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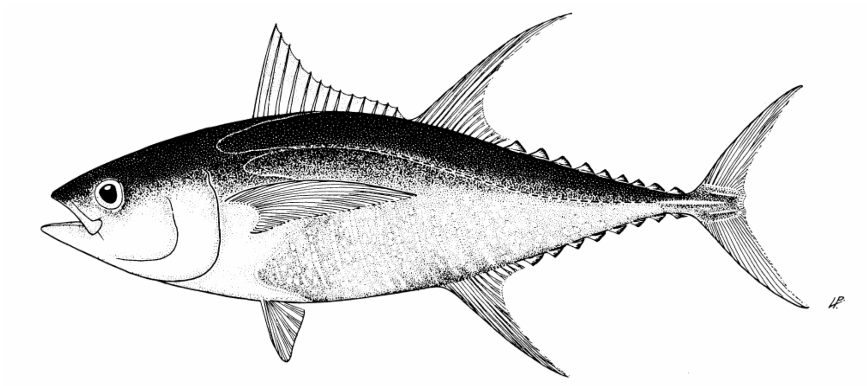
Estimates of sustainable catch and effort levels for target species and the impacts on stocks of potential management measures



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1 Introduction

At WCPFC-1 in Pohnpei in December 2005 a "Resolution on Conservation and Management Measures" was passed[1]. This resolution requested certain scientific analyses to inform future management decisions. This paper describes the technical issues that were considered in undertaking these analyses, and present the results, focussing on the requests outlined in 1(a), 1(b) and 1(c) of the Resolution, i.e. estimates of sustainable catch and effort levels for bigeye, yellowfin and South Pacific albacore and the estimation of potential consequences of alternative management options for bigeye and yellowfin tuna based on projections of the population models. The relevant text from the Resolution is provided as Annex I.

2 Methods

The methods used to conduct the analyses described below are based on the 2005 stock assessments (base-case runs) for yellowfin (SA WP-1, Hampton et al. 2005a), bigeye (SA WP-2, Hampton et al. 2005b) and South Pacific albacore (SA WP-3, Langley and Hampton 2005). These assessments have been conducted using the MULTIFAN-CL software (see http://www.MULTIFAN-CL.org).

2.1 Determining sustainable catch and effort levels

The estimation of sustainable catch and effort levels first requires a definition of what constitutes "sustainable". We can view this from two related perspectives – that of sustaining population viability and that of sustaining viable fisheries.

The issue of sustaining population viability is usually dealt with by defining a biological reference point (to be used as either a limit or a target) and estimating catch and effort levels consistent with that reference point. The most frequently used paradigm for constructing reference points is that of maximum sustainable yield (MSY). This approach entails estimating equilibrium yield (which can be viewed as a long-term average catch) as a function of relative fishing mortality (which is directly related to fishing effort). When age- or size-structured models are used as the basis of the stock assessment, it is necessary to define the age- or size-specific selectivity of the overall fishery. While the stock assessment model is dynamic (i.e. time series of biomass and other parameters are estimated), the MSY-based reference point analysis is an equilibrium analysis, with all estimated quantities being considered long-term averages.

The above concepts are represented in Figure 1, in which equilibrium yield is plotted against relative fishing mortality. On the x-axis, the value of 1.0 usually represents an average of "recent" age-specific fishing mortality. In the stock assessments, "recent" is taken as a three-year period terminating in the penultimate year of the analysis. We do not include the final year of the assessment in this average because fishing mortality may be under-estimated because of incomplete data, and even if data are complete, the statistical uncertainty associated with terminal fishing mortality estimates is high. For the 2005 bigeye and yellowfin tuna assessments the last year is 2004; therefore, the period over which "recent" age-specific fishing mortality is averaged is 2001–2003. For South Pacific albacore, the final year in the assessment is 2003, therefore the averaging period used is 2000–2002. All points on the x-axis represent scaled values of this average age-specific fishing mortality. The maximum of the yield curve defines, on the x-axis, the fishing mortality at MSY (F_{MSY}) and, on the y-axis, the MSY. We need to bear in mind that absolute values of MSY may not necessarily be comparable with recent catch levels. This is because MSY is related to the equilibrium recruitment, which is determined in western and central Pacific Ocean (WCPO) tuna assessments and elsewhere from a Beverton-Holt (BH) stock-recruitment relationship. This

[1] The Resolution was provided in Annex II of WCPFC/Comm.1/8

relationship produces long-term average recruitment associated with various levels of equilibrium spawning biomass. In many tuna assessments, we have seen that time-series recruitment estimates are highly variable, and often show prolonged phases of above- and below-average recruitment, possibly related to environmental conditions. If recent recruitment has been above average, we would expect that recent catches would be higher than the long-term average yields predicted by the yield curve. Similarly, if recent recruitment has been below average, recent catches would be relatively low. MSY estimates therefore need to be interpreted with this in mind. It is for this reason that the ratio of $F_{current}$ to F_{MSY} is usually used as the (limit or target) reference point, rather than MSY itself. $F_{current}/F_{MSY}$ is therefore better suited to determining appropriate effort levels, and this is the approach that we have taken in this paper to estimating sustainable effort levels. However, if management measures are to be framed in terms of catches, we need to use the MSY in spite of the potential difficulties of relating it to catch levels in a specific year or years. We have therefore taken two approaches in presenting sustainable catch estimates – one based on the standard approach of using the BH stock-recruitment relationship to determine MSY; and one based using recent (1994-2003) average recruitment to determine maximum yield. Recruitment time-series showing the period used for estimating recent average recruitment are shown in Figure 2.

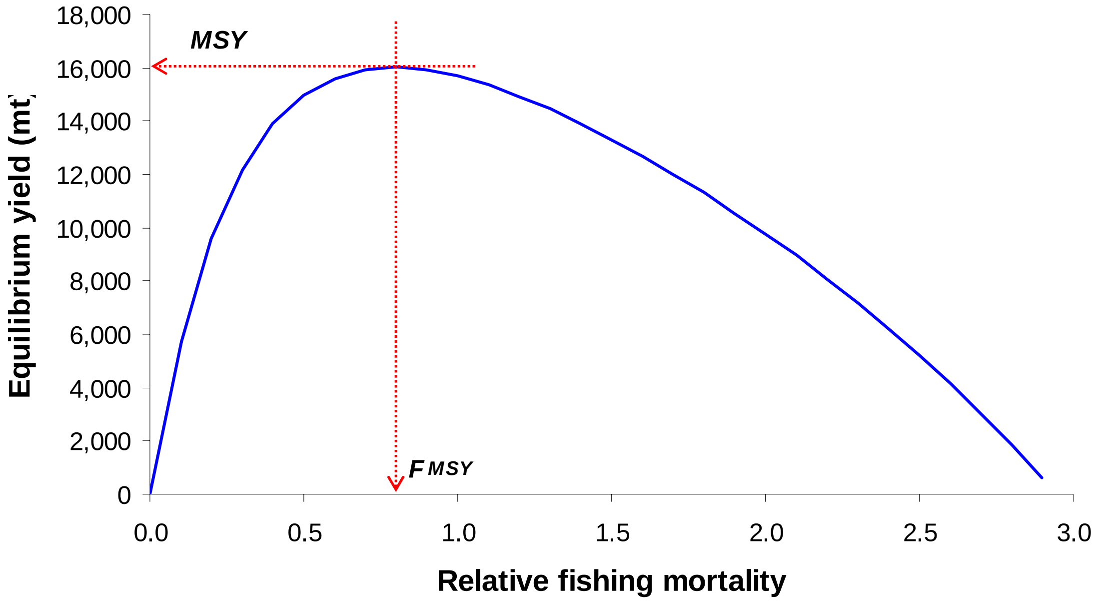

Figure 1. Equilibrium yield as a function of relative fishing mortality.

For species that, on the basis of MSY-based reference points, are estimated to be relatively lightly exploited, the issue of fishery sustainability may also need to be considered. Even though it may be possible to increase catch and effort on biological overfishing criteria, increasing catch and effort to such levels may have significant negative impacts on exploitable abundance[2] for some fisheries. Such impacts would need to be considered before policies to increase catch or effort were implemented. Information on impacts on exploitable abundance is provided for South Pacific albacore tuna, which is estimated to be under-exploited on MSY criteria. Impacts of adopting MSY levels of effort are estimated by forward projections of exploitable biomass under various assumptions. The methodology used for such projections is discussed in the following section.

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[2] Exploitable abundance of a fishery is the population abundance available to the fishery taking account of its selectivity characteristics.

