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Compatibility and consequences of alternative potential Target Reference Points for the south Pacific albacore stock

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Compatibility and consequences of alternative potential Target Reference Points for the south Pacific albacore stock

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 represent places we want to be and are defined by management objectives. Both biological and economic objectives for the south Pacific albacore fishery have been proposed in previous WCPFC MOW meetings. The key question we address in this paper is: "are candidate target reference points capable of meeting both biological and economic management objectives?"

A range of work has been undertaken that may help managers identify candidate TRP levels for south Pacific albacore. This paper summarises the latest work, and examines the implications of different candidate TRP levels for the stock and fishery. The paper aims to:

1. Identify the consequences of using the 'minimum' south Pacific albacore biomass target reference point levels compatible with different levels of risk of falling below the agreed LRP, estimated through Project 57 of the WCPFC;
2. Examine the consequence of achieving the 'default' reference point of MSY;
3. Examine candidate TRPs based upon fishery objectives such as catch rates, fishery profitability and MEY;
4. Motivate discussion on the compatibility and acceptability of these biological, fishery and economic target levels, and the potential implications of those management options for the southern longline fishery.

Approach

There are two main areas of relevant work:

- Work under WCPFC Project 57 (Research related to development of limit reference points (LRP)) which examines the consequences of different levels of risk of falling below the agreed LRP for the four key tuna species. The analysis informs discussions on minimum standards for target reference points, and is discussed more fully in MOW3-WP-02;
- Examination of biological and economic status of the south Pacific albacore fishery, in relation to MSY and both CPUE and MEY (economic) conditions. The economic analyses used within this study are presented within Appendix 1 of this paper.

The stock and fishery consequences of candidate TRP levels were examined through 20 year stochastic projections, based upon the recommendations of WCPFC SC10 for capturing existing and future uncertainty. Following identification of future longline fishing levels that achieved the TRP using the approaches described below, summary metrics related to the median population biomass and consequences for longline CPUE and catch were calculated. See methods within the Annex for more information.

Risk evaluation: A range of future longline effort levels were tested, and the risk relative to the LRP was calculated as the proportion of projection runs where the spawning biomass in 2030 was below the LRP. The scalars used on future longline effort were iteratively adjusted to achieve specified levels of LRP risk by 2030, where that risk was 5%, 10%, 15% and 20% of runs.

MSY evaluation: MSY can be considered as the current 'default' management level for stocks for which targets have not been selected. Similar to the risk evaluation, the scalar on 2010 longline effort that achieved MSY conditions on average in 2030 was identified.

Maintaining CPUE levels: Confronted with declining CPUE levels within the fishery, which affects fishery economics, the potential to maintain CPUEs at 'acceptable' target levels has been discussed. As an example, future longline effort levels were adjusted so that average vulnerable biomass estimates for the southern WCP-CA longline fishery (a proxy for CPUE) were comparable to those seen in 2010.

MEY and related evaluations: Appendix 1 presents an updated analysis of the financial performance of the southern longline fishery, as previously presented to MOW2. This analysis takes into account the economic costs of fishing at a given level, and the value of the multispecies catch obtained at that level. The analysis has been updated to include:

- most recent prices for the main tuna species (which are lower than those used in the previous analysis, and imply that greater cuts in fishing effort would be required to achieve a lower MEY);
- the decisions made at WCPFC SC10 on the key south Pacific albacore model runs to be used to capture uncertainty, and their relevant 'weights';

- an alternative 'target' level of rents being 10% of the catch value, which is used as an example to identify conditions that could represent a 'minimum' average economic target for the fishery, and which might better balance economic, social and biological management objectives.

Therefore, three economic levels were examined, being the stock consequences of changes in fishing effort required to achieve MEY, a rent level 10% of the catch value, as well as 'breakeven' conditions (value from the fishery = economic cost of fishing expended, noting that these costs include the return required to justify the investment associated with the fishery operation, that is, "breakeven" means that where no rents are made). These were evaluated for three different levels of fishing cost (cost-per-hook).

Analysis

TRP defined by LRP risk levels

The risk evaluation indicates that the lower the level of permissible risk of falling below the limit reference point, the further away the average $SB_{2030}/SB_{F=0}$ level must be from the LRP (**Table 1**, **Figure 2**). If an acceptable LRP risk level of 5% (one in 20 chance of falling below the LRP) is selected, the minimum average adult stock size ($SB_{2030}/SB_{F=0}$) compatible with that risk is 38% of unfished levels, almost double the LRP level. If a less precautionary 20% risk (a one in five chance) is allowed an average stock size of 33%, just over 50% greater than the LRP level, is permissible. It follows that the average level of fishing mortality 'allowable' within a fishery at a 5% risk level is accordingly lower; a 5% level of risk equates to an average F/F_{MSY} of 0.86, while at a 20% level of risk it is 0.95 F/F_{MSY}.

Under all four levels of risk, average fishing mortality levels are below F_{MSY} levels, and the corresponding spawning biomass levels are 20-45% greater than those at MSY. Minimum permissible stock levels consistent with limiting the LRP risk to defined levels all equate to over a 50% decrease in vulnerable biomass (CPUE) levels by 2030 compared to those in 2010. The 'minimum' TRP levels appear inconsistent with economic objectives for the fishery, and suggests that economic, rather than biological, requirements will provide the standards for a TRP for this fishery.

