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Potential Target Reference Points for South Pacific Albacore Fisheries

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POTENTIAL TARGET REFERENCE POINTS FOR SOUTH PACIFIC ALBACORE FISHERIES

HSW-WP-05

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SPC-OFP[1]

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Overview:

In conjunction with limit reference points (LRPs) and harvest control rules (HCRs), Target Reference Points (TRPs) form a critical part of a management strategy (**Figure 1**). While limit reference points are places we want to stay away from, targets are defined by management objectives and represent places we want to be. Both biological and, in particular, economic objectives for south Pacific albacore fishery have been proposed in previous WCPFC MOW meetings, and work has been presented on this to recent WCPFC Scientific Committee meetings and Management Objective Workshops. Following the recommendation of SC11 (para 36 of the Executive Summary), this paper updates those previous analyses using the 2015 assessment of south Pacific albacore to estimate and evaluate the performance of candidate target reference points to achieve both biological and economic management objectives.

In identifying economic targets, the performance measure for the southern longline albacore fishery used is the Net Present Value (NPV) of economic profits earned by the fleet over a 20 year projection period, before payments for access fees. NPV is calculated taking into account the value of both the target albacore catch and that of associated non-target species. We calculate potential target reference points consistent with either i) maximizing the NPV of economic profits (MEY), ii) achieving economic profits that equate to a 10% revenue margin over economic costs, or iii) levels where revenue equals the economic costs ('break-even'), and compare these to both current and future stock status if fishing continues at recent levels. These represent the average – individual fleets may have worse or better outcomes.

The paper therefore aims to identify southern longline fishery conditions that:

1. Result from no changes to current conditions (status quo);

and that <u>on average</u> achieve alternative fishery objectives, namely:

2. the 'default' TRP of Maximum Sustainable Yield (MSY);
3. maximisation of the economic benefits for the fleet (Maximum Economic Yield, MEY);
4. economic returns that just allow vessels to remain within the fishery; and
5. provide profitability within the southern longline fleet.

Approach:

All analyses were developed using the 2015 assessment for south Pacific albacore (Harley et al., 2015).

Status quo and risk relative to the LRP

The stock and fishery consequences of continued fishing at 2013 levels and key economic reference point levels were examined through 20 year stochastic projections, based upon WCPFC SC10 recommendations for capturing existing and future uncertainty, using a subset of the runs selected by SC11 and projecting future status accounting for variability in future recruitment. We examine median adult biomass and consequences for longline catch and catch rates. See methods in the Annex for more details.

Economic analysis

We evaluate economic outcomes by calculating the Net Present Value (NPV) of economic profits earned by the fleet over the 20 year projection period, before payments for access fees. The NPV is calculated taking into account the economic costs of fishing at a given level, and the value of the multispecies catch obtained at that level. An advantage of this approach is that it does not require assumptions of equilibrium conditions and can be readily estimated using the existing capabilities of MULTIFAN-CL projections. It does, however, require a range of economic data, some of which are not currently available for all fisheries.

The analysis seeks to estimate the level of effort associated with levels of economic yield, defined as the net present value of the economic profit earned above the minimum required to continue undertaking the fishing activity[2] (resource rent) over a specified time horizon (here 20 years to reflect the lifetime of a typical business loan and to ensure the stock had reached equilibrium with the projected exploitation level by the end of the period). It examines the conditions that maximise economic benefits for the fleet (i.e. MEY, here the maximum NPV of economic profits) as well as other 'candidate profit level' targets that might be more consistent with balancing economic, social and biological management objectives than MEY.

[2] The amount left over when all costs of a fishing activity have been deducted from revenues, taking into account a 'normal' return to capital and risk and entrepreneurship.

The general steps taken in this analysis were to:

i. deterministically project a 20 year time series of south Pacific albacore catch resulting from longline fishing in the southern WCP-CA at different future effort levels, and estimate associated bycatch levels;
ii. overlay price information to obtain a time series of revenue from the predicted catch and the economic cost associated with the fishing effort level for nine price/cost combinations;
iii. calculate economic profits (resource rent) across the time series, discount future rents at 5% per annum, and sum across the discounted time series to get the NPV; and
iv. predict the levels of effort that over the 20 year period: i) maximize NPV (MEY); ii) provide an average 10% revenue margin over economic costs; and iii) equate to the 'break-even' point for the fishery, i.e. where economic profits are zero.

Note this analysis focuses on the NPV of economic profits earned by the harvest sector. Costs incurred therefore cover the costs incurred in the operation of the vessel (vessel operating costs, other cash costs and capital costs), and the opportunity cost of capital. Fish prices are ex-vessel prices to key markets, and represent 'real term' 2014 US$ prices. As the study examines economic profits generated in the harvest sector of the fishery only, other wider economic benefits to national economics from the fishery, such as employment, on-shore processing, government taxes received, etc., are not considered. See annex for more information.

