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Review of the Implementation and Effectiveness of CMM 2008-01

Executive Summary

The paper provides a review of the implementation and effectiveness of CMM 2008-01 using the most current data and stock assessments available.

Implementation of CMM 2008-01

The implementation of the CMM was reviewed for its key components – purse seine effort, the FAD closure, the high seas pockets (HSP) closure, longline catches and catches by other fisheries. The main conclusions from the paper regarding implementation are as follows:

Purse seine effort

Purse seine effort has expanded since the introduction of CMM 2008-01, with effort (excluding domestic purse seiners based in Indonesia and Philippines) in 2010 estimated to have increased by approximately 18% compared to effort in 2004. VMS data for 2011 indicate a further increase in effort of approximately 11% over 2010 and 31% over 2004.

FAD closure

The incidence of reported activity related to use of drifting FADs was considerably lower in 2010 (5.8%) compared to 2009 (14.0%). However, the observed incidence of vessels drifting at night with fish aggregation lights on increased from 2.2% to 6.2%. Total catch was below average during the 2009 closure and in September of the 2010 closure, although effort remained at around normal levels throughout both closures. Catches of skipjack and yellowfin were moderately reduced during the closures, but bigeye catches were strongly reduced. In 2010, the proportions of effort associated with FAD usage outside the closure period, particularly the months immediately before and after the closure, had lower FAD usage than is typically the case. However, available logsheet data indicates a return to high levels of FAD usage prior to FAD closure in 2011. While catches were reduced during the closures, the average size of the catch was higher for all species, particularly yellowfin, during the closures because of the larger average size of fish caught in unassociated sets. These larger average sizes, which have higher unit value, may offset to some extent the loss of revenue that occurs as a result of lower catches during the closures.

High seas pockets closure

Available data from all sources indicate that the HSP closure since 1 January 2010 has largely been respected. Since January 2010, effort has been concentrated mainly in the EEZs, with no apparent re-distribution of effort to the eastern high seas. The ENSO cycle remains a key driver of purse seine effort distribution, with the *La Niña* event that has occurred since Q1 2010 continuing to push purse seine effort to the west.

Longline catches

The 2010 longline catch of bigeye tuna in the WCPFC Convention Area of 64,953 tonnes[1] is approximately 77% of the average catch for 2001-2004. The main reason for the reduction was the reduced catches reported by several of the major fishing nations – e.g. Japan caught 14,565 tonnes in 2010 compared to their limit of 22,480 tonnes, and Korea caught 13,862 tonnes in 2010 compared to their limit of 17,159 tonnes. These reductions are greater than what is required under the CMM and therefore there is considerable scope for the catches to increase from the 2010 level in the future if conditions in the fishery were to allow.

The 2010 longline catch of yellowfin tuna in the WCPFC Convention Area was 73,836 tonnes[1] and so within the 2001-2004 average catch of 75,604 tonnes.

Other fisheries

For fisheries other than tropical purse seine and longline, total catches for 2010 are less than their respective average levels for 2001-2004 for both bigeye and yellowfin tuna.

Effectiveness of CMM 2008-01

To evaluate the effectiveness of CMM 2008-01, stock projections were undertaken using the reference case models for the 2011 assessments for bigeye, skipjack, and yellowfin tunas. These models were adopted by SC7 for the provision of management advice, and as such do not yet incorporate the revisions of longline catch provided by China in late 2010. The impact of the revised catch estimates on the projection results is expected to be minor. Similar methods were used as in previous years and the results are provided in the form of two excel files with a separate worksheet for each species contained therein.

Of particular interest from the projections is that maintenance of bigeye tuna catch and effort levels observed in the fishery in 2009 results in F/F_{MSY} remaining high, with a projected level of 1.39 in 2021. However, for the scenario best approximating the reported catch and effort in the fishery in 2010, F/F_{MSY} declines and is at a projected level of 0.97 in 2021. This is driven by several factors: the lower than usual FAD use in 2010, the lower longline catches, and a large (30%) reduction in reported catches from the domestic fisheries of Indonesia and the Philippines.

For scenarios that mimic a total purse seine closure, there is a relatively small incremental reduction in F/F_{MSY} compared to that achieved by a FAD closure. However, this comes at a cost of substantial reductions in total catch, particularly in the purse seine fishery. This conclusion is robust to the use of base years from 2001-2009 to characterize the differences.

The projection results were also used to quantify in an approximate way the impact of the various exemptions contained within CMM 2008-01. It was estimated that if the CMM was implemented without exemptions, approximately half of the overfishing that is estimated could occur under the CMM as written could be removed (reduction of bigeye tuna F/F_{MSY} from 1.35 to 1.17). This result is similar to previous analyses of this issue.

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[1] Incorporating recent catch revisions submitted by China, but not including the estimates of 2,441 tonnes of bigeye and 9,513 tonnes of yellowfin reported by Vietnam for its fleet operating in the South China Sea. These estimates have been provided for 2010 only.

Finally, we estimated the individual impacts on bigeye tuna F/F_{MSY} of observed levels of catch or effort for the longline, purse seine and domestic Philippines and Indonesia fishery groups in 2009 and 2010 against a base of 2004. The reduction in purse seine FAD effort in 2010 has the greatest effect in terms of removing overfishing (67.4% of overfishing removed) followed by the reduction in longline catch in 2010 (34.7% of the overfishing removed).

1 Introduction

CMM 2008-01, adopted in December 2008, seeks to reduce fishing mortality on bigeye tuna by 30% from the 2001-2004 average level and limit yellowfin tuna fishing mortality to its 2001-2004 level, in order to maintain stocks at levels capable of producing the maximum sustainable yield (MSY). This objective is currently pursued though a combination of measures including longline catch limits, purse seine effort limits, a closure relating to purse seine fishing using fish aggregation devices (FADs) and a closure of two high-seas pockets (HSP) to purse seine fishing. Most of these measures have various exemptions or alternatives built in and are to be phased in over the period 2009-2011.

In section 2 of this paper, we review the implementation to date of the key elements of CMM 2008-01. This review covers primarily the year 2010, for which data are now reasonably complete, but also includes preliminary information for 2011 where possible. The key elements of the CMM reviewed here are purse seine effort levels, the 2009 and 2010 FAD closures, the high seas pockets closure to purse seine fishing, longline catches of bigeye and yellowfin tuna, and catches of bigeye and yellowfin tuna by fisheries other than purse seine and longline.

Section 3 of the paper focuses on an assessment of the impacts of a variety of combinations of catch and effort levels on bigeye tuna overfishing and on the catches of all three species, as recommended by SC7 (a preliminary version of which was presented to TCC7 as WCPFC-TCC7-2011-31). Two specific issues, the use of FAD versus total purse seine closures and the impact of the exemptions, are also analysed.

2 Implementation of key elements of CMM 2008-01

In this section we briefly review, on the basis of available data, the implementation to date of the key elements of CMM 2008-01 as they pertain to the achievement of the objectives.

2.1 Purse seine effort

CMM 2008-01 specifies certain limits on purse seine effort between 20ºN and 20ºS, as follows:

- Effort (measured in days fished) in the EEZs of PNA members combined is limited to no greater than 2004 levels;
- Compatible measures to reduce purse seine fishing mortality on bigeye tuna in the EEZs of non-PNA CCMs; and
- Effort on the high seas (measured in days fished) is limited for each individual CCM to no more than the 2004 or 2001-2004 average level[2];
- Purse seine fishing is prohibited in the two western high seas pockets (since 1 January 2010).
- Exemptions, exclusions and variations to the above include:
    - Small Island Developing States in paragraph 10 with respect to high seas effort;
    - Fleets of 4 vessels or less in footnote 2 of the CMM;
    - Preservation of existing rights under registered regional or bilateral fisheries partnership arrangements or agreements in paragraph 7; and
    - Exclusion of archipelagic waters from the scope of the CMM.

[2] Since the CMM provides a choice between 2004 and 2001-2004, it is assumed that CCMs would always choose the higher of the two.

Purse seine effort from 2001 to 2010, broken down by various categories of EEZs and high seas, is provided in WCPFC-TCC7-2011-IP11 and shown graphically in Figure 1.

Because of the difficulties of specifying purse seine effort of Indonesian and Philippines purse seiners both in their EEZs and on the high seas, it is not currently possible to precisely determine total purse seine effort in days fished in 2004 and subsequent years. However, based on the available raised logsheet data, it is clear that purse seine effort in the WCPFC tropical purse seine fishery in 2010, excluding domestic purse seiners based in Indonesia and Philippines, has increased considerably (by approximately 18%) compared to effort in 2004. Complete logsheet data are not yet available for 2011. However, complete VMS data (adjusted to remove in-port and other non-fishing days) for 2011 indicate a further increase in effort of approximately 11% over 2010 and 31% over 2004 (Figure 1, Figure 2).

2.2 FAD closure

Information on the implementation of the 2009 and 2010 FAD closures was reported to SC7 (WCPFC-SC7-2011-MI-WP-01). The key findings were:

- The incidence of reported activity related to use of drifting FADs was considerably lower in 2010 (5.8%) compared to 2009 (14.0%) (Table 1);
- The observed incidence of vessels drifting at night with fish aggregation lights on increased from 2.2% in 2009 to 6.2% in 2010;
- Total catch was below average during the 2009 closure and in September of the 2010 closure. Catches in July and August 2010 were about average. Effort remained at around normal levels throughout both closures;
- The catches of bigeye tuna were strongly reduced during both closure periods compared to the other months of those years (Figure 3);
- The impacts of the closures on skipjack and yellowfin catches were more moderate (Figure 3);
- The proportions of associated sets conducted during the 2010 closure were close to zero (Figure 4);
- In 2010, the proportions of effort associated with FAD usage outside the closure period, particularly the months immediately before and after the closure, had lower FAD usage than is typically the case. This may be associated with the retrieval and re-deployment of FADs, although this needs to be verified by other data (Figure 4);
- While catches were reduced during the closures, the average size of the fish in the catch was higher for all species, particularly yellowfin, during the closures because of the larger average size of fish caught in unassociated sets (Figure 5). These larger average sizes, which have higher unit value, may offset to some extent the loss of revenue that occurs as a result of lower catches during the closures.

