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REVIEW OF THE IMPLEMENTATION AND EFFECTIVENESS OF KEY MANAGEMENT MEASURES FOR TROPICAL TUNA

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Review of the Implementation and Effectiveness of Key management Measures for Tropical Tuna

Executive Summary

The paper provides a review of the implementation and effectiveness of key management measures for tropical tuna, using the most current data and stock assessments available. For the most part, these measures relate to CMM 2008-01, although where possible, consideration is given to elements of that CMM that have been continued in 2012, pending the development of a comprehensive replacement tropical tuna CMM scheduled for WCPFC9 in December 2012.

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 continuously since the introduction of CMM 2008-01, with effort (excluding domestic purse seiners based in Indonesia and Philippines) in 2011 estimated to have increased by approximately 31% compared to effort in 2004. Further, stock assessment results indicate that the effectiveness of the effort has typically increased on top of the increase in total effort.

FAD closure and FAD usage

The incidence of reported activity related to use of drifting FADs during the FAD closures was considerably lower in 2010 and 2011 (6.0 and 8.2%) compared to 2009 (16.1%). However, the observed incidence of vessels drifting at night with fish aggregation lights on increased from 2.3% in 2009 to 6.8% in 2010 and 3.4% in 2011. Effort remained at around normal levels throughout the closures. In 2010, the proportions of effort associated with FAD usage outside the closure period, particularly the months immediately before and after the closure, were lower than is typically the case. In 2011, overall FAD usage returned to more typical levels prior to the 2011 closure. It is evident that several fleets (notably Japan, Philippines, New Zealand) have substantially changed their fishing operations, focusing more on unassociated set fishing in 2010 and 2011 than they had in the past, but it is not known if this is a deliberate strategy or rather a response to the availability of surface schools. In spite of this, the total estimated number of FAD sets made in 2011 was a record high, largely due to increased purse seine effort overall.

Skipjack, yellowfin and total catches were slightly below average during the 2009 and 2010 closures. Sustained high total catches (particularly skipjack and bigeye) occurred between the 2010 and 2011 closures; however total (and skipjack) catches during the 2011 closure were very depressed. Catches recovered somewhat following the 2011 closure, but did not reach the levels experienced earlier in the year. The catches of bigeye tuna were strongly reduced during closure periods compared to the

other months of those years. While catches were reduced during the closures, the average size of the fish in the catch was generally higher for all species 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 began in Q1 2010 continuing to push purse seine effort to the west. Effort in this area could increase with the predicted return of ENSO-neutral or *El Niño* conditions.

Longline catches

The total average bigeye longline catch for 2001-2004 was 83,879 tonnes. In 2010, the bigeye catch was 66,336 tonnes, approximately 79% of the average catch for 2001-2004. In 2011, reported catch fell slightly to 64,175 tonnes, or 76% of the 2001-2004 level. For some flag states, current catches are lower than their limits and therefore there is scope for increased longline catches within existing management arrangements.

The effectiveness of bigeye catch reductions in reducing fishing mortality depends on whether the reductions occurred because of reduced fishing effort (which would imply reduced fishing mortality) or were simply the result of further declines in the bigeye stock. In the core area of the tropical longline fishery, the reduced catches have been paralleled by a decline in CPUE, which indicate that the recent catch declines could be more the result of further declines in adult bigeye tuna abundance than reduced fishing mortality.

For yellowfin tuna, the longline catch in 2001-2004 averaged 84,075 tonnes. In 2010 and 2011, the catches were 83,809 tonnes 84,918 tonnes, respectively and so close to the 2001-2004 average level.

Other fisheries

For fisheries other than tropical purse seine and longline, total catches for 2010 and 2011 are reported to be 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. 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 1.40 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 0.96 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 the scenario approximating 2011 fishery conditions, F/F_{MSY} stabilises at a projected level of 1.29. The difference between 2010 and 2011 fishery outcomes is mainly due to the return to higher levels of FAD-based purse seine effort in 2011.

For scenarios that mimic a total purse seine closure (i.e., where FAD effort is not transferred to unassociated fishing), 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.

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, sought 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 has been 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 were phased in over the period 2009-2011.

In section 2 of this paper, we review the implementation of the key elements of CMM 2008-01. This review covers the three year period of CMM 2008-01, 2009-2011, for which data are now reasonably complete, but also includes preliminary information for 2012 where possible. The key elements of the CMM reviewed here are purse seine effort levels, the 2009 - 2011 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. Earlier versions of these analyses were presented to TCC7 as WCPFC-TCC7-2011-31 and to WCPFC8 as WCPFC8-2011-43 (Rev 1). 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 20°N and 20°S, 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 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 2011, excluding domestic purse seiners based in Indonesia and Philippines, has increased considerably (by approximately 31%) compared to effort in 2004 (Figure 1). Further, stock assessment results indicate that the effectiveness of the effort has typically increased on top of the increase in total effort.

The increase in purse seine effort in recent years is confirmed by VMS data (Figure 2). Data for 2012 to 30 June indicates that effort has continued at the record level observed for 2011.

2.2 FAD closure and overall FAD usage patterns

Information on the implementation of the 2009 and 2010 FAD closures was reported to SC7 (WCPFC-SC7-2011-MI-WP-01) and updated for WCPFC8 (WCPFC8-2011-43 (Rev 1)). This information has been further updated using the latest observer data holdings and extended to cover the 2011 FAD closures. The key findings are:

The incidence of reported activity related to use of drifting FADs during the FAD closures was considerably lower in 2010 and 2011 (6.0 and 8.2%) compared to 2009 (16.1%) (

- Table 1);
- The observed incidence of vessels drifting at night with fish aggregation lights on increased from 2.3% in 2009 to 6.8% in 2010 and 3.4% in 2011;
- The proportions of associated sets conducted during the closure periods were substantially lower than other months (Figure 3). Note that some level of associated set fishing is expected in the closure months, mainly in archipelagic waters;
- Effort remained at around normal levels throughout the closures (Figure 3);
- In 2010, the proportions of effort associated with FAD usage outside the closure period, particularly the months immediately before and after the closure, were lower than is typically the case. In 2011, overall FAD usage returned to more typical levels prior to the 2011 closure (Figure 3);
- It is evident that several fleets (notably Japan, Philippines, New Zealand) have substantially changed their fishing operations, focusing more on unassociated set fishing in 2010 and 2011 than they had in the past (Table 2). This change, indicated in logsheet data, is generally corroborated by available observer data. It is not known if this is a deliberate strategy or rather a response to the availability of surface schools.
- In spite of this, the total estimated number of FAD sets made in 2011 was a record high, largely due to increased purse seine effort overall (Figure 4).
- Skipjack, yellowfin and total catches were slightly below average during the 2009 and 2010 closures. Sustained high total catches (particularly skipjack and bigeye) occurred between the 2010 and 2011 closures; however total (and skipjack) catches during the 2011 closure were very depressed. Catches recovered somewhat following the 2011 closure, but did not reach the levels experienced earlier in the year (Figure 5);
- The catches of bigeye tuna were strongly reduced during closure periods compared to the other months of those years (Figure 5);
- While catches were reduced during the closures, the average size of the fish in the catch was generally higher for all species during the closures (Figure 6) 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.

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 7 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. Effort in this area could increase with the predicted return of ENSO-neutral or *El Niño* conditions.

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.