Analysis:

The results for the medium price scenario are summarized in Table 1, as this reflects the real-term price of caught species on key markets. The cost/hook of $1.10 is considered representative of average costs for most fleets operating within the southern longline fishery. However there is considerable uncertainty and fleet-specific variability around this value. Therefore the results for the lower and higher cost scenarios are also presented to identify the sensitivity of results to this uncertainty.

The 2015 assessment results indicate that the south Pacific albacore stock in 2013 is estimated to be on average at 0.41 $SB_{F=0}$.

What happens if recent effort levels continue?

Under 2013 effort levels the stock is estimated to fall from average levels of 0.41 $SB_{F=0}$ in 2013 to 0.32 $SB_{F=0}$ in 2033. In turn, under status quo conditions longline CPUE is estimated to fall by 14% from 2013 levels. Stochastic projections suggest that the risk of the stock falling below the agreed limit reference point (LRP; 20% $SB_{F=0}$) by 2033 is 20% (1 in 5 chance). Although acceptable levels of risk of falling below the LRP have not yet been agreed by WCPFC, this level is the highest level of LRP risk being considered. To maintain the stock at 2013 levels, effort needs to be reduced by approximately 35%.

Continuing at current fishing levels also implies the majority of fleets will not be profitable in the future. Those fleets operating at the cheapest cost per hook examined ($0.90 per hook) will only break even at that effort level (revenue equals economic costs).

What happens if we use the 'default' TRP of Maximum Sustainable Yield?

Achieving MSY catch levels implies fishery conditions worse than that resulting under the status quo. Within the 2015 assessment, SB_{MSY} is estimated to be below the LRP (reference case assessment SB_{MSY} = 0.14$SB_{F=0}$). The use of MSY as a long-term target for south Pacific albacore is incompatible with a low risk of falling below the agreed limit reference point. CPUE is estimated to fall by nearly 65%.

What about maximising economic conditions for the vessels?

Achieving maximum economic yield (MEY) requires considerable reductions in effort to be achieved, down to 25% of 2013 levels or less (25% of 2013 effort was the lowest effort scalar level examined within the analysis). Resulting spawning biomass levels were at 59% of $SB_{F=0}$, catch rates were predicted to be 49% higher than 2013 levels, and catches 41% of 2013 levels. Equivalent percentage profits (percentage revenue

margin over economic costs) ranged from 28-55%, dependent upon the cost per hook (Table 2). The significant management actions required to achieve MEY levels may reduce the desirability of this target.

What conditions will on average provide sufficient returns for vessels to remain within the fishery?

Ensuring fleets break-even on average generally required fishing effort levels lower than those in 2013 (reductions of up to 39%, unless the lowest cost per hook was assumed where break-even was at 2013 effort levels). Corresponding catches were 62-72% of 2013 levels. There was a risk of the stock falling below the LRP at some candidate break-even targets. Of particular note, under medium price and cost assumptions ($0.77SB_{F=0}$), that risk was 4% (1 in 25 chance), and a 20% risk occurred where the cost was $0.90 per hook (a 1 in 5 chance).

Results suggest recent economic returns from the south Pacific albacore fishery are below the break-even point for many fleets. On average, fleets with costs per hook above $0.90 could begin to leave the fishery at recent effort levels as they will not earn a sufficient return to justify long term participation in the fishery.

What conditions bring profitability?

Achieving a candidate average 'reasonable return' of 10% revenue margin over economic costs requires reductions from 2013 fishing effort levels of between 12% and 47%, dependent on fishing costs. Corresponding spawning biomass was $0.34\text{-}0.45SB_{F=0}$, and catches were 59-70% of 2013 levels. There was a 9% risk of falling below the LRP where cost/hook was $0.90 (approximately a 1 in 10 chance), but no risk at other cost levels.

How much profitability is desired?

Above we examined specific levels of fleet profitability (break-even and 10% revenue margin over economic costs). However, alternative profit levels can be defined by managers and the stock conditions required to achieve them identified. Table 2 presents for different candidate south Pacific albacore stock sizes (i.e. candidate Target Reference Point levels) presented in Table 1, corresponding average percentage profit levels for fleets with the three cost per hook levels examined. As an example, if costs per hook were $1.10 (our best estimate of the operating costs of southern longline fleets) and an average profitability of 15% were desired, the equivalent stock size target would be 42% $SB_{F=0}$, and a 39% reduction in effort (scalar=0.61) relative to 2013 levels would be needed to achieve it.

Discussion points

In this analysis we identify candidate target reference point levels consistent with stated economic objectives for the south Pacific longline fishery. We note that to maintain the stock at 2013 levels, and potentially gain some profitability within fleets, a reduction in effort by approximately a third of 2013 levels is required. Noting that future profitability depends upon future recruitment levels to the stock, further reductions may be required to ensure profitability, of up to an additional 15% for example. The results raise the following discussion points:

- Continuing to fish at recent levels will lead to both stock size and fishery CPUE falling, and a 20% chance of the stock falling below the limit reference point (LRP). Is this acceptable?
- Is it enough to ensure a low risk of breaching the LRP? This 'minimum' TRP (~37% $SB_{F=0}$) would imply a slight decline in CPUE from recent levels, a stock size 4% lower than recent levels – its lowest level ever, and zero profit.
- If fleet profitability is desired, what profit levels are preferred?
- Do the corresponding changes in fishing effort/catch to achieve those levels affect your decision?