As noted above, a significant observation is the relatively low proportion of total sets conducted on FADs and other floating objects in 2010 compared to previous years (26% FAD sets in 2010 compared to 48% in 2001-2009). However, available logsheet data for 2011 indicate a return to relatively high FAD usage in the months leading up to the 2011 FAD closure (Figure 4).

2.3 High seas pockets closure

CMM 2008-01 established a closure to all purse seine fishing in the two high seas pockets (HSP) shown in Attachment D of the CMM from 1 January 2010. Previous analyses (WCPFC6-2009-IP17) have determined that the impact of the closure on bigeye tuna overfishing depends on what happens to the purse seine effort that would have otherwise fished in the HSP (approximately 7,400 days per year in 2001-2004, or about 14% of the total managed purse seine effort). If that effort is removed from the fishery, there is a small reduction in F/F_{MSY}, while if the effort is redistributed, there is a small increase in F/F_{MSY} – under the assumption that such effort would redistribute to the eastern high seas areas (EHS)[3] given the existing limits on EEZ effort (see Table 7, WCPFC6-2009-IP17).

Figure 6 shows the distribution of purse seine effort since 1 January 2010 from three independent sources of data – logsheet, observer and VMS data. The three data sets show similar patterns, with both HSP largely devoid of effort since 1 January 2010. There is a small amount of VMS days in the HSP, presumably for transiting purposes. Historically, the proportion of total purse seine effort occurring on in the HSP has been about 10-20% annually; since 1 January 2010, on the basis of available logsheet data, it is 0.7%. While there is some purse seine effort in the eastern high seas area, there is no evidence of an increase in activity in this region since January 2010 compared to previous years (where it has comprised around 2-8% of total purse seine effort annually). However, the occurrence of purse seine effort in the eastern high seas is related to some extent to the ENSO cycle, being higher during *El Niño* events. Since most of the period since January 2010 has been under *La Niña* conditions, relatively low effort in the eastern high seas was expected.

2.4 Longline catch

CMM 2008-01 established certain bigeye longline catch limits for CCMs other than Small Island Developing States and Territories (SIDS). These limits, with some exemptions and variations, are based on reductions (10%, 20% and 30% in 2009, 2010 and 2011, respectively) from 2001-2004 average bigeye longline catches and are aimed at achieving an overall 30% reduction in bigeye longline catch from 2001-2004 or 2004 levels. The various exemptions and variations are:

- SIDS are exempted from the measure and therefore have no limits on bigeye catches by their domestic longline fleets;
- Non-SIDS CCMs with a base catch of <2,000 tonnes of bigeye tuna are limited to 2,000 tonnes;
- China, Indonesia and USA use 2004 as the base, rather than 2001-2004;
- The limits for China will remain at 2004 levels pending agreement regarding the attribution of Chinese catch taken as part of domestic fisheries in the EEZs of coastal states; and
- The reductions specified for 2010 and 2011 shall not apply to fleets with a total longline catch of <5,000 tonnes and landing exclusively fresh fish. This exemption effectively applies to the United States Hawaii-based fleet only.

[3] For the purpose of this paper, we define the eastern high seas as the high seas areas of the WCPFC convention area between 10°N and 20°S and east of 170°E. That part of the high seas pocket bounded by the EEZs of Federated States of Micronesia, Marshall Islands, Nauru, Kiribati, Tuvalu, Fiji and Solomon Islands that is east of 170°E is excluded from this definition.

The base bigeye tuna catches by flag were provided in CMM 2008-01 Attachment F. The inferred limits under the CMM as well as provisional catches by flag for 2010 are provided in WCPFC8-2011-21.Rev.2, Attachment 1, Table 3. The most notable revisions to the base catches compared to Attachment F in the CMM are a slight increase in the Chinese Taipei catch (from 15,854 to 16,125 tonnes) and a major decrease in the Indonesian catch (from 8,413 to 2,192 tonnes). Both of these revisions are consistent with the latest data provided by these CCMs and have been used in the most recent assessments.

The total average bigeye longline catch for 2001-2004 was 83,879 tonnes. In 2010, the bigeye catch (incorporating revisions in the catch by China provided in late 2011) was 64,953 tonnes (excluding a catch of 2,441 tonnes of bigeye reported for the first time by Vietnam from the South China Sea), the lowest since 1996 and approximately 77% of the average catch for 2001-2004. The main reason for the fall was reduced catches by several of the major fishing nations, e.g., Japan caught 14,565 tonnes in 2010 compared to their limit of 22,480 tonnes and Korea caught 13,862 tonnes in 2010 compared to their limit of 17,159 tonnes. These reductions are greater than what is required under the CMM and therefore there is considerable scope for the catches to increase from the 2010 level in the future if conditions in the fishery were to allow.

CMM 2008-01 also limited longline catches of yellowfin tuna to their 2001-2004 average levels for each CCM, excluding SIDS. The catches from 2001 to 2010, along with the inferred limits for each CCM, are provided in WCPFC8-2011-21.Rev.2, Attachment 1, Table 6. Total annual yellowfin catch in 2001-2004 averaged 75,604 tonnes. In 2010, the provisional total longline catch of yellowfin was 73,836 tonnes (excluding the catch of 9,513 tonnes by Vietnam from the South China Sea), and so within the overall limit of 75,604 tonnes as specified by the CMM.

2.5 Gear types other than tropical purse seine and longline

CMM 2008-01 requires CCMs to "ensure that the total capacity of their respective other commercial tuna fisheries for bigeye and yellowfin tuna, including purse seining that occurs north of 20^{o}N or south of 20^{o}S, but excluding artisanal fisheries and those taking less than 2,000 tonnes of bigeye and yellowfin, shall not exceed the average level for the period 2001-2004 or 2004." (paragraph 39). The reference to "fishing capacity" as the limited quantity makes monitoring of the measure difficult, as the term is not defined for the purpose of this CMM (although there is reference to fishing effort) and data are not comprehensively provided. In the absence of specific data on fishing capacity or fishing effort for most of these fisheries, catch has been used as a proxy. WCPFC8-2011-21.Rev.2, reports bigeye tuna catches by gears other than longline and tropical purse seine in Attachment 1 Table 4, and similarly for yellowfin in Attachment 1 Table 5. In summary, the average bigeye catch for 2001-2004 was 12,817 tonnes, while the provisional catch for 2010 is 7,638 tonnes. For yellowfin, the average catch in 2001-2004 was 101,264 tonnes, while the provisional catch for 2010 is 90,687. Therefore, for both species, 2010 catches are less than their respective average levels for 2001-2004.

3 Effectiveness of the measure

3.1 Introduction

In this section of the paper, we present a series of stock projections for bigeye, yellowfin and skipjack tuna, to inform discussions regarding the effectiveness of CMM 2008-01, and how the stocks and catches might respond to strengthened measures. This work was presented at TCC7 WCPFC-TCC7-2011-31, and is reproduced here for convenience, along with follow-up work requested through the WCPFC Chair by the Delegation of the United States. The projections comprised a set of 'generic' projections of various combinations of catch and effort in the purse seine, longline, domestic Indonesian and Philippines and other fisheries. The full results of the projections are posted as Excel files next to this paper on the WCPFC8 web page. Using this set of projections, we (1) compared the results of continuing the 2009 and 2010 fishing conditions, as have been reported by CCMs; (2) compared the outcomes resulting from FAD and total purse seine closures; and (3) evaluated the impact of exemptions on the performance of the CMM.

3.2 Methodology

Similar assumptions were made in the current projections as in previous analyses (e.g. WCPFC7-2010-15). The main assumptions were:

- The reference case models from the 2011 bigeye (WCPFC-SC7-2011-SA-WP-02) yellowfin (WCPFC-SC7-2011-SA-WP-03) and skipjack (WCPFC-SC7-2011-SA-WP-04) stock assessments were used - these models were those adopted by SC7 for the provision of management advice in 2011;
- The projections were deterministic in that no process or estimation error was assumed;
- The projections were run for ten years after the full implementation of CMM2008-01, i.e. from 2012-2021;
- Two sets of results were generated for two hypotheses regarding future recruitment: (1) recruitment was assumed to occur at the average of the level estimated over the period 2000-2009, as recommended by SC6; and (2) recruitment was assumed to occur according to the stock-recruitment relationship estimated/assumed in the reference case assessments. There are separate spreadsheets available for each of these recruitment hypotheses. In this paper, we refer only to the first hypothesis (recent average recruitment).
- 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.

The projections started from the beginning of 2012, after the final year of reductions in fishing impact under CMM2008-01, allowing the investigation of management options following on from the CMM's implementation. It was assumed that the levels of catch and effort reported in 2010 would continue through to 2011. This assumption impacts the short-term post-2010 projections of biomass and catches, but does not significantly impact the main performance measures, which are the equilibrium outcomes at the end of the projection period.

A "base year" is chosen in order to express the catch and effort values for 2012 - 2021, which make up the particular fishing strategy or management option being projected into the future, in relative terms. These relative catch or effort values are referred to as scalars. Therefore, a scalar of 1.0

would mean a catch or effort level for a particular fishery group equivalent to that which occurred in 2009. We chose 2009 as the base year rather than 2010 (as recommended by SC7) for several reasons: a) at the time the projections were undertaken, there was considerable uncertainty in reported longline catches for 2010, and final estimates were not available for some key fleets (subsequently provided by China); b) the proportion of total purse seine effort that was based on FADs was abnormally low in 2010 and there is uncertainty as to whether this change in behaviour will persist into the future; and c) the use of 2009 means that results are more comparable to the previous analysis (WCPFC7-2010-15) which also used 2009 as a base.

We stress that the choice of base year is not critical for the projections, as a wide range of catch/effort levels are explored in the various scenarios. As stated above, the choice of 2009 as the base year simply means that all other catch or effort levels used in the projections are expressed relative to their respective levels in 2009. For example using Table 2 to approximate the 2004 conditions, the scalars would be: longline – 1.2; purse seine associated sets – 1.14; and purse seine unassociated sets – 0.57. These conditions can be approximated by a run from the grid – or by simple linear interpolation.

