.7	2.0	2.9	2.3	0.252
0	1 only	0.927	7.7	29.7	0.5	1.1	0.7	0.8	2.2	1.4	0.135
1	1 only	0.920	8.7	30.2	1.6	3.2	1.9	1.9	4.9	3.5	0.128
2	1 only	0.910	9.2	31.9	0.9	2.0	1.1	1.3	3.8	2.6	0.160
3	1 only	0.965	4.8	24.6	0.0	0.1	0.0	0.1	0.4	0.1	0.069
4	1 only	0.948	6.1	27.2	0.0	0.4	0.1	0.2	1.3	0.6	0.103
5	1 only	0.936	6.3	28.2	0.0	1.0	0.5	0.2	1.9	1.2	0.111
6	1 only	0.911	10.3	32.2	1.1	1.5	1.2	1.7	3.0	2.1	0.169
7	1 only	0.933	7.3	29.1	0.1	1.0	0.6	0.4	2.1	1.3	0.131
8	1 only	0.921	8.3	30.5	0.7	1.3	0.8	1.0	2.7	1.7	0.143
9	1 only	0.914	8.8	31.2	1.0	1.6	1.0	1.3	3.0	1.9	0.151
10	1 only	0.931	0.3	10.7	0.0	0.3	0.1	0.0	0.7	0.3	0.134
11	1 only	0.921	15.3	38.9	1.3	2.5	1.6	2.9	5.4	3.7	0.134
12	1 only	0.946	6.2	27.3	0.1	0.8	0.4	0.3	1.8	1.2	0.104
13	1 only	0.932	7.3	29.1	0.5	1.0	0.6	0.7	2.1	1.3	0.127
14	1 only	0.908	7.5	29.7	0.8	1.5	0.9	1.1	2.8	1.6	0.166
15	1 only	0.941	8.1	30.1	0.0	1.0	0.5	0.4	2.1	1.4	0.114

Table 4e. Risk summary for jack mackerel when the Tier 1 rate is selected based on a target reference point of $0.7B_0$ and a maximum risk (over all sensitivity tests) over the all years of the projection period of dropping below $0.3B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey Frequency	Final Depletion	$P(B<0.5B_0)$	$P(B<0.7B_0)$	$P(B<0.2B_0)$ Last 20	$P(B<0.2B_0)$ All years	$P(B<0.2B_0)$ Blocks	$P(B<0.3B_0)$ Last 20	$P(B<0.3B_0)$ All years	$P(B<0.3B_0)$ Blocks	Catch / MSY
0	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
1	5	0.772	20.8	49.8	1.4	2.7	1.5	4.1	5.9	4.7	0.416
2	5	0.740	24.2	54.9	0.6	1.5	0.7	3.3	5.8	4.0	0.485
3	5	0.878	9.6	35.7	0.0	0.1	0.0	0.3	0.6	0.3	0.241
4	5	0.825	14.2	43.4	0.0	0.3	0.1	0.9	1.8	1.0	0.339
5	5	0.794	17.4	47.5	0.2	0.7	0.2	1.5	3.0	1.8	0.352
6	5	0.746	23.8	54.2	0.4	1.1	0.6	3.2	5.2	3.6	0.522
7	5	0.786	18.5	48.7	0.2	0.8	0.2	1.7	3.1	2.0	0.410
8	5	0.764	21.0	51.6	0.4	1.0	0.4	2.4	4.0	2.9	0.447
9	5	0.752	22.5	53.3	0.5	1.2	0.5	2.9	4.9	3.3	0.467
10	5	0.779	4.7	36.5	0.0	0.3	0.1	0.1	0.7	0.2	0.413
11	5	0.774	28.7	55.6	1.1	2.3	1.3	5.6	7.9	6.3	0.434
12	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
13	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
14	5	0.736	21.8	54.6	0.3	0.9	0.3	2.3	3.7	2.6	0.496
15	5	0.806	18.7	47.0	0.2	0.8	0.3	1.9	3.3	2.3	0.369
0	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
1	15	0.824	17.2	42.3	2.5	3.4	2.5	4.5	6.5	5.0	0.282
2	15	0.799	19.2	46.6	1.3	2.0	1.4	3.8	5.5	4.3	0.340
3	15	0.912	7.8	31.4	0.0	0.2	0.1	0.4	0.7	0.4	0.159
4	15	0.871	11.4	37.1	0.3	0.5	0.3	1.0	1.4	1.1	0.230
5	15	0.845	13.7	40.3	0.4	1.0	0.5	1.7	2.5	1.8	0.243
6	15	0.806	18.7	46.4	1.0	1.7	1.2	3.2	4.6	3.8	0.364
7	15	0.839	14.7	41.2	0.5	1.0	0.5	1.8	2.8	2.0	0.283
8	15	0.819	16.8	44.0	1.0	1.4	1.0	2.7	3.9	2.9	0.310
9	15	0.807	18.1	45.4	1.3	1.9	1.3	3.3	4.4	3.5	0.324
10	15	0.835	3.4	25.7	0.1	0.4	0.2	0.4	0.7	0.4	0.286
11	15	0.827	24.2	50.0	1.7	3.0	2.0	5.4	7.5	6.2	0.299
12	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
13	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
14	15	0.797	16.6	45.5	0.8	1.5	0.8	2.5	3.5	2.7	0.348
15	15	0.855	15.2	40.7	0.5	1.0	0.7	2.0	2.9	2.3	0.252
0	1 only	0.927	7.7	29.7	0.5	1.1	0.7	0.8	2.2	1.4	0.135
1	1 only	0.920	8.7	30.2	1.6	3.2	1.9	1.9	4.9	3.5	0.128
2	1 only	0.910	9.2	31.9	0.9	2.0	1.1	1.3	3.8	2.6	0.160
3	1 only	0.965	4.8	24.6	0.0	0.1	0.0	0.1	0.4	0.1	0.069
4	1 only	0.948	6.1	27.2	0.0	0.4	0.1	0.2	1.3	0.6	0.103
5	1 only	0.936	6.3	28.2	0.0	1.0	0.5	0.2	1.9	1.2	0.111
6	1 only	0.911	10.3	32.2	1.1	1.5	1.2	1.7	3.0	2.1	0.169
7	1 only	0.933	7.3	29.1	0.1	1.0	0.6	0.4	2.1	1.3	0.131
8	1 only	0.921	8.3	30.5	0.7	1.3	0.8	1.0	2.7	1.7	0.143
9	1 only	0.914	8.8	31.2	1.0	1.6	1.0	1.3	3.0	1.9	0.151
10	1 only	0.931	0.3	10.7	0.0	0.3	0.1	0.0	0.7	0.3	0.134
11	1 only	0.921	15.3	38.9	1.3	2.5	1.6	2.9	5.4	3.7	0.134
12	1 only	0.946	6.2	27.3	0.1	0.8	0.4	0.3	1.8	1.2	0.104
13	1 only	0.932	7.3	29.1	0.5	1.0	0.6	0.7	2.1	1.3	0.127
14	1 only	0.908	7.5	29.7	0.8	1.5	0.9	1.1	2.8	1.6	0.166
15	1 only	0.941	8.1	30.1	0.0	1.0	0.5	0.4	2.1	1.4	0.114