The total average bigeye longline catch for 2001-2004 was 83,879 tonnes (incorporating recent revisions by fishing nations but excluding new catch estimates provided by Vietnam which are believed to derive from the South China Sea). In 2010, the bigeye catch was 66,336 tonnes, approximately 79% of the average catch for 2001-2004. In 2011, reported catch fell slightly to 64,175 tonnes, or 76% of the 2001-2004 level (Figure 8). The main reason for these reductions was reduced catches by the major fishing nations, Japan, Korea and Chinese Taipei. These reductions are greater than what was required under the CMM and therefore there is considerable scope for the catches to increase from the 2011 level in the future if conditions in the fishery were to allow.

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[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 effectiveness of bigeye catch reductions in reducing fishing mortality depends on whether the reductions occurred because of reduced fishing effort (which would imply reduced fishing mortality) or were simply the result of further declines in the bigeye stock. To evaluate these alternatives, we examined longline effort and bigeye catches in the core area of the tropical fishery (130^{o}E – 150^{o}W, 20^{o}N – 10^{o}S) where bigeye tuna are the target species of the longline fishery. In this core area (which comprises 82% of the total Convention Area longline catch of bigeye during 2000-2011), the bigeye catch declined with a similar pattern as the Convention Area as a whole; however, longline effort showed a different pattern of moderate decline from 2003 to 2006, followed by an increase to 2009 (Figure 9). Estimates of longline effort for 2009-2011 in fact are at similarly high levels reported for the early 2000s. This implies that the reduction in catch has resulted not from effort reduction but from declining CPUE (Figure 9, bottom panel and see also Harley et al. 2012). If CPUE is an indicator of bigeye tuna abundance, the conclusion would be that recent catch declines have occurred in response to further declines in adult bigeye tuna abundance and have therefore been ineffective in reducing fishing mortality.

CMM 2008-01 also limited longline catches of yellowfin tuna to their 2001-2004 average levels for each CCM, excluding SIDS. Total annual yellowfin catch in 2001-2004 averaged 84,075 tonnes (again including recent revisions provided by fishing nations but excluding catches by Vietnam in the South China Sea). In 2010, the provisional total longline catch of yellowfin was 83,809 tonnes, and in 2011 was 84,918 tonnes and so close to the 2001-2004 average level.

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. The average bigeye catch for 2001-2004 was 13,194 tonnes, while the reported catch is 8,431 tonnes for 2010 and 7,254 for 2011. For yellowfin, the average catch in 2001-2004 was 101,910 tonnes, while the reported catch is 92,829 for 2010 and 62,360 for 2011. Therefore, for both species, 2010 and 2011 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, 2010 and 2011 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 (the spreadsheet of results for this option is at Projections-recent-av-recruitment) ; and (2) recruitment was assumed to occur according to the stock-recruitment relationship estimated/assumed in the reference case assessments (spreadsheet of results at Projections-SRR-recruitment). In this paper, we refer only to the first hypothesis (recent average recruitment) as recommended by SC6.
- 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 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^{o}N – 20^{o}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 3), 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 (as available in Oct 2011, at the time the projections were constructed) are shown in Table 4.

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, 2010 and 2011 conditions

Table 5 shows the projected values of F_{2021}/F_{MSY} for bigeye, skipjack and yellowfin for the base (2009) conditions, and approximations to 2010 and 2011 conditions. The time series of projected F/F_{MSY} for bigeye tuna is shown in Figure 10. There is a strong reduction F/F_{MSY} under 2010 conditions, particularly significant for bigeye tuna, but F/F_{MSY} under 2011 conditions sees a return to high F/F_{MSY}. The fall in F/F_{MSY} under 2010 conditions is driven by several factors: the lower than usual FAD use in 2010, the reduced longline catches, and a large (30%) reduction in reported catches from the domestic fisheries of Indonesia and the Philippines. The main change in 2011 was a return to higher FAD usage in the purse seine fishery, which is primarily responsible for the higher F/F_{MSY} under 2011 conditions. Therefore, 2010 provides a good example of the sort of regime that would achieve MSY-based reference points for bigeye tuna. 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 6 and Figure 11). 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 4) 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 7 provides the estimates of bigeye tuna fishing mortality and species-specific catches as predicted for the year 2021 and Figure 12 provides a graphical summary of the relative performance for bigeye fishing mortality and total catch. Figure 13 and Figure 14 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 8. 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} assuming that 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 9. 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, 2010 and 2011. 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 11 Jul 2012.

	2009 (Aug – Sep)	**2010 (Jul – Sep)**	**2011 (Jul – Sep)**
Number of observer trips processed to date	167	342	111
Number of observed fishing and searching days processed to date (Coverage rate)	3,225 (51.0%)	6,289 (67.1%)	1,891 (18.6%)
Number of observed sets processed to date (Coverage rate)	3,296 (52.0%)	6,961 (62.3%)	1,578 (18.2%)
Number of nights drifting with fish aggregation lights (activity = 14) (% of total)	74 (2.3%)	428 (6.8%)	65 (3.4%)
Number of days setting or investigating Drifting FADs (SCH_ID = 4) (% of total)	152 (4.7%)	196 (3.1%)	71 (3.8%)
Number of days reported as "No fishing, drifting with floating object" (Activity = 12) (% of total)	183 (5.6%)	111 (1.8%)	9 (0.5%)
Number of days reported with any activity related to a drifting FAD (Activity = 9,10,12,23,24,25,26) (% of total)	523 (16.1%)	377 (6.0%)	156 (8.2%)

Table 2. Estimated proportions of total sets that are associated sets, by flag, for 2005 – 2009, 2010 and 2011. Shaded rows indicate fleets for which the proportion is substantially lower in 2011 compared to 2005 – 2009.

Flag	Proportion of total sets that are ASSOCIATED				
	2005 - 2009	2010		2011	
	Logsheet	Logsheet	Observer	Logsheet	Observer
China	0.54	0.25	0.29	0.60	0.65
Chinese Taipei	0.49	0.23	0.21	0.40	0.40
Ecuador	0.74	0.93	0.99	0.91	0.99
El Salvador	0.88	0.97	0.99	0.98	
FSM	0.63	0.41	0.48	0.69	0.72
Japan	0.45	0.17	0.10	0.20	0.23
Kiribati	0.47	0.35	0.24	0.44	0.51
Korea	0.25	0.15	0.17	0.32	0.36
Marshall Is	0.79	0.35	0.42	0.75	0.77
NZ	0.48	0.24	0.53	0.28	
Philippines	0.51	0.27	0.24	0.26	0.24
PNG	0.52	0.32	0.26	0.42	0.44
Solomon Is	0.78	0.79	0.88	0.79	0.86
Spain	0.81	0.86	0.79	0.94	
Tuvalu	0.25	0.12	0.08	0.17	0.00
USA	0.49	0.28	0.27	0.54	0.70
Vanuatu	0.46	0.34	0.21	0.42	0.39

Table 3. 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 4. Catch and effort levels (as available in October 2011, when the projections were undertaken) 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	PS UNA effort (transfer)	PS UNA effort (managed)	Indonesia-Philippines catch (mt)			Other catch (mt)		
	Bigeye	Yellowfin	(days)	(days)	(days)	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 5. Scalars for each fishery group estimated to represent the continuation of 2009, 2010 and 2011 fishing conditions (with 2009 as the base) and the F_{2021}/F_{MSY} performance measure estimated for each set of conditions.