For each species, catch was used in projections for all longline fisheries and the fisheries in Indonesian and Philippines archipelagic waters, while effort was used for all others. The SC7 request, along with our comments and explanations for deviating from the request, are provided in Appendix 1.

For the generic projections, we applied catch or effort scalars (i.e. multipliers of the 2009 base values) to each of the (grouped) longline fisheries, purse seine fisheries, Indonesia and Philippines domestic fisheries and other fisheries (predominantly non-Indonesian pole-and-line and purse seine fisheries outside of 20°N – 20°S). The application of the catch or effort scalars for the respective fishery groups in all possible combinations resulted in 768 (8x8x2x2x3) projection scenarios for each of bigeye and yellowfin tuna (Table 2), and 96 (8x2x2x3) projection scenarios for skipjack (there are no commercially significant longline fisheries in the skipjack assessment, so this factor is omitted). The actual levels of catch and effort corresponding to the various scalars, and their observed values from 2001 to 2010 are shown in Table 3.

Two scenarios for the application of scalars to purse seine effort were modelled in the projections. In the first (denoted "transfer"), the scalars for the purse seine fishery were applied to the associated set effort, and the effort so removed (added) was added to (subtracted from) the unassociated set effort. This maintained total purse seine effort at a constant level and is intended to mimic the use of FAD closures with complete mobility of effort between set types. In the second scenario (denoted "managed"), the same scalars were applied simultaneously to both the purse seine associated set and unassociated set effort. This was intended to mimic a total purse seine closure measure, or other control on total purse seine effort that maintains the same composition of associated and unassociated sets in the total purse seine effort.

Performance statistics for all projections included F_{2021}/F_{MSY}, estimates of spawning biomass, and catches for different fisheries groups. Because of the use of recent average recruitment in the projections, the historical estimates of SB_{MSY} and SB_0 are no longer valid, especially when there is a considerable difference between the recent average recruitment level and the long-term average level (e.g. in the bigeye tuna assessment). In this circumstance, a depletion estimate ($SB_y/SB_{F=0}$) would be more appropriate and this is included in the spreadsheet columns labelled "SB2021_SBF0".

Also included are the spawning biomass per recruit (SPR) reference points recommended by SC7 at three alternative levels of SPR depletion – 20%, 30% and 40% of unfished levels. These are provided in the spreadsheet columns labelled "spr20", "spr30" and "spr40". The values provided are the ratios of the fishing mortality in 2021 to the fishing mortality that results in reduction of SPR to 20%, 30% and 40% of unfished levels.

3.3 Results and discussion

3.3.1 Projection of 2009 and 2010 conditions

Figure 7, Figure 8 and Figure 9 show the projected values of F/F_{MSY} for bigeye, skipjack and yellowfin, respectively, for the base (2009) conditions and an approximation to 2010 conditions (given by scenario (0.8, 0.7, 1.34, 0.7, 1.2) for bigeye and yellowfin and scenario (1, 0.7, 1.32, 0.7, 1.2) for skipjack. Maintenance of 2009 conditions results in F_{2021}/F_{MSY} of 1.39, 0.50 and 0.74 for bigeye, skipjack and yellowfin tuna respectively. For the scenario approximating 2010 conditions, we obtain F_{2021}/F_{MSY} of 0.97, 0.47 and 0.62 for bigeye, skipjack and yellowfin tuna respectively. This reduction, particularly significant for bigeye tuna, is driven by several factors: the lower than usual FAD use in 2010, the lower longline catches, and a large (30%) reduction in reported catches from the domestic fisheries of Indonesia and the Philippines. Therefore, 2010 as currently reported (see Table 3) provides a good example of the sort of regime that would meet MSY-based reference points as have been applied to date. In addition, under 2010 conditions, F_{2021} for bigeye is projected to be less than the SPR20 and SPR30 reference levels but above the SPR40 level. For skipjack and yellowfin, F_{2021} is well below all of the SPR reference levels.

3.3.2 Total purse seine closure vs. FAD closure

It is of interest to some Delegations to quantify the incremental advantage of a total closure of the purse seine fishery over a FAD closure. We investigated this by comparing the "transfer" and "managed" options for purse seine effort reductions (equivalent to FAD and total closures, respectively), both in terms of their impact on bigeye tuna (F_{2021}/F_{MSY}) and on the total catch of bigeye, skipjack and yellowfin tuna (Table 4 and Figure 10). The results indicate small percentage reductions in bigeye tuna F_{2021}/F_{MSY} by applying a total closure instead of a FAD closure. For example, for a 6 month closure, F_{2021}/F_{MSY} is 0.98 for a FAD closure and 0.88 for a total closure, representing an additional 10.3% reduction in F_{2021}/F_{MSY} of a 6 month total closure over a 6 month FAD closure. However, the additional reduction in total catch of a 6 month total closure is 22.2%. This is because, with a FAD closure, purse seiners can continue to fish on unassociated tuna schools, whereas with a total closure, the catch during the closure is zero. Interestingly, the projections predict that total catch is quite stable (and in fact increases slightly) for increasing duration of FAD closure. This is because of the higher yield-per-recruit that is achieved for all species resulting from the larger average size of tuna taken in unassociated sets compared to FAD sets (WCPFC-SC7-2011-MI-WP-01). On the other hand, total catch drops sharply for increasing total closure duration. Therefore, it can be concluded that a total closure results in a small additional reduction in bigeye tuna fishing mortality compared to a FAD closure, but the price that must be paid in terms of total catch reduction is relatively large.

Subsequent to TCC7, the WCPFC Chair received a letter (dated 19 October 2011) from the Delegation of the United States requesting that additional work be done to further evaluate the potential benefit of a total purse seine closure – in particular, basing analyses on years when no FAD closure was in place, rather than 2009. In response, we conducted further analyses in which the purse seine fishing conditions in 2001-2008 (see Table 3) were used as the baseline for evaluating the relative impact of FAD and total closures of two and three month duration on bigeye fishing mortality and total tuna catches. Eight sets of projections were run – each using the pattern of FAD and unassociated purse seine effort that existed in each individual year of the period 2001-2008 – which therefore allows an assessment of the variation in the estimated impacts. For the FAD closure, the FAD fishery effort was transferred to the unassociated set fishery; for the total closures the effort of both FAD and unassociated purse seine setting was removed. Affected effort was 2/12 and 3/12 of the base effort for the two and three month closures respectively. Scalars for the non-purse seine gears were set to 1 so as to allow a direct comparison of the impacts of the closures in isolation. A total of 40 projections were run for each species – 8 years x 5 simulations per year (no closures, 2 and 3 month FAD closures, 2 and 3 month total closures).

Table 5 provides the estimates of bigeye tuna fishing mortality and species-specific catches as predicted for the year 2021 and Figure 11 provides a graphical summary of the relative performance for bigeye fishing mortality and total catch. Figure 12 and Figure 13 provide species-specific estimates of fishing mortality and catches, respectively, under the various closure regimes. This new set of projections using years 2001-2008 as the base provides a similar conclusion to the original analysis presented to TCC7, i.e., that total purse seine closures provide a small additional reduction in bigeye tuna F/F_{MSY} compared to FAD closures, but they also result in a proportionately greater reduction in total catches.

3.3.3 Effect of exemptions

In a previous analysis (WCPFC7-2010-15) we attempted to quantify the impact of the exemptions on the performance of CMM 2008-01. In this analysis, it was argued that scalars of 1.0 for longline catch, 1.0 for purse seine effort and 0.9 for the fisheries based in Indonesia and Philippines were consistent with CMM 2008-01 as written. Further, a hypothetical "no exemptions" set of scalars was estimated to be 0.9, 0.9 and 0.8, respectively for the above three fishery groups. The rationale for these choices is described in detail in WCPFC7-2010-15. Using these scalars in the current analysis (and retaining a scalar of 1.0 for other fisheries in both scenarios), we obtain the results as shown in Table 6. The removal of the exemptions is estimated to potentially remove approximately 50% of the overfishing estimated to occur under CMM 2008-01 (i.e. reducing F_{2021}/F_{MSY} from 1.35 to 1.17). This is a similar result to that obtained in WCPFC7-2010-15.

3.3.4 Individual fishery impacts under CMM 2008-01

At TCC7, the Delegation of Japan requested that the impacts of the different fishery reductions (or increases) that have occurred under CMM 2008-01 be quantified separately. This was done as follows:

- Estimate F_{2021}/F_{MSY} if the observed fishery catch and effort conditions in 2004 occurred for 10 years, from 2012. This is used as a base for comparison.
- Compute the F_{2021}/F_{MSY} that would have occurred under the 2004 baseline but with the following changes, implemented separately:
    - Longline catch in 2009
    - Longline catch in 2010
    - Purse seine effort in 2009 (incorporating FAD closure)

    - Purse seine effort in 2010 (incorporating FAD closure)
    - Domestic Indonesia and Philippines catch in 2009
    - Domestic Indonesia and Philippines catch in 2010
- The percentage of overfishing removed from the 2004 base F_{2021}/F_{MSY} obtained in each of the above scenarios indicates the separate contribution to overfishing reduction of the 2009 and 2010 conditions reported for each of the three main fishery components.

This analysis was conducted at TCC7 by interpolating the required catch and effort scalars in the suite of projections. This is an approximation, and so the analysis was subsequently repeated post-TCC7 with specific projections for each of the scenarios required. The results are given in Table 7. They vary only slightly from the approximation distributed at TCC7. They indicate that the reduction in purse seine FAD effort in 2010 has the greatest effect in terms of removing overfishing (67.4% of overfishing removed) followed by the reduction in longline catch in 2010 (34.7% of the overfishing removed).

4 References

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Table 1. Summary statistics for various vessel behaviours documented by observers during the CMM 2008-01 FAD Closures in 2009 (1 Aug – 30 Sep) and 2010 (1 Jul – 30 Sep). Archipelagic waters, which are outside the scope of CMM 2008-01, are not included in the summary statistics. Based on processed observer data available as at 10 Nov 2011.