Table 4f. Risk summary for jack mackerel when the Tier 1 rate is selected based on a target reference point of $0.7B_0$ and a maximum risk (over all sensitivity tests) over 20-year blocks of years over the projection period of dropping below $0.3B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey Frequency	Final Depletion	$P(B<0.5B_0)$	$P(B<0.7B_0)$	$P(B<0.2B_0)$			$P(B<0.3B_0)$			Catch / MSY
					Last 20	All years	Blocks	Last 20	All years	Blocks	
0	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
1	5	0.772	20.8	49.8	1.4	2.7	1.5	4.1	5.9	4.7	0.416
2	5	0.740	24.2	54.9	0.6	1.5	0.7	3.3	5.8	4.0	0.485
3	5	0.878	9.6	35.7	0.0	0.1	0.0	0.3	0.6	0.3	0.241
4	5	0.825	14.2	43.4	0.0	0.3	0.1	0.9	1.8	1.0	0.339
5	5	0.794	17.4	47.5	0.2	0.7	0.2	1.5	3.0	1.8	0.352
6	5	0.746	23.8	54.2	0.4	1.1	0.6	3.2	5.2	3.6	0.522
7	5	0.786	18.5	48.7	0.2	0.8	0.2	1.7	3.1	2.0	0.410
8	5	0.764	21.0	51.6	0.4	1.0	0.4	2.4	4.0	2.9	0.447
9	5	0.752	22.5	53.3	0.5	1.2	0.5	2.9	4.9	3.3	0.467
10	5	0.779	4.7	36.5	0.0	0.3	0.1	0.1	0.7	0.2	0.413
11	5	0.774	28.7	55.6	1.1	2.3	1.3	5.6	7.9	6.3	0.434
12	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
13	5	0.776	19.6	50.0	0.3	0.9	0.3	2.0	3.5	2.5	0.425
14	5	0.736	21.8	54.6	0.3	0.9	0.3	2.3	3.7	2.6	0.496
15	5	0.806	18.7	47.0	0.2	0.8	0.3	1.9	3.3	2.3	0.369
0	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
1	15	0.824	17.2	42.3	2.5	3.4	2.5	4.5	6.5	5.0	0.282
2	15	0.799	19.2	46.6	1.3	2.0	1.4	3.8	5.5	4.3	0.340
3	15	0.912	7.8	31.4	0.0	0.2	0.1	0.4	0.7	0.4	0.159
4	15	0.871	11.4	37.1	0.3	0.5	0.3	1.0	1.4	1.1	0.230
5	15	0.845	13.7	40.3	0.4	1.0	0.5	1.7	2.5	1.8	0.243
6	15	0.806	18.7	46.4	1.0	1.7	1.2	3.2	4.6	3.8	0.364
7	15	0.839	14.7	41.2	0.5	1.0	0.5	1.8	2.8	2.0	0.283
8	15	0.819	16.8	44.0	1.0	1.4	1.0	2.7	3.9	2.9	0.310
9	15	0.807	18.1	45.4	1.3	1.9	1.3	3.3	4.4	3.5	0.324
10	15	0.835	3.4	25.7	0.1	0.4	0.2	0.4	0.7	0.4	0.286
11	15	0.827	24.2	50.0	1.7	3.0	2.0	5.4	7.5	6.2	0.299
12	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
13	15	0.831	15.6	42.5	0.6	1.1	0.7	2.1	3.3	2.4	0.294
14	15	0.797	16.6	45.5	0.8	1.5	0.8	2.5	3.5	2.7	0.348
15	15	0.855	15.2	40.7	0.5	1.0	0.7	2.0	2.9	2.3	0.252
0	1 only	0.927	7.7	29.7	0.5	1.1	0.7	0.8	2.2	1.4	0.135
1	1 only	0.920	8.7	30.2	1.6	3.2	1.9	1.9	4.9	3.5	0.128
2	1 only	0.910	9.2	31.9	0.9	2.0	1.1	1.3	3.8	2.6	0.160
3	1 only	0.965	4.8	24.6	0.0	0.1	0.0	0.1	0.4	0.1	0.069
4	1 only	0.948	6.1	27.2	0.0	0.4	0.1	0.2	1.3	0.6	0.103
5	1 only	0.936	6.3	28.2	0.0	1.0	0.5	0.2	1.9	1.2	0.111
6	1 only	0.911	10.3	32.2	1.1	1.5	1.2	1.7	3.0	2.1	0.169
7	1 only	0.933	7.3	29.1	0.1	1.0	0.6	0.4	2.1	1.3	0.131
8	1 only	0.921	8.3	30.5	0.7	1.3	0.8	1.0	2.7	1.7	0.143
9	1 only	0.914	8.8	31.2	1.0	1.6	1.0	1.3	3.0	1.9	0.151
10	1 only	0.931	0.3	10.7	0.0	0.3	0.1	0.0	0.7	0.3	0.134
11	1 only	0.921	15.3	38.9	1.3	2.5	1.6	2.9	5.4	3.7	0.134
12	1 only	0.946	6.2	27.3	0.1	0.8	0.4	0.3	1.8	1.2	0.104
13	1 only	0.932	7.3	29.1	0.5	1.0	0.6	0.7	2.1	1.3	0.127
14	1 only	0.908	7.5	29.7	0.8	1.5	0.9	1.1	2.8	1.6	0.166
15	1 only	0.941	8.1	30.1	0.0	1.0	0.5	0.4	2.1	1.4	0.114