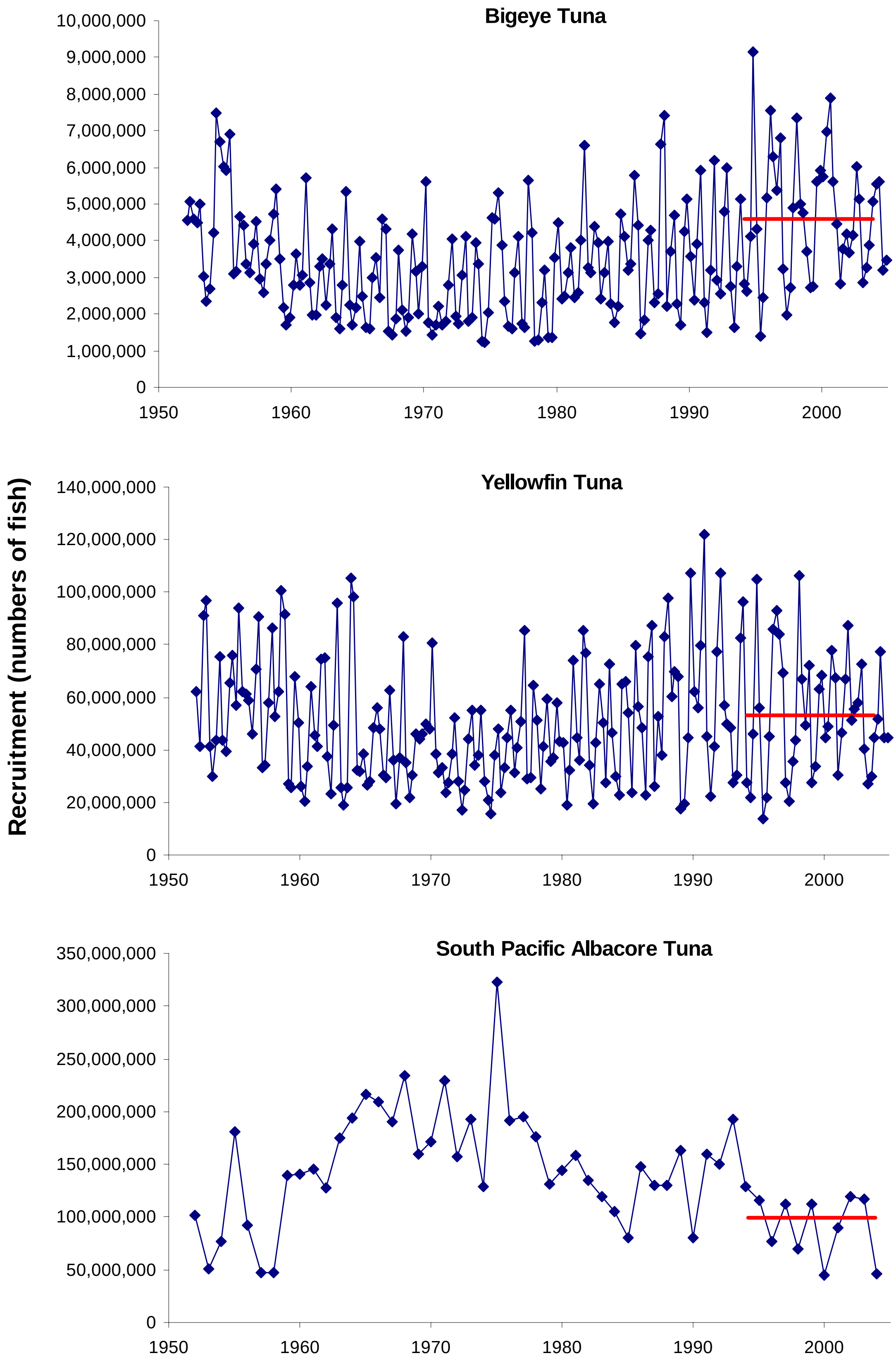

Figure 2. Recruitment estimates for bigeye, yellowfin and South Pacific albacore tuna, based on the 2005 assessments. The red horizontal lines represent the 1994-2003 average recruitment.

2.2 Estimating the impacts of potential management measures using projections

Stock projections are a common method for assessing the relative merits of potential management measures in relation to some management objective. The procedure involves projecting population-at-age forwards in time using various parameters estimated (or assumed) in the stock assessment model (terminal population-at-age, natural mortality, growth, movement, BH stock-recruitment parameters, catchability and selectivity), various assumptions regarding future processes (such as recruitment and catchability changes) and a definition of the potential management option to be considered. In conducting this analysis in a comprehensive way for the first time, it has been necessary to take a number of technical decisions regarding the way in which the projections were implemented. These are described below.

2.2.1 Treatment of uncertainty in projections

Ideally when undertaking projections it is preferable to incorporate important sources of uncertainty in current status and stock productivity (e.g. estimates of current stock status and model parameters), and uncertainty in future conditions (e.g. potential future recruitment scenarios). Given the large number of scenarios required, the complexity of the models, and the exploratory status of these analyses it has not been feasible to undertake a full analysis of uncertainty in these projections.

The approach taken was to use the "best estimate" of current stock status and project the age-structured population forward in time to provide an estimate of the potential "average" future status under a given management option and certain assumptions on the future population dynamics. It should be recognised that even though we have not attempted to characterise uncertainty in a quantitative fashion, it is clear that future population states are highly uncertain and this uncertainty increases as the projection progresses in time. For this reason, the results of projections should only be used to assess the relative merits of potential management measures, and not as a basis for stock or catch forecasting.

> *Decision: use deterministic projections*

2.2.2 Areas / fisheries to consider

In the context of WCPO tuna assessments using the MULTIFAN-CL model, a fishery generally refers to fleet of vessels using the same fishing gear in a general area that may comprise vessels from a single country or several countries. Practically, the only areas and fisheries that could be used in the projections are based on the regions used in the respective assessments. Annex II provides a figure describing the six-region spatial stratification used in the 2005 bigeye and yellowfin tuna assessments and a table describing the fisheries defined.

The Resolution requires that analyses be undertaken for the "purse-seine, longline and other surface fisheries which have a major impact on bigeye tuna and yellowfin tuna (both separately and combined)". The structure of the assessment models is amenable to defining such fishery groupings in the projections.

> *Decision: that the regional stratification used in the assessment models be applied for spatially-specific potential management measures and that the fisheries as defined in the assessment models be similarly used as the basis for fishery groupings in the projections.*

2.2.3 Years / data to use

The Resolution indicated that 2003 levels of catch and effort should be used as the basis for constructing potential management options, and that projections should be undertaken over 5 and 10 year horizons. The 2004 year is included in the stock assessment models for each species, but for some fisheries, catch and effort may be incomplete. Therefore, using 2003, which is the last year of complete data in the analysis, as the basis for constructing potential management measures is appropriate. The 2003 catch and effort data for each fishery used as the basis of the projections is given in Annex III. Projections were started in 2005 and cover a ten-year period (to end 2014). As the projections had a quarterly time step consistent with the stock assessment model, the seasonal variation in catch and effort in 2003 was preserved in the projection period.

Decision: use 2003 catch and effort as the basis for constructing potential management options and start projections in year 2005.

2.2.4 Future catchability

For some fisheries, catchability in the assessment model is treated as a cumulative trend and effort deviations represent the random noise around the catchability. For the projections, it was assumed that catchability remains constant at the 2004 level, including the estimated seasonal patterns for those fisheries for which such seasonality was estimated. If it is suspected that catchability might increase in the future, then it would be relatively easy to build this into the projection by simply having a regular expansion of fishing effort. Effort deviations were assumed to be zero during the projection period.

Decision: fix future catchability at Q4 2004 levels (including the seasonal component)

2.2.5 Future recruitment

Future recruitment levels are a critical component of any projections. There are two choices that can be considered (a) average recruitment as predicted by the spawner-recruitment relationship, in this case the BH stock-recruitment curve; and (b) recent average recruitment levels. The reason why this choice is important is that, if recent recruitment has been very different to the equilibrium BH recruitment levels, then large changes in projected stock biomass and catches (under effort-based scenarios) will be estimated in the initial years of the projection, which could be misleading. On the other hand, it may be overly optimistic/pessimistic to assume that recent above/below average recruitment levels will continue over the duration of a projection. For this reason we present projection results for both BH recruitment and recent average recruitment. For multi-region assessments, the BH recruitment is distributed among model regions according to the estimated average spatial distribution of recruitment. The period over which recent average recruitment is computed is 1994–2003, which is sufficient to capture the phase of current recruitment in each assessment. In the case of multi-region assessments, the average is constructed by model region.

Decision: use future recruitment predicted by both the BH stock-recruitment relationship and by the 1994-2003 average recruitment.

2.2.6 Levels of reductions to consider

The Resolution refers to “possible scenarios of changes in catch and effort” without providing any specific guidance as to the number of levels to consider and what they might be. Furthermore, the Commission has yet to adopt management objectives that could be used in determining appropriate reductions for potential rebuilding of the stocks over five and ten year periods. Therefore, rather than anticipating a request for very specific advice (e.g. effort should be reduced by 25%), we are assuming that the Commission is seeking guidance on “ballpark” estimates of the likely levels of management intervention that they may required to ensure the principles of the Convention text are realized. The analyses described here should not be used to attempt to determine “precise” management advice – particularly given the absence of treatment of uncertainty in the projections.

Notwithstanding these concerns, in interpreting the Resolution text we have assumed that (a) only reductions in catch and effort be considered, and (b) the levels of reductions considered should result in noticeable changes from the projections undertaken under “status-quo” conditions. Because of the interaction between the fisheries that catch yellowfin and bigeye, the same levels of reductions will be applied to each. We should also note that applying the same percentage reductions to each fishery type will have different absolute impacts on those fisheries. For example, a 30% reduction in longline bigeye catch will represent a more significant catch reduction than 30% reductions in other fishery types because longline is the largest component of the overall bigeye fishery. This needs to be born in mind when comparing percentage reductions applied to different fishery types.

Decision: test 15% and 30% reductions from the 2003 levels of catch and effort.

2.2.7 Closed area simulation - redistribution

Analysis of time/area closures is complex and there are a large number of simulations that could potentially be undertaken. Without considerable work to re-stratify the stock assessment models, any analyses of time/area closures that are integrated into the stock assessment model are limited to the spatial and fishery definitions in the current stock assessments. While it is possible to undertake “ad-hoc” analyses of time area closures outside the assessment models, these approaches are extremely limited and do not consider important process such as the growth of fish, size-specific vulnerability of fish to different gear types, and the movement of fish between areas.

A further complexity in these analyses is the redistribution of effort from the closed area. It is unrealistic to expect that all fishers will not fish if the area in which they fish is closed. Some local domestic fleets maybe unable to redistribute their effort, and while distant water fishing fleets should be able to move areas, with the extent of this governed by access agreements, location of unloading and transshipment facilities, etc. Finally, the distribution of fish within the convention area can shift quite dramatically with changes in environmental conditions, e.g. El Nino, but these dynamics are not incorporated in the analysis.

Finally, guidance on the duration of closures was not provided in the Resolution, but as the model uses a quarterly time step, and closures of about this duration have been undertaken in the Atlantic and Eastern Pacific Oceans, this may be a reasonable starting point.