MSY

Achieving conditions comparable to maximum sustainable yield would require almost 7 times the level of effort present in 2010 (**Table 1**). For that increased effort, the albacore catch increases by just over 50% compared to 2010 levels. The resulting average spawning biomass relative to $SB_{F=0}$ at MSY is 0.25, which is close to the LRP. Indeed, at MSY the risk of falling below the LRP is 34% (a 1 in 3 chance). MSY as a long-term target is not compatible with a low risk of falling below the LRP (**Figure 3**).

Maintaining CPUE at 2010 levels

Maintaining CPUE at 2010 levels required a reduction in future longline effort of 17% from 2010 levels. This implied a reduction in overall catch of approximately 20%. Resulting $SB_{F=0}$ levels were two and a half times that at the LRP, and fishing mortality was a third of that required to achieve MSY. However, when comparing the results to the break-even levels from the economic analysis, the reduction in effort to maintain CPUE at 2010 levels is insufficient to develop profits within the fishery at current price levels, unless costs are at the lowest level examined.

MEY

Breaking even financially – on average – at recent low price levels required fishing effort levels lower than those in 2010. Reduced effort led to lower catches but higher catch rates. The exception was where the cost-per-hook was a low US$ 0.90; breakeven conditions were then achieved at fishing effort levels 12% higher than those in 2010 (comparable to the provisional effort estimate for 2013). At all breakeven levels, average fishing mortality was 28-44% of that required to achieve MSY, while spawning biomass levels were three to four times the LRP level. Evaluations indicated no risk of falling below the LRP at those levels.

Maximum economic yield was achieved at very low effort levels (<25% of 2010 effort, which was the lowest effort level examined within the analysis), due to the current low albacore catch value. Resulting spawning biomass levels were at 90% of $SB_{F=0}$, catch rates were predicted to be 36% higher than 2010 levels, and catches just over a third of 2010 levels. The significant management actions required to achieve MEY levels may reduce the suitability of this target under current price and cost conditions.

Achieving a candidate average 'reasonable return' of rents being 10% of the catch value also required reductions from 2010 effort levels, but those reductions are less extreme than those required to achieve MEY. Dependent upon the assumed cost-per-hook, rents being 10% of the catch value required fishing effort reductions to between 94% and 47% of 2010 levels (i.e. between a 6% and 53% reduction in effort). Corresponding 'target' spawning biomass levels were between 68% and 81% of $SB_{F=0}$, with fishing mortality levels well below those required to achieve MSY.

Discussion points

- Do the candidate TRP levels examined adequately reflect all the management objectives for the fishery?
- Which outcomes are acceptable to managers?
- Do we want to maximise economic yield – or just get 'pretty good' economic yield? And what does this mean in a multi-species context?
- Noting that estimated future CPUE and catch values represent 'average' conditions across fleets, do we need to consider the differing economic performance of fleets, in particular consideration of SIDs fleet performance when considering MEY-based target reference points? Should a specific 'indicator' fleet be used within the analyses to guide management?
- Should bioeconomic analyses like this form part of the work of the Commission? If yes, how might it be done?

Table 1. Average stock and fishery status under alternative candidate Target Reference Point levels.

Risk of exceeding LRP	LL effort scalar (2010)	Median $SB_{2030}/SB_{F=0}$	Median F_{2030}/F_{MSY}	Median SB_{2030}/SB_{MSY}	Median longline VB_{2030}/VB_{2010}	Median albacore catch ($Catch_{2030}/Catch_{2010}$)
Minimum TRPs based on LRP risk levels						
5%	3.74	0.38	0.86	1.45	0.46	1.41
10%	4.00	0.37	0.88	1.40	0.44	1.43
15%	4.31	0.35	0.91	1.33	0.42	1.44
20%	4.75	0.33	0.95	1.26	0.39	1.46
Candidate TRPs						
MSY	6.8	0.25	1.00	1.00	0.28	1.51
Maintain CPUE @ 2010	0.83	0.71	0.36	2.66	1.00	0.81
MEY[1]						
costs $0.9-1.3 per hook	<0.25	0.90	0.15	3.36	1.36	0.37
Rents at 10% of catch value[1]						
cost $0.9 per hook	0.94	0.68	0.39	2.57	0.97	0.86
cost $1.1 per hook	0.65	0.76	0.31	2.85	1.10	0.70
cost $1.3 per hook	0.47	0.81	0.24	3.04	1.20	0.57
Breakeven[1]						
cost $0.9 per hook	1.12	0.64	0.44	2.41	0.90	0.94
cost $1.1 per hook	0.78	0.72	0.35	2.72	1.03	0.78
cost $1.3 per hook	0.57	0.78	0.28	2.94	1.14	0.65

[1] values presented for financial levels calculated using the 'medium' prices of the main species caught, which are recent ex-vessel prices. See Appendix 1 for further details.
Approximate effort scalars for recent years relative to 2010: 2011 = 1.07; 2012=1.26; 2013=1.13
Conditions under 2010 status quo: Median $SB_{2030}/SB_{F=0}$=0.67; Median F_{2030}/F_{MSY}=0.41; Median longline VB_{2030}/VB_{2010}=0.93