Table 5a. Risk summary for blue mackerel when the Tier 1 rate is selected based on a target reference point of 0.5B_0 and a maximum risk (over all sensitivity tests) over the last 20 years of the projection period of dropping below 0.2B_0 not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey	Final	P(B<0.5B_0)	P(B<0.7B_0)	P(B<0.2B_0)			P(B<0.3B_0)			Catch /
	Frequency	Depletion			Last 20	All years	Blocks	Last 20	All years	Blocks	MSY
0	5	0.726	21.7	52.1	1.4	4.0	1.4	4.1	8.3	4.1	0.553
1	5	0.723	23.4	51.3	3.5	6.6	3.5	7.1	10.2	7.1	0.529
2	5	0.681	27.9	58.4	2.6	7.2	2.7	6.8	11.8	6.8	0.618
3	5	0.853	7.6	33.2	0.1	0.4	0.1	0.3	1.0	0.5	0.328
4	5	0.787	13.9	43.4	0.4	2.0	0.6	1.5	3.6	1.5	0.453
5	5	0.754	17.4	47.7	0.9	3.4	1.0	2.8	6.8	2.8	0.475
6	5	0.673	30.3	59.8	2.6	5.4	2.6	7.4	10.0	7.4	0.670
7	5	0.756	17.6	48.2	0.3	1.1	0.3	2.1	5.1	2.1	0.514
8	5	0.682	27.4	58.0	3.2	6.6	3.3	6.9	10.3	6.9	0.607
9	5	0.691	26.5	56.9	2.8	6.5	2.9	6.4	10.0	6.4	0.589
10	5	0.732	11.0	46.0	0.5	3.0	0.6	1.4	4.1	1.5	0.546
11	5	0.698	42.9	62.2	9.5	12.6	9.5	19.1	21.8	19.1	0.572
12	5	0.726	21.7	52.1	1.4	3.7	1.4	4.1	7.6	4.1	0.553
13	5	0.726	21.7	52.1	1.4	4.3	1.4	4.1	8.6	4.1	0.553
14	5	0.676	26.4	59.0	2.0	5.5	2.2	5.5	9.3	5.5	0.636
15	5	0.764	18.7	47.5	0.9	3.2	1.0	3.2	6.9	3.2	0.483
0	10	0.770	17.4	45.0	2.1	4.0	2.5	3.9	8.3	4.6	0.457
1	10	0.766	19.5	44.5	4.4	6.8	4.8	6.9	10.2	7.2	0.429
2	10	0.727	23.2	51.0	3.7	7.3	4.5	6.7	11.8	7.6	0.516
3	10	0.883	5.9	29.0	0.1	0.4	0.2	0.3	1.0	0.5	0.261
4	10	0.827	11.1	37.1	0.7	2.0	0.9	1.6	3.6	1.9	0.368
5	10	0.796	14.0	41.1	1.4	3.4	1.5	2.6	6.8	3.2	0.392
6	10	0.720	24.7	52.5	3.9	6.8	4.5	7.2	11.3	7.7	0.553
7	10	0.800	14.1	41.3	0.4	1.1	0.5	2.0	5.1	2.1	0.424
8	10	0.721	23.3	50.7	5.1	8.0	6.0	7.7	12.5	8.7	0.491
9	10	0.730	22.3	49.8	4.5	7.2	5.2	7.1	10.9	7.8	0.478
10	10	0.778	8.1	36.4	1.0	3.0	1.4	1.8	4.1	2.3	0.454
11	10	0.736	38.7	58.4	10.0	13.7	10.0	18.0	23.3	18.0	0.462
12	10	0.770	17.4	45.0	2.1	3.7	2.3	3.9	7.6	4.2	0.457
13	10	0.770	17.4	45.1	2.1	4.3	2.5	3.9	8.6	4.7	0.457
14	10	0.723	21.3	51.0	3.2	5.6	3.9	5.5	9.5	6.3	0.529
15	10	0.805	15.4	41.3	1.4	3.2	1.5	3.0	6.9	3.4	0.396
0	1 only	0.914	5.4	24.2	1.3	4.0	2.3	1.5	8.3	3.8	0.166
1	1 only	0.902	7.5	25.1	3.6	6.8	4.6	3.7	10.2	6.2	0.150
2	1 only	0.889	7.7	27.3	2.6	7.3	4.5	2.9	11.8	6.6	0.196
3	1 only	0.963	2.1	18.5	0.0	0.3	0.1	0.0	1.0	0.4	0.086
4	1 only	0.938	3.7	21.1	0.8	2.0	1.0	0.8	3.6	1.5	0.126
5	1 only	0.931	3.3	21.6	0.1	3.4	1.3	0.2	6.8	2.4	0.142
6	1 only	0.873	10.5	30.1	4.6	6.7	4.6	4.8	10.0	6.4	0.196
7	1 only	0.932	3.9	22.5	0.0	1.1	0.4	0.2	5.1	1.6	0.154
8	1 only	0.875	9.0	27.9	4.8	6.6	4.8	4.9	10.3	6.2	0.174
9	1 only	0.881	8.5	27.3	4.2	6.5	4.2	4.3	10.0	5.7	0.169
10	1 only	0.918	1.5	11.8	1.0	3.0	1.5	1.0	4.1	2.0	0.166
11	1 only	0.865	25.9	45.3	7.5	12.6	8.8	11.3	19.5	13.9	0.156
12	1 only	0.922	4.8	23.2	1.2	3.7	2.0	1.3	7.6	3.3	0.152
13	1 only	0.911	5.6	24.6	1.4	4.3	2.5	1.6	8.6	3.9	0.170
14	1 only	0.881	7.2	25.9	3.4	5.6	3.7	3.5	9.3	5.4	0.194
15	1 only	0.933	4.9	24.0	0.4	3.2	1.4	0.5	6.9	2.7	0.141