	2009 (Aug – Sep)	2010 (Jul – Sep)
Number of observer trips processed to date	156	264
Number of observed fishing and searching days processed to date (Coverage rate)	3,073 (43.4%)	4,917 (47.3%)
Number of observed sets processed to date (Coverage rate)	3,158 (45.6%)	6,032 (49.4%)
Number of nights drifting with fish aggregation lights (activity = 14) (% of total)	69 (2.2%)	303 (6.2%)
Number of days setting or investigating Drifting FADs (SCH_ID = 4) (% of total)	122 (4.0%)	135 (2.7%)
Number of days reported as "No fishing, drifting with floating object" (Activity = 12) (% of total)	171 (5.6%)	108 (2.2%)
Number of days reported with any activity related to a drifting FAD (Activity = 9,10,12,23,24,25,26) (% of total)	430 (14.0%)	286 (5.8%)

Table 2. Combinations of catch and effort used for fishery groups modelled in the generic projections.

Factor	Options	Dimensions
Longline catch	1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.6, and 0.5 times **2009** catches	8
Purse seine FAD effort 20N - 20S	1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.6, and 0.5 times **2009** effort	8
Purse seine UNA effort 20N - 20S	Identical reduction as for FAD effort and perfect reallocation of FAD effort changes	2
Indonesia & Philippines domestic fisheries	1 and 0.7 times **2009** catch	2
Other fisheries (Pole and line, and purse seine outside 20N - 20S)	1.2, 1.0, and 0.8 times **2009** effort	3
TOTAL RUNS		768

Table 3. Catch and effort levels of projected fishery groups associated with the various scalars. The two columns for purse seine unassociated (PS UNA) effort refer to the alternative projection scenarios: 1. ASS effort changes are transferred to UNA effort, thus maintaining total PS effort at a constant level (transfer); and 2. The same scalars are simultaneously applied to both PS ASS and PS UNA effort (managed). The observed values of catch and effort for the projected fishery groups for 2001-2010 are provided in the lower panel. Note that catches are reported for 'Other' fisheries to indicate their relative contribution to the overall fishery; in the projections, effort was specified rather than catch.

Scalar/ Year	Longline catch (mt)		PS ASS effort (days)	PS UNA effort (transfer) (days)	PS UNA effort (managed) (days)	Indonesia-Philippines catch (mt)			Other catch (mt)		
	Bigeye	Yellowfin				Bigeye	Yellowfin	Skipjack	Bigeye	Yellowfin	Skipjack
1.2	80,200	92,674	30,646	17,405	27,016				2,046	7,236	103,466
1.1	73,516	84,951	28,092	19,959	24,764						
1.0	66,833	77,228	25,538	22,513	22,513	17,777	142,085	392,295	1,705	6,030	86,222
0.9	60,150	69,505	22,984	25,067	20,262						
0.8	53,466	61,782	20,430	27,621	18,010				1,364	4,824	68,978
0.7	46,783	54,060	17,877	30,174	15,759	12,444	99,460	274,606			
0.6	40,100	46,337	15,323	32,728	13,508						
0.5	33,417	38,614	12,769	35,282	11,257						
2001	62,080	66,717	15,714	17,501		15,842	139,692	256,630	2,326	5,307	187,817
2002	79,267	69,526	18,633	17,875		13,550	140,803	275,630	2,992	5,199	175,217
2003	71,488	74,748	20,292	18,829		14,907	154,612	284,983	2,302	6,118	225,645
2004	80,193	75,300	29,177	12,932		15,385	158,754	297,347	4,161	5,162	142,558
2005	66,213	66,893	23,087	20,299		18,552	175,458	297,568	1,788	6,491	195,976
2006	70,819	62,677	24,208	16,628		19,272	170,310	350,973	4,849	6,369	158,185
2007	69,872	58,915	21,870	20,924		14,791	186,763	368,893	3,767	4,391	152,345
2008	73,314	60,526	23,332	22,749		17,866	180,175	396,051	1,845	7,203	140,778
2009	66,833	77,228	25,538	22,513		17,777	142,085	392,295	1,705	6,030	86,222
2010	55,420	78,313	17,415	33,739		11,897	112,569	324,661	2,432	4,119	109,596

Table 4. Effect on F_{2021}/F_{MSY} and total catch of FAD only and total purse seine closures of different durations. The columns labelled "Increment (%)" provide the percentage change of a total closure over a FAD closure. Catch levels for the longline, Indonesia-Philippines and other fisheries were held at the base level (scalar = 1.0).

Scalar	Closure duration (months additional to 2009 closure)	Bigeye F_{2021}/F_{MSY}			Total catch (mt)		
		FAD closure	Total closure	Increment (%)	FAD closure	Total closure	Increment (%)
1.0	-	1.39	1.39	-	2,357,314	2,357,314	-
0.9	1.2	1.31	1.29	-1.4	2,366,335	2,284,568	-3.5
0.8	2.4	1.23	1.19	-3.1	2,375,026	2,201,002	-7.3
0.7	3.6	1.14	1.09	-5.1	2,383,381	2,104,842	-11.7
0.6	4.8	1.06	0.98	-7.5	2,391,384	1,993,985	-16.6
0.5	6.0	0.98	0.88	-10.3	2,399,029	1,865,933	-22.2

Table 5. Simulations of the predicted impact of two and three month FAD and total purse seine closures based on the conditions in each year from 2001-08.

TYPE	Base year	BET-F/FMSY	BET catch	YFT catch	SKJ catch	TOTAL catch
Base	2001	1.01	132,337	479,480	1,495,448	2,107,265
FAD2	2001	0.93	130,668	487,402	1,505,252	2,123,322
TOTAL2	2001	0.9	128,716	452,846	1,394,831	1,976,393
FAD3	2001	0.88	129,641	491,228	1,509,469	2,130,338
TOTAL3	2001	0.85	126,426	437,602	1,337,343	1,901,371
Base	2002	1.12	134,540	489,593	1,544,446	2,168,580
FAD2	2002	1.02	133,186	498,418	1,554,296	2,185,900
TOTAL2	2002	1	131,404	463,156	1,442,357	2,036,917
FAD3	2002	0.97	132,306	502,839	1,559,094	2,194,239
TOTAL3	2002	0.93	129,302	447,820	1,383,780	1,960,902
Base	2003	1.19	135,577	498,554	1,582,184	2,216,315
FAD2	2003	1.08	134,508	507,923	1,592,219	2,234,650
TOTAL2	2003	1.05	132,813	472,332	1,479,702	2,084,847
FAD3	2003	1.02	133,757	512,597	1,597,086	2,243,440
TOTAL3	2003	0.98	130,865	457,059	1,420,990	2,008,914
Base	2004	1.49	136,184	489,447	1,602,399	2,228,030
FAD2	2004	1.33	136,557	502,283	1,616,446	2,255,286
TOTAL2	2004	1.31	135,546	465,293	1,499,316	2,100,155
FAD3	2004	1.25	136,391	508,726	1,623,192	2,268,309
TOTAL3	2004	1.21	134,485	450,960	1,439,943	2,025,388
Base	2005	1.3	136,695	511,488	1,638,642	2,286,825
FAD2	2005	1.17	136,170	521,547	1,648,428	2,306,145
TOTAL2	2005	1.14	134,654	485,847	1,535,957	2,156,458
FAD3	2005	1.11	135,656	526,583	1,653,170	2,315,409
TOTAL3	2005	1.06	132,999	470,719	1,476,930	2,080,648
Base	2006	1.32	136,383	496,526	1,597,700	2,230,609
FAD2	2006	1.19	135,882	507,345	1,609,155	2,252,382
TOTAL2	2006	1.16	134,495	471,073	1,494,465	2,100,033
FAD3	2006	1.12	135,350	512,724	1,614,532	2,262,606
TOTAL3	2006	1.08	132,902	456,280	1,435,650	2,024,832
Base	2007	1.25	136,498	511,893	1,633,024	2,281,416
FAD2	2007	1.13	135,800	521,556	1,642,715	2,300,071
TOTAL2	2007	1.11	134,194	486,196	1,531,360	2,151,750
FAD3	2007	1.07	135,202	526,368	1,647,137	2,308,707
TOTAL3	2007	1.03	132,402	470,787	1,471,808	2,074,997
Base	2008	1.31	137,081	522,482	1,674,772	2,334,335
FAD2	2008	1.19	136,722	532,380	1,683,682	2,352,784
TOTAL2	2008	1.16	135,204	497,223	1,573,050	2,205,477
FAD3	2008	1.12	136,298	537,433	1,688,287	2,362,018
TOTAL3	2008	1.08	133,610	482,049	1,513,967	2,129,626

Table 6. Approximate scalars of catch and effort that are estimated to reflect the requirements of CMM 2008-01 as written, and CMM 2008-01 without exemptions. The last row of the table indicates the estimated F_{2021}/F_{MSY} resulting from the application of the catch and effort levels represented by these scalars.

Fishery group	CMM 2008-01	No exemptions
Scalars		
Longline	1.0	0.9
Purse seine	1.0	0.9
Indonesia and Philippines domestic	0.9	0.8
Other fisheries	1.0	1.0
Bigeye F_{2021}/F_{MSY}	1.35	1.17

Table 7. Percentages of overfishing removed from the 2004 base for individual changes in catch and effort of various fishery groups that have occurred under CMM 2008-01.