	Bigeye			Skipjack			Yellowfin		
Fishery group scalars	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**
Longline	1.00	0.83	0.84				1.00	0.93	0.95
Purse seine ASSOCIATED sets	1.00	0.63	1.11	1.00	0.63	1.11	1.00	0.63	1.11
Purse seine UNASSOCIATED sets	1.00	1.50	1.25	1.00	1.50	1.25	1.00	1.50	1.25
Indonesia-Philippines domestic	1.00	0.77	0.64	1.00	0.93	0.78	1.00	0.84	0.58
Other	1.00	1.50	1.30	1.00	0.90	0.85	1.00	1.46	1.13
Performance measure									
F_{2021}/F_{MSY}	1.40	0.96	1.29	0.50	0.50	0.53	0.74	0.68	0.70

Table 6. 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 7. 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 8. 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 9. 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

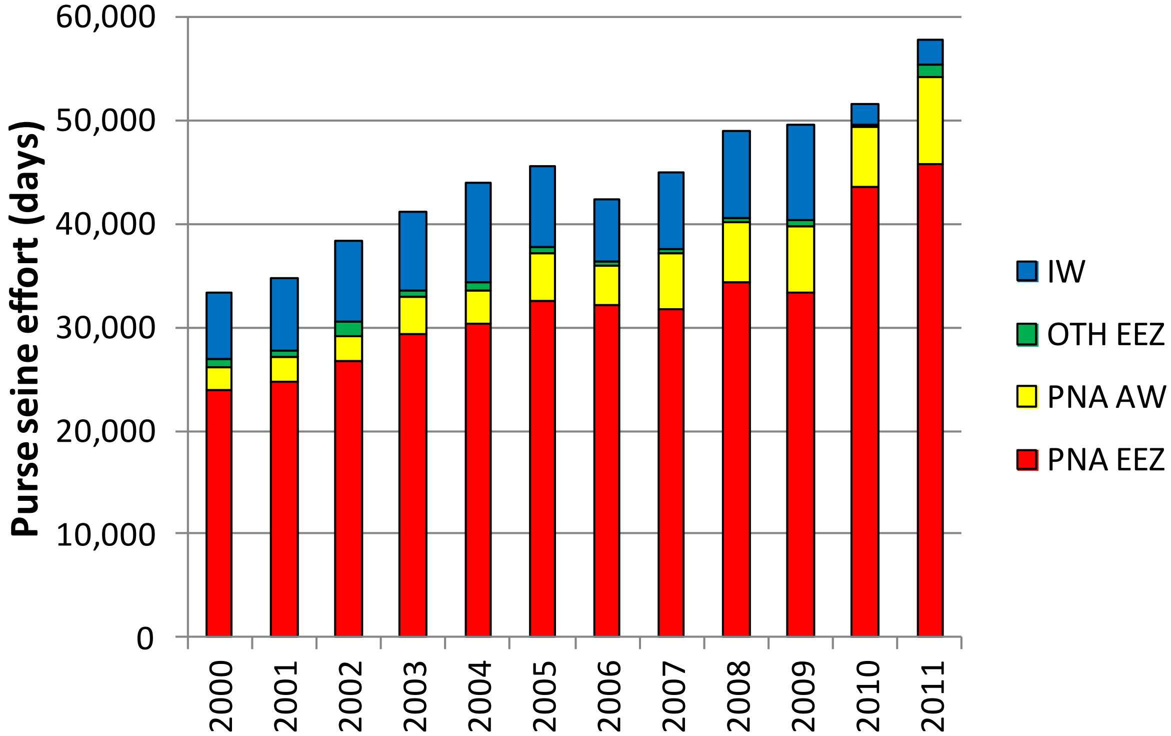

Figure 1. Purse seine effort (days fishing and searching) in the WCPFC Convention Area between 20^{o}N and 20^{o}S, excluding domestic purse seine effort in Philippines and Indonesia. Estimates are based on raised logsheet data.

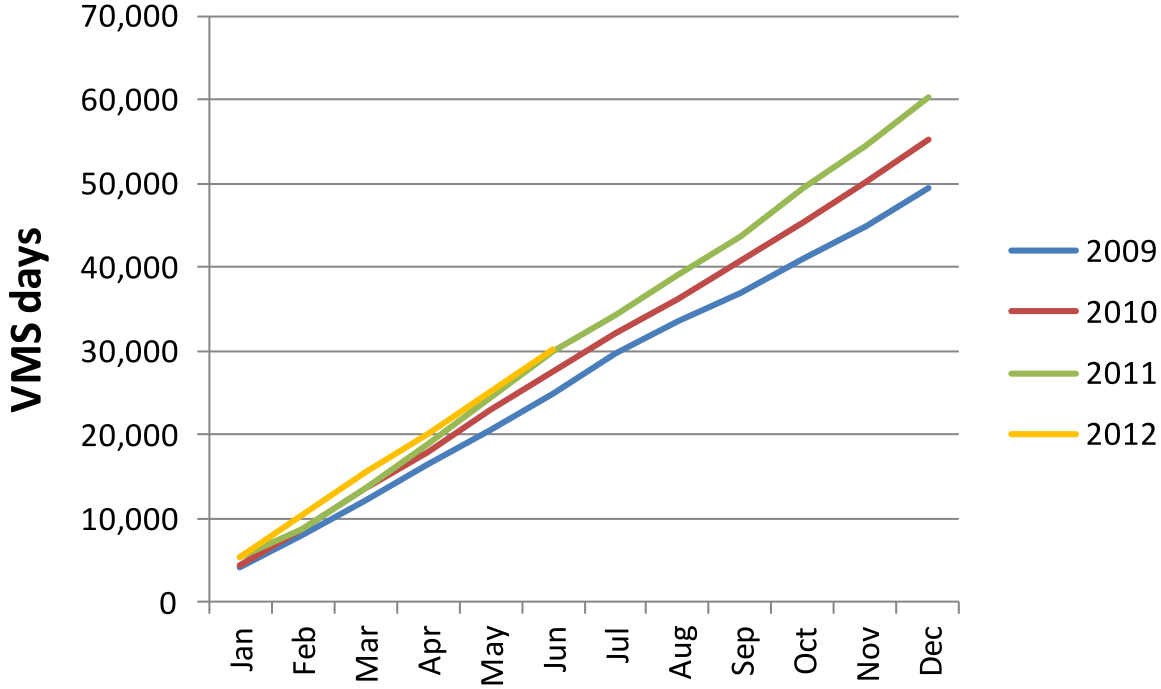

Figure 2. Cumulative purse seine effort by month, 2009-2012, as measured by VMS (days in port and end-of-trip transit days omitted).

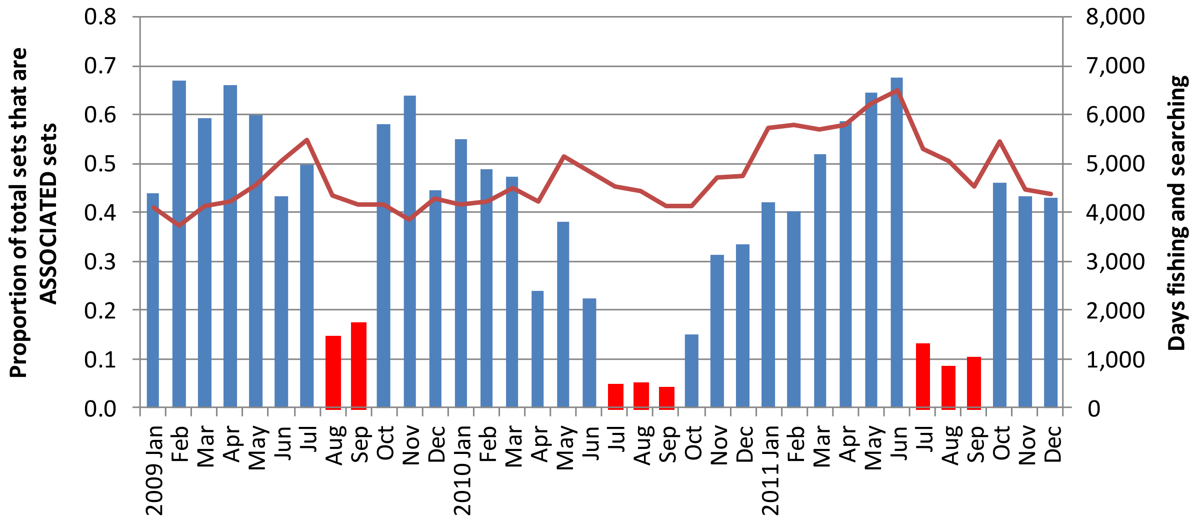

Figure 3. Proportion of the total purse seine fishing activity comprising associated sets, as indicated by logsheet data. Red bars indicate the FAD closure months. Total effort in days is shown by the plotted line. Activities in the domestic purse seine fisheries of Indonesia and Philippines are excluded.