Table 5b. Risk summary for blue mackerel when the Tier 1 rate is selected based on a target reference point of $0.5B_0$ and a maximum risk (over all sensitivity tests) over the all years of the projection period of dropping below $0.2B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey Frequency	Final Depletion	$P(B<0.5B_0)$	$P(B<0.7B_0)$	$P(B<0.2B_0)$ Last 20	$P(B<0.2B_0)$ All years	$P(B<0.2B_0)$ Blocks	$P(B<0.3B_0)$ Last 20	$P(B<0.3B_0)$ All years	$P(B<0.3B_0)$ Blocks	Catch / MSY
0	5	0.763	16.6	46.9	0.7	2.6	0.8	2.4	5.1	2.4	0.493
1	5	0.759	18.7	46.7	2.2	4.8	2.4	4.8	7.5	4.8	0.476
2	5	0.723	22.1	52.6	1.4	4.3	1.4	4.3	8.6	4.3	0.558
3	5	0.874	6.0	29.9	0.0	0.2	0.0	0.1	0.7	0.3	0.284
4	5	0.817	10.8	38.7	0.2	0.9	0.3	0.8	2.6	0.9	0.397
5	5	0.787	13.4	42.7	0.5	2.1	0.6	1.6	3.9	1.7	0.420
6	5	0.718	23.8	53.8	1.3	3.2	1.5	4.4	6.7	4.4	0.606
7	5	0.788	13.8	43.3	0.2	0.7	0.2	1.3	3.0	1.3	0.456
8	5	0.727	21.3	51.7	1.6	3.5	1.8	4.1	7.0	4.1	0.548
9	5	0.733	20.5	50.9	1.4	3.4	1.6	3.7	6.9	3.7	0.530
10	5	0.769	7.0	38.4	0.2	1.3	0.3	0.7	2.9	0.9	0.485
11	5	0.740	38.4	58.8	6.8	9.4	6.8	15.4	17.8	15.4	0.517
12	5	0.763	16.6	46.9	0.7	2.4	0.8	2.4	4.6	2.4	0.493
13	5	0.763	16.6	46.9	0.7	3.0	0.8	2.4	5.2	2.4	0.493
14	5	0.719	19.9	52.7	1.0	3.2	1.2	3.2	5.9	3.2	0.574
15	5	0.797	14.8	43.0	0.5	2.1	0.6	1.9	4.3	1.9	0.427
0	10	0.805	13.5	40.3	1.2	2.6	1.4	2.4	5.1	2.7	0.404
1	10	0.800	15.5	40.3	3.0	4.8	3.5	4.7	7.2	5.1	0.383
2	10	0.767	17.8	45.3	2.2	4.3	2.6	4.1	8.6	4.8	0.461
3	10	0.901	4.8	26.3	0.0	0.3	0.1	0.2	0.6	0.3	0.224
4	10	0.853	8.3	33.3	0.3	0.9	0.4	0.8	2.6	1.1	0.320
5	10	0.826	10.5	36.6	0.7	2.1	0.8	1.7	3.9	1.9	0.343
6	10	0.764	19.3	46.8	2.1	3.9	2.6	4.2	7.5	4.8	0.497
7	10	0.829	11.0	37.0	0.2	0.6	0.3	1.3	3.0	1.3	0.372
8	10	0.767	17.6	44.9	2.9	5.0	3.2	4.5	7.6	4.9	0.444
9	10	0.773	17.0	44.2	2.6	4.4	2.7	4.1	7.0	4.5	0.430
10	10	0.812	5.1	29.7	0.4	1.3	0.7	0.8	2.9	1.2	0.398
11	10	0.776	34.6	55.1	7.1	10.0	7.1	14.1	18.4	14.1	0.416
12	10	0.805	13.5	40.3	1.2	2.4	1.2	2.4	4.6	2.5	0.404
13	10	0.805	13.5	40.3	1.2	3.0	1.4	2.4	5.2	2.7	0.404
14	10	0.765	15.8	44.9	1.7	3.4	2.2	3.3	5.9	3.8	0.473
15	10	0.835	12.0	37.2	0.7	2.1	0.9	1.9	4.3	2.0	0.347
0	1 only	0.930	4.1	22.2	0.8	2.6	1.4	0.9	5.1	2.2	0.141
1	1 only	0.920	5.9	23.2	2.6	4.8	3.2	2.7	6.9	4.3	0.130
2	1 only	0.912	5.6	24.5	1.4	4.3	2.5	1.6	8.6	3.9	0.168
3	1 only	0.969	1.9	17.7	0.0	0.2	0.0	0.0	0.6	0.2	0.072
4	1 only	0.950	2.8	19.8	0.3	0.9	0.4	0.3	2.6	0.9	0.108
5	1 only	0.943	2.6	20.1	0.0	2.1	0.7	0.1	3.9	1.4	0.120
6	1 only	0.902	7.9	27.1	2.7	3.9	2.7	2.9	6.5	3.9	0.174
7	1 only	0.943	3.2	20.9	0.0	0.6	0.3	0.1	3.0	0.9	0.130
8	1 only	0.905	6.4	24.7	2.7	3.7	2.7	2.8	7.0	3.8	0.155
9	1 only	0.908	6.0	24.4	2.4	3.4	2.4	2.5	6.9	3.5	0.150
10	1 only	0.934	0.8	10.0	0.5	1.3	0.7	0.5	2.9	1.1	0.141
11	1 only	0.893	23.4	43.2	5.4	9.4	6.3	8.9	17.0	11.2	0.136
12	1 only	0.936	3.8	21.4	0.8	2.4	1.1	0.9	4.6	1.9	0.129
13	1 only	0.929	4.2	22.4	0.8	3.0	1.5	0.9	5.2	2.3	0.145
14	1 only	0.905	5.0	22.8	2.2	3.4	2.2	2.3	5.9	3.3	0.168
15	1 only	0.945	4.1	22.6	0.2	2.1	0.9	0.3	4.3	1.5	0.119

Table 5c. Risk summary for blue mackerel when the Tier 1 rate is selected based on a target reference point of $0.5B_0$ and a maximum risk (over all sensitivity tests) over 20-year blocks of years over the projection period of dropping below $0.2B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey Frequency	Final Depletion	$P(B<0.5B_0)$	$P(B<0.7B_0)$	$P(B<0.2B_0)$			$P(B<0.3B_0)$			Catch / MSY
					Last 20	All years	Blocks	Last 20	All years	Blocks	
0	5	0.726	21.7	52.0	1.4	3.9	1.4	4.0	8.3	4.0	0.553
1	5	0.723	23.4	51.3	3.5	6.6	3.5	7.0	10.2	7.0	0.529
2	5	0.681	27.9	58.4	2.6	7.2	2.7	6.8	11.8	6.8	0.618
3	5	0.853	7.6	33.2	0.1	0.4	0.1	0.3	1.0	0.5	0.328
4	5	0.787	13.9	43.4	0.4	2.0	0.6	1.5	3.6	1.5	0.452
5	5	0.754	17.3	47.7	0.9	3.4	1.0	2.8	6.8	2.8	0.474
6	5	0.673	30.3	59.7	2.6	5.4	2.6	7.3	10.0	7.3	0.669
7	5	0.756	17.6	48.1	0.3	1.1	0.3	2.1	5.1	2.1	0.514
8	5	0.683	27.4	57.9	3.2	6.6	3.3	6.9	10.3	6.9	0.607
9	5	0.691	26.4	56.9	2.8	6.5	2.9	6.4	10.0	6.4	0.589
10	5	0.733	11.0	46.0	0.5	3.0	0.6	1.4	4.1	1.5	0.546
11	5	0.698	42.8	62.2	9.5	12.6	9.5	19.1	21.8	19.1	0.572
12	5	0.726	21.7	52.0	1.4	3.7	1.4	4.0	7.6	4.0	0.553
13	5	0.726	21.7	52.0	1.4	4.3	1.4	4.0	8.6	4.0	0.553
14	5	0.676	26.4	59.0	2.0	5.4	2.2	5.5	9.3	5.5	0.635
15	5	0.764	18.7	47.5	0.9	3.2	1.0	3.2	6.9	3.2	0.483
0	10	0.770	17.4	45.0	2.1	3.9	2.4	3.9	8.3	4.5	0.457
1	10	0.766	19.5	44.5	4.4	6.8	4.8	6.9	10.2	7.2	0.429
2	10	0.727	23.2	51.0	3.6	7.3	4.5	6.7	11.8	7.6	0.516
3	10	0.884	5.9	29.0	0.1	0.4	0.2	0.3	1.0	0.5	0.260
4	10	0.827	11.1	37.1	0.7	2.0	0.9	1.6	3.6	1.9	0.368
5	10	0.796	14.0	41.0	1.4	3.4	1.5	2.6	6.8	3.2	0.392
6	10	0.720	24.6	52.5	3.9	6.8	4.5	7.2	11.2	7.6	0.553
7	10	0.800	14.1	41.3	0.4	1.1	0.5	2.0	5.1	2.1	0.424
8	10	0.721	23.3	50.7	5.1	8.0	5.9	7.7	12.5	8.7	0.490
9	10	0.730	22.3	49.8	4.5	7.2	5.2	7.1	10.9	7.8	0.478
10	10	0.778	8.1	36.4	1.0	3.0	1.4	1.8	4.1	2.3	0.453
11	10	0.736	38.7	58.4	10.0	13.7	10.0	17.9	23.3	18.0	0.461
12	10	0.770	17.4	45.0	2.1	3.7	2.2	3.9	7.6	4.2	0.457
13	10	0.770	17.4	45.0	2.1	4.3	2.5	3.9	8.6	4.7	0.457
14	10	0.723	21.2	51.0	3.2	5.6	3.9	5.5	9.5	6.3	0.529
15	10	0.805	15.4	41.3	1.4	3.2	1.5	2.9	6.9	3.4	0.396
0	1 only	0.914	5.4	24.2	1.3	3.9	2.3	1.5	8.3	3.8	0.166
1	1 only	0.902	7.4	25.1	3.6	6.8	4.5	3.7	10.2	6.2	0.150
2	1 only	0.889	7.7	27.3	2.6	7.3	4.5	2.9	11.8	6.6	0.195
3	1 only	0.963	2.1	18.5	0.0	0.3	0.1	0.0	1.0	0.4	0.086
4	1 only	0.938	3.7	21.1	0.8	2.0	1.0	0.8	3.6	1.5	0.126
5	1 only	0.931	3.3	21.6	0.1	3.4	1.3	0.2	6.8	2.4	0.142
6	1 only	0.873	10.5	30.1	4.6	6.6	4.6	4.8	10.0	6.4	0.196
7	1 only	0.932	3.9	22.4	0.0	1.1	0.4	0.2	5.1	1.6	0.154
8	1 only	0.875	9.0	27.9	4.7	6.6	4.7	4.8	10.3	6.2	0.174
9	1 only	0.881	8.4	27.3	4.2	6.5	4.2	4.3	10.0	5.6	0.169
10	1 only	0.919	1.4	11.8	1.0	3.0	1.5	1.0	4.1	2.0	0.165
11	1 only	0.865	25.9	45.3	7.5	12.6	8.8	11.3	19.5	13.9	0.155
12	1 only	0.922	4.8	23.2	1.2	3.7	2.0	1.3	7.6	3.2	0.152
13	1 only	0.912	5.6	24.6	1.4	4.3	2.5	1.6	8.6	3.9	0.170
14	1 only	0.881	7.2	25.9	3.4	5.6	3.7	3.5	9.3	5.4	0.194
15	1 only	0.933	4.9	24.0	0.4	3.2	1.4	0.5	6.9	2.7	0.141