Tables and Figures:

Table 1. Average stock and fishery status under alternative candidate Target Reference Point levels from deterministic projections (risk assessed through stochastic projections). Economic reference points presented for the 'medium' price structure[3].

	LL effort scalar (2013)	Median $SB_{2033}/SB_{F=0}$	Median F_{2033}/F_{MSY}	Median SB_{2033}/SB_{MSY}	Median longline VB_{2033}/VB_{2013}	Median albacore catch ($Catch_{2033}/Catch_{2013}$)	Risk SB_{2033} < LRP
Status quo (2013)	1	0.32	0.44	2.59	0.86	0.72	20%
MEY							
costs $0.9-1.3 per hook	0.25	0.59	0.18	4.20	1.49	0.41	0%
10% revenue margin over costs							
cost $0.9 per hook	0.88	0.34	0.40	2.76	0.92	0.70	9%
cost $1.1 per hook	0.67	0.40	0.33	3.12	1.05	0.64	0%
cost $1.3 per hook	0.53	0.45	0.29	3.41	1.17	0.59	0%
Break-even							
cost $0.9 per hook	1	0.32	0.44	2.59	0.86	0.72	20%
cost $1.1 per hook	0.77	0.37	0.37	2.94	0.99	0.67	4%
cost $1.3 per hook	0.61	0.42	0.31	3.24	1.10	0.62	0%

[3] Annex **Tables A3-5** provide details of conditions under candidate targets for the full range of cost and price scenarios. **Table A6** summarises, for a given fishery effort levels the cost per hook that would on average be required to achieve: a 10% revenue margin over costs, and break-even (opportunity cost achieved). MEY is not evaluated, as economics are maximised where costs are 'zero'.

Table 2. Percentage profit levels at particular candidate stock levels (from Table 1), for the three cost-per-hook levels examined. '-' represents an on average loss (revenue less than economic costs); '0' represents the break-even level (revenue equal to economic costs). Medium fish price scenario assumed. Shading added for visualisation only.

Median $SB_{2033}/SB_{F=0}$	LL effort scalar	Cost per hook ($/hook)		
		0.90	1.10	1.30
0.32	1	0%	-	-
0.34	0.88	10%	-	-
0.37	0.77	22%	0%	-
0.40	0.67	30%	10%	-
0.42	0.61	35%	15%	0%
0.45	0.53	41%	20%	10%
0.59	0.25	55%	39%	28%