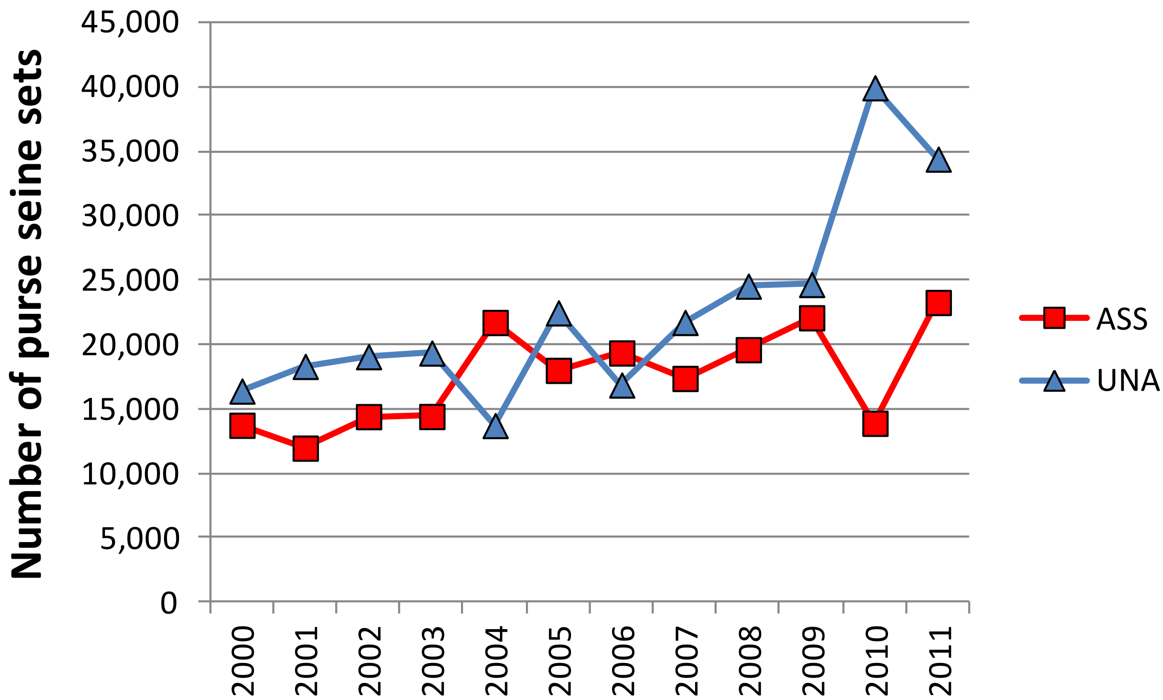

Figure 4. Number of associated (ASS) and unassociated (UNA) sets made in the WCPO tropical purse seine fishery, 2000 – 2011. Activities in the domestic purse seine fisheries of Indonesia and Philippines are excluded.

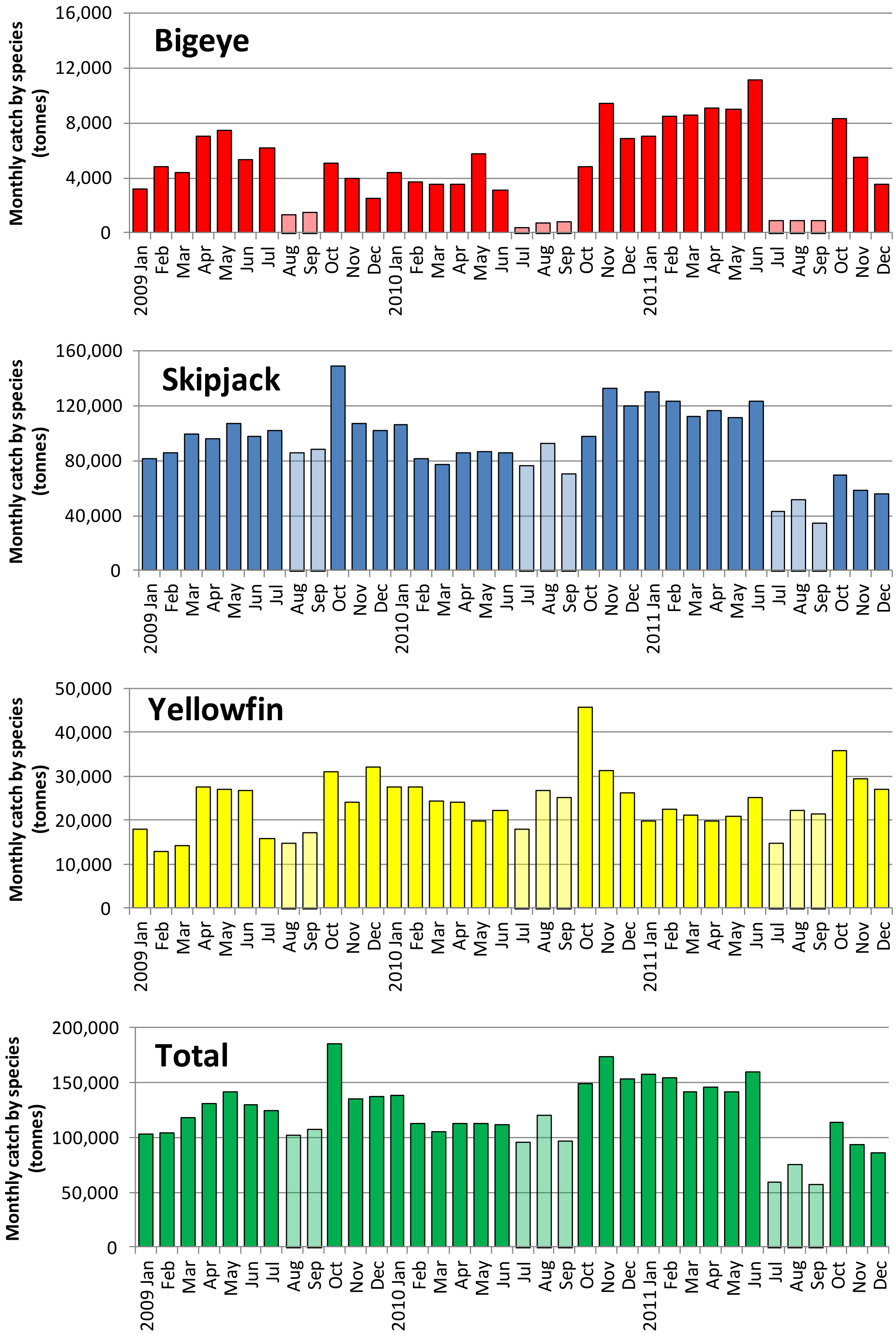

Figure 5. Monthly catch by species (raised logsheet data with species composition adjusted using observer sampling with grab sample bias correction). FAD closure months are shaded in lighter colour. Data excludes the domestic fisheries of Indonesia and Philippines.