Table 5d. Risk summary for blue mackerel when the Tier 1 rate is selected based on a target reference point of $0.7B_0$ and a maximum risk (over all sensitivity tests) over the last 20 years of the projection period of dropping below $0.3B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey	Final	$P(B<0.5B_0)$	$P(B<0.7B_0)$	$P(B<0.2B_0)$			$P(B<0.3B_0)$			Catch /
	Frequency	Depletion			Last 20	All years	Blocks	Last 20	All years	Blocks	MSY
0	5	0.822	10.4	38.0	0.2	0.8	0.3	0.7	2.2	0.8	0.388
1	5	0.817	12.3	38.3	1.0	3.1	1.1	2.2	3.8	2.3	0.381
2	5	0.790	13.6	42.9	0.4	1.9	0.5	1.4	3.4	1.5	0.447
3	5	0.907	4.0	25.3	0.0	0.0	0.0	0.1	0.2	0.1	0.214
4	5	0.863	6.8	31.6	0.0	0.4	0.1	0.2	0.8	0.3	0.306
5	5	0.839	8.1	34.6	0.1	0.6	0.2	0.5	1.7	0.6	0.327
6	5	0.789	14.7	44.1	0.3	1.2	0.5	1.4	3.1	1.5	0.487
7	5	0.840	8.7	35.2	0.0	0.4	0.1	0.4	1.6	0.5	0.356
8	5	0.795	12.9	41.9	0.4	1.2	0.5	1.2	2.8	1.4	0.438
9	5	0.799	12.6	41.4	0.3	1.1	0.5	1.1	2.7	1.2	0.421
10	5	0.826	2.7	26.8	0.0	0.4	0.1	0.1	0.7	0.2	0.380
11	5	0.805	31.3	53.1	3.5	5.4	3.5	10.0	12.6	10.0	0.416
12	5	0.822	10.4	38.0	0.2	0.6	0.2	0.7	2.1	0.8	0.388
13	5	0.822	10.4	38.0	0.2	0.8	0.3	0.7	2.2	0.8	0.388
14	5	0.787	11.4	41.9	0.2	0.8	0.3	0.8	2.5	1.0	0.459
15	5	0.848	9.7	35.8	0.2	0.6	0.2	0.7	2.0	0.7	0.332
0	10	0.857	7.9	32.7	0.3	0.8	0.4	0.7	2.2	1.0	0.312
1	10	0.852	9.6	33.3	1.4	3.1	1.8	2.4	3.8	2.7	0.302
2	10	0.829	10.8	36.7	0.6	1.9	0.9	1.5	3.4	1.8	0.363
3	10	0.928	3.2	22.6	0.0	0.1	0.0	0.0	0.2	0.1	0.167
4	10	0.892	5.4	27.6	0.1	0.4	0.2	0.2	0.8	0.4	0.242
5	10	0.872	6.4	29.8	0.2	0.6	0.2	0.5	1.7	0.7	0.262
6	10	0.830	11.9	38.0	0.4	1.3	0.8	1.4	2.9	1.7	0.393
7	10	0.873	6.7	30.5	0.1	0.4	0.1	0.4	1.6	0.6	0.285
8	10	0.833	10.2	35.9	0.7	1.3	0.9	1.5	2.8	1.7	0.353
9	10	0.837	9.9	35.5	0.6	1.2	0.8	1.4	2.6	1.5	0.340
10	10	0.861	1.8	20.5	0.1	0.4	0.2	0.2	0.7	0.3	0.306
11	10	0.838	28.3	49.8	3.5	5.4	3.5	9.0	12.6	9.0	0.331
12	10	0.857	7.9	32.7	0.3	0.7	0.3	0.7	2.1	0.9	0.312
13	10	0.857	7.9	32.7	0.3	0.8	0.4	0.7	2.2	1.0	0.312
14	10	0.828	8.8	35.3	0.3	1.0	0.6	0.9	2.5	1.3	0.373
15	10	0.879	7.8	31.2	0.2	0.6	0.3	0.6	2.0	0.8	0.265
0	1 only	0.952	2.8	19.7	0.3	0.8	0.4	0.3	2.2	0.8	0.105
1	1 only	0.946	3.7	20.1	1.2	3.1	1.7	1.3	3.8	2.2	0.098
2	1 only	0.939	3.6	20.9	0.7	1.9	0.9	0.8	3.4	1.4	0.125
3	1 only	0.977	1.6	16.6	0.0	0.0	0.0	0.0	0.2	0.1	0.053
4	1 only	0.966	2.0	18.1	0.0	0.3	0.1	0.0	0.8	0.3	0.079
5	1 only	0.959	1.8	18.0	0.0	0.6	0.1	0.0	1.7	0.5	0.087
6	1 only	0.940	4.7	23.1	0.6	1.3	0.8	0.7	2.9	1.5	0.134
7	1 only	0.959	2.3	18.9	0.0	0.3	0.1	0.0	1.6	0.4	0.095
8	1 only	0.939	3.6	20.8	0.9	1.2	0.9	1.0	2.8	1.3	0.119
9	1 only	0.943	3.3	20.6	0.6	1.1	0.7	0.7	2.6	1.2	0.115
10	1 only	0.955	0.1	7.5	0.0	0.2	0.1	0.0	0.6	0.2	0.103
11	1 only	0.931	19.9	40.4	2.7	5.4	3.3	5.6	11.3	7.4	0.105
12	1 only	0.956	2.6	19.1	0.3	0.6	0.3	0.3	2.1	0.7	0.095
13	1 only	0.951	2.8	19.7	0.3	0.8	0.4	0.3	2.2	0.8	0.107
14	1 only	0.940	2.4	18.7	0.4	1.0	0.5	0.4	2.5	1.1	0.129
15	1 only	0.961	3.1	20.6	0.0	0.5	0.2	0.0	2.0	0.6	0.087