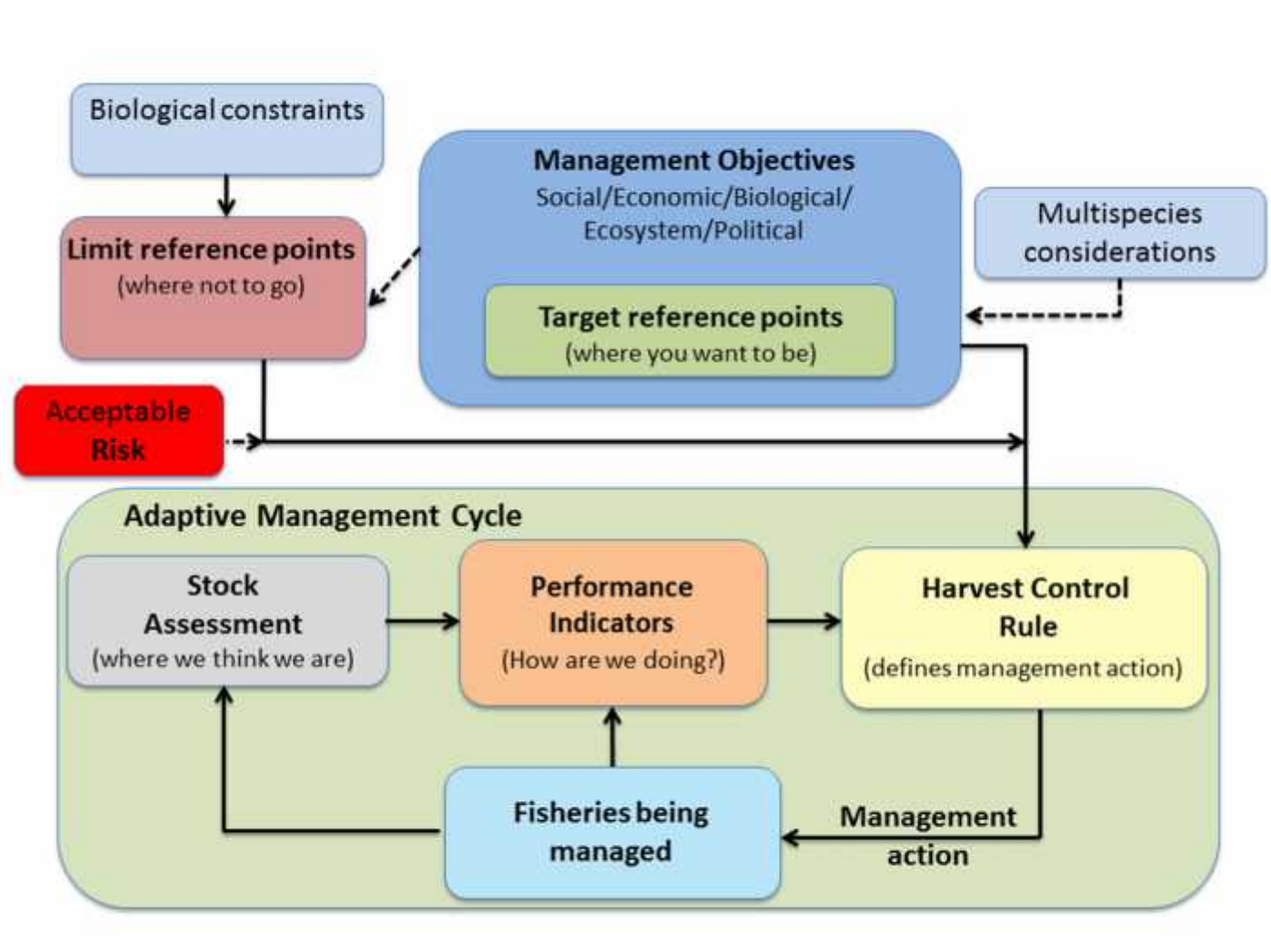

Figure 1. The Management Framework

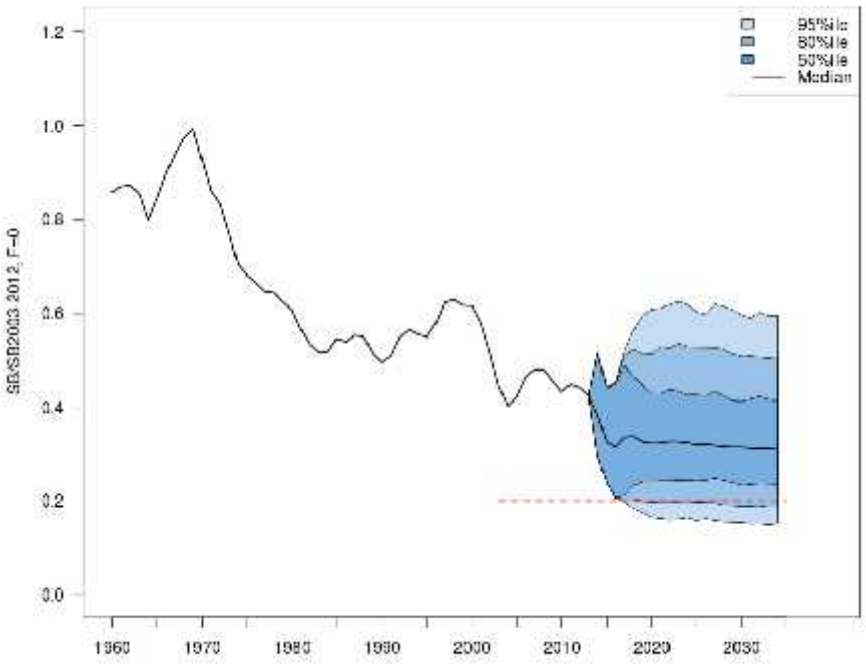

Figure 2. Stochastic projections of adult stock status under 2013 longline and troll effort levels. The limit reference point (20% $SB_{F=0}$) is indicated by horizontal dashed red line. Note: uncertainty from 1960 up to 2013 inclusive represents structural uncertainty only (median across the 9 assessment model runs presented for that period); uncertainty after 2013 represents both structural uncertainty and stochastic recruitment (1800 simulation runs).