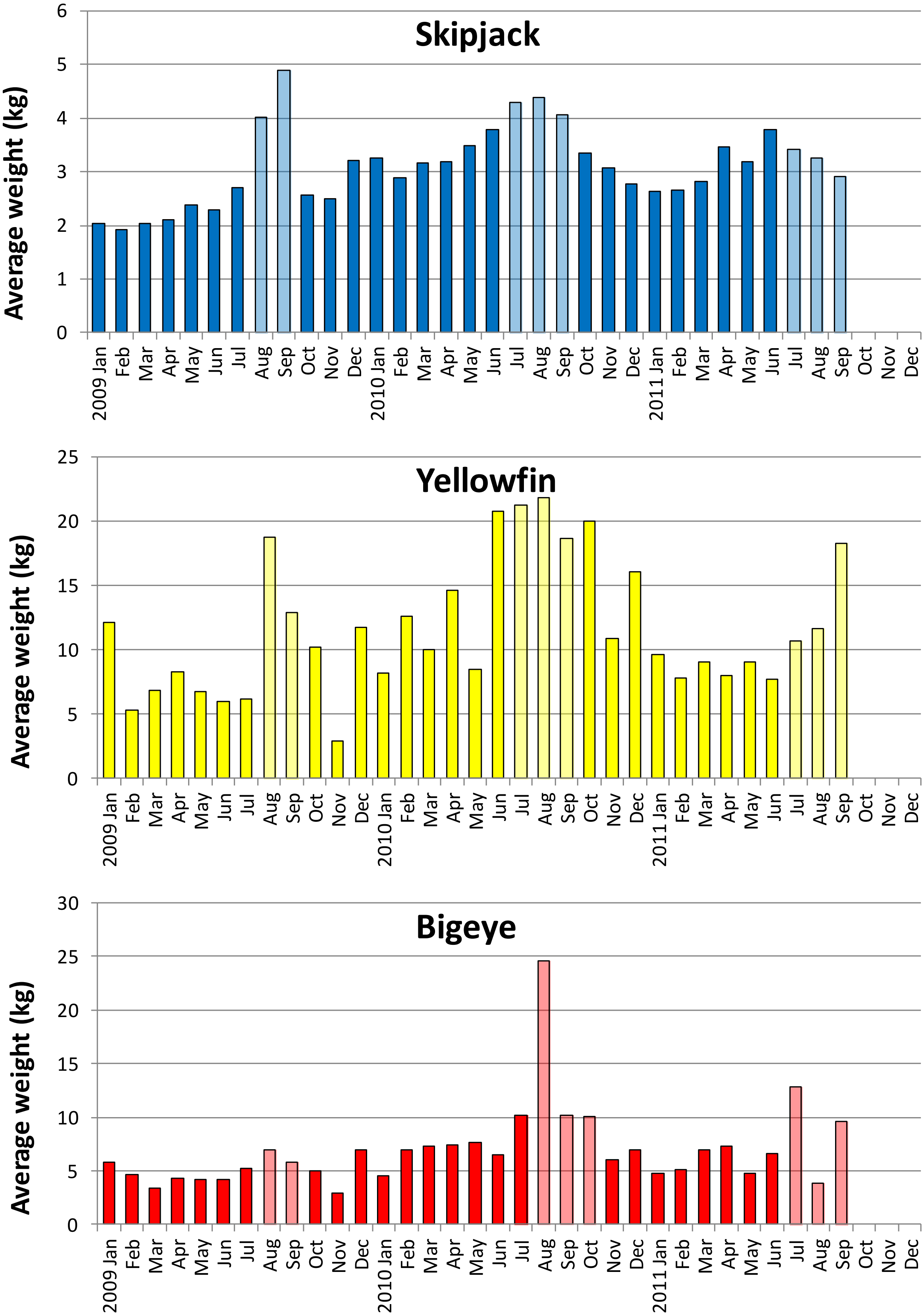

Figure 6. Average weight of bigeye, skipjack and yellowfin tuna, estimated from observer sampling data, during 2009, 2010 and 2011.

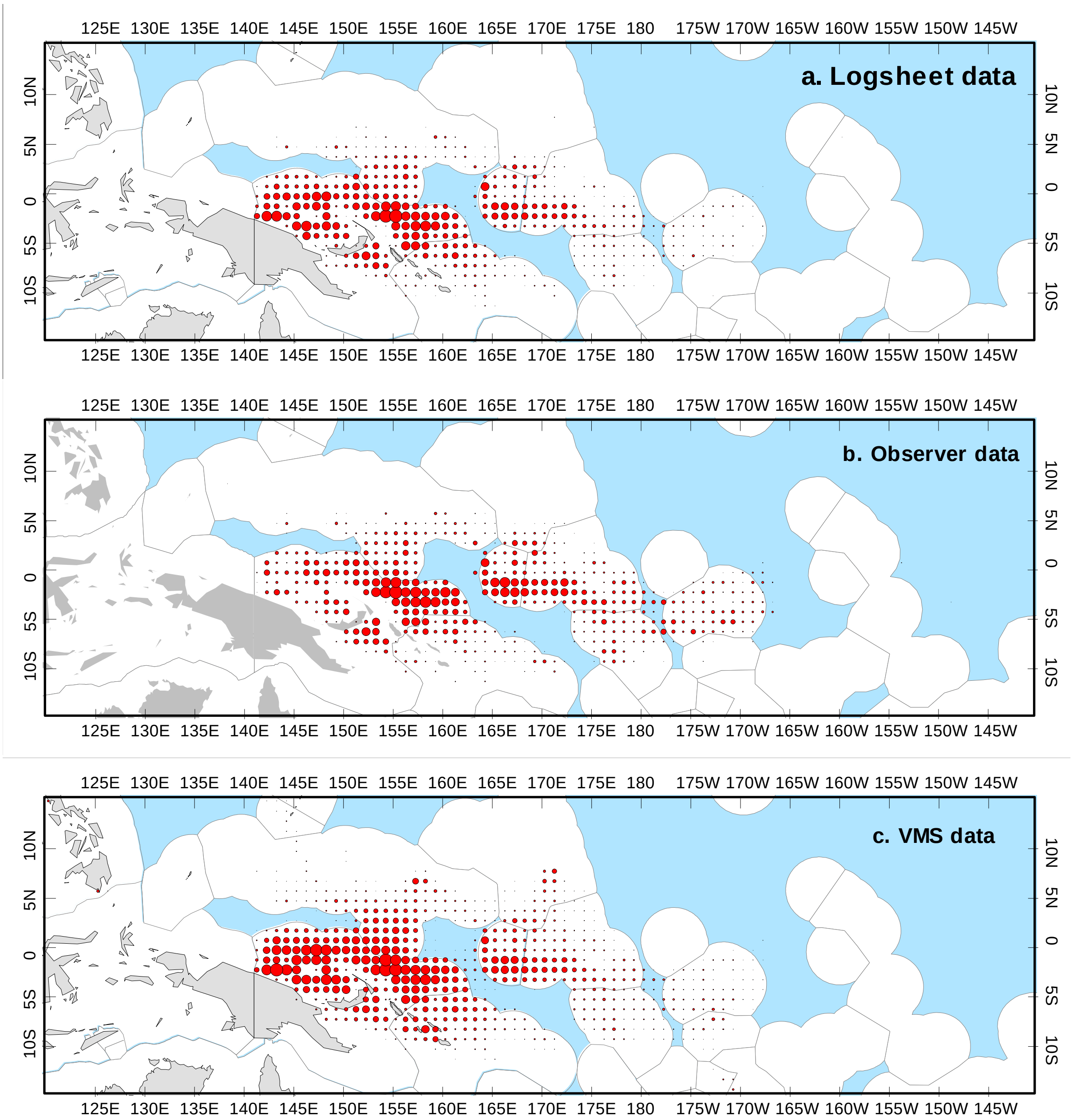

Figure 7. Distribution of purse seine effort (days) since 1 January 2010 from a. logsheet data, b. observer data, and c. VMS data.