Table 5e. Risk summary for blue mackerel when the Tier 1 rate is selected based on a target reference point of $0.7B_0$ and a maximum risk (over all sensitivity tests) over the all years of the projection period of dropping below $0.3B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey Frequency	Final Depletion	P(B<0.5B_0)	P(B<0.7B_0)	P(B<0.2B_0) Last 20	P(B<0.2B_0) All years	P(B<0.2B_0) Blocks	P(B<0.3B_0) Last 20	P(B<0.3B_0) All years	P(B<0.3B_0) Blocks	Catch / MSY
0	5	0.849	7.9	33.8	0.1	0.4	0.1	0.3	1.1	0.5	0.336
1	5	0.844	9.6	34.4	0.6	2.0	0.7	1.4	3.0	1.5	0.332
2	5	0.821	10.4	38.1	0.2	0.8	0.3	0.7	2.2	0.8	0.389
3	5	0.921	3.3	23.2	0.0	0.0	0.0	0.0	0.2	0.1	0.182
4	5	0.884	5.3	28.3	0.0	0.2	0.0	0.1	0.6	0.2	0.262
5	5	0.863	6.2	30.9	0.1	0.4	0.1	0.2	0.9	0.4	0.282
6	5	0.821	11.5	39.3	0.1	0.5	0.2	0.7	1.8	0.9	0.424
7	5	0.864	6.7	31.4	0.0	0.3	0.1	0.2	0.8	0.3	0.307
8	5	0.826	9.8	37.3	0.2	0.5	0.2	0.6	2.1	0.8	0.381
9	5	0.829	9.6	36.9	0.1	0.5	0.2	0.6	2.0	0.7	0.366
10	5	0.852	1.6	21.5	0.0	0.3	0.0	0.0	0.4	0.1	0.328
11	5	0.835	28.3	50.4	2.3	4.0	2.3	8.1	10.0	8.1	0.362
12	5	0.849	7.9	33.8	0.1	0.4	0.1	0.3	1.0	0.5	0.336
13	5	0.849	7.9	33.8	0.1	0.4	0.1	0.3	1.2	0.5	0.336
14	5	0.819	8.4	36.8	0.1	0.5	0.1	0.3	1.3	0.6	0.400
15	5	0.871	7.7	32.2	0.1	0.4	0.1	0.4	1.1	0.5	0.286
0	10	0.880	6.1	29.4	0.1	0.4	0.2	0.4	1.1	0.6	0.267
1	10	0.876	7.5	29.8	0.8	2.0	1.0	1.5	3.0	1.9	0.262
2	10	0.857	8.0	32.8	0.3	0.8	0.4	0.7	2.2	1.0	0.313
3	10	0.939	2.6	21.0	0.0	0.0	0.0	0.0	0.2	0.1	0.141
4	10	0.910	4.2	25.0	0.0	0.2	0.0	0.1	0.5	0.3	0.206
5	10	0.892	4.8	26.8	0.1	0.4	0.1	0.3	0.8	0.4	0.224
6	10	0.858	9.1	34.2	0.2	0.7	0.3	0.7	1.8	0.9	0.339
7	10	0.893	5.4	27.5	0.0	0.2	0.1	0.2	0.8	0.3	0.243
8	10	0.860	7.6	32.2	0.3	0.9	0.4	0.7	2.1	0.8	0.304
9	10	0.863	7.5	31.9	0.3	0.7	0.4	0.6	2.0	0.8	0.292
10	10	0.883	1.0	16.8	0.1	0.4	0.1	0.1	0.4	0.2	0.261
11	10	0.865	25.4	47.5	2.4	4.0	2.4	7.2	9.4	7.2	0.287
12	10	0.880	6.1	29.4	0.1	0.4	0.2	0.4	1.0	0.5	0.267
13	10	0.880	6.1	29.4	0.1	0.4	0.2	0.4	1.2	0.6	0.267
14	10	0.855	6.3	31.1	0.2	0.6	0.3	0.4	1.3	0.6	0.321
15	10	0.898	6.3	28.6	0.1	0.4	0.1	0.3	1.0	0.5	0.226
0	1 only	0.962	2.2	18.6	0.0	0.3	0.2	0.0	1.1	0.4	0.088
1	1 only	0.956	3.1	19.0	0.7	2.0	1.1	0.8	3.0	1.6	0.084
2	1 only	0.952	2.8	19.7	0.3	0.8	0.4	0.3	2.2	0.8	0.105
3	1 only	0.981	1.5	16.1	0.0	0.0	0.0	0.0	0.1	0.0	0.044
4	1 only	0.971	1.8	17.3	0.0	0.1	0.0	0.0	0.4	0.1	0.066
5	1 only	0.966	1.6	17.1	0.0	0.3	0.1	0.0	0.8	0.2	0.073
6	1 only	0.951	3.8	21.6	0.3	0.5	0.3	0.4	1.8	0.8	0.114
7	1 only	0.966	2.0	18.1	0.0	0.2	0.0	0.0	0.8	0.3	0.079
8	1 only	0.953	2.7	19.4	0.3	0.6	0.3	0.3	2.1	0.7	0.102
9	1 only	0.954	2.6	19.3	0.2	0.5	0.3	0.2	2.0	0.6	0.098
10	1 only	0.963	0.1	6.6	0.0	0.1	0.0	0.0	0.2	0.1	0.086
11	1 only	0.948	18.3	39.2	1.5	4.0	2.2	4.1	9.4	6.0	0.092
12	1 only	0.965	2.0	18.2	0.0	0.3	0.1	0.0	1.0	0.4	0.080
13	1 only	0.961	2.2	18.7	0.0	0.3	0.2	0.0	1.2	0.4	0.090
14	1 only	0.951	1.8	17.3	0.2	0.3	0.2	0.2	1.3	0.5	0.108
15	1 only	0.968	2.7	19.7	0.0	0.3	0.1	0.0	1.0	0.3	0.073

Table 5f. Risk summary for blue mackerel when the Tier 1 rate is selected based on a target reference point of $0.7B_0$ and a maximum risk (over all sensitivity tests) over 20-year blocks of years over the projection period of dropping below $0.3B_0$ not exceeding 0.1. The case that drives the selection of the harvest rate is highlighted in block-italic-underline font.