Decision: for closures in the tropical regions it was assumed that effort was redistributed to the ‘open’ tropical region while it was assumed that when closures occurred in the temperate strata, effort was not redistributed. All simulated closures were for one quarter.

2.2.8 Multi-species interactions

Any management measure aimed at reducing fishing mortality on yellowfin and bigeye tuna would undoubtedly impact on catches of the other tunas and billfish taken in these fisheries. The Resolution does not provide advice on whether it requires estimates of the impacts on other fisheries and undertaking such analyses could presently only be undertaken for South Pacific albacore and skipjack tuna and these analyses would take considerable time. Also, assessments for these species have different spatial stratifications and fishery definitions, which would complicate equivalent analyses of the various potential management measures.

Decision: no analysis will be undertaken of the possible impacts of catch/effort reductions of other species at this time.

2.2.9 Model runs to be undertaken

Table 1 below describes the projections undertaken. In each case, the projections were undertaken using two future recruitment hypotheses: future recruitment determined by the Beverton-Holt stock-recruitment relationship (BH recruitment); and future recruitment determined by average recruitment for 1994-2003 (average recruitment).

Table 1. Summary of projections undertaken.

Run	Model Regions	Restricted Fisheries	Reductions	Number of Projections	Description
1	All	All	Current catches	1	Status-quo under 2003 catches
2	All	All	Current effort	1	Status-quo under 2003 effort
3a 3b 3c 3d	3, 4	14-17	15% catch reduction 30% catch reduction 15% effort reduction 30% effort reduction	4	Purse seine reductions in tropical regions (all set types)
4a 4b 4c 4d	1-6	1-13	15% catch reduction 30% catch reduction 15% effort reduction 30% effort reduction	4	Longline reductions in all areas
5a 5b 5c 5d	3	18-19	15% catch reduction 30% catch reduction 15% effort reduction 30% effort reduction	4	Indonesia/Philippines reductions
6a 6b 6c 6d	All	All	15% catch reduction 30% catch reduction 15% effort reduction 30% effort reduction	4	Reductions in all fisheries
7	3, 4	14, 16	No reduction in total purse seine effort, but effort transferred from log/FAD to school sets	1	Transfer future effort from log/FAD sets to school sets in each of regions 3 and 4 (14 to 15 and 16 to 17) to represent a ban on log/FAD fishing
8	3, 4	14, 16	Reduce catchability of log/FAD sets by 50%	1	Represents some (as yet) undetermined measure to reduce the catchability of BET and YFT from log/FAD sets by 50%
9i 9ii 9iii 9iv	3	14, 15	No effort quarter 1 No effort quarter 2 No effort quarter 3 No effort quarter 4	4	A quarterly closure to log/FAD purse-seine fishing in region 3 – effort transfer to school set fishery in region 3
9Ai 9Aii 9Aiii 9Aiv	3	14	No effort quarter 1 No effort quarter 2 No effort quarter 3 No effort quarter 4	4	A quarterly closure to purse-seine fishing in region 3 – effort transfer to region 4 in each set-type category
10i 10ii 10iii 10iv	4	16, 17	No effort quarter 1 No effort quarter 2 No effort quarter 3 No effort quarter 4	4	A quarterly closure to log/FAD purse-seine fishing in region 4 – effort transfer to school set fishery in region 4
10Ai 10Aii 10Aiii 10Aiv	4	16	No effort quarter 1 No effort quarter 2 No effort quarter 3 No effort quarter 4	4	A quarterly closure to purse-seine fishing in region 4 – effort transfer to region 3 in each set-type category
11i 11ii 11iii 11iv	3	4-6	No effort quarter 1 No effort quarter 2 No effort quarter 3 No effort quarter 4	4	A quarterly closure to longline fishing – effort transfer of distant-water fishery (4) to equivalent fishery in region 4 (7)
12i 12ii 12iii 12iv	4	7-9	No effort quarter 1 No effort quarter 2 No effort quarter 3 No effort quarter 4	4	A quarterly closure to longline fishing – effort transfer of distant-water fishery (7) to equivalent fishery in region 3 (4)

Runs 1-2 represent alternative views of the status-quo and will be used for comparison; runs 3-6 seek to address 1(b) from the Resolution (excluding the time/area closures); runs 7-8 seek to address 1(c) from the Resolution, without specifying the management measures to be used; and runs 9-12 seek to address 1(b) from the Resolution relating to time/area closures.

Output from the projections

The Resolution text asked for "Five and ten year projections of total biomass and spawning stock biomass". The way that the projections are undertaken allows these variables to be provided for all ten years if necessary. Furthermore, there are other outputs that might be of interest to the Commission that have not been requested, but these can easily be collected from the simulations. Outputs that may be of use include:

- Exploitable biomass for each fishery (which would also represent relative CPUE)
- Depletion of total and spawning biomass in from unexploited levels
- Catch by year and fishery (for the effort projections)
- Effort by fishery (for the catch projections)

In this report, we have provided tables summarising results with respect to (i) total biomass, (ii) adult (or spawning) biomass and (iii) exploitable biomass. Results are presented relative to 2003 levels. For total and adult biomass, results are also expressed as a ratio with their respective MSY-based quantities.

3 Results and discussion

3.1 Sustainable catch and effort levels

Sustainable catch and effort estimates have been derived using the base-case yield analyses for bigeye, yellowfin and South Pacific albacore (Table 2). The yield analyses themselves are described in the respective assessment documents.

Sustainable effort levels are indicated by the ratios of F_{MSY} to "current" F. In the case of bigeye and yellowfin tuna, effort levels would need to be reduced in all fisheries[3] to 81% and 82%, respectively, of their average 2001–2003 levels in order to reach F_{MSY}. The average 2001–2003 levels of effort for the major gear types and the bigeye and yellowfin tuna F_{MSY} levels of effort assuming a static fishery composition, are shown in Table 3. For South Pacific albacore, the yield analysis indicates that fishing mortality (effort) could be greatly increased from the 2000–2002 average.

Sustainable catch levels are estimated under two assumptions concerning recruitment. The MSY estimates reflect recruitment at long-term average levels arising from the BH stock-recruitment relationship. The maximum yield estimates based on recent average recruitment may provide a more realistic basis for determining short-term sustainable catch levels, assuming that recruitment remains similar to the recent average over the period for which sustainable catch levels are applied. Taking this approach, it is estimated that maximum yield represents 95% and 77% of average 2001–2003 model catches[4] of bigeye and yellowfin tuna, respectively. For South Pacific albacore, maximum yield is three times the 2000–2002 average model catch.

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[3] These ratios assume that the relative proportions of fishing effort by the various fisheries remains the same as the 2001–2003 average. However, it would also be possible to achieve F_{MSY} conditions under different gear mixes.

[4] Model catches are the appropriate comparator with yields because they are computed under the same model structure and parameterization as the yield estimates. Also, catch data included in the model represent a high, but not necessarily complete coverage of actual total catches.

Table 2. Estimates of F_{MSY} relative to "current" average *F*, MSY based on Beverton-Holt stock-recruitment (95% confidence intervals shown in parentheses), and maximum yield based on 1994–2003 average recruitment. MSY and maximum yield are also shown relative to the "current" catches predicted by the assessment models. "Current" *F* and model catch for bigeye and yellowfin tuna are represented by the 2001–2003 averages; for South Pacific albacore, average *F* and model catch in 2000–2002 were used.

Stock	F_{MSY} relative to "current" *F*	MSY BH recruitment	MSY relative to "current" model catch	Maximum Yield 1994–2003 Average Recruitment	Maximum yield relative to "current" model catch
Bigeye tuna (WCPO)	0.81	66,040 (62,222–69,858)	0.67	93,300	0.95
Yellowfin tuna (WCPO)	0.82	262,400 (229,790–295,010)	0.65	312,200	0.77
South Pacific albacore	19.10	183,000 (73,100–292,300)	3.55	156,700	3.04

Table 3. Longline (millions of hooks) and purse seine (days fishing/searching) effort by model region, 2001–2003. Note: only tropical purse seining (regions 3 and 4) is included in this analysis.

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total
Longline							
2001	29.15	24.64	234.45	135.11	44.86	90.00	558.20
2002	24.09	29.55	256.82	196.58	64.99	114.48	686.50
2003	22.59	37.89	212.16	120.52	79.88	117.52	590.55
Average	25.28	30.69	234.47	150.73	63.24	107.33	611.75
Bigeye F_{MSY}	20.47	24.86	189.92	122.09	51.23	86.94	495.52
Yellowfin F_{MSY}	20.73	25.17	192.27	123.60	51.86	88.01	501.64
Purse seine							
2001			25,292	12,449			37,741
2002			24,654	16,081			40,735
2003			39,831	4,949			44,779
Average			29,926	11,159			41,085
Bigeye F_{MSY}			24,240	9,039			33,279
Yellowfin F_{MSY}			24,539	9,150			33,690

For South Pacific albacore, one of the reasons that F_{MSY} and MSY are much greater than the current levels is that most of the catch is made by longline and comprises individuals with an average age significantly older than the age at first maturity (see SA WP-3, Langley and Hampton 2005 for details). While this type of exploitation confers substantial resilience to biological overfishing, the impact of fishing on longline exploitable abundance is still significant – a reduction of approximately 30% from unexploited levels in 2003 in the case of the Fiji longline fishery. Projecting forward assuming that effort from 2004 on was at the F_{MSY} level, we find that exploitable longline abundance falls precipitously (Figure 3). By contrast, exploitable abundance for the NZ troll fishery, which targets juvenile albacore, remains relatively stable. Under constant catchability conditions, exploitable abundance is proportional to catch per unit effort (CPUE). It is unlikely that any longline fisheries could continue to operate at CPUEs predicted at F_{MSY} levels of fishing effort.