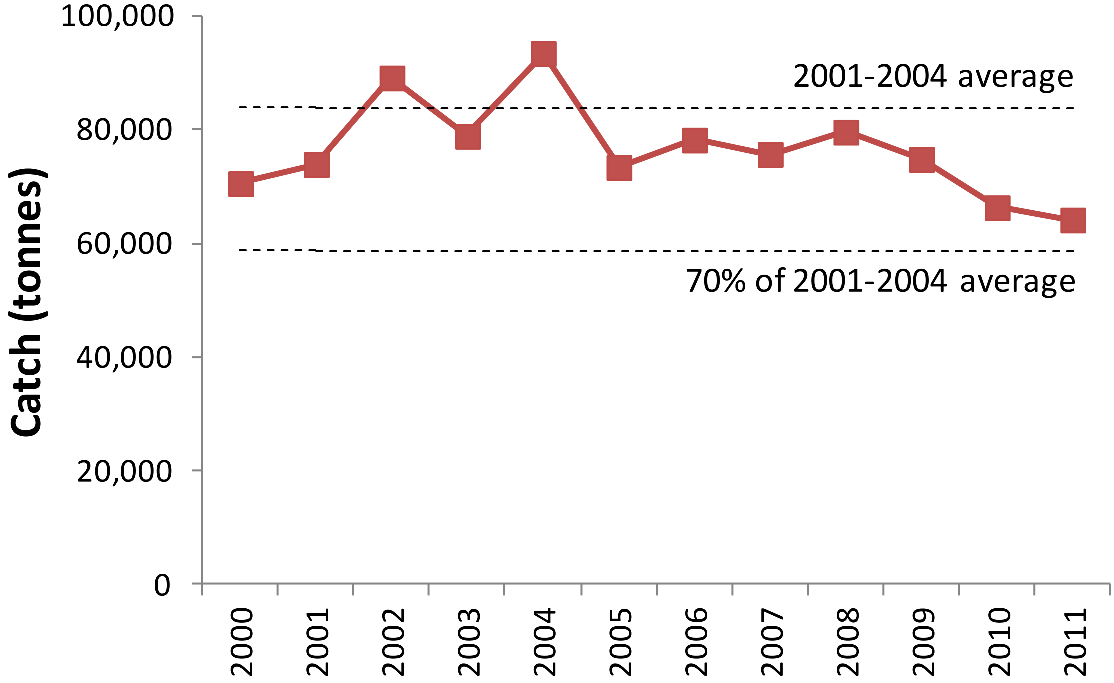

Figure 8. Estimates of bigeye tuna catch by longline in the WCPFC Convention Area, 2000 - 2011.

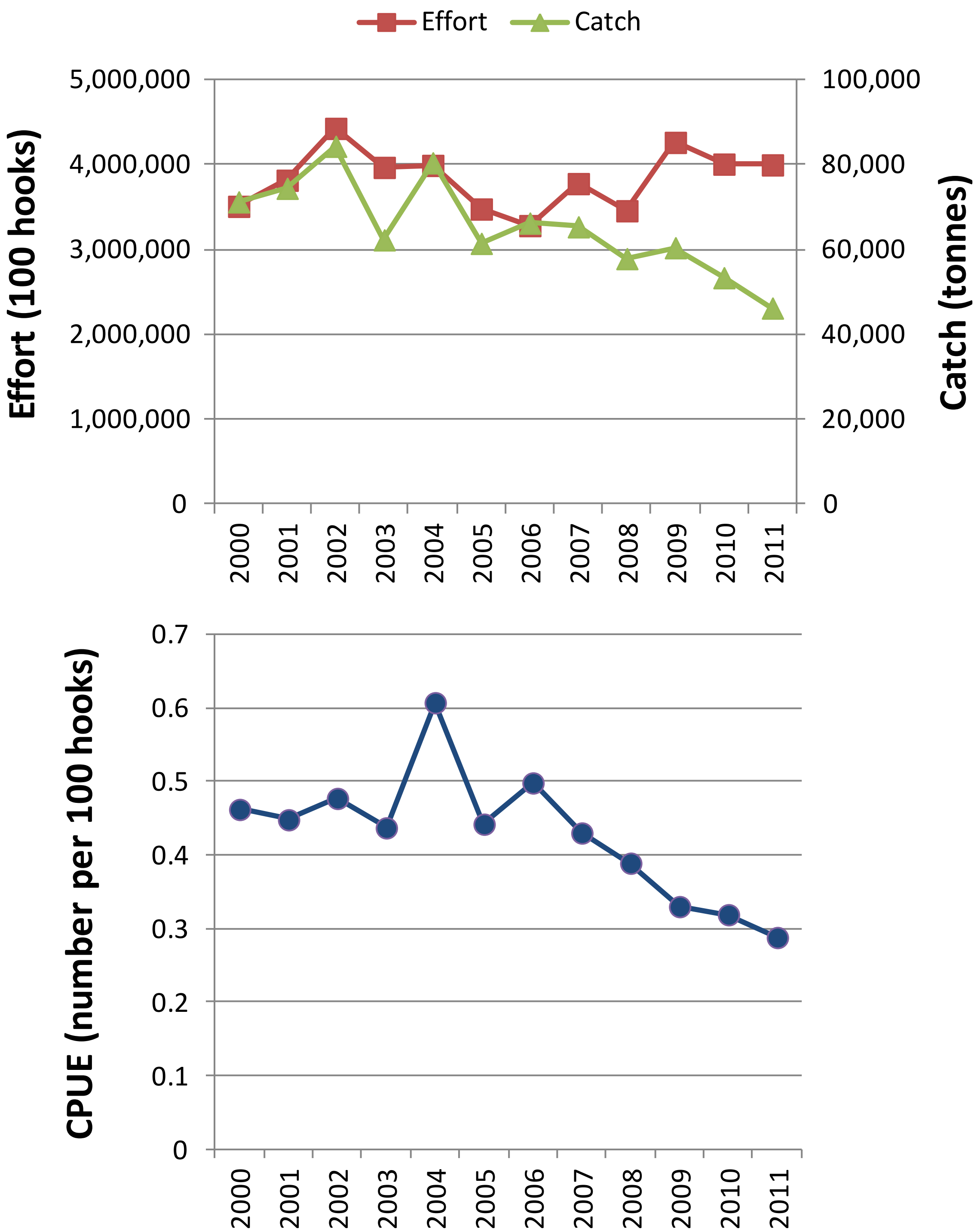

Figure 9. Estimates of longine effort and bigeye catch (upper panel) and bigeye CPUE (lower panel) for the core area of the tropical longline fishery (130°E - 150°W, 20°N - 10°S).