Annex: Methods and further results (please contact Graham Pilling grahamp@spc.int) for further details)

Status quo analysis

To examine the consequences of status quo fishing levels and LRP risk under candidate TRPs, the stochastic projection approach described more fully in WCPFC-SC10-2014/MI-WP-01 was used, and is summarised here. Stochastic projections were performed for south Pacific albacore, incorporating SC9's recommendations on capturing uncertainty (WCPFC SC9, 2013). The main assumptions made within the projections were:

- Nine alternative assessment runs from the 2015 south Pacific albacore stock assessment uncertainty grid (Harley et al., 2015) were used to capture uncertainty in 'current' stock status and biological characteristics. These runs were a subset of the runs specified by SC11 for reporting stock assessment advice, and covered alternative stock recruitment relationship steepness assumptions and assumed values of the natural mortality rate (see Table below);
- Variability in future recruitment was modelled around the stock-recruitment relationship; Berger et al., 2013), with future deviates from the stock-recruitment relationship sampled from those calculated for the whole of the historical assessment time period, minus the final year where recruits were fixed within the assessment;
- Catchability (which can have a trend in the historical component of the model) was assumed to remain constant in the projection period at the level estimated in the terminal year of the assessment model;
- Projections were run for twenty years from 2013;
- Scalars for future fishing levels were applied on the level of effort within the longline fishery (rather than catch);
- Levels of activity in the troll fishery were kept constant at 2013 levels;
- Two hundred projections were performed for each assessment run under a given effort scalar.

When examining results, those from each of the nine models were weighted as in the table below, consistent with the approach taken at SC10; the run SC considered most biologically plausible was given the most weight, and results from runs considered less biologically plausible were 'down-weighted'.

Table A1. Nine stock assessment model runs from the 2015 assessment selected to capture uncertainty in current conditions and knowledge of south Pacific albacore biology, and weighting values assigned to each run for analysis of results.

Run #	Settings	Weighting
500	M = 0.30, Steepness 0.80 (ref case)	1
504	M = 0.25, Steepness 0.80	0.8
508	M = 0.40, Steepness 0.80	0.8
512	M = 0.30, Steepness 0.65	0.8
513	M = 0.30, Steepness 0.95	0.8
520	M = 0.25, Steepness 0.65	0.64
521	M = 0.25, Steepness 0.95	0.64
528	M = 0.40, Steepness 0.65	0.64
529	M = 0.40, Steepness 0.95	0.64

The unfished biomass level ($SB_{F=0}$, calculated as the average of the spawning biomass over the period 2003-12 that would have occurred in the absence of fishing) was calculated within each of the nine assessment model runs to ensure consistency with the underlying biological assumptions. The agreed Limit Reference Point was 20% of that unfished level.

Economic analysis

Deterministic projections to the year 2033 (time horizon of 20 years from 2013 conditions) were used to estimate alternative future south Pacific albacore catch levels under a range of longline effort scalars using the 2015 south Pacific albacore assessment. These projections were run from the nine different models defined by SC11 as best representing uncertainty in our knowledge of albacore biology and current conditions, and results weighted as described above. Catch of yellowfin, bigeye, billfish, sharks and a combined 'other species' category was then calculated according to the estimated albacore catch and a fleet- and species-specific scaling factor. Oceanic whitetip and silky sharks were excluded from the catch data to mimic the future impact of recent non-retention CMMs. Troll fleet effort levels remained at 2013 levels.

Cost per hook estimates were based on an 'average' cost of putting a hook in the southern waters of the WCPFC-CA for a 'typical' longline vessel (USD 1.10 per hook). Sensitivity analyses were conducted with a cost structure of ±USD 0.20 per hook. The lower range is generally consistent with other cost estimates of a heavily fuel-subsidized fleet. The cost of putting a hook in the water is assumed to be constant throughout the projection period.

Three price structures were used (low, medium, and high prices) to capture recent market fluctuations. The 'medium' price reflects recent ex-vessel prices at key regional markets, while the low and high levels were calculated +/-20% from that level. Revenues were based on an average price received for an average metric ton of fish caught by species category. Market prices are assumed to be constant (in real terms) throughout the projection period, invariant to the landing location and total catch, and do not take into account any size-based market differences. While there are short-term fluctuations in response to changes in supply and demand, the long term trend in real prices for albacore imports into Thailand since 1997 has been flat (see SC11-MI-WP-03), despite the upward trend in catch levels over the period. The use of a price reflective of the long-term trend price is not unreasonable, as the analysis is focused on long-term outcomes within a 20 year projection period. The lower and higher price structures were designed to examine uncertainties arising from these assumptions.

Three different discount rates were examined (3%, 5%, 7%). While the value chosen affected the absolute NPVs estimated, they did not substantially affect the effort levels required to achieve candidate target levels, nor the stock status at those levels (being the focus of the paper). Therefore results are only presented for the 5% discount rate assumption.

Table A2. List of price and cost scenario options used to calculate net present value. Nine scenarios were examined, covering each combination of the three scenarios for price and cost/hook.

Parameter	Species	High	Medium	Low
Price/mt (US$)	ALB	3000	2500	2000
	YFT	6360	5300	4240
	BET	10800	9000	7200
	Billfish	5400	4500	3600
	Sharks	1860	1550	1240
	Other[1]	2957	2464	1971
Cost/hook (US$)		1.30	1.10	0.90

[1] Other finfish

The predicted catch and value composition by species in the final year of the projection (2033) for the 8 longline fleets modelled within the 2015 stock assessment is presented within the Annex (**Figure A1**). On average, predicted catches of albacore composed approximately 50% of all longline catches by weight across fleets but only 40% of the total value. In contrast, yellowfin and bigeye composed a higher proportion of the value (22% each) compared to total landed catch in weight (17% and 11%, respectively). While albacore are generally the target species, the catches of other species, especially yellowfin, are critical to the economic performance of all southern longline fleets.