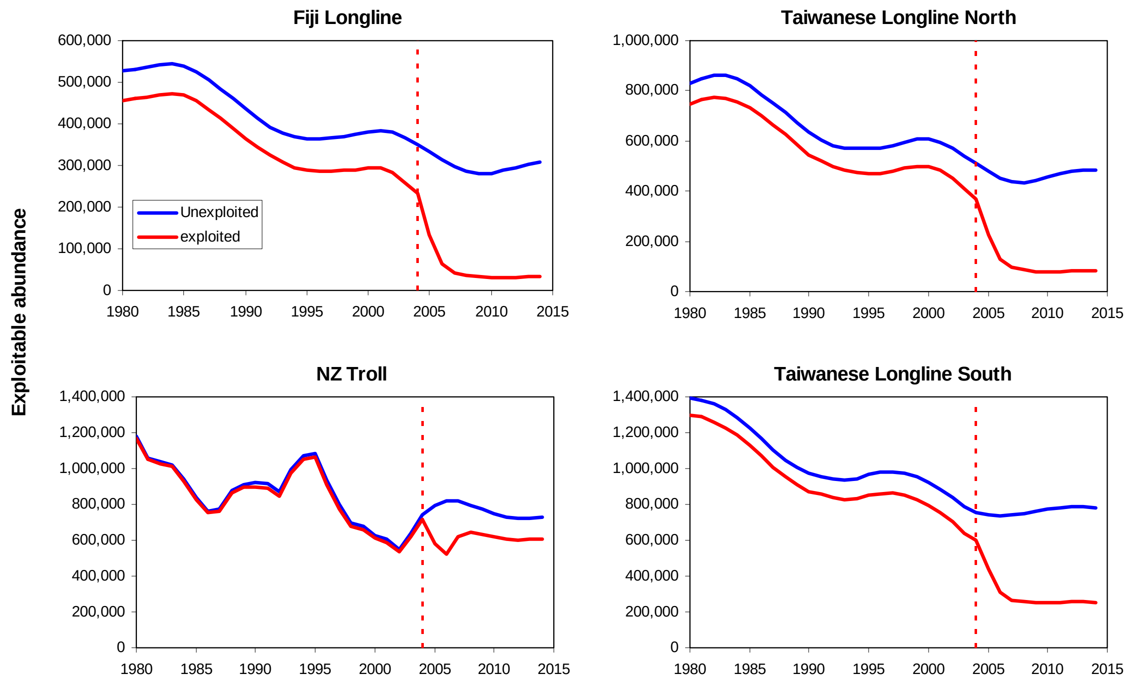


Figure 3. Exploitable abundance (which is proportional to CPUE) of selected South Pacific albacore fisheries with (red line) and without (blue line) fishing. From 2004 (vertical dashed line), effort is presumed to occur at the F_{MSY} level.

3.2 Projected impacts of potential management measures

Detailed results of the projections are provided in tabular form in Annex IV. Results are shown for total biomass (Tables A1 and A4), adult biomass (Tables A2 and A5) and exploitable abundance for selected fisheries (Tables A3 and A6). Results are presented relative to the biomass/exploitable abundance levels at the end of 2003. For total and adult biomass, results are presented by region and the spatially-aggregated biomass is also expressed relative to its MSY level. A graphical summary of projection results for runs 1 and 2 is given in Figure 4. Graphical summaries of the spatially-aggregated results for all projection runs are presented in Figure 5 (bigeye tuna) and Figure 6 (yellowfin tuna). In these figures, total and adult biomass as proportions of their respective MSY levels are plotted for each projection run, providing an easy visual means of comparing the results of the various projections.

3.2.1 Bigeye tuna

Some observations on the results of the projections for bigeye tuna (Figure 5, Tables A1–A3) are as follows:

o The 2003 catches (run 1) are not sustainable[5] under the BH recruitment hypothesis. The population in region 3 is rapidly depleted and quickly reaches a point where there are insufficient fish to enable the specified catches to be taken. Under the average recruitment hypothesis, the 2003 catches are sustainable, with both total and adult biomass remaining above their MSY levels. However, catches may not be sustainable in some regions, as the sub-population in region 3 declines to zero even under these favourable recruitment conditions.

[5] We use the term “sustainable” in this discussion as indicating that 2014 biomass levels are above their MSY levels.

- The 2003 effort (run 2) produces total population biomass approaching the MSY level under BH recruitment conditions and exceeding it under average recruitment conditions. Results are slightly more optimistic for adult biomass.
- Overall, reductions in catch/effort simultaneously in all fisheries (run 6) resulted in the strongest increases in total and adult biomass. All reduction scenarios resulted in adult biomass levels greater than their respective MSY levels under both recruitment hypotheses.
- Restrictions on longline catch and effort (run 4) have a greater positive impact on adult biomass than reductions in other fishery types. This is because longliners target adult fish, so reductions in their catch or effort have an immediate impact on the adult population. It is also because the longline fishery is the largest component of the fishery, and as such, proportional reductions in longline catch/effort would be expected to have a greater impact on bigeye tuna biomass than the same proportional reductions in smaller fisheries.
- Switching purse seine effort from log/FAD sets to unassociated school sets (run 7) was the most effective of the purse seine measures investigated. Under this scenario, total and adult biomass moved above their MSY levels under both recruitment hypotheses (the only purse seine measure to have this result). The simulated 50% reduction in log/FAD purse seine catchability (run 8) also showed positive results, but not to the extent of run 7.
- Of the runs simulating some form of quarterly closure of purse seining in region 3 (runs 9 and 9A), the runs in which the closure pertained to log/FAD sets, with that effort being redirected to unassociated school sets in the same region (run 9), was more effective than a closure of all region 3 purse seining with redirection of the effort to region 4 (run 9A). In fact, run 9A resulted in 2014 biomass levels both less than the MSY levels and less than those obtained under the status quo (run 2). For the same set of measures in region 4 (runs 10 and 10A), there was little difference between set type versus regional redistribution of effort.
- There was little difference in biomass outcomes with regards to which quarter of the year the purse seine seasonal closures were applied.
- For the quarterly longline closures in regions 3 (run 11) and 4 (run 12), the region 4 closures resulted in better biomass outcomes. In region 4, a quarter 1 closure resulted in the greatest biomass gains, followed by closures in quarter 2, 3 and 4. There was little difference among the quarters for seasonal closures in region 3.
- Differences in average projected bigeye catches (relative to the average annual catch for run 2) are shown in Figure 6. It is interesting to note that the longline reductions result in the largest negative movements in total catch. Positive catch differentials result because of interaction effects among the fisheries (i.e., catch foregone in one fishery results in increased catches in other fisheries). The strongest positive effect occurred for run 7 (simulating a ban on log/FAD sets).

3.2.2 Yellowfin tuna

Some observations on the results of the projections for yellowfin tuna (Figure 7, Tables A4–A6) are as follows:

- The 2003 catches are not sustainable under any of the catch-based schemes investigated. In these projections, the population in region 3 is depleted towards zero. All of the effort-based scenarios investigated were found to result in biomass levels above their MSY levels, including the 2003 effort.
- Overall, reductions in effort simultaneously in all fisheries (run 6) resulted in the strongest increases in total and adult biomass.

- o Reductions in purse seine (run 3) and Indonesia/Philippines (run 5) effort resulted in better biomass outcomes than reductions in longline effort (run 4).
- o Perhaps surprisingly, reductions in effort in the Philippines-Indonesian domestic fisheries (run 5) did not result in appreciably better biomass outcomes than the corresponding purse seine reductions. This is probably because much of the Philippines-Indonesian catch is taken at small size where natural mortality is relatively high.
- o Switching purse seine effort from log/FAD sets to unassociated school sets (run 7) resulted in a slight improvement in biomass. However, the effect is not as strong as seen for bigeye because the effort re-directed into purse seine school sets continues to catch yellowfin but very little bigeye. The 50% reduction in log/FAD set catchability (run 8) resulted in better biomass outcomes for yellowfin compared to run 7.
- o Management measures simulating quarterly closures with various transfers of fishing effort (runs 9, 9A, 10, 10A, 11 and 12) were not found to improve biomass over the status quo outcome (run 2).

4 Conclusions

This paper has provided information on sustainable catch and effort levels for bigeye, yellowfin and South Pacific albacore tuna, as well as information on the impacts on the bigeye and yellowfin stocks of potential management measures.

The results of yield analyses for bigeye and yellowfin tuna indicate that overfishing is occurring on both species, based on the average fishing mortality-at-age over the period 2001–2003. If we use F_{MSY} as an upper limit (or limit reference point) for fishing mortality, then we would conclude that fishing mortality should be reduced to at least 81% of average 2001–2003 levels in the case of bigeye tuna, and 82% in the case of yellowfin tuna. Since essentially the same fisheries capture both species, an “across the board” effort cut designed to eliminate overfishing of bigeye tuna would automatically eliminate overfishing of yellowfin tuna as well. Sustainable catch levels are more difficult to estimate because they are sensitive to assumptions regarding future recruitment. The most optimistic recruitment assumption (continuation of recent above-average recruitment) would still mean sustainable bigeye and yellowfin tuna catches approximately 5% and 23%, respectively, less than the average 2001–2003 levels.

The current analyses have considered only a static fishery composition in constructing the yield curves used to estimate sustainable catch and effort. In reality, it may be possible to change the catch or effort of individual fisheries by different proportionate amounts to obtain both better stock outcomes and better fishery outcomes. Further work is required to identify such potentially beneficial harvesting regimes from the virtually limitless range of possibilities that exist in theory.

For South Pacific albacore, current levels of fishing represent a relatively small fraction of what would be biologically sustainable. The key question is however whether sustainable fisheries can occur at higher levels of catch or effort. We used stock projections to investigate the impact on exploitable abundance of pursuing a MSY-based effort strategy. Longline exploitable abundance declined to very low levels that would be very unlikely to sustain profitable fishing operations. Therefore, it would not be prudent to recommend such a fishing strategy. How much could we expand longline fishing for albacore? The answer to this question requires more detailed research that would include, *inter alia*, economic data, fine-scale spatial data, and information on the variability of fishing performance related to oceanographic variability on various time scales.