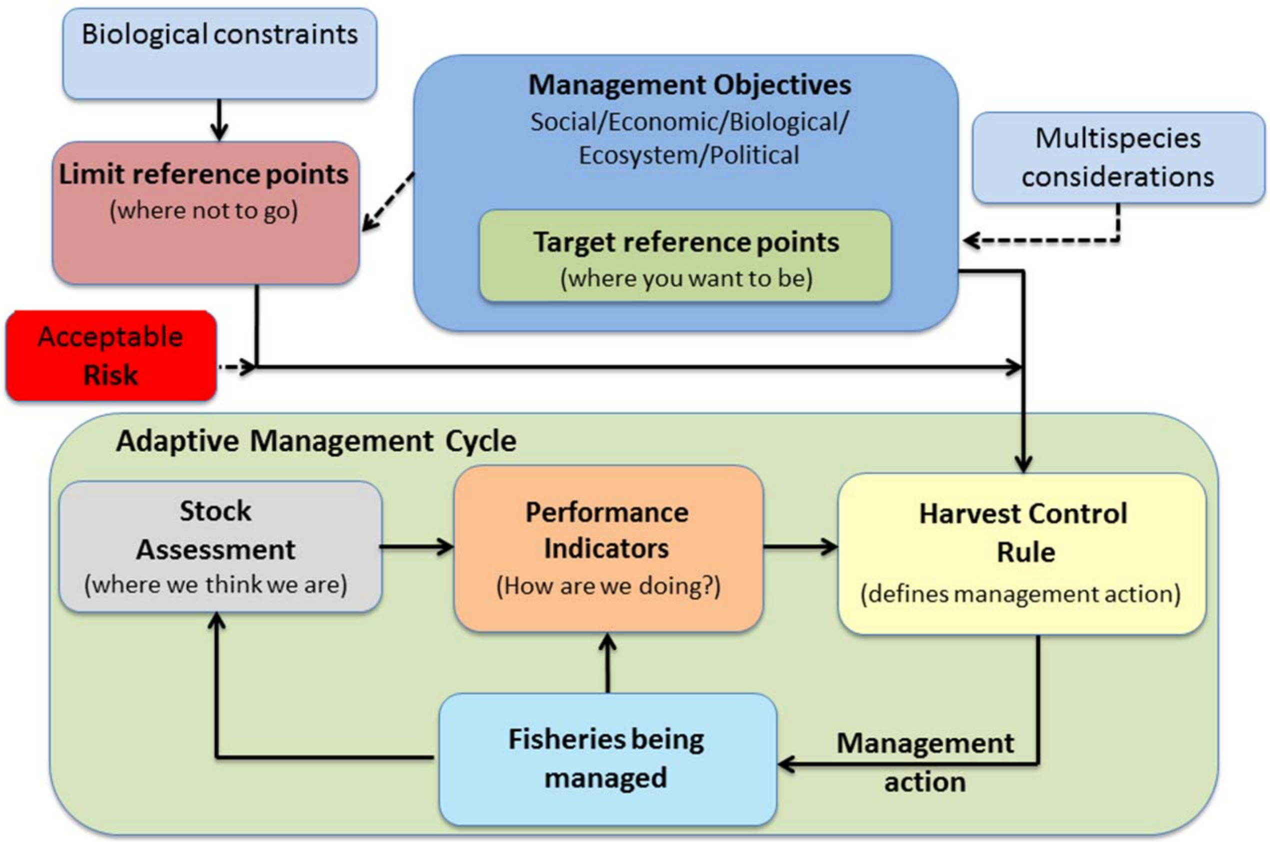

Figure 1. The Management Framework

P=0.05 (5%) P=0.20 (20%)

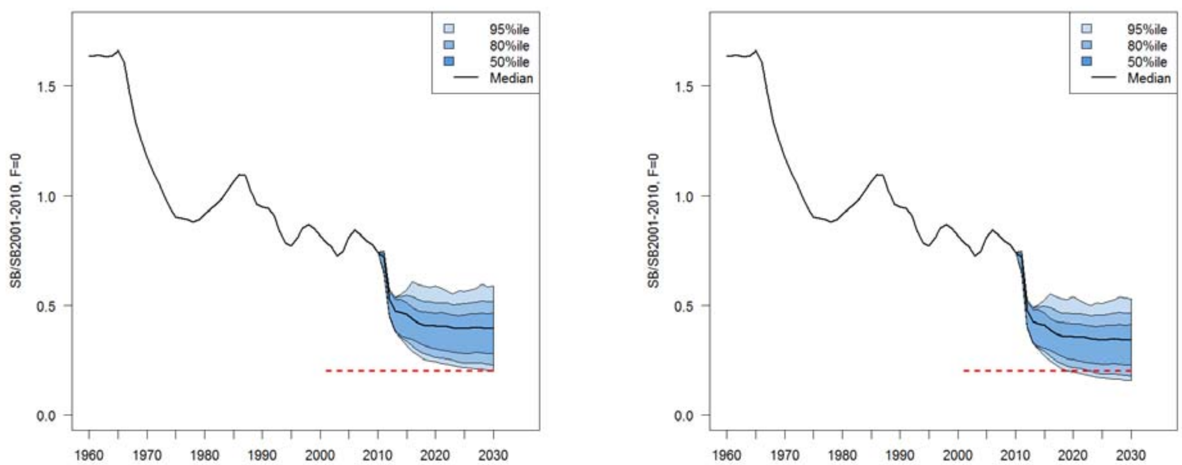

Figure 2. Stochastic projections of future adult stock status under effort levels that achieved different probabilities of the spawning biomass falling below the biomass Limit Reference Point (20% $SB_{F=0}$, indicated by horizontal dashed red line). The historical average status from 1960 up to 2010 inclusive represents that across the 9 assessment model runs (structural uncertainty only). Uncertainty after 2010 represents both structural uncertainty and stochastic recruitment.