Catch/Effort Conditions	F/F_{MSY}	% of 2004 overfishing removed
2004 (base)	1.57	-
LL 2009, rest 2004	1.46	19.1
LL 2010, rest 2004	1.37	34.7
PS 2009, rest 2004	1.46	18.8
PS 2010, rest 2004	1.19	67.4
PH/ID 2009, rest 2004	1.65	-13.5
PH/ID 2010, rest 2004	1.47	17.2
Combined effects – 2009	1.39	31.6
Combined effects – 2010	0.97	105.3

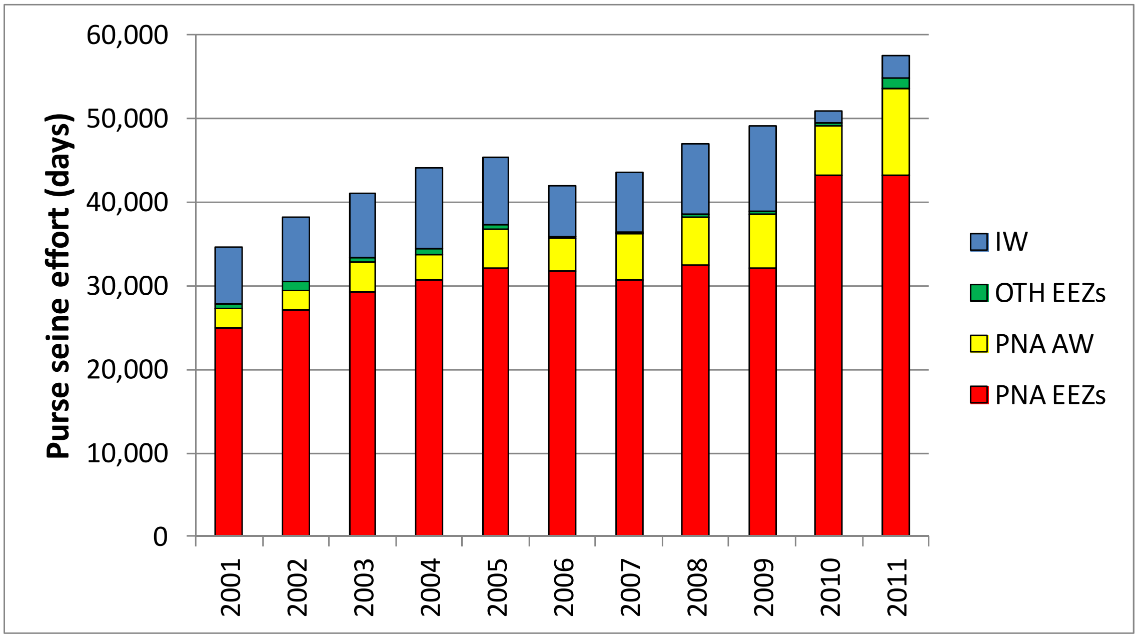

Figure 1. Purse seine effort (days fishing and searching) in the WCPFC Convention Area between 20^{o}N and 20^{o}S, excluding domestic purse seine effort in Philippines and Indonesia. 2001 – 2010 estimates are based on raised logsheet data. The 2011 estimate is provisional and is based on VMS data adjusted to represent fishing days.

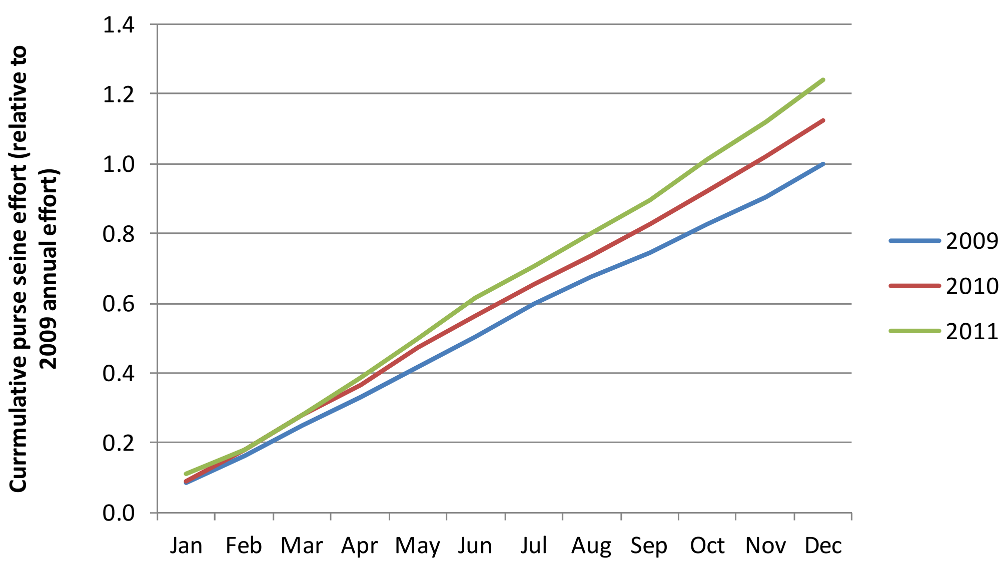

Figure 2. Cumulative VMS days at sea in 2009, 2010 and 2011 for the WCPFC Convention Area between 20^{o}N and 20^{o}S. Source: composite VMS data (WCPFC and FFA) excluding days in port. Fleets not covered by VMS (e.g. the domestic purse seine fleets of Philippines and Indonesia) or not providing VMS data to either of the FFA or WCPFC systems are not included.

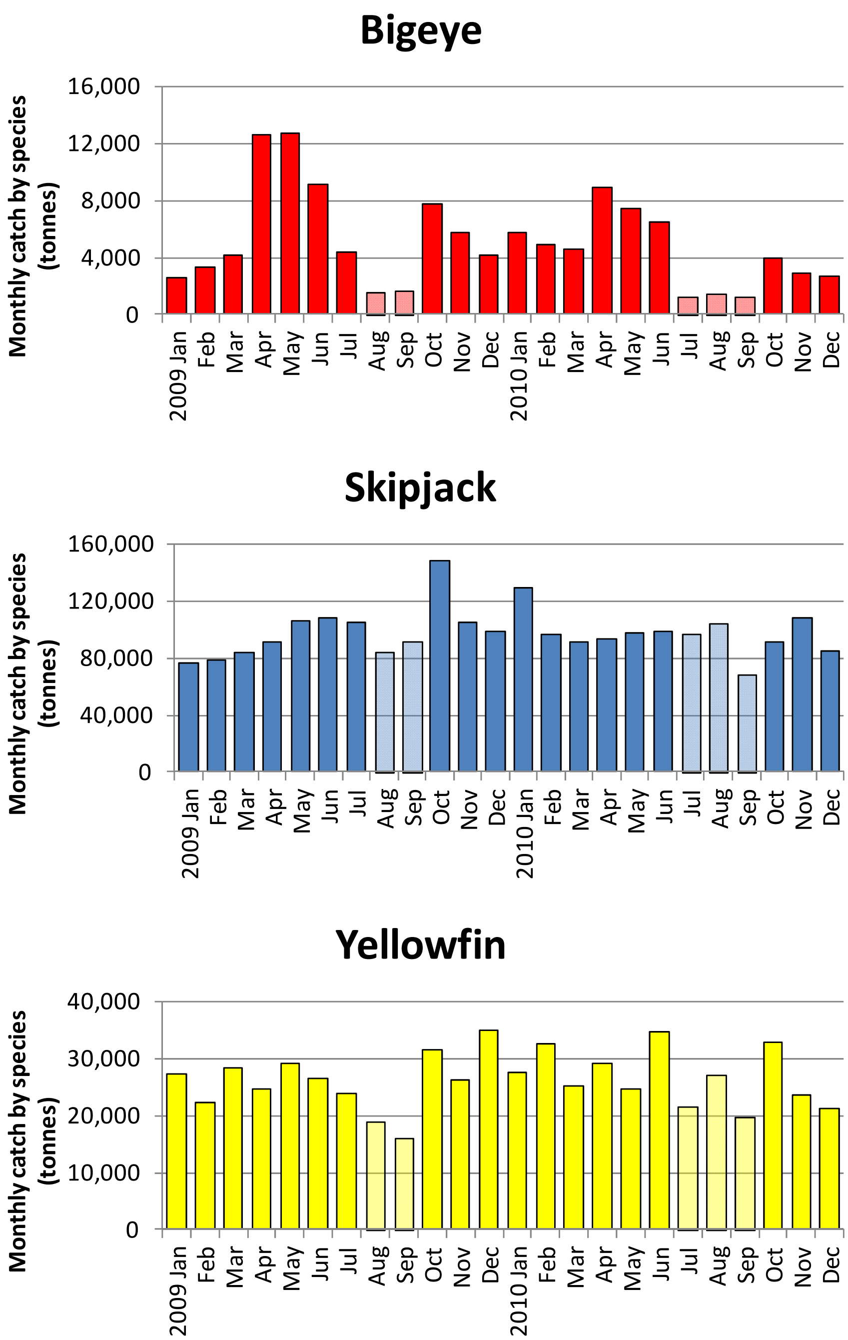

Figure 3. Monthly catch by species (raised logsheet data with species composition adjusted using observer sampling with grab sample bias correction). FAD closure months are shaded in lighter colour. Data excludes the domestic fisheries of Indonesia and Philippines.

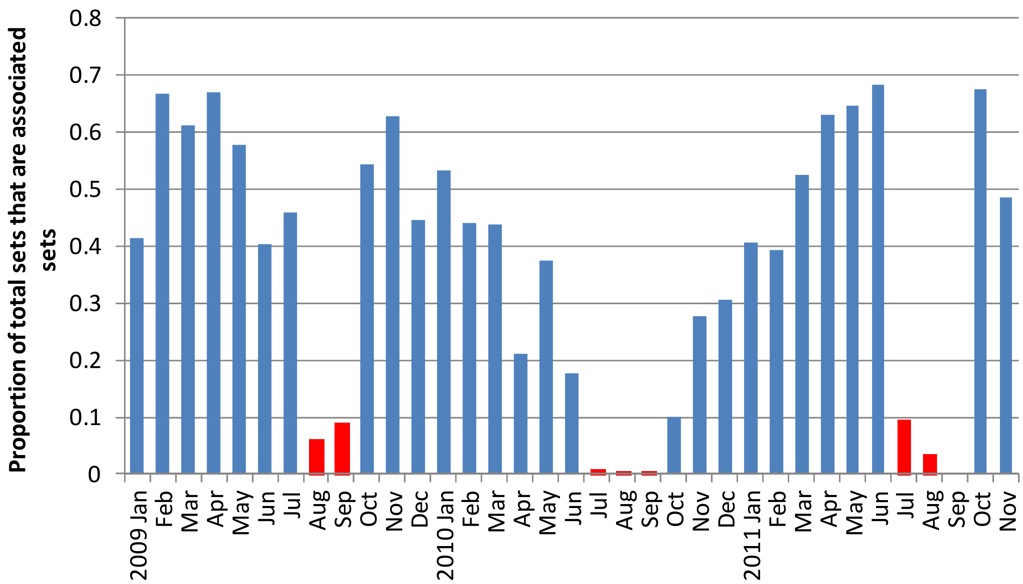

Figure 4. Proportion of the total purse seine fishing activity comprising associated sets, as indicated by logsheet data. Red bars indicate the FAD closure months. Activities in archipelagic waters and in the domestic purse seine fisheries of Indonesia and Philippines are excluded. Estimates from July 2011 on are based on low logsheet coverage and are therefore provisional.