Estimates of NPV changed considerably with the level of longline fishing effort applied for each of the nine alternative economic scenarios examined (**Figure A2**). Note that the current analysis has 2013 as a baseline year – a year within higher effort than the 2010 baseline used in previous analyses. Estimated MEY continues to occur at extremely low effort levels, generally at or below 25% of the 2013 effort (**Table A3**). Seven of the nine price/cost scenarios examined suggested that the fishery was below the break-even point (no long-term resource rent available) when fished at 2013 effort levels, indicating that there would be insufficient returns to justify new vessels entering the fishery under current fish prices ('medium prices') and all examined cost structures. Currently the south Pacific albacore fishery is operating well below the MEY level (determined using the NPV approach) and economic returns are below the break-even point for many fleets.

The low effort levels required to achieve MEY at current price levels implies low catches, around 40% of the 2013 level. However, we can still attain greatly improved economic performance without rebuilding all the way to the MEY level. Conditions required to achieve a 10% profit within the fishery imply albacore catches between 51% and 74% of 2013 catches, dependent on the cost and price structure (**Table A4**). The biomass which supported a 10% profit was much higher than that which supported the MSY catch (1.4 to 2.8 times higher) and the increased biomass levels were generally associated with increased catch rates, except where costs were low and prices higher, where a 10% profit could be made despite lower catch rates than those in 2013. The effort level to achieve both MEY and 10% profit levels are considerably lower than the MSY or 2013 effort levels, and biomass needs to be maintained to achieve those economic returns.

Vessels with lower overall operational costs (such as subsidized vessels) can make a profit at much lower catch rates. Considering the medium price structure for the catch, vessels with lower costs have a break-even point at around 2013 effort levels, whereas those vessels with average (USD 1.1) operational costs require a 23% reduction in effort from 2013 levels to break-even (**Table A5**). Those vessels with lower operating costs have more 'flexibility' before they reach their break-even point.

Detailed table of results for different candidate economic target levels under alternative price and cost structures, and further economic observations

Table A3. Population and fishery performance indicators are shown for the level of fishing effort that **maximizes the net present value (NPV)** according to alternative catch price structures (see Table A1 in Annex) and cost per hook (USD) estimates over the projection time horizon (20 years) using an annual discount rate of 5%. Values refer to estimates in the final year (2033) for the longline fishery. Forgone value is the difference between the net resource rents available when fishing at 2013 effort levels and at the level that maximizes NPV. Shading added for visualisation only.

Relative price structure	Cost/hook	Scalar at Max NPV (rel. 2013 effort)	Forgone value (million USD)	Median albacore catch (Catch MEY/Catch 2013)	Median albacore catch MEY/MSY %	SB_{MEY}/SB_{MSY} (ratio)	Change ALB CPUE (MEY) (ratio to 2013)	Median $SB_{MEY}/SB_{F=0}$	Median F_{MEY}/F_{MSY}
LOW	1.3	0.25	4,351	0.41	1.67	4.20	1.49	0.59	0.18
	1.1	0.25	3,465	0.41	1.67	4.20	1.49	0.59	0.18
	0.9	0.25	2,579	0.41	1.67	4.20	1.49	0.59	0.18
MEDIUM	1.3	0.25	3,999	0.41	1.67	4.20	1.49	0.59	0.18
	1.1	0.25	3,113	0.41	1.67	4.20	1.49	0.59	0.18
	0.9	0.25	2,227	0.41	1.67	4.20	1.49	0.59	0.18
HIGH	1.3	0.25	3,647	0.41	1.67	4.20	1.49	0.59	0.18
	1.1	0.25	2,761	0.41	1.67	4.20	1.49	0.59	0.18
	0.9	0.25	1,874	0.41	1.67	4.20	1.49	0.59	0.18

Table A4. Population and fishery performance indicators are shown for the level of fishing effort that achieves **a 10% revenue margin over economic costs** according to alternative catch price structures (see Table A1 in Annex) and cost per hook (USD) estimates over the projection time horizon (20 years) using an annual discount rate of 5%. Values refer to estimates in the final year (2033) for the longline fishery. Forgone value is the difference between the net resource rents available when fishing at 2013 effort levels and at the level that achieves a 10% revenue over economic costs. Shading added for visualisation only.