Stock projections were used to investigate the consequences of potential management measures in relation to the bigeye and yellowfin tuna stocks. While simplistic, the projections offer a “first look” at the relative merits of various types of management measures. However, given the absence of treatment of uncertainty and the various assumptions that needed to be made, the results are best interpreted in a qualitative rather than quantitative fashion. The most important points to emerge were that:

- o Reductions in longline catch/effort have an immediate and significant impact on bigeye tuna adult biomass.
- o Switching effort from log/FAD to unassociated school sets was the most effective purse seine measure investigated in the case of bigeye. For yellowfin, a simulated 50% reduction in log/FAD set catchability provided somewhat greater biomass gains.
- o Quarterly closures in individual regions were not particularly effective when effort is allowed to transfer to the neighbouring region during the closure (the possible exception being longline closures in region 4 in the case of bigeye).
- o A feature of the catch-based projections for both bigeye and yellowfin was the continued decline in abundance in region 3 towards zero. In both assessments, but particularly for bigeye, recruitment in region 3 has shown an increasing trend over time. It is possible that model estimates of recruitment have responded in this way to explain the increase in catch. In the projections, recruitment is fixed and even catches 30% less than those in 2003 cause rapid depletion of the region 3 sub-population. It is possible that these features of the assessment and the projections are related. This is a key area of future stock assessment research.

As noted earlier, we have not analysed the corresponding impacts that purse seine effort restrictions would have on skipjack tuna. This is work that could usefully be carried out in the future. However, it is clear from the skipjack assessment (Langley et al. 2005) that current skipjack yields (average catches) would tend to have approximately a linear response to reductions in effort. Therefore, we would expect a 30% reduction in purse seine effort to result in roughly a 30% reduction in purse seine skipjack catch. The current skipjack assessment is not conveniently structured (spatial stratification, fishery definitions and consistency of purse seine effort units) to allow examination of options involving some form of effort transfer. However, these are technical issues that could be dealt with relatively easily in future skipjack assessments.

5 References

Hampton, J., P. Kleiber, A. Langley, Y. Takeuchi, and M. Ichinokawa. 2005a. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. WCPFC SC1 SA WP-1.

Hampton, J., P. Kleiber, A. Langley, Y. Takeuchi, M. Ichinokawa, and M. Maunder. 2005b. Stock assessment of bigeye tuna in the western and central Pacific Ocean, with comparisons to a Pacific-wide assessment. WCPFC SC1 SA WP-2.

Langley, A., and J. Hampton. 2005. Stock assessment of albacore tuna in the South Pacific Ocean. WCPFC SC1 SA WP-3.

Langley, A., J. Hampton, and M. Ogura. 2005. Stock assessment of skipjack tuna in the western and central Pacific Ocean. WCPFC SC1 SA WP-4.

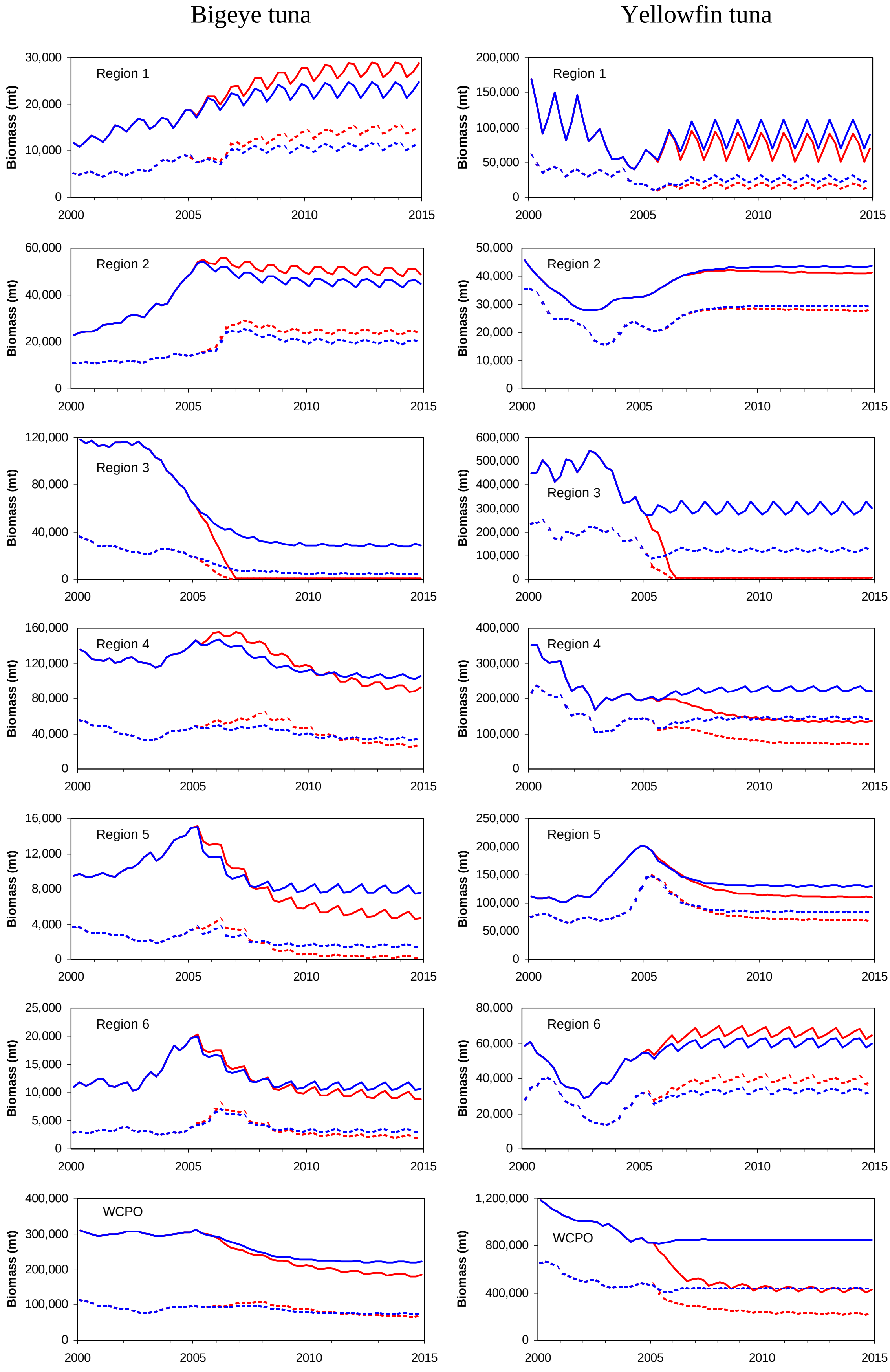


Figure 4. Example of projection dynamics for run 1 (constant catch – red series) and run 2 (constant effort – blue series). Both total (solid lines) and adult (dashed lines) biomass are shown. The BH recruitment hypothesis was used.

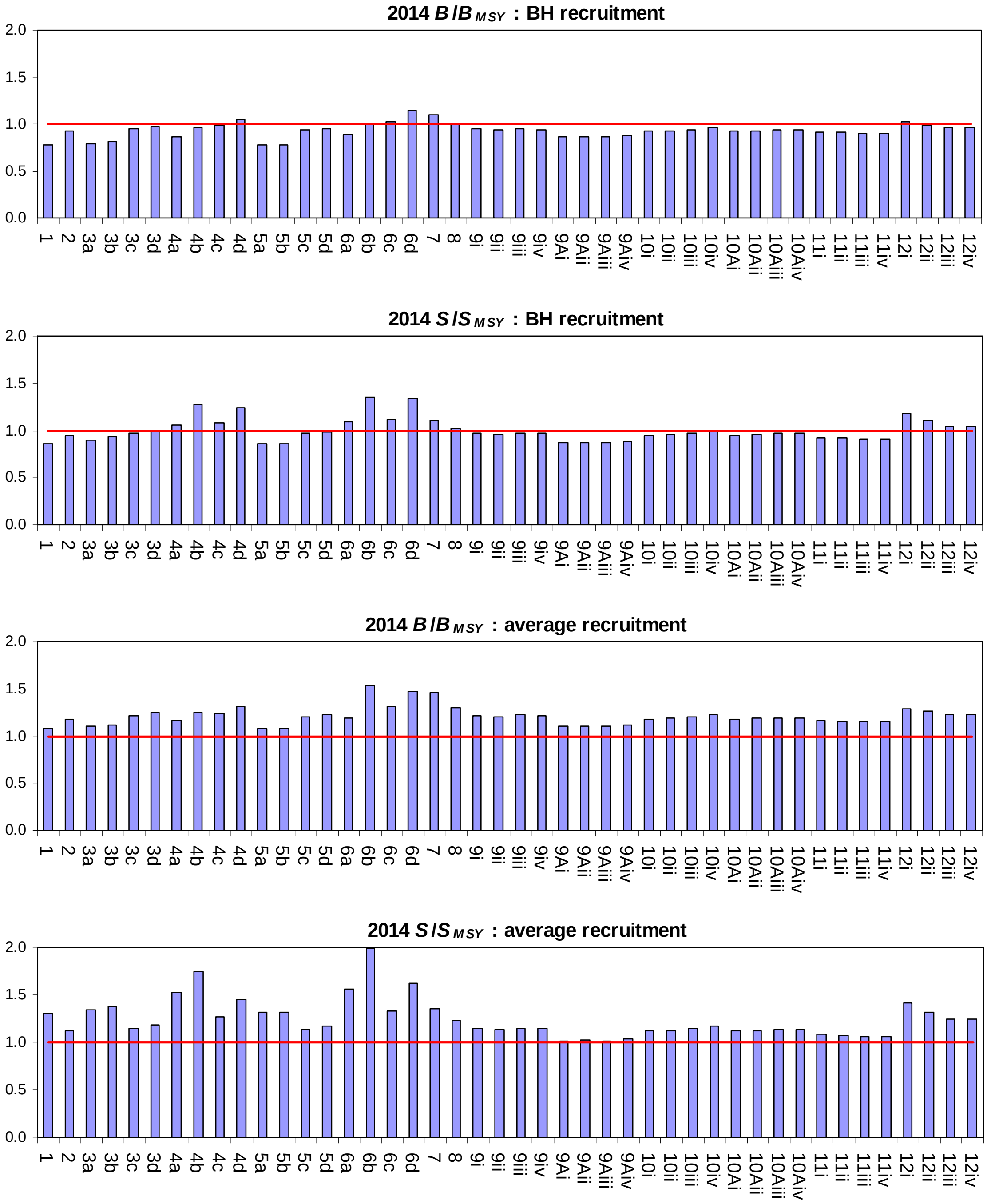


Figure 5. Summary of bigeye tuna projections: 2014 biomass (total and adult) plotted in relation to the respective MSY levels under both the BH and average recruitment models. See Table 1 for definition of projection runs.