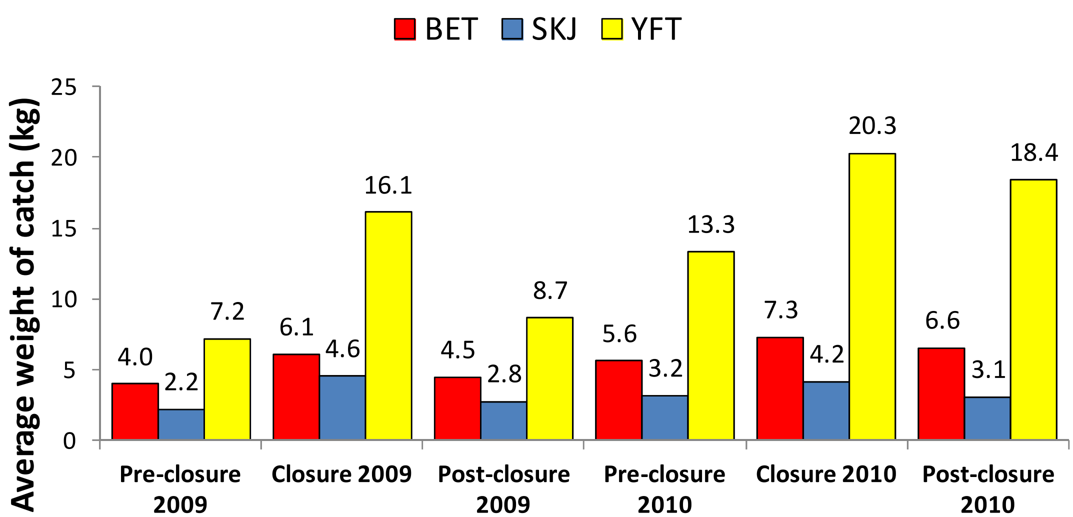

Figure 5. Average weight of bigeye, skipjack and yellowfin tuna, estimated from observer sampling data, during 2009 and 2010.

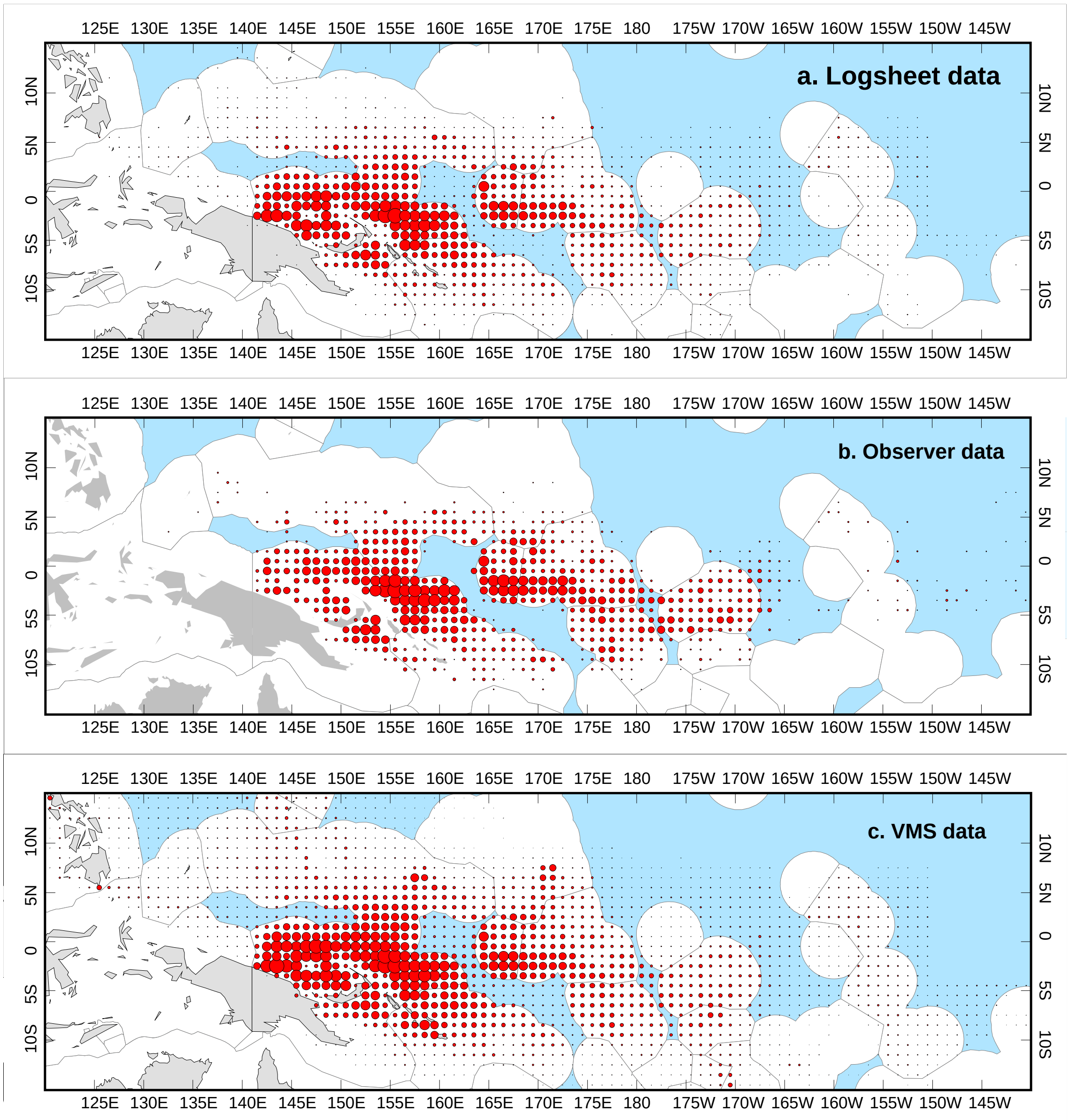

Figure 6. Distribution of purse seine effort (days) since 1 January 2010 from a. logsheet data, b. observer data, and c. VMS data.

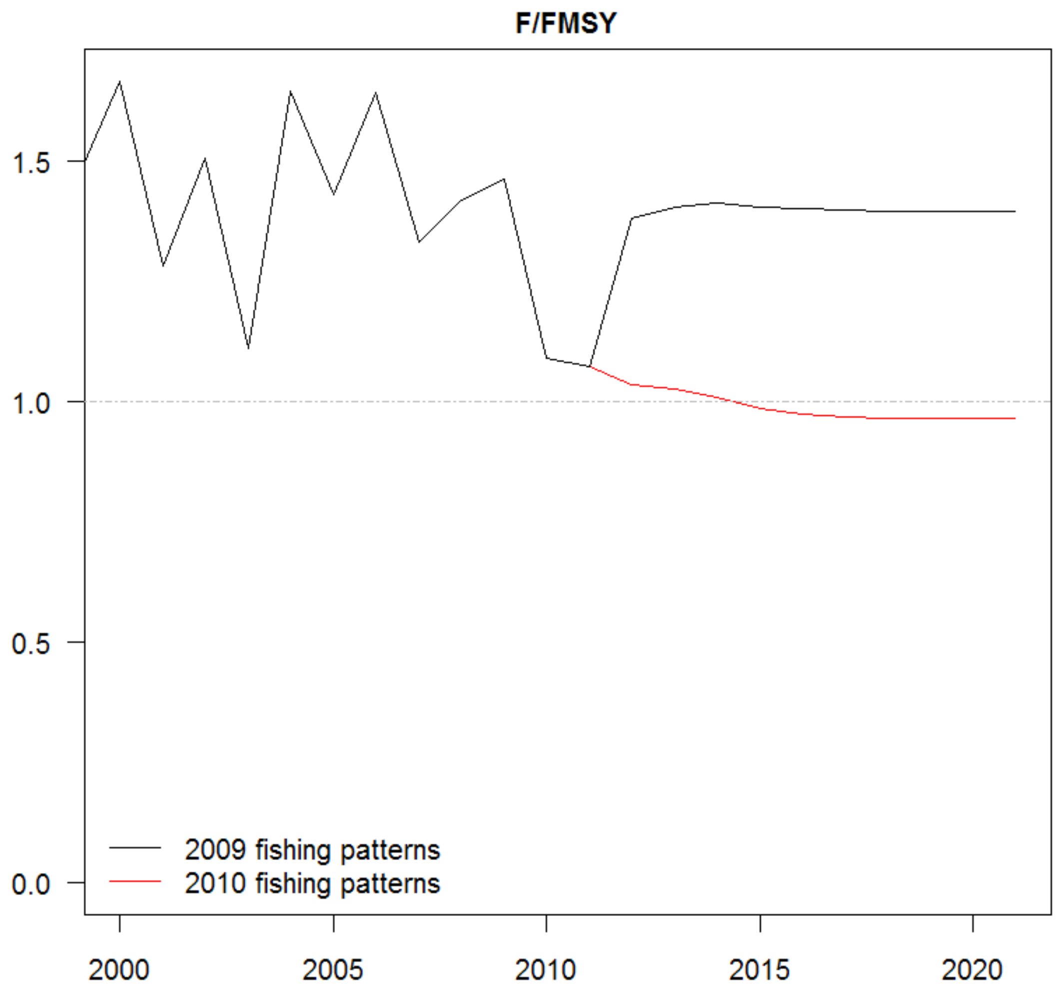

Figure 7. Recent historical and projected F/F_{MSY}, for BIGEYE tuna under the 2009 and 2010 fishing patterns, assuming that future recruitment is constant at its average 2000-2009 level.