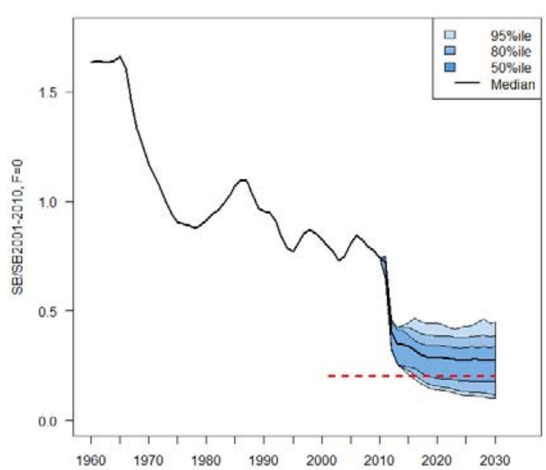

Figure 3. Stochastic projections of adult stock status under longline effort levels that achieve MSY. The limit reference point (20% $SB_{F=0}$) is indicated by horizontal dashed red line. See Figure 1 for further notes.

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

The general approach is described more fully in WCPFC-SC10-2014/MI-WP-01 and MOW3/WP02, 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 2012 south Pacific albacore stock assessment uncertainty grid (Hoyle et al., 2012) were used to capture uncertainty in 'current' stock status and biological characteristics. These runs were as agreed by SC10 and represent a sub-set of those used within results presented in MI-WP-01. The level of uncertainty is notably reduced;
- 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;
- 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 2010;
- 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 2010 levels;
- Two hundred projections were performed for each assessment run under a given effort scalar.

As noted above, the selection of a feasible number of assessment runs that best captured the key uncertainties present within the South Pacific albacore stock assessment 'uncertainty grid' was based upon the decisions of SC10. The runs selected covered uncertainty in two main biological parameters, being:

- the steepness of the stock recruitment relationship (h=0.65, 0.8 or 0.95); and
- the natural mortality rate (M=0.3, 0.4 or 0.5).

Projections were run from nine different models, and future longline fishing effort adjusted to achieve the candidate TRP level on average (or exceed the LRP by the desired level of risk). When examining results, those from each model were weighted according to the weightings agreed at SC10 when calculating the average consequences across those runs; the run considered most biologically plausible was given the most weight, and results from runs considered less biologically plausible were 'down-weighted'.

The unfished biomass level ($SB_{F=0}$, calculated as the average of the spawning biomass over the period 2001-10 that would have occurred in the absence of fishing, the time period recommended by SC9) 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.

Appendix 1. *Potential target reference points that consider profitability of fleets: updating the example analysis for south Pacific albacore longlining*

Overview

The purpose of this paper is to take two of the most commonly mentioned management objectives from MOW1 – maximizing the economic yields from the fishery (i.e., MEY) and 'profitability' – and provide an example of how they could be made operational to help inform discussion of candidate target reference points for a fishery.

In this example we use Net Present Value (NPV) as one potential economic quantity that could be used as an indicator, and apply it to the southern longline albacore fishery.

Using the NPV approach we can calculate potential target reference points consistent with either maximizing economic returns (e.g. MEY) or achieving a specified level of profitability (here rents equivalent to 10% of the catch value, and zero rents ('breakeven')), and can compare these to current stock status, while taking into account the additional value of non-target species catches. We also examine the economic loss that is associated with harvesting at rates greater than MEY.

The paper seeks to stimulate discussion on a range of matters from the overall objective of identifying the appropriate economic quantities to consider, to the potential implications of management options for the southern longline fishery using the results presented in the example.

It is suggested that emphasis is placed on the principles and broad strategic approach outlined in the paper rather than the specifics of the costs and assumptions used in the analysis.

Approach

Maximizing the net present value (NPV) of a fishery is a promising approach for determining the level of fishing effort required to optimize a wide-range of economic benefits. An advantage of this approach is that it doesn't require assumptions of equilibrium conditions and can be readily estimated using the existing capabilities of MULTIFAN-CL projections. It does, however, require the collection of a range of economic data, some of which is not currently available for all fisheries.

Net present value can be defined as the sum of the current discounted future value of the fishery over a specified time horizon.

Discounted: The discount rate seeks to discount (reduce) future cash flows to their present value. This is done as the expectation of receiving a given return in the future is likely worth less than receiving it today. For example, an individual who is indifferent to receiving $90 today or $100 in one year's time has a discount rate of 10%.