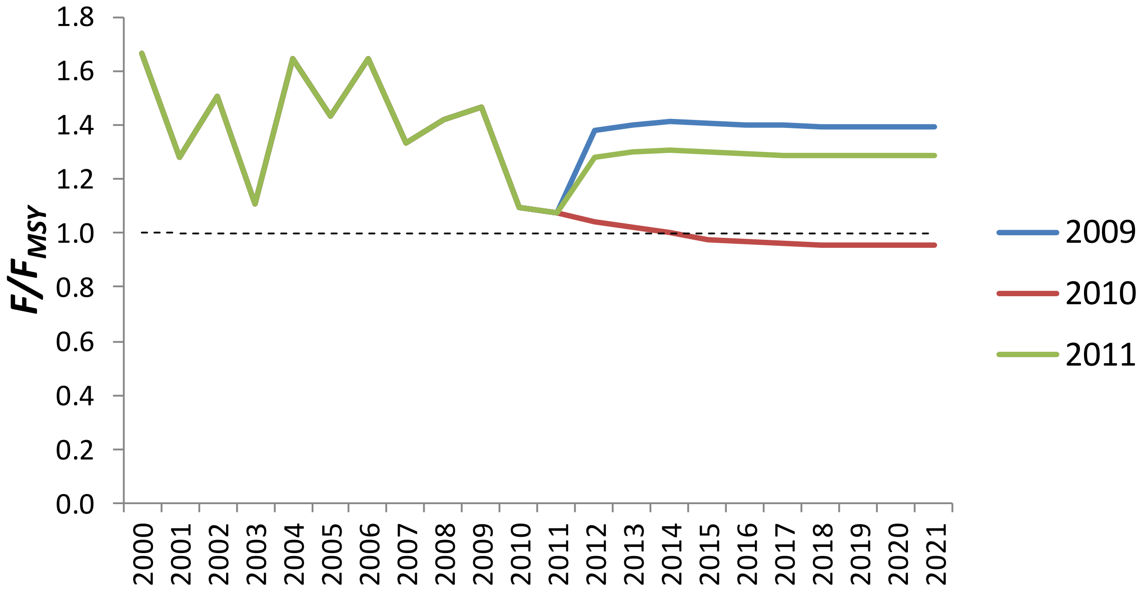

Figure 10. Recent historical and projected F/F_{MSY}, for BIGEYE tuna under the 2009, 2010 and 2011 fishing patterns, assuming that future recruitment is constant at its average 2000-2009 level.

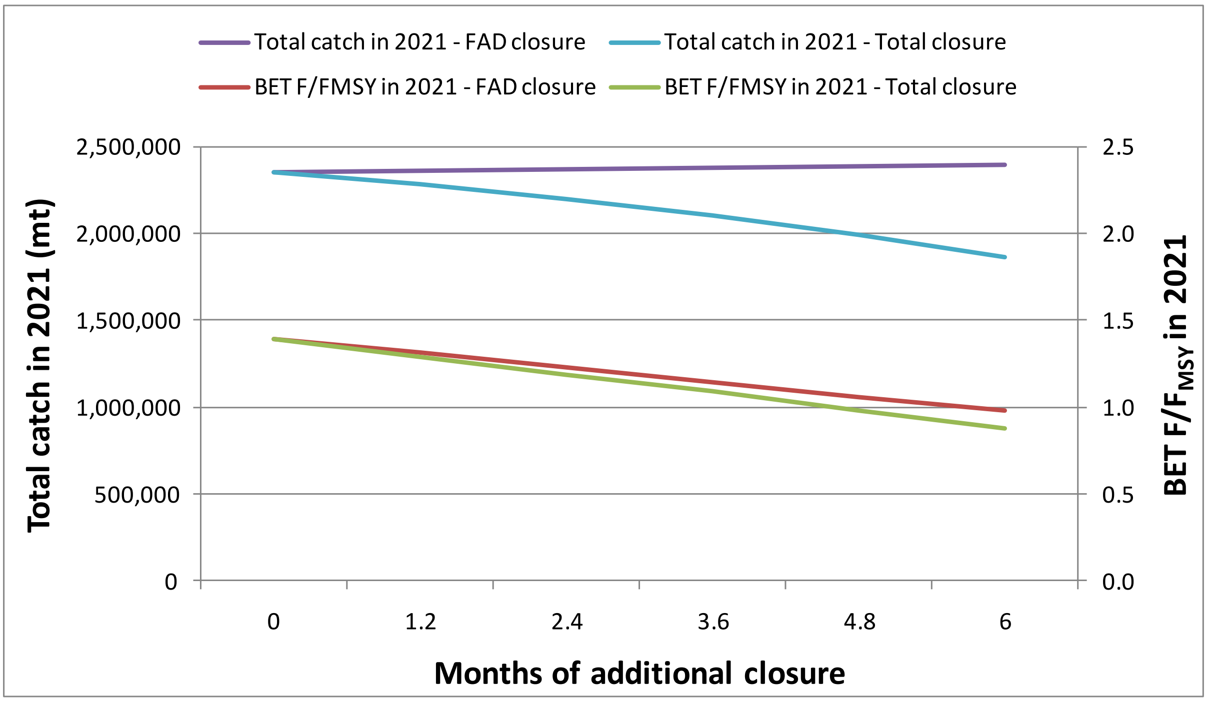

Figure 11. Change in predicted bigeye tuna fishing mortality and total tuna catches of FAD and total purse seine closures of increasing duration compared to the base year of 2009.

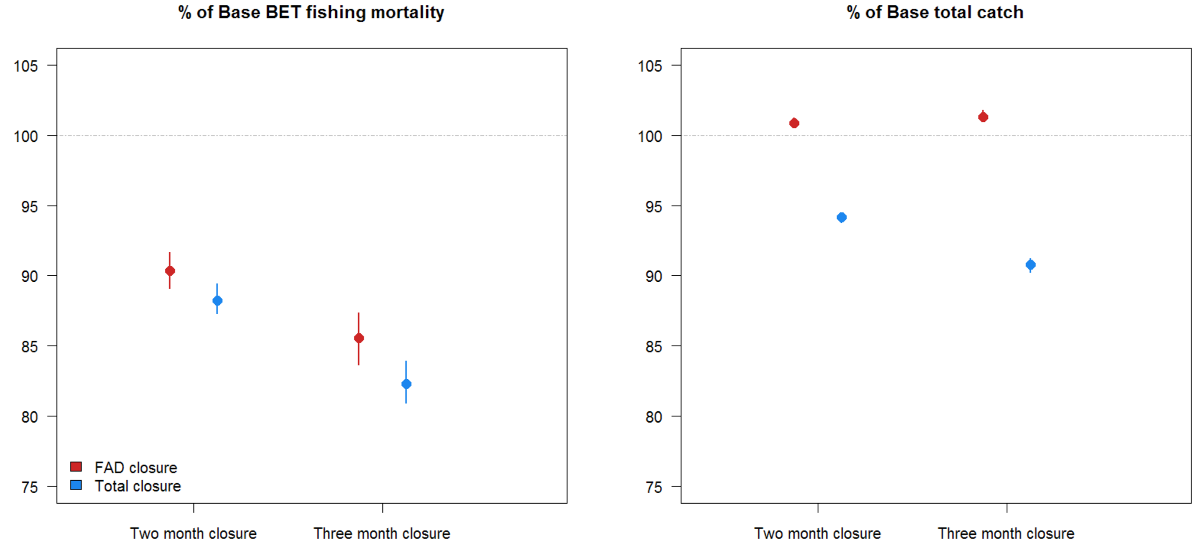

Figure 12. Relative change in predicted bigeye tuna fishing mortality and total tuna catches of two and three month FAD (red points) and total (blue points) purse seine closures based on the conditions in each year from 2001-2008. The points represent the mean change across the eight simulations and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