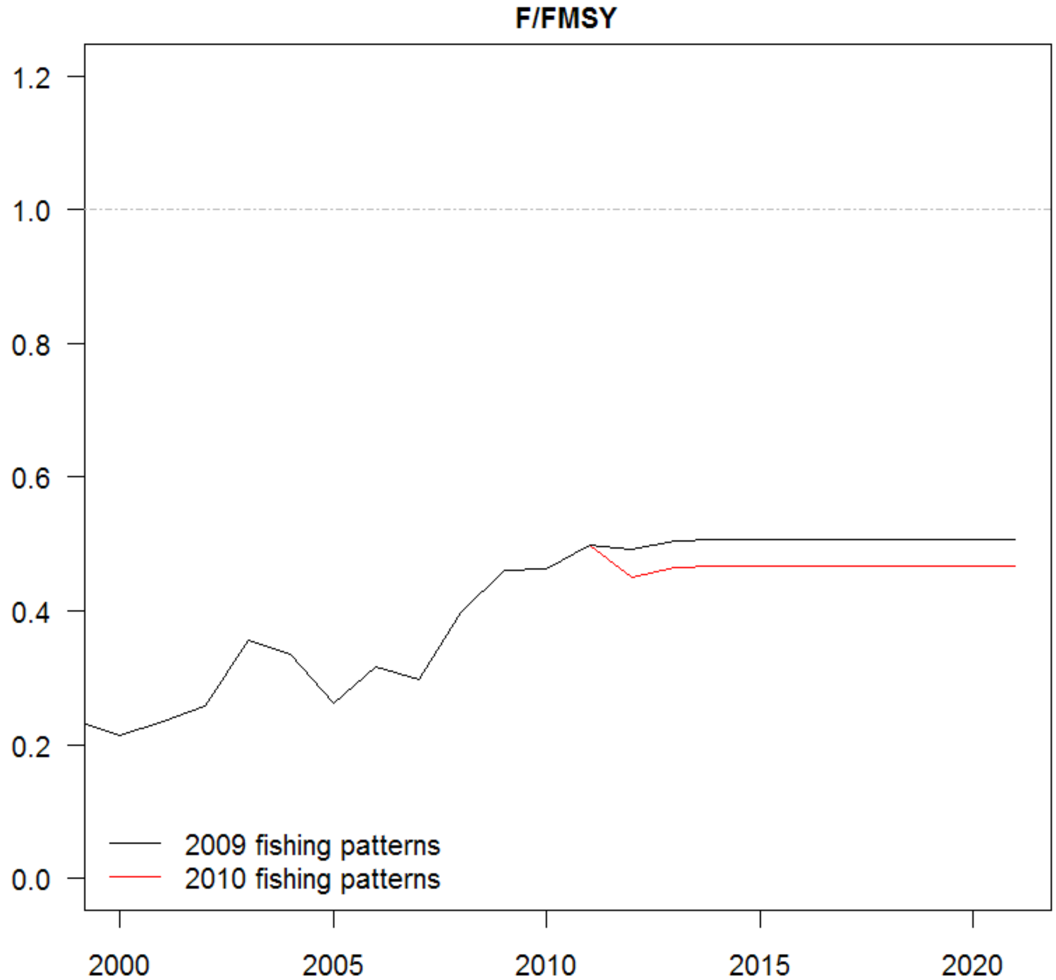

Figure 8. Recent historical and projected F/F_{MSY}, for SKIPJACK tuna under the 2009 and 2010 fishing patterns, assuming that future recruitment is constant at its average 2000-2009 level.

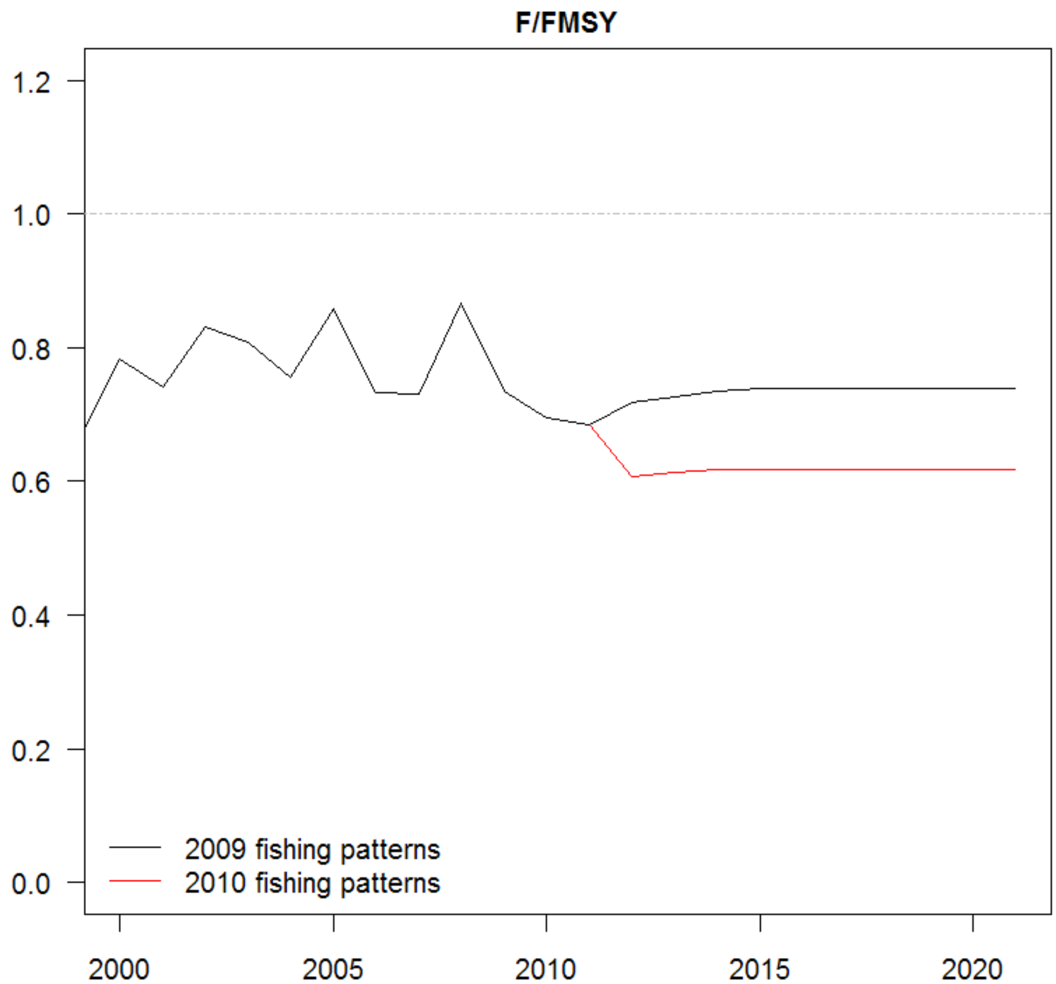

Figure 9. Recent historical and projected F/F_{MSY}, for YELLOWFIN tuna under the 2009 and 2010 fishing patterns, assuming that future recruitment is constant at its average 2000-2009 level.

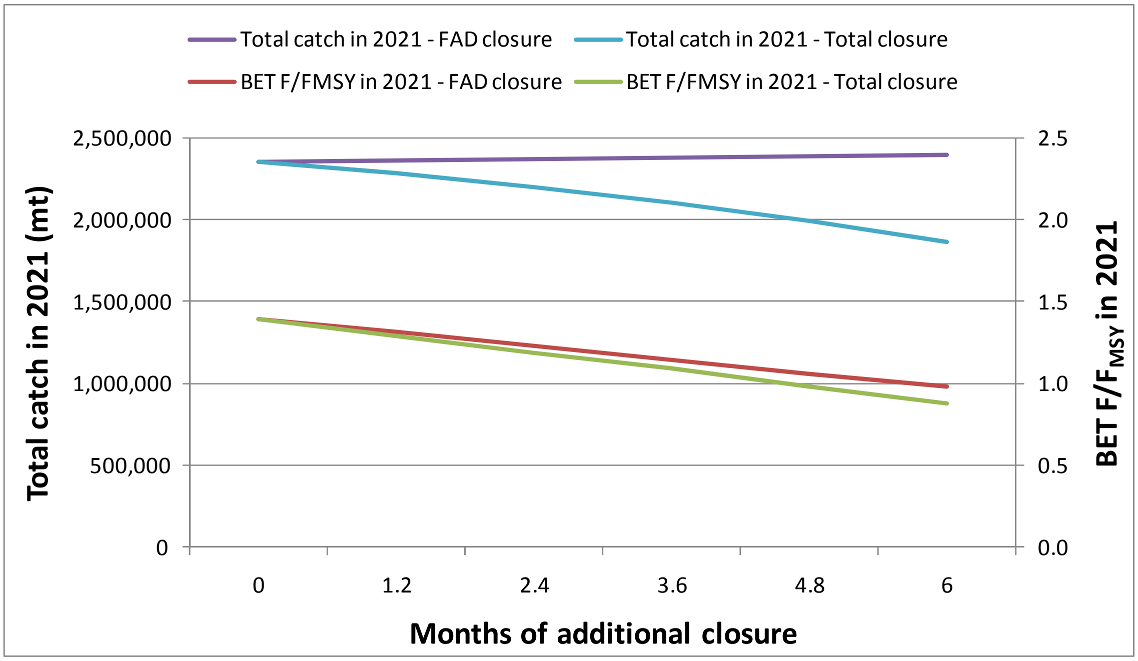

Figure 10. Change in predicted bigeye tuna fishing mortality and total tuna catches of FAD and total purse seine closures of increasing duration compared to the base year of 2009.