Value: We define value in this paper as the economic yield gained from resource rents through the harvesting of the fish stock; while south Pacific albacore is the target species, we also take into account the value of 'bycatch' species which includes valuable tropical tuna species. Resource rents are defined as the profit earned above and beyond that required to justify undertaking fishing activity[1].

Time horizon: The time horizon is normally chosen to inform commercial (and management) decisions concerning potential investment (e.g., increase/decrease fishing effort). In this analysis we use 20 years to reflect the lifetime of a typical business loan.

In effect, the analysis seeks to estimate the level of effort associated with maximum economic yield (MEY) where economic yield is defined as the net present value of the resource rent earned over the specified time horizon. It also examines the results of achieving a 'candidate profit level' target, rather than the maximum, which might be more consistent with balancing economic, social and biological management objectives.

It is also possible to use other definitions of 'value' (or economic yield) in the analysis to incorporate economic benefits accruing to an economy beyond resource rents, such as crew employment or benefits arising from onshore processing of the catch. It is intended as part of future analyses to estimate the level of catch/effort associated with maximum economic yield under a range of definitions of value. In general, the level of effort that results in MEY increases when other economic benefits such as employment and onshore processing are included in addition to resource rent.

[1] Or 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.

In this example we focussed on south Pacific albacore tuna as the primary species for the southern longline fishery using the 2012 stock assessment. The general steps taken in this analysis were to:

i. project a 20 year time series of longline catch (all species) and effort levels resulting from longline fishing at different future levels and under different future stock and economic conditions;
ii. overlay economic information to obtain a time series of revenue from the predicted catch and the opportunity cost associated with the predicted fishing effort;
iii. calculate resource rent across the time series (revenues minus opportunity costs) and other performance indicators;
iv. discount future rents;
v. sum rents across the discounted time series to get the NPV; and
vi. predict the levels of effort (across projections) that i) maximize NPV ii) provide an average overall rent of 10% of the catch value and iii) equates to the long-term 'break-even' (or zero rent) point for the fishery.

Note that the 2010 effort underlying this analysis as used within the 2012 stock assessment for south Pacific albacore has changed following updated data provisions by WCPFC members. It should also be noted that a new South Pacific albacore assessment is scheduled for 2015.

Analysis

The predicted catch and value composition by species in the final year of the projection (2030) was variable among longline fleets (**Figure A1**). On average, predicted catches of albacore composed approximately 50% of all longline catches by weight across fleets but only 30% of the total value. Similarly, catches of billfish and that for 'other' species amounted to a higher proportion of the total catch compared to their proportion of the total value of the catch. In contrast, yellowfin and bigeye composed a higher proportion of the value (26% and 24%, respectively) compared to total landed catch in weight (19% and 10%, 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 fishing effort applied in the southern WCPFC-CA for each of the nine alternative economic scenarios examined (**Figure A2**). Compared to the previous analysis presented at MOW2, subsequent reductions in fish prices mean that the estimated MEY occurred at extremely low effort levels, substantially lower than effort levels observed in 2010 and lower than in the MOW2 analysis, and generally at effort levels at or below 25% of the 2010 effort. Eight of the nine scenarios examined suggest that the fishery is below the break-even point (no long-term resource rent available) when fished at 2012 effort levels (which are higher than 2010 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 at 2012 effort levels. 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 25% of the MSY level (**Table A1**). In turn, conditions required to achieve a rent of 10% of the catch value within the fishery implies albacore catches between 37,000 and 87,000mt, dependent on the cost and price structure. The biomass which supported a rent of 10% of the catch value was much higher than that which supported the MSY catch (2.6 to 3.3 times higher) and the increased biomass levels were generally associated with increased catch rates, except where prices were higher and costs lower where a rent of 10% of the catch value could be made despite lower catch rates. The effort level to achieve both MEY and a rent of 10% of the catch value are considerably lower than the MSY level, and higher 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 that allows for a 10% decline from 2010 catch rates (**Table A2**), whereas those vessels with higher operational costs require a 14% increase from 2010 catch rate levels to break even. While the fishery is operating below the MEY level, those vessels with lower operating costs have more 'flexibility' before they reach their break-even point.

Increased resource rents and profitability can be achieved following reductions in longline fishing effort of 22% (medium price and cost per hook structure) down to the level that maximizes the NPV (**Figure A3**). The largest amount of savings is gained with initial reductions in effort. We can still attain greatly improved economic performance without rebuilding all the way to the MEY level.

Figure A4 presents three different factors that influence the level of Maximum Economic Yield and the effort required to achieve it. Each of these factors can be influenced by fisheries managers and/or businesses. As examples:

- Fishing costs can also be influenced by subsidies, licensing fees, port fees and other operational factors;
- CPUE levels can be influenced by the level of effort allowed within a fishery;
- Fish value can for example be influenced by the level of supply to markets, entry into certification schemes (also influencing market access).

The feasibility of influencing these different factors varies between the different fishery stakeholders, and the acceptability may vary between fleets and regions. However, we present this graphic to highlight that the status of the stock is only one (important) factor affecting fleet profitability.

Table A1. 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 (2030) for the longline fishery in the whole of the South Pacific (SP) and when operating in the southern WCPFC convention area (SPCA) only. Forgone value is the difference between the net resource rents available when fishing at 2012 effort levels and at the level that maximizes NPV. Shading added for visualisation only.