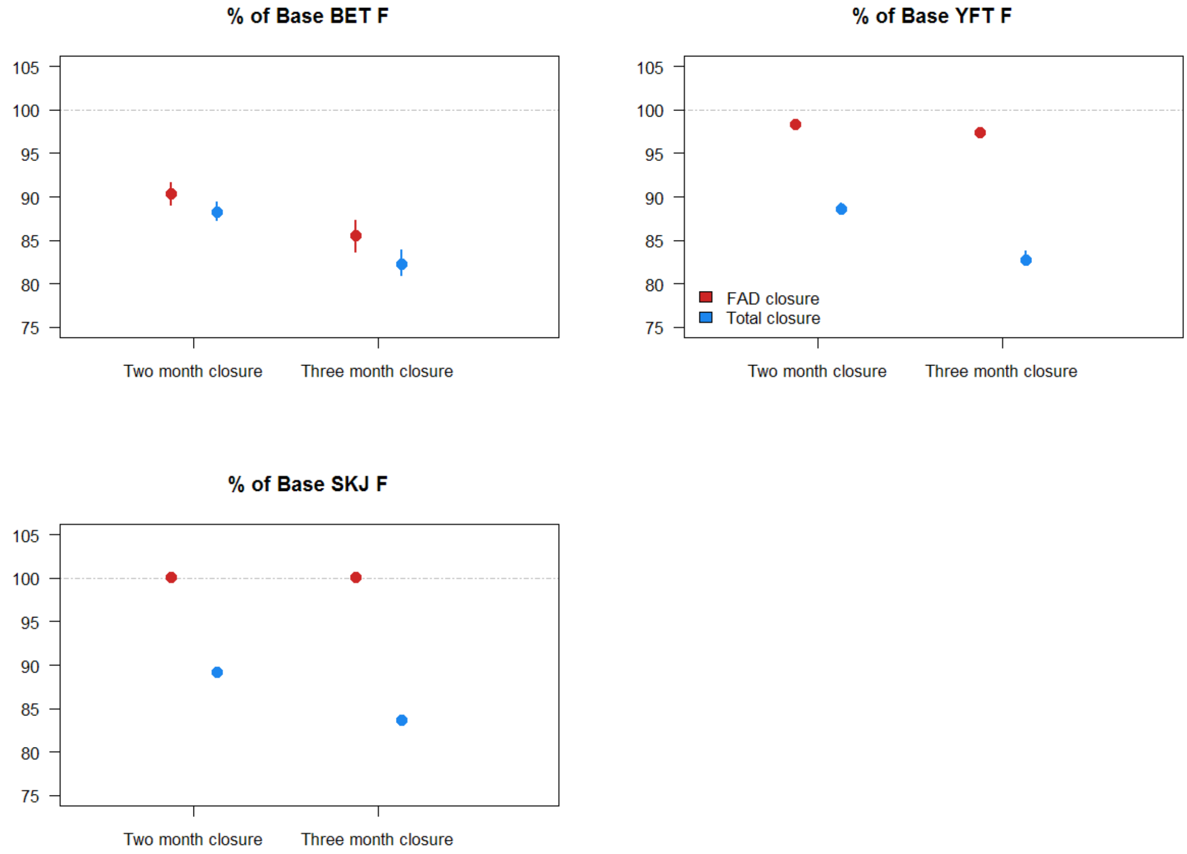

Figure 13. Relative change in predicted fishing mortality for bigeye, yellowfin, and skipjack tunas of two and three month FAD (red points) and total (blue points) purse seine closures based on the conditions in each year from 2001-2008. The points represent the mean change across the eight simulations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

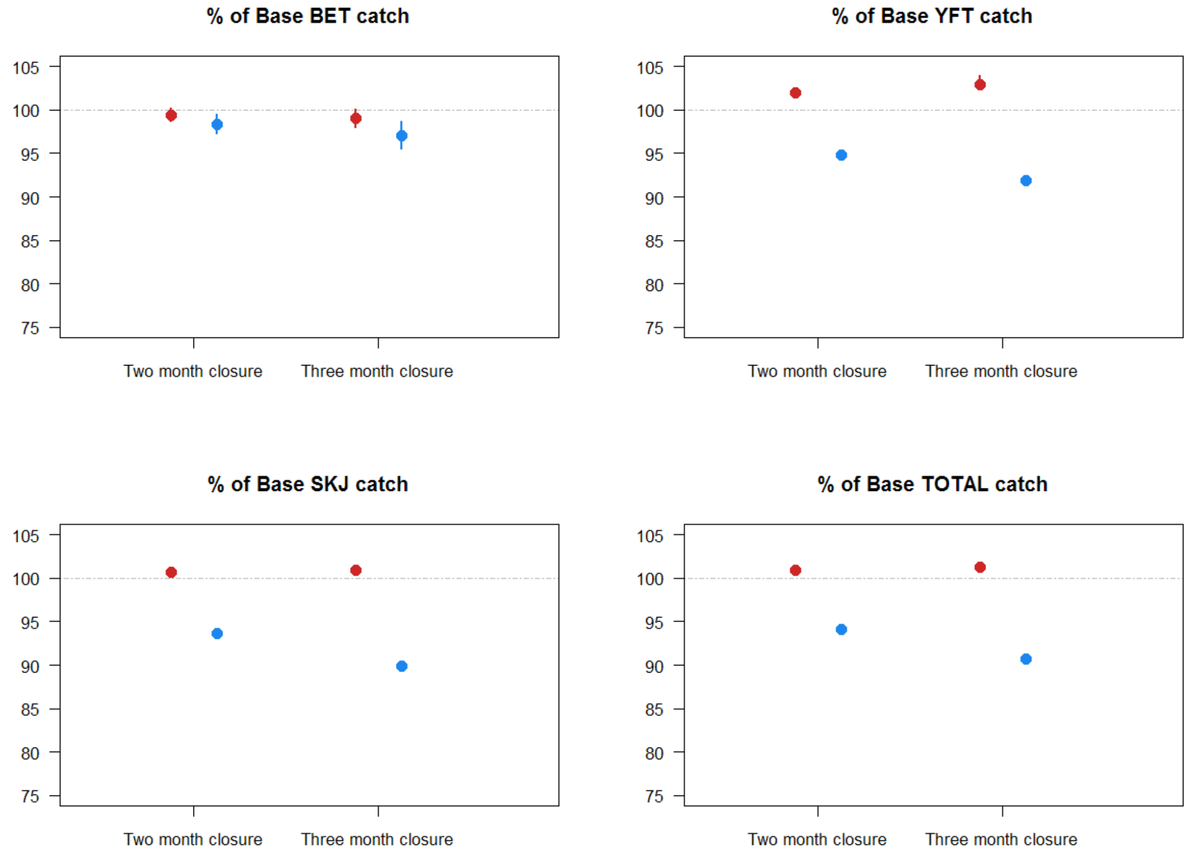

Figure 14. Relative change in predicted catches for bigeye, yellowfin, and skipjack tunas of two and three month FAD (red points) and total (blue points) purse seine closures based on the conditions in each year from 2001-2008. The points represent the mean change across the eight simulations and the 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.