Case	Survey	Final	P(B<0.5B_0)	P(B<0.7B_0)	P(B<0.2B_0)			P(B<0.3B_0)			Catch /
	Frequency	Depletion			Last 20	All years	Blocks	Last 20	All years	Blocks	MSY
0	5	0.822	10.4	38.0	0.2	0.8	0.3	0.7	2.2	0.8	0.388
1	5	0.817	12.3	38.3	1.0	3.1	1.1	2.2	3.8	2.3	0.381
2	5	0.790	13.6	42.9	0.4	1.9	0.5	1.4	3.4	1.5	0.447
3	5	0.907	4.0	25.3	0.0	0.0	0.0	0.1	0.2	0.1	0.214
4	5	0.863	6.8	31.6	0.0	0.4	0.1	0.2	0.8	0.3	0.306
5	5	0.839	8.1	34.6	0.1	0.6	0.2	0.5	1.7	0.6	0.327
6	5	0.789	14.7	44.1	0.3	1.2	0.5	1.4	3.1	1.5	0.487
7	5	0.840	8.7	35.2	0.0	0.4	0.1	0.4	1.6	0.5	0.356
8	5	0.795	12.9	41.9	0.4	1.2	0.5	1.2	2.8	1.4	0.438
9	5	0.799	12.6	41.4	0.3	1.1	0.5	1.1	2.7	1.2	0.421
10	5	0.826	2.7	26.8	0.0	0.4	0.1	0.1	0.7	0.2	0.380
11	5	0.805	31.3	53.1	3.5	5.4	3.5	10.0	12.6	10.0	0.416
12	5	0.822	10.4	38.0	0.2	0.6	0.2	0.7	2.1	0.8	0.388
13	5	0.822	10.4	38.0	0.2	0.8	0.3	0.7	2.2	0.8	0.388
14	5	0.787	11.4	41.9	0.2	0.8	0.3	0.8	2.5	1.0	0.459
15	5	0.848	9.7	35.8	0.2	0.6	0.2	0.7	2.0	0.7	0.332
0	10	0.857	7.9	32.7	0.3	0.8	0.4	0.7	2.2	1.0	0.312
1	10	0.852	9.6	33.3	1.4	3.1	1.8	2.4	3.8	2.7	0.302
2	10	0.829	10.8	36.7	0.6	1.9	0.9	1.5	3.4	1.8	0.363
3	10	0.928	3.2	22.6	0.0	0.1	0.0	0.0	0.2	0.1	0.167
4	10	0.892	5.4	27.6	0.1	0.4	0.2	0.2	0.8	0.4	0.242
5	10	0.872	6.4	29.8	0.2	0.6	0.2	0.5	1.7	0.7	0.262
6	10	0.830	11.9	38.0	0.4	1.3	0.8	1.4	2.9	1.7	0.393
7	10	0.873	6.7	30.5	0.1	0.4	0.1	0.4	1.6	0.6	0.285
8	10	0.833	10.2	35.9	0.7	1.3	0.9	1.5	2.8	1.7	0.353
9	10	0.837	9.9	35.5	0.6	1.2	0.8	1.4	2.6	1.5	0.340
10	10	0.861	1.8	20.5	0.1	0.4	0.2	0.2	0.7	0.3	0.306
11	10	0.838	28.3	49.8	3.5	5.4	3.5	9.0	12.6	9.0	0.331
12	10	0.857	7.9	32.7	0.3	0.7	0.3	0.7	2.1	0.9	0.312
13	10	0.857	7.9	32.7	0.3	0.8	0.4	0.7	2.2	1.0	0.312
14	10	0.828	8.8	35.3	0.3	1.0	0.6	0.9	2.5	1.3	0.373
15	10	0.879	7.8	31.2	0.2	0.6	0.3	0.6	2.0	0.8	0.265
0	1 only	0.952	2.8	19.7	0.3	0.8	0.4	0.3	2.2	0.8	0.105
1	1 only	0.946	3.7	20.1	1.2	3.1	1.7	1.3	3.8	2.2	0.098
2	1 only	0.939	3.6	20.9	0.7	1.9	0.9	0.8	3.4	1.4	0.125
3	1 only	0.977	1.6	16.6	0.0	0.0	0.0	0.0	0.2	0.1	0.053
4	1 only	0.966	2.0	18.1	0.0	0.3	0.1	0.0	0.8	0.3	0.079
5	1 only	0.959	1.8	18.0	0.0	0.6	0.1	0.0	1.7	0.5	0.087
6	1 only	0.940	4.7	23.1	0.6	1.3	0.8	0.7	2.9	1.5	0.134
7	1 only	0.959	2.3	18.9	0.0	0.3	0.1	0.0	1.6	0.4	0.095
8	1 only	0.939	3.6	20.8	0.9	1.2	0.9	1.0	2.8	1.3	0.119
9	1 only	0.943	3.3	20.6	0.6	1.1	0.7	0.7	2.6	1.2	0.115
10	1 only	0.955	0.1	7.5	0.0	0.2	0.1	0.0	0.6	0.2	0.103
11	1 only	0.931	19.9	40.4	2.7	5.4	3.3	5.6	11.3	7.4	0.105
12	1 only	0.956	2.6	19.1	0.3	0.6	0.3	0.3	2.1	0.7	0.095
13	1 only	0.951	2.8	19.7	0.3	0.8	0.4	0.3	2.2	0.8	0.107
14	1 only	0.940	2.4	18.7	0.4	1.0	0.5	0.4	2.5	1.1	0.129
15	1 only	0.961	3.1	20.6	0.0	0.5	0.2	0.0	2.0	0.6	0.087

Table 6. Risk summary for blue mackerel in the absence of exploitation. The final depletion is 1 because this statistic is based on the expected biomass. The shading indicates the case that drives risk in this case.

Case	Survey	Final	$P(B<0.5B_0)$	$P(B<0.7B_0)$	$P(B<0.2B_0)$			$P(B<0.3B_0)$			Catch /
	Frequency	Depletion			Last 20	All years	Blocks	Last 20	All years	Blocks	MSY
0	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.3	3.1	0
1	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.3	3.1	0
2	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.3	3.1	0
3	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.3	3.1	0
4	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.3	3.1	0
5	5	1.000	13.0	32.8	0.1	0.7	0.4	1.3	3.2	2.0	0
6	5	1.000	18.8	37.7	0.9	2.5	1.5	4.1	8.2	5.6	0
7	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.3	3.1	0
8	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.1	3.1	0
9	5	1.000	15.1	34.8	0.3	1.2	0.7	2.1	5.1	3.1	0
10	5	1.000	3.3	20.0	0.0	0.1	0.0	0.1	0.5	0.2	0
11	5	1.000	38.5	51.6	10.7	15.8	11.9	20.2	26.5	21.5	0
12	5	1.000	15.1	34.8	0.3	3.2	1.1	2.1	12.5	4.3	0
13	5	1.000	15.1	34.8	0.3	0.9	0.6	2.1	4.4	2.9	0
14	5	1.000	13.4	33.4	0.1	0.8	0.5	1.5	3.7	2.3	0
15	5	1.000	16.4	35.7	0.4	1.9	0.8	2.7	6.3	3.8	0

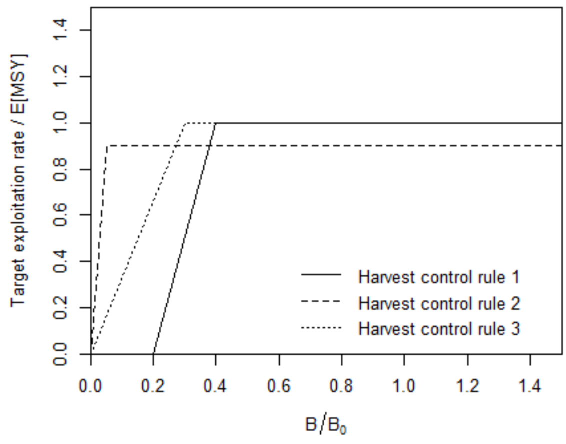

Figure 1. Three examples of "threshold" harvest control rules. Each of these harvest control rules will achieve a different trade-off between average catch, risk and catch variation.