Relative price structure	Cost/hook	Scalar at Max NPV (rel. 2010 effort)	Forgone value (million USD)	Catch ALB-SP (MEY) (mt)	Catch MEY/MSY %	Biomass SB_{MEY}/SB_{MSY} (ratio)	Change ALB CPUE (MEY) (ratio)	Catch YFT-SP (mt)	Catch BET-SP (mt)	Catch All-SP (mt)	Median % $SB_{F=0}$ at MEY
HIGH	1.3	0.25	2,779	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9
	1.1	0.25	1,827	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9
	0.9	0.38	923	42,803	35	3.16	1.26	15,242	10,378	86,923	0.84
MEDIUM	1.3	0.25	3,347	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9
	1.1	0.25	2,395	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9
	0.9	0.25	1,443	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9
LOW	1.3	0.25	3,916	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9
	1.1	0.25	2,963	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9
	0.9	0.25	2,011	31,064	25	3.36	1.36	14,206	9,325	69,405	0.9

Note: effort scalars of 1.07 and 1.26 correspond to observed 2011 and 2012 effort levels relative to 2010. Median $SB_{2010}/SB_{F=0}$ = 0.70.

Table A2. Population and fishery performance indicators are shown for the level of fishing effort that achieves **a 10% profit margin** 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 (2030) for the longline fishery in the whole of the South Pacific (SP) and when operating in the southern WCPFC convention area (SPCA) only. Forgone value is the difference between the net resource rents available when fishing at 2012 effort levels and at the level that maximizes NPV. Shading added for visualisation only.

Relative price structure	Cost/hook	Scalar achieving 10% profit (rel. 2010 effort)	Forgone value (million US$)	Catch ALB-SP (mt)	Catch 10%rent/MSY %	Biomass $SB_{10\%}/SB_{MSY}$ (ratio)	Change ALB CPUE (ratio)	Catch YFT-SP (mt)	Catch BET-SP (mt)	Catch All-SP (mt)	Median % $SB_{F=0}$ at 10% rent
HIGH	1.3	0.67	572	62,413	51	2.83	1.09	17,339	12,069	116,577	75
	1.1	0.91	652	74,124	61	2.60	0.98	18,684	13,068	134,427	69
	0.9	1.28	777	87,305	72	2.31	0.85	20,241	14,225	154,689	61
MEDIUM	1.3	0.47	427	49,717	41	3.04	1.20	15,948	10,982	97,343	81
	1.1	0.65	474	61,282	50	2.85	1.10	17,212	11,973	114,859	76
	0.9	0.94	552	75,382	62	2.57	0.97	18,831	13,176	136,352	68
LOW	1.3	0.31	285	36,770	30	3.26	1.31	14,675	9,840	77,881	88
	1.1	0.42	335	45,984	38	3.10	1.23	15,561	10,657	91,711	83
	0.9	0.62	381	59,533	49	2.88	1.11	17,016	11,824	112,205	77

Note: effort scalars of 1.07 and 1.26 correspond to observed 2011 and 2012 effort levels relative to 2010. Median $SB_{2010}/SB_{F=0}$ = 0.70.

Table A3. 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 (2030) for the longline fishery in the whole of the South Pacific (SP). Shading added for visualisation only.

Relative price structure	Cost/hook (US$)	Scalar at break even (rel. 2010 effort)	Catch ALB SP (mt)	Change ALB CPUE (2030/2010)	Catch YFT-SP (mt)	Catch BET-SP (mt)	Median % $SB_{F=0}$ at breakeven
HIGH	1.3	0.8	69,146	1.02	18,107	12,642	72
	1.1	1.08	80,770	0.92	19,464	13,644	65
	0.9	1.51	93,510	0.79	20,987	14,797	57
MEDIUM	1.3	0.57	56,470	1.14	16,677	11,563	78
	1.1	0.78	68,175	1.03	17,995	12,560	72
	0.9	1.12	82,178	0.90	19,630	13,768	64
LOW	1.3	0.38	42,803	1.26	15,242	10,378	84
	1.1	0.52	53,205	1.17	16,321	11,283	80
	0.9	0.75	66,676	1.05	17,824	12,432	73

Note: effort scalars of 1.07 and 1.26 correspond to observed 2011 and 2012 effort levels relative to 2010. Median $SB_{2010}/SB_{F=0}$ = 0.70.