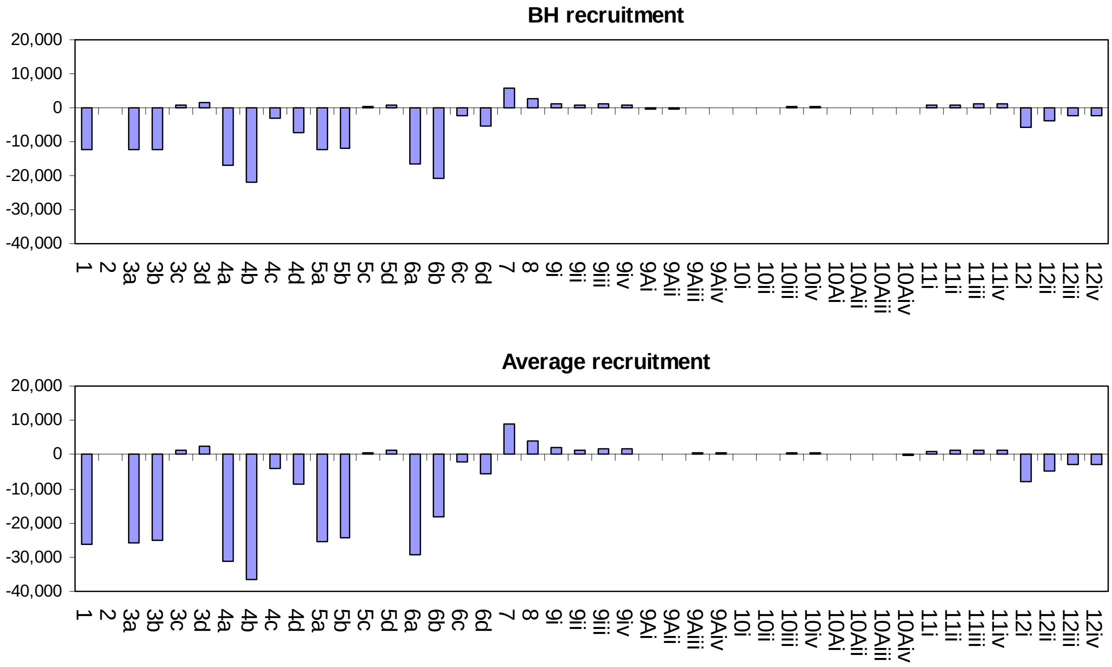


Figure 6. Bigeye tuna average annual catch differentials. Differentials are computed as the average annual catch (in metric tonnes) over the 10-year projection minus the average annual projected catch under run 2 (2003 effort maintained).

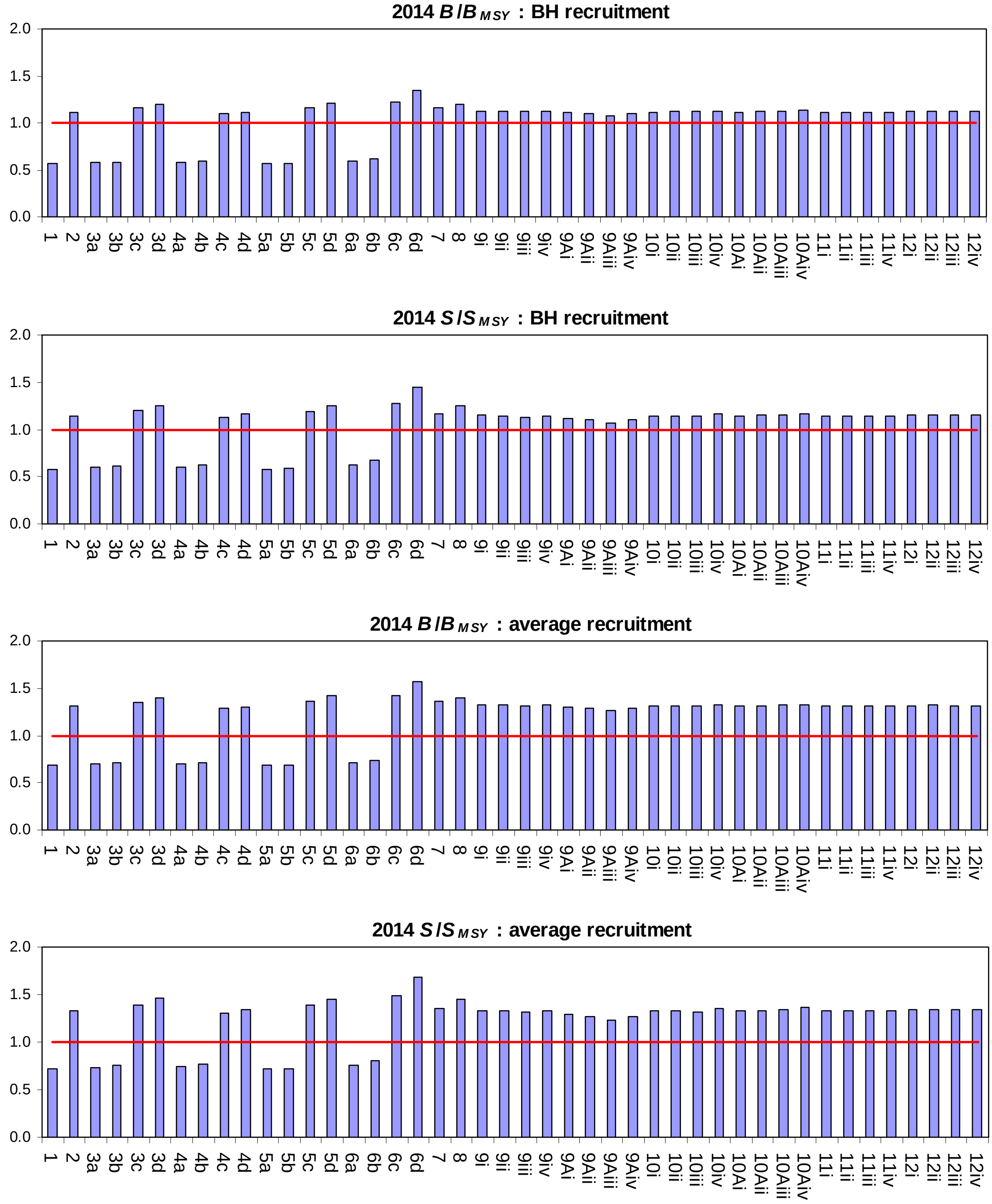


Figure 7. Summary of yellowfin tuna projections: 2014 biomass (total and adult) plotted in relation to the respective MSY levels under both the BH and average recruitment models. See Table 1 for definition of projection runs.

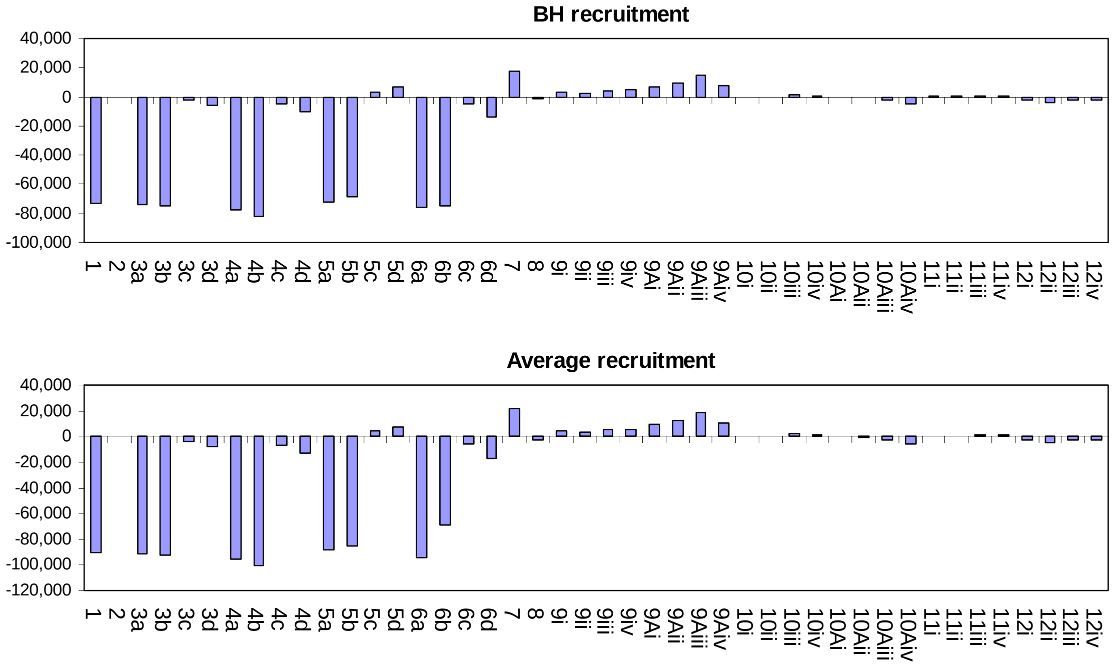


Figure 8. Yellowfin tuna average annual catch differentials. Differentials are computed as the average annual catch over the 10-year projection minus the average annual projected catch under run 2 (2003 effort maintained).