Relative price structure	Cost/hook	Scalar at 10% profit (rel. 2013 effort)	Forgone value (million USD)	Median albacore catch (10% profit/ 2013)	Median albacore catch 10% profit/MSY %	Biomass $SB_{10\%profit}/SB_{MSY}$ (ratio)	Change ALB CPUE (10% profit, ratio to 2013)	Median $SB_{10\%profit}/SB_{F=0}$	Median $F_{10\%profit}/F_{MSY}$
LOW	1.3	0.39	273	0.51	2.02	3.76	1.31	0.51	0.24
	1.1	0.49	318	0.57	2.19	3.51	1.20	0.47	0.27
	0.9	0.65	347	0.64	2.40	3.16	1.07	0.41	0.33
MEDIUM	1.3	0.53	411	0.59	2.25	3.41	1.17	0.45	0.29
	1.1	0.67	441	0.64	2.42	3.12	1.05	0.40	0.33
	0.9	0.88	481	0.70	2.60	2.76	0.92	0.34	0.40
HIGH	1.3	0.69	502	0.65	2.45	3.08	1.04	0.40	0.34
	1.1	0.86	567	0.69	2.59	2.79	0.93	0.35	0.40
	0.9	1.12	611	0.74	2.72	2.43	0.80	0.29	0.48

Table A5. Population and fishery performance indicators are shown for the level of fishing effort equivalent to the estimated **break-even point** according to alternative catch price structures (see Table A1 in Annex) and cost per hook (USD) estimates over the projection time horizon (20 years) using an annual discount rate of 5%. Values refer to estimates in the final year (2033) for the longline fishery.

Relative price structure	Cost/hook (US$)	Scalar at break-even (rel. 2010 effort)	Median albacore catch (Catch break-even/Catch 2013)	Median albacore catch break-even/MSY %	Biomass $SB_{break\text{-}even}/SB_{MSY}$ (ratio)	Change ALB CPUE (break-even) (ratio to 2013)	Median $SB_{break\text{-}even}/SB_{F=0}$	Median $F_{break\text{-}even}/F_{MSY}$
LOW	1.3	0.44	0.54	2.11	3.63	1.25	0.49	0.25
	1.1	0.56	0.60	2.29	3.35	1.14	0.44	0.30
	0.9	0.74	0.66	2.49	2.99	1.01	0.38	0.36
MEDIUM	1.3	0.61	0.62	2.36	3.24	1.10	0.42	0.31
	1.1	0.77	0.67	2.52	2.94	0.99	0.37	0.37
	0.9	1	0.72	2.67	2.59	0.86	0.32	0.44
HIGH	1.3	0.78	0.68	2.53	2.92	0.98	0.37	0.37
	1.1	0.98	0.72	2.66	2.62	0.87	0.32	0.43
	0.9	1.27	0.76	2.77	2.26	0.74	0.27	0.52

Table A6. Cost per hook required to achieve 'break-even' (10% opportunity cost) or 10% revenue over economic costs for a given level of effort relative to 2013 effort levels. Shading added for visualisation only.

Effort scalar relative to 2013	Cost/hook required to achieve	
	10% revenue over costs	'Break-even' (opportunity cost achieved)
0.50	2.03	2.23
0.55	1.90	2.08
0.60	1.78	1.95
0.65	1.68	1.85
0.70	1.58	1.75
0.75	1.50	1.65
0.80	1.43	1.58
0.85	1.38	1.50
0.90	1.30	1.45
0.95	1.25	1.38
1.00	1.20	1.33
1.05	1.15	1.28
1.10	1.13	1.23
1.15	1.08	1.18
1.20	1.05	1.15
1.25	1.00	1.10
1.30	0.98	1.08
1.35	0.95	1.05
1.40	0.93	1.03
1.45	0.90	0.98
1.50	0.88	0.95