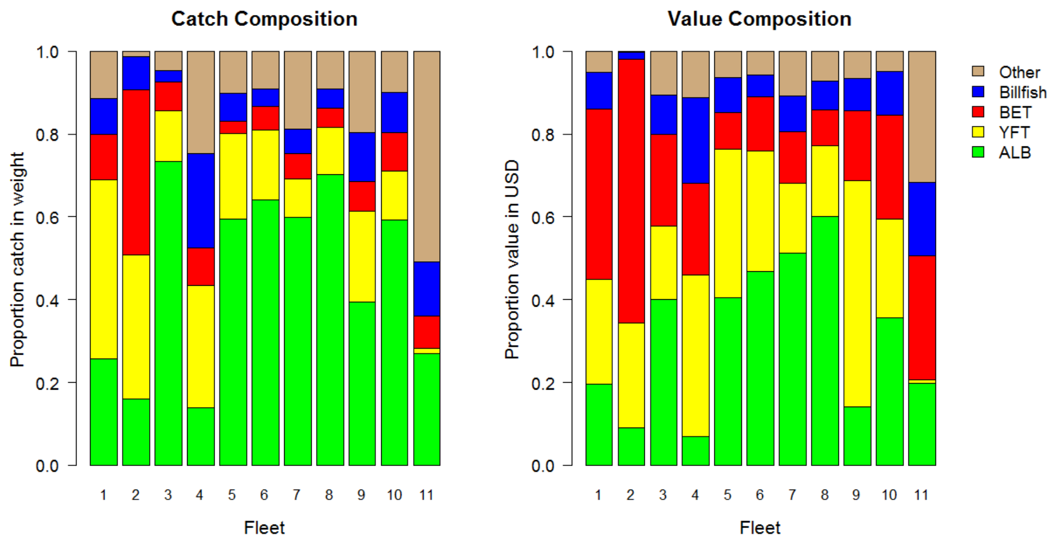

Figure A1. Predicted catch (left) and value (right; 'medium' price structure) composition by fleet and species category.

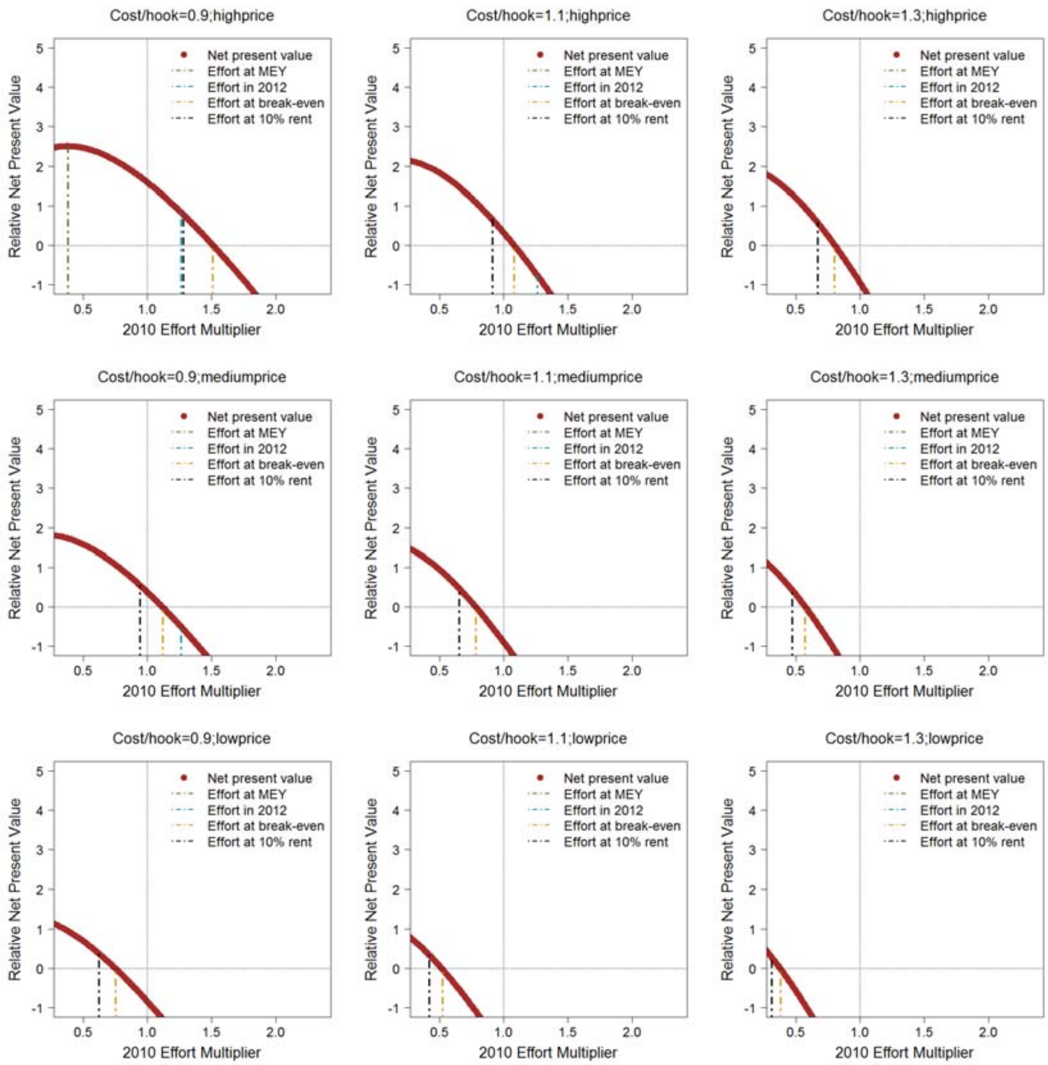

Figure A2. Estimates of net present value (NPV) are shown for the South Pacific longline fishery operating in the WCPFC convention area for different cost per hook (USD) and price structure (see Table 1) assumptions using a discount rate of 5%. Effort multipliers are relative to 2010 levels. Effort in 2012 was observed at 1.26 times 2010 levels (according to logsheet information).