ANNEX 1: RESOLUTION ON CONSERVATION AND MANAGEMENT MEASURES

The Commission For The Conservation And Management Of Highly Migratory Fish Stocks In The Western And Central Pacific Ocean,

Resolves as follows:

WORK BY THE SCIENTIFIC AND TECHNICAL AND COMPLIANCE COMMITTEES

1. Utilising the transitional arrangements for the provision of the Commission's scientific advice and taking into consideration the management options identified as feasible by the Scientific Coordinating Group, the following advice shall be given to the Commission at its second annual session:

(a) Estimates of both sustainable catch and effort levels for bigeye, yellowfin and South Pacific albacore;

(b) Five and ten year projections of total biomass and spawning stock biomass for bigeye and yellowfin tuna under: 2003 catch and effort levels, and possible scenarios of changes in catch and effort (i.e. separate analysis of catch limits and effort limits) in the Convention Area for the purse seine, longline and other surface fisheries which have a major impact on bigeye tuna and yellowfin tuna (both separately and combined); including the effects on the stocks of possible time/area closures by fishing method for bigeye and yellowfin tuna;

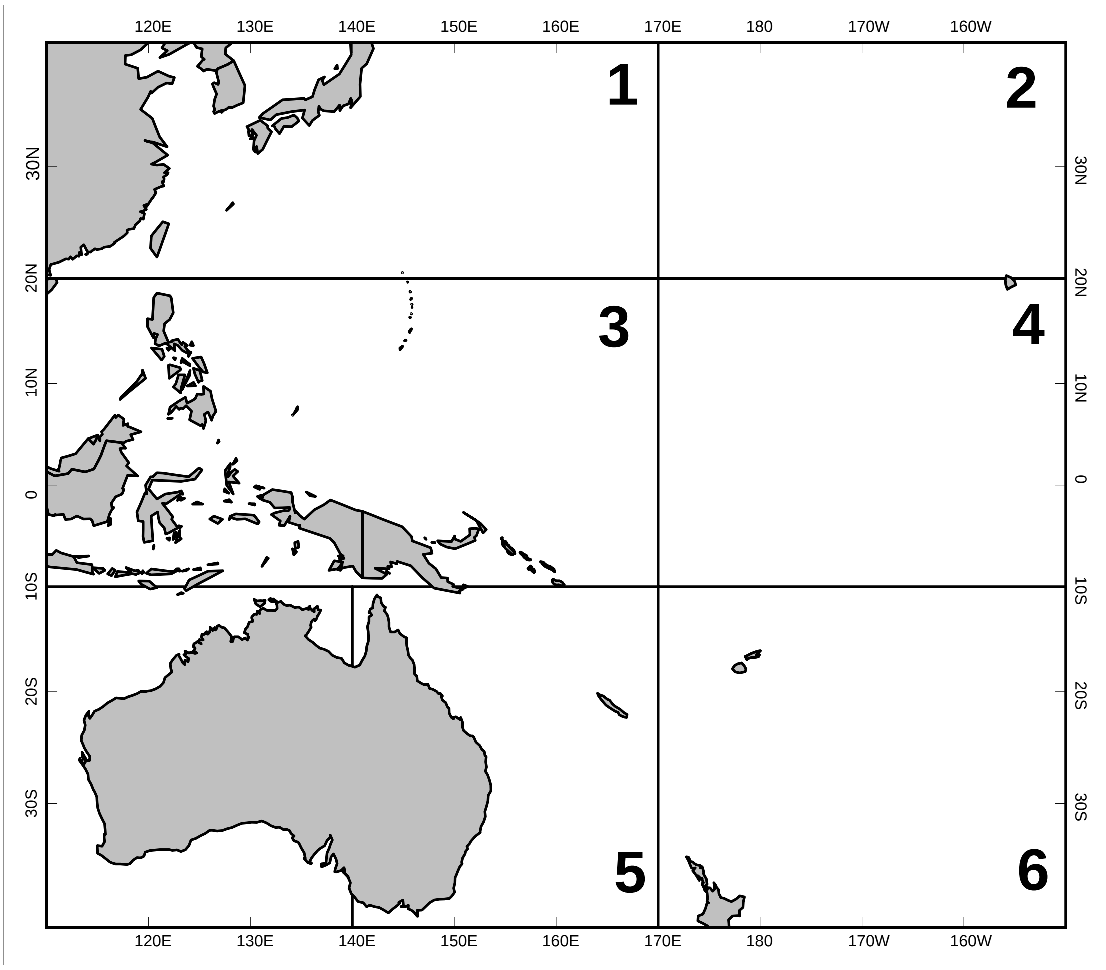
(c) The effects on the stocks of measures to mitigate the catch of juvenile bigeye and yellowfin including controls on setting on floating objects; and

(d) Estimates of the mortality of non-target species with an initial focus on seabirds, turtles and sharks.

2. The preliminary analyses shall be completed, reviewed by the Scientific Committee, and made available to the Commission at least sixty (60) days in advance of its second session.

ANNEX II: SPATIAL STRATIFICATION AND FISHERY DEFINITIONS FOR YELLOWFIN AND BIGEYE TUNA ASSESSMENTS

Spatial Stratification



Fishery Definitions

Fishery Number	Nationality	Gear	Region
1	Japan, Korea, Chinese Taipei	Longline	1
2	Japan, Korea, Chinese Taipei	Longline	2
3	United States	Longline	2
4	All excl. Chinese Taipei & China	Longline	3
5	Chinese Taipei and China	Longline	3
6	Papua New Guinea	Longline	4
7	Japan, Korea	Longline	4
8	Chinese Taipei and China	Longline	4
9	United States	Longline	4
10	All excl. Australia	Longline	5
11	Australia	Longline	5
12	Japan, Korea, Chinese Taipei	Longline	6
13	Pacific Island Countries/Territories	Longline	6
14	All	Purse seine, log/FAD sets	3
15	All	Purse seine, school sets	3
16	All	Purse seine, log/FAD sets	4
17	All	Purse seine, school sets	4
18	Philippines, Indonesia	Miscellaneous (small fish)	3
19	Philippines, Indonesia	Handline (large fish)	3
20[1]	United States[2]	Handline	4

[1]Bigeye tuna model only

[2]Hawaii-based fleet

ANNEX III: 2003 CATCH AND EFFORT

			2003/Q1		2003/Q2		2003/Q3		2003/Q4	
	Catch units	Effort units	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort
Bigeye fisheries[1]										
1	# fish	std. hooks	14,572	373	10,671	219	4,864	309	15,202	436
2	# fish	std. hooks	14,760	128	953	79	31,407	297	33,534	297
3	# fish	1,000 hooks	6,093	17	2,577	15	20,215	54	20,841	51
4	# fish	std. hooks	49,941	192	88,730	261	85,092	345	43,992	189
5	# fish	1,000 hooks	17,873	74	30,423	122	43,561	175	21,189	110
6	# fish	1,000 hooks	1,215	6	1,747	6	1,331	8	687	7
7	# fish	std. hooks	321,089	1,053	128,165	700	66,118	491	68,378	239
8	# fish	1,000 hooks	3,605	18	6,230	23	4,922	19	39,348	52
9	# fish	1,000 hooks	27,889	58	9,193	51	1,232	7	10,840	25
10	# fish	std. hooks	13,948	492	45,083	2,007	19,902	900	11,511	480
11	# fish	1,000 hooks	6,889	36	13,238	36	10,459	35	3,893	29
12	# fish	std. hooks	4,936	261	9,749	593	14,206	276	2,168	110
13	# fish	1,000 hooks	9,369	129	20,642	138	14,918	200	11,360	186
14	mt	days	3,465	4,504	2,027	3,626	3,436	5,369	3,571	5,041
15	mt	days	662	6,103	385	6,429	432	4,741	283	2,998
16	mt	days	9	12	73	343	480	1,017	2,078	2,168
17	mt	days	0	5			14	170	39	728
18	mt	relative	4,282	8	4,262	8	4,532	8	4,419	8
19	mt	days	1,282	488,694	1,282	399,099	1,282	500,033	1,282	525,042
20	mt	days	26	482	36	747	4	1,365	76	596
Yellowfin fisheries[1]										
1	# fish	std. hooks	8,334	262,604	2,581	71,328	1,129	37,429	1,742	97,054
2	# fish	std. hooks	1,681	62,329	305	28,098	593	47,961	4,466	151,642
3	# fish	1,000 hooks	1,311	17,459	1,186	14,805	1,114	53,808	1,522	50,959
4	# fish	std. hooks	163,475	189,021	224,406	224,990	200,374	315,508	109,614	308,020
5	# fish	1,000 hooks	33,747	74,363	46,193	121,772	44,012	174,594	30,625	109,688
6	# fish	1,000 hooks	6,388	5,632	9,105	6,053	8,893	7,786	8,734	6,989
7	# fish	std. hooks	187,216	525,673	182,659	951,276	94,556	516,327	82,310	246,786
8	# fish	1,000 hooks	1,937	17,928	3,918	22,592	2,771	18,806	10,911	51,805
9	# fish	1,000 hooks	13,314	58,207	4,823	51,058	694	6,585	2,510	24,826
10	# fish	std. hooks	33,529	190,487	114,615	1,116,204	44,853	390,310	31,775	141,106
11	# fish	1,000 hooks	25,459	35,613	25,304	35,946	41,772	35,061	22,499	28,915
12	# fish	std. hooks	13,772	791,355	14,016	492,838	20,902	115,105	2,951	187,557
13	# fish	1,000 hooks	37,805	142,388	54,449	167,620	26,661	216,830	24,564	192,744
14	mt	days	13,318	4,504	9,685	3,626	17,556	5,369	18,300	5,041
15	mt	days	43,232	6,103	23,467	6,429	27,642	4,741	18,208	2,998
16	mt	days	26	12	288	343	2,015	1,017	9,225	2,168
17	mt	days	0	5			1,217	170	1,708	728
18	mt	relative	34,407	7	34,427	7	34,157	7	34,270	7
19	mt	days	13,623	488,694	13,623	399,099	13,623	500,033	13,623	525,042

[1]See Annex II for fishery definitions

ANNEX IV: DETAILED PROJECTION RESULTS

Table A-1. Projected total biomass of bigeye tuna as a proportion of the biomass at the end of 2003. B/B_{MSY} represents the ratio of total biomass in the year indicated to the total biomass at MSY. R1–R6 denote the six model regions. The definition of projection runs is given in Table 1.