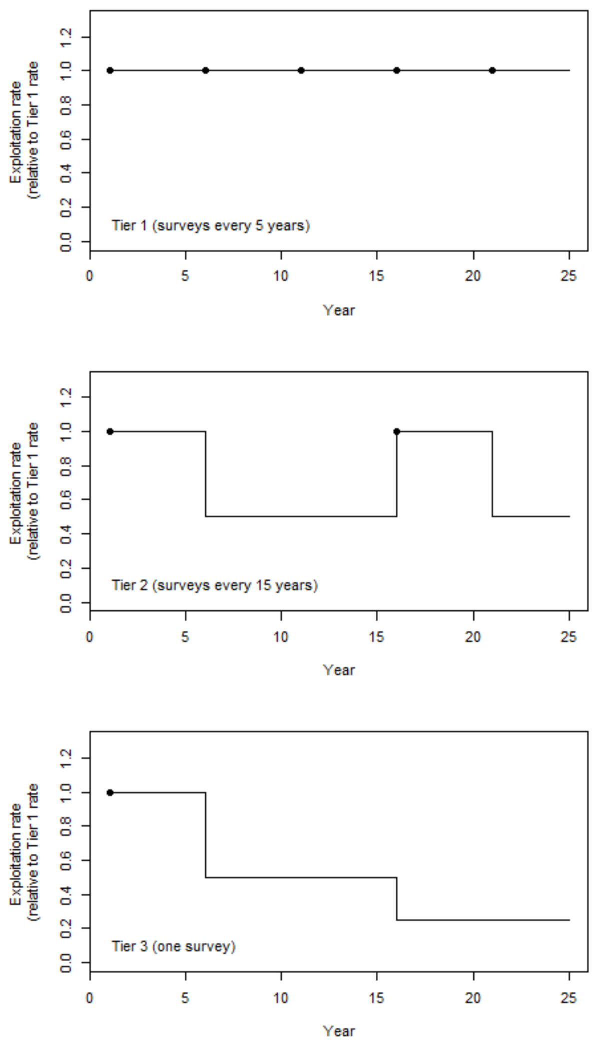

Figure 2. Examples of the Tier 1, Tier 2 and Tier 3 variants of the harvest control rule, illustrated for eastern jack mackerel. The dots indicate that a survey has taken place and the lines indicate the resulting exploitation for computing the RBC.

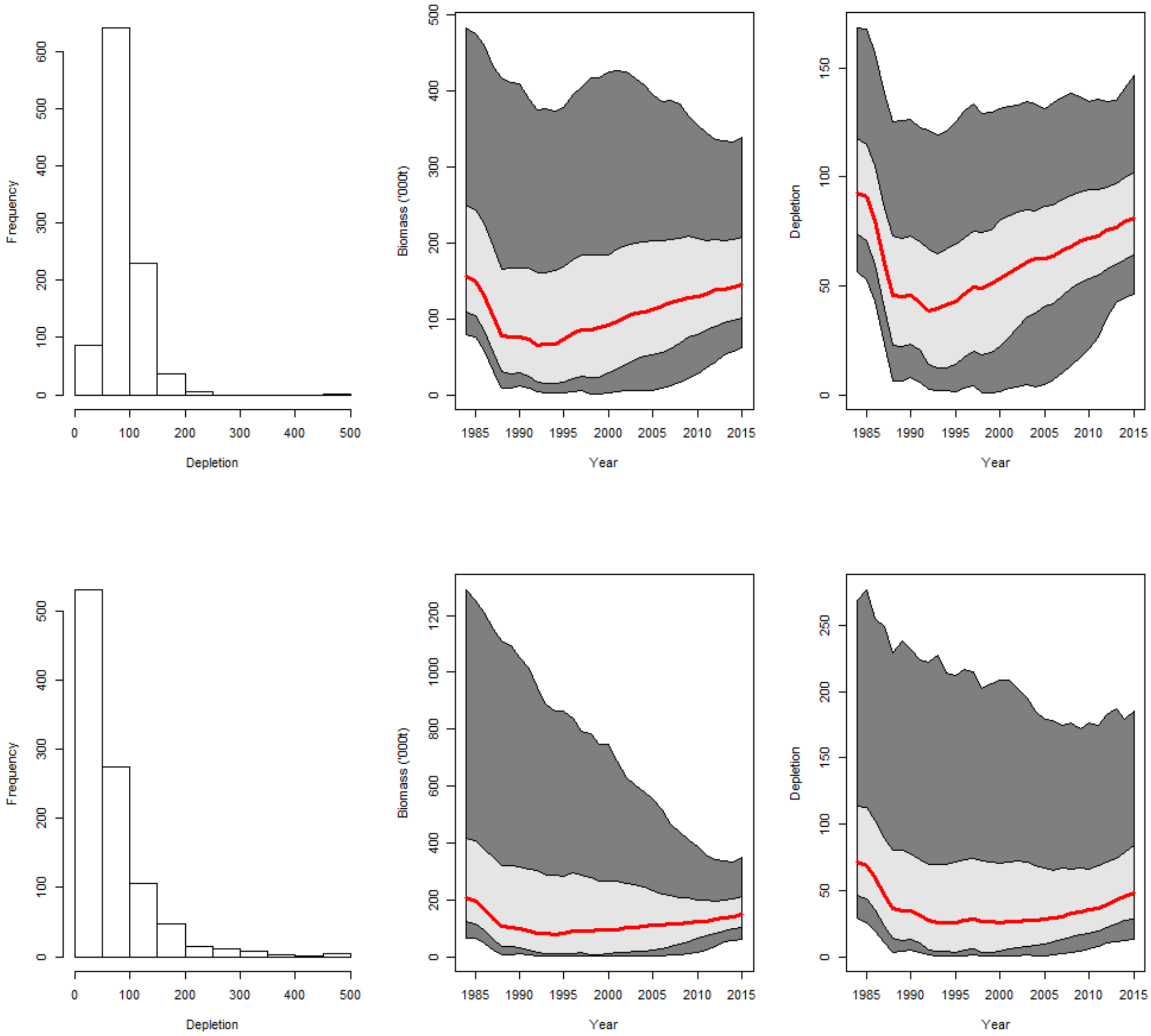

Figure 3. Distribution for 2015 depletion of eastern jack mackerel (expressed as a percentage) and the time-series for spawning stock biomass and depletion when steepness = 0.75 and σ_R = 0.6 based on SSRA. Results are shown for ρ=0 in the upper panels, and for ρ=0.9 in the lower panels. The red line denotes the median of the distribution.