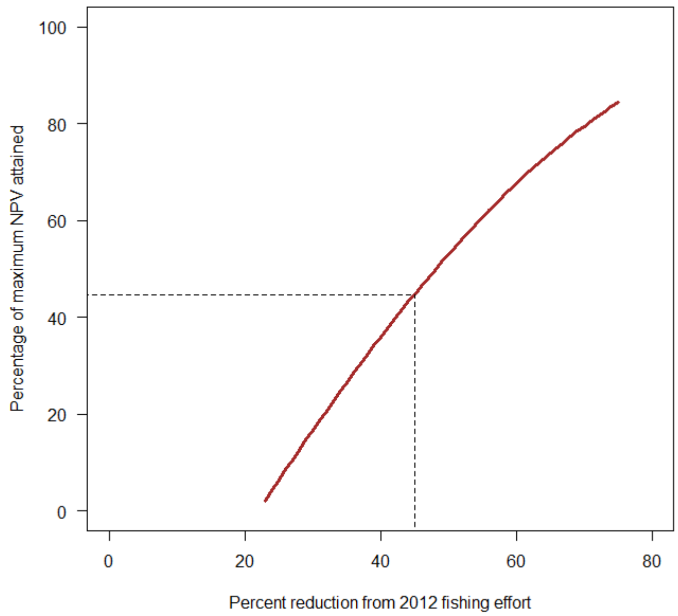

Figure A3. The expected level of the maximum net present value (NPV) attained as a function of the amount of reduction in 2012 fishing effort in the South Pacific WCPFC-CA (solid line) for the 'medium' price structure and USD 1.10 cost/hook scenario. Note that the function is slightly concave, so that after initial gains in maximum NPV occur, reducing fishing effort further provides slightly lower gains in NPV. However, under the current cost and price structure, gains are much closer to 1:1 than seen in previous analyses where fish prices were greater.

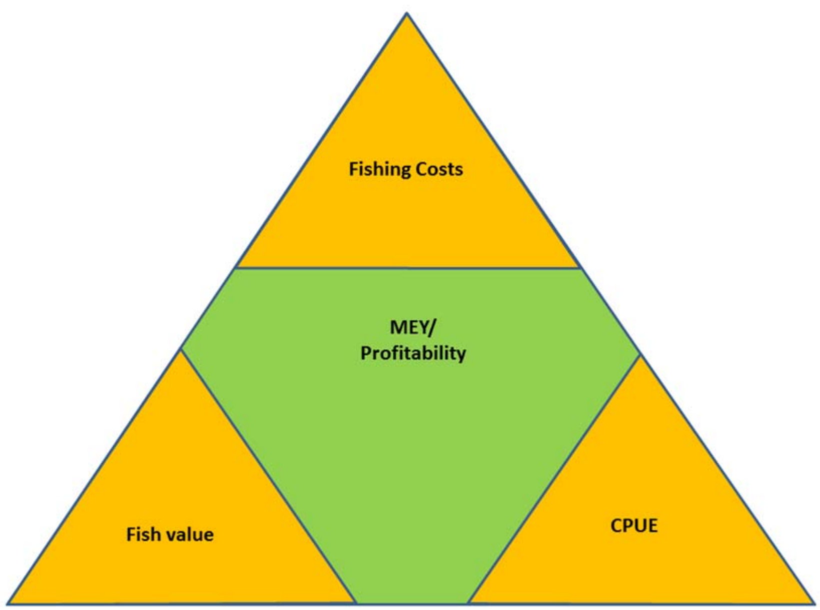

Figure A4: What factors influence the level of MEY/profitability?

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

Deterministic projections to the year 2030 (time horizon of 20 years from 2010 conditions) were used to estimate alternative future South Pacific albacore catch levels under a range of longline effort scalars using the 2012 south Pacific albacore assessment. These projections were run from the nine different models defined by SC10 as best representing uncertainty in our knowledge of albacore biology and current conditions. Results were weighted as per SC10 agreement. The catch of yellowfin, bigeye, billfish, and a combined 'other species' category was then calculated according to the estimated albacore catch and a fleet- and species-specific scaling factor. Longline effort scalars were applied to fleets operating in the South Pacific WCPFC-CA only; longline fleets in the eastern South Pacific and troll fleets effort levels remained at 2010 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, (noting that this costs includes a return to capital of around 15%). 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 pricing levels, 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 throughout the projection period, invariant to the landing location, and do not take into account any size-based market differences.

Table Annex1. List of price, cost, and discount rate scenario options used to calculate net present value. Twenty-seven total scenarios were examined, covering each combination of the three scenarios for price, cost/hook and discount rate. Note that a price supplement was defined for the Japanese fleet (not shown here, ~ +9% for the main tuna species.

Parameter	Species	High	Medium	Low
Price/mt (US$)	ALB	2957	2464	1971
	YFT	6376	5313	4250
	BET	9365	7804	6243
	Billfish	5400	4500	3600
	Sharks	1860	1550	1240
	Other[1]	2957	2464	1971
Cost/hook (US$)		1.30	1.10	0.90
Discount rate		7% (0.07)	5% (0.05)	3% (0.03)

[1] Other finfish