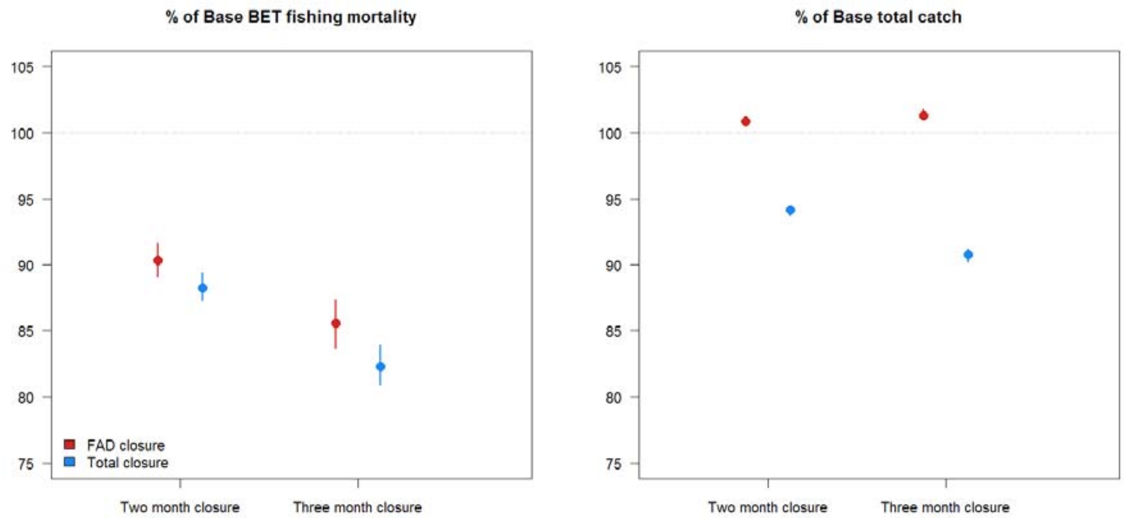

Figure 11. Relative change in predicted bigeye tuna fishing mortality and total tuna catches of two and three month FAD (red points) and total (blue points) purse seine closures based on the conditions in each year from 2001-2008. The points represent the mean change across the eight simulations and the extents of the bars represent their ranges.

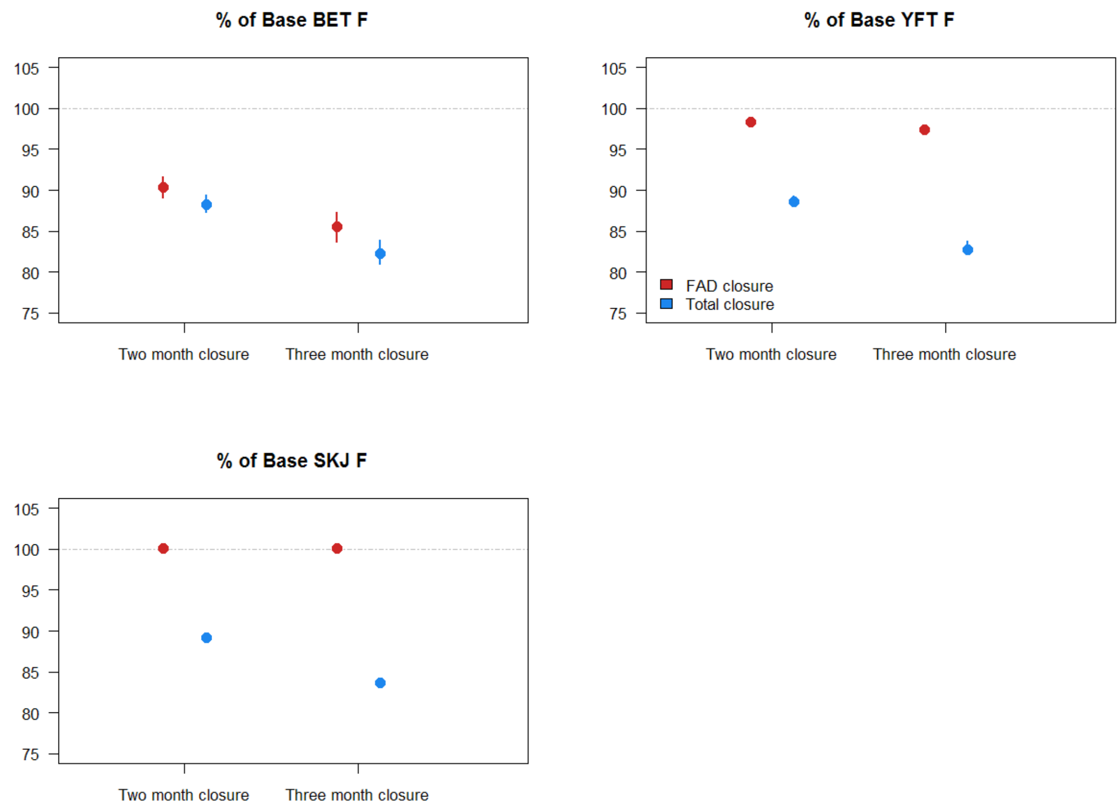

Figure 12. Relative change in predicted fishing mortality for bigeye, yellowfin, and skipjack tunas of two and three month FAD (red points) and total (blue points) purse seine closures based on the conditions in each year from 2001-2008. The points represent the mean change across the eight simulations and the extents of the bars represent their ranges.

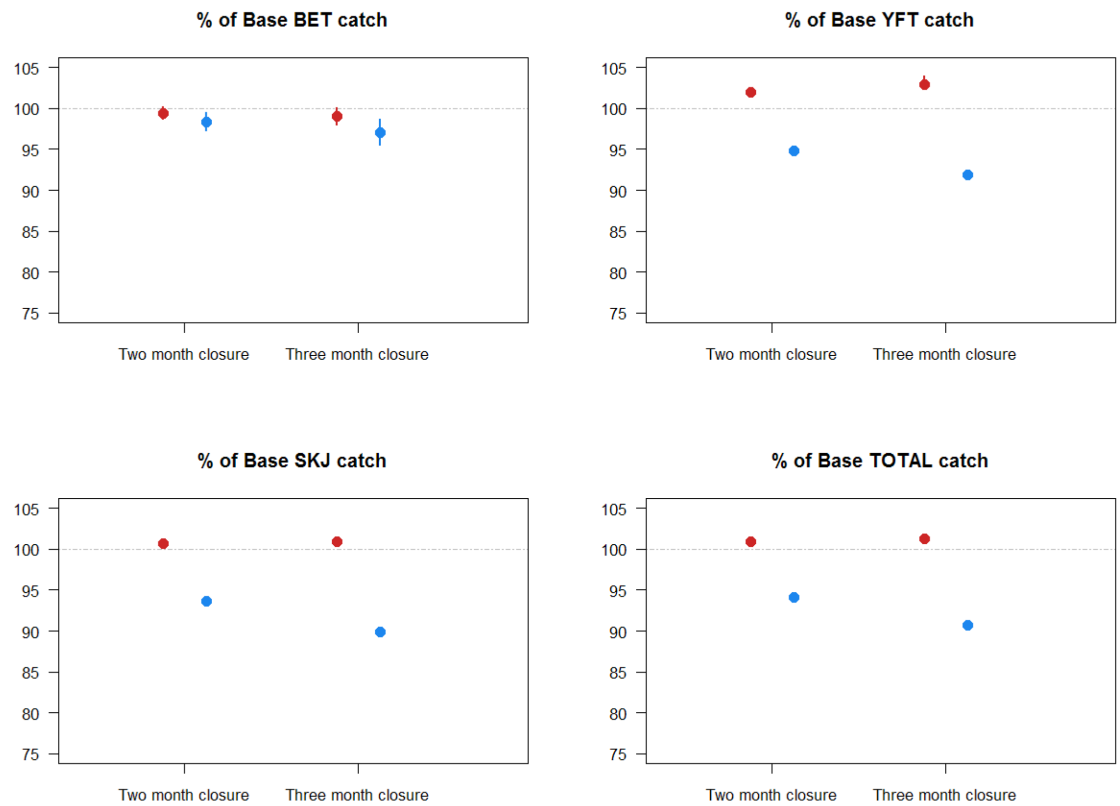

Figure 13. Relative change in predicted catches for bigeye, yellowfin, and skipjack tunas of two and three month FAD (red points) and total (blue points) purse seine closures based on the conditions in each year from 2001-2008. The points represent the mean change across the eight simulations and the extents of the bars represent their ranges.

APPENDIX 1. Comments on the SC7 Projections Request

The request from SC7 for analyses to be presented to TCC7 and WCPFC8 was summarized in paragraph 365 of the SC7 report. Recognizing that some scenarios can be approximated by either specific sets of scalars or through linear interpolation and some are redundant, some minor changes were made and are described in the comments section of the table. We are currently enhancing the implementation of stochastic projections in MULTIFAN-CL in order to account for the reference points requested by SC7 and alternative recruitment assumption – these analyses are now scheduled for completion for the 2012 Management Objectives Workshop.

Factor	Options	Dimensions	Comments
Model runs	Base case model	1	Done
Species	BET, SKJ, YFT	3	Done
Recruitment	Recent average and SRR	2	Done. The SRR results are not referred in the paper
Longline catch	1.2, 1.1, 1.0, 0.9, 0.8 times 2010 catches	5	Used 2009 catches as the base and 8 scalars to give a wider range (0.5 – 1.2; by 0.1) to better account for the wide range of catches observed over the past ten years. Longline variations were not required for skipjack.
Purse seine total effort (excl. ID/PH ex-APW)	2009 (low); 2010 (high)	2	We used 2009 effort levels of total effort with a wider range of scalars (0.5 – 1.2; by 0.1). FAD effort was either transferred to UNA effort (to simulate a FAD closure) or UNA effort had the same scalar applied (to simulate a total closure). 2010 FAD effort is consistent with a scalar of 0.7.
FAD/UNA set effort split (outside FAD closure)	2009 (high FAD use); 2010 (low FAD use)	2	
Purse seine FAD effort (including ID/PH ex-APW)	1.2, 1.1, 1.0, 0.9, 0.8, times total effort (with redistribution)	5	
ID/PH APW fisheries	2009 and 2010 catch	2	Done. We used 2009 catches with scalars of 1 and 0.7 – the latter approximated 2010 catches.
Other fisheries (e.g. Pole and line and JP coastal PS)	1.2, 1.1, 1.0, 0.9, 0.8 times 2010 effort	5	Only three scalars were used that covered the initial range. Initial projections results were relatively insensitive so only scalars of 1.2, 1.0, and 0.8 were used. 2009 was used as the base.