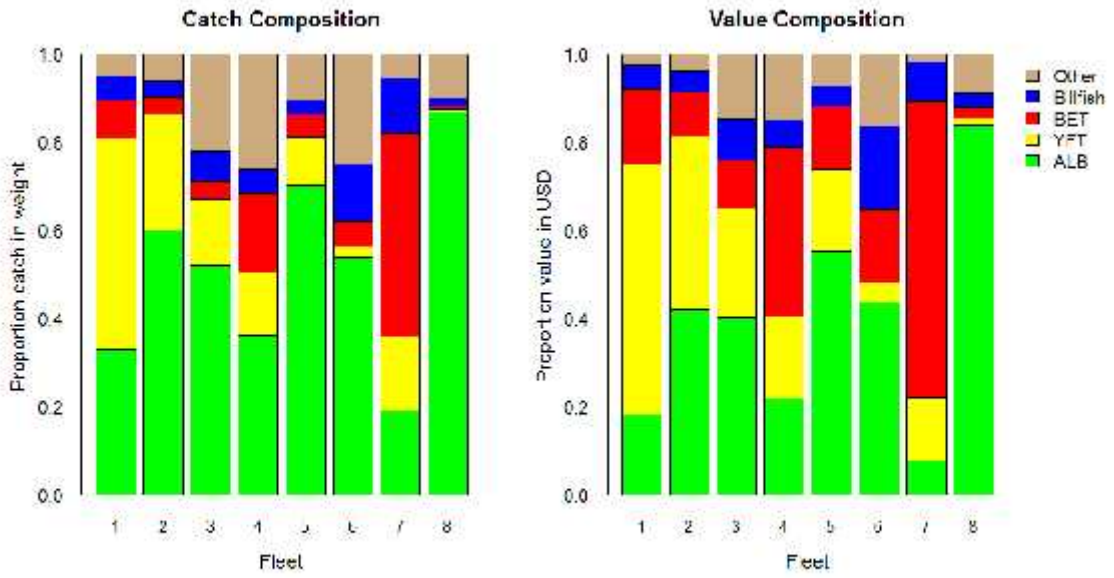

Figure A1. Predicted catch (left) and value (right; 'medium' price structure) composition by fleet and species category.

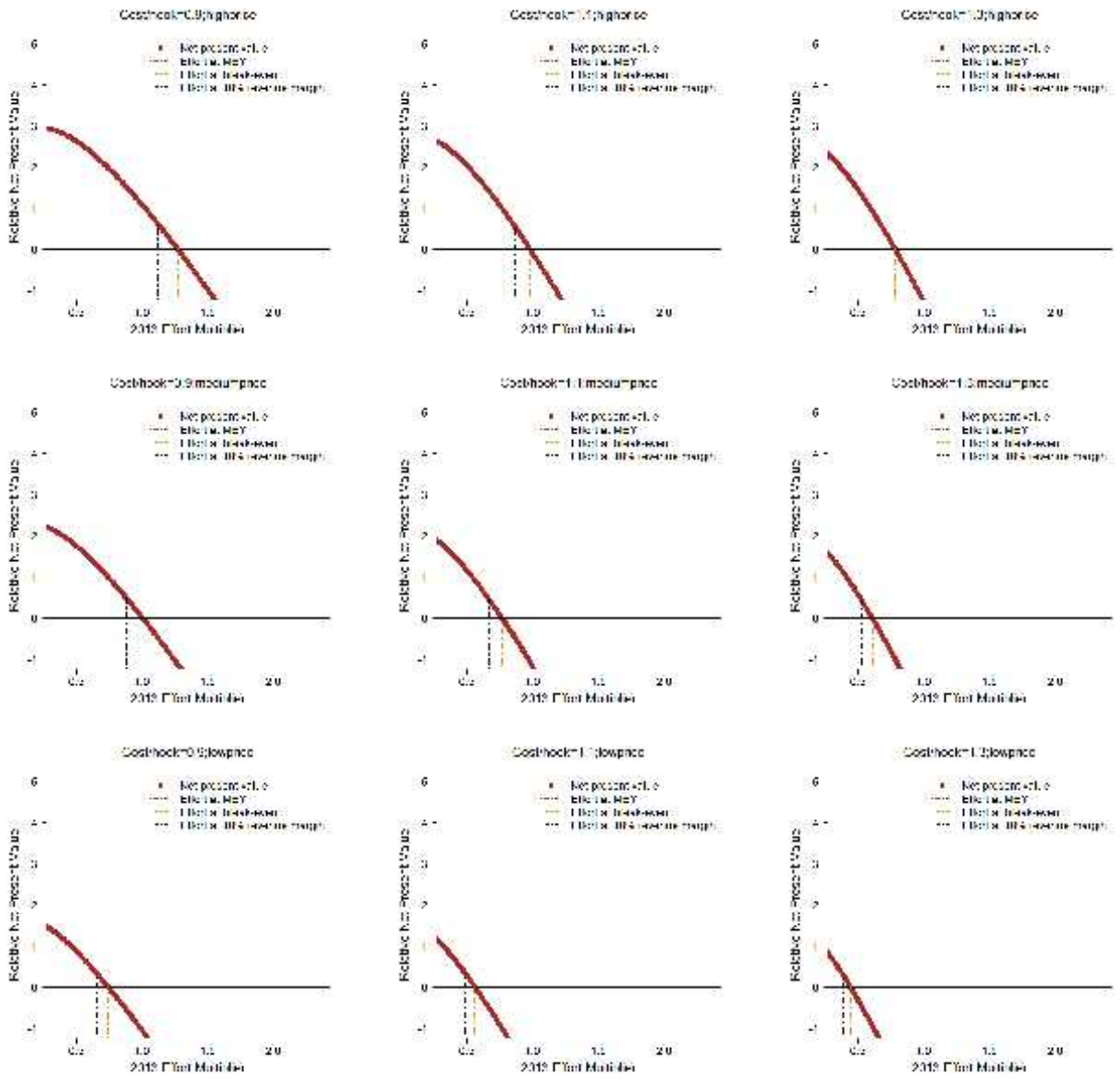

Figure A2. Estimates of net present value (NPV) are shown for the southern longline fishery (in the WCPFC convention area) for different cost per hook (USD) and price structure assumptions using a discount rate of 5%. Effort multipliers are relative to 2013 levels.