		BH Recruitment								1994-2003 Average Recruitment							
Run	Year	R1	R2	R3	R4	R5	R6	Total	B/B_{MSY}	R1	R2	R3	R4	R5	R6	Total	B/B_{MSY}
1	2009	1.63	1.40	0.01	0.94	0.50	0.70	0.71	0.89	1.30	1.13	0.01	1.43	0.72	0.82	0.89	1.10
	2014	1.70	1.37	0.00	0.74	0.40	0.63	0.62	0.77	1.22	1.01	0.01	1.44	0.67	0.80	0.87	1.08
2	2009	1.44	1.28	0.31	0.88	0.67	0.77	0.77	0.96	1.17	1.07	0.56	1.21	0.81	0.86	0.96	1.19
	2014	1.45	1.25	0.31	0.83	0.66	0.76	0.74	0.92	1.12	1.01	0.56	1.22	0.81	0.87	0.95	1.18
3a	2009	1.63	1.40	0.01	0.97	0.50	0.70	0.73	0.90	1.30	1.13	0.01	1.46	0.72	0.82	0.90	1.12
	2014	1.70	1.37	0.01	0.78	0.40	0.63	0.64	0.79	1.22	1.01	0.01	1.48	0.67	0.80	0.89	1.10
3b	2009	1.63	1.40	0.01	0.99	0.50	0.70	0.74	0.92	1.30	1.13	0.01	1.50	0.72	0.82	0.92	1.14
	2014	1.70	1.37	0.01	0.81	0.40	0.64	0.66	0.81	1.22	1.01	0.01	1.52	0.67	0.80	0.90	1.12
3c	2009	1.44	1.28	0.34	0.90	0.67	0.77	0.79	0.98	1.17	1.07	0.61	1.24	0.81	0.86	0.99	1.22
	2014	1.45	1.26	0.34	0.85	0.66	0.76	0.76	0.95	1.12	1.01	0.61	1.24	0.81	0.87	0.98	1.21
3d	2009	1.44	1.28	0.38	0.92	0.67	0.77	0.81	1.00	1.17	1.07	0.68	1.26	0.81	0.86	1.02	1.26
	2014	1.45	1.26	0.37	0.87	0.66	0.76	0.78	0.97	1.12	1.01	0.68	1.27	0.81	0.87	1.01	1.25
4a	2009	1.69	1.46	0.01	1.04	0.63	0.78	0.78	0.96	1.35	1.20	0.01	1.53	0.85	0.90	0.95	1.18
	2014	1.78	1.46	0.01	0.85	0.53	0.72	0.70	0.86	1.29	1.08	0.01	1.55	0.81	0.88	0.94	1.17
4b	2009	1.75	1.53	0.01	1.14	0.78	0.87	0.84	1.04	1.41	1.26	0.01	1.63	1.01	0.98	1.01	1.26
	2014	1.86	1.54	0.01	0.97	0.68	0.82	0.77	0.96	1.35	1.15	0.01	1.67	0.98	0.97	1.01	1.26
4c	2009	1.51	1.34	0.32	0.95	0.72	0.82	0.82	1.01	1.22	1.13	0.57	1.29	0.87	0.91	1.01	1.25
	2014	1.53	1.33	0.32	0.90	0.71	0.81	0.79	0.98	1.18	1.06	0.57	1.30	0.87	0.91	1.00	1.24
4d	2009	1.58	1.42	0.33	1.03	0.80	0.87	0.87	1.08	1.29	1.19	0.58	1.38	0.95	0.96	1.07	1.32
	2014	1.63	1.41	0.32	0.97	0.78	0.86	0.85	1.05	1.24	1.12	0.58	1.39	0.95	0.97	1.06	1.32
5a	2009	1.63	1.40	0.01	0.94	0.50	0.70	0.72	0.89	1.30	1.13	0.01	1.44	0.72	0.82	0.89	1.11
	2014	1.70	1.37	0.00	0.74	0.40	0.63	0.62	0.77	1.22	1.01	0.01	1.44	0.67	0.80	0.87	1.08
5b	2009	1.63	1.40	0.01	0.94	0.50	0.70	0.72	0.89	1.30	1.13	0.01	1.45	0.72	0.82	0.90	1.11
	2014	1.70	1.37	0.00	0.74	0.40	0.63	0.62	0.77	1.22	1.01	0.01	1.45	0.67	0.80	0.87	1.08
5c	2009	1.44	1.28	0.35	0.88	0.67	0.77	0.78	0.97	1.17	1.07	0.61	1.22	0.81	0.86	0.98	1.21
	2014	1.45	1.26	0.34	0.84	0.66	0.76	0.76	0.94	1.12	1.01	0.61	1.22	0.81	0.87	0.97	1.20
5d	2009	1.44	1.28	0.38	0.88	0.67	0.77	0.79	0.98	1.17	1.07	0.68	1.22	0.81	0.86	1.00	1.24
	2014	1.45	1.26	0.37	0.84	0.66	0.76	0.77	0.95	1.12	1.01	0.68	1.22	0.81	0.87	0.99	1.23
6a	2009	1.69	1.46	0.01	1.07	0.63	0.78	0.79	0.98	1.35	1.20	0.01	1.57	0.86	0.90	0.97	1.20
	2014	1.78	1.46	0.01	0.89	0.53	0.72	0.71	0.88	1.29	1.08	0.01	1.59	0.81	0.88	0.96	1.19
6b	2009	1.75	1.53	0.01	1.21	0.78	0.87	0.87	1.08	1.41	1.26	0.54	1.76	1.02	0.99	1.24	1.53
	2014	1.87	1.55	0.01	1.05	0.69	0.82	0.81	1.00	1.35	1.15	0.45	1.86	1.00	0.97	1.23	1.53
6c	2009	1.51	1.34	0.39	0.97	0.73	0.82	0.85	1.05	1.22	1.13	0.69	1.32	0.87	0.91	1.06	1.31
	2014	1.54	1.33	0.38	0.92	0.71	0.81	0.82	1.02	1.18	1.06	0.69	1.33	0.88	0.92	1.05	1.31
6d	2009	1.58	1.42	0.50	1.08	0.80	0.87	0.95	1.17	1.29	1.19	0.86	1.45	0.96	0.97	1.19	1.47
	2014	1.63	1.42	0.49	1.02	0.79	0.87	0.92	1.15	1.24	1.12	0.87	1.47	0.96	0.97	1.19	1.47
7	2009	1.44	1.28	0.57	1.00	0.67	0.77	0.90	1.12	1.17	1.07	1.02	1.38	0.81	0.86	1.17	1.46
	2014	1.46	1.26	0.57	0.96	0.66	0.77	0.88	1.10	1.12	1.01	1.03	1.40	0.82	0.87	1.17	1.45
8	2009	1.44	1.28	0.43	0.94	0.67	0.77	0.83	1.03	1.17	1.07	0.76	1.30	0.81	0.86	1.06	1.31
	2014	1.45	1.26	0.42	0.90	0.66	0.76	0.81	1.00	1.12	1.01	0.76	1.31	0.81	0.87	1.05	1.30
9i	2009	1.44	1.28	0.36	0.88	0.67	0.77	0.79	0.98	1.17	1.07	0.64	1.22	0.81	0.86	0.99	1.22
	2014	1.45	1.26	0.35	0.84	0.66	0.76	0.76	0.94	1.12	1.01	0.64	1.22	0.81	0.87	0.98	1.21
9ii	2009	1.44	1.28	0.35	0.88	0.67	0.77	0.78	0.97	1.17	1.07	0.63	1.22	0.81	0.86	0.98	1.22
	2014	1.45	1.26	0.35	0.84	0.66	0.76	0.76	0.94	1.12	1.01	0.63	1.22	0.81	0.87	0.97	1.21
9iii	2009	1.44	1.28	0.37	0.88	0.67	0.77	0.79	0.98	1.17	1.07	0.66	1.22	0.81	0.86	0.99	1.23
	2014	1.45	1.26	0.37	0.84	0.66	0.76	0.77	0.95	1.12	1.01	0.67	1.22	0.81	0.87	0.98	1.22
9iv	2009	1.44	1.28	0.36	0.88	0.67	0.77	0.78	0.97	1.17	1.07	0.63	1.22	0.81	0.86	0.98	1.22
	2014	1.45	1.26	0.35	0.84	0.66	0.76	0.76	0.94	1.12	1.01	0.64	1.22	0.81	0.87	0.98	1.21

Table A-1. (Continued)

		BH Recruitment								1994-2003 Average Recruitment							
Run	**Year**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	***B/B*** $_{MSY}$	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	***B/B*** $_{MSY}$
9Ai	2009	1.43	1.28	0.36	0.73	0.67	0.76	0.72	0.89	1.17	1.07	0.65	1.01	0.81	0.86	0.90	1.11
	2014	1.44	1.25	0.35	0.68	0.65	0.75	0.69	0.86	1.12	1.01	0.65	1.01	0.81	0.86	0.89	1.10
9Aii	2009	1.43	1.28	0.36	0.74	0.67	0.77	0.72	0.90	1.17	1.07	0.64	1.03	0.81	0.86	0.90	1.12
	2014	1.44	1.25	0.35	0.69	0.65	0.75	0.70	0.87	1.12	1.01	0.64	1.02	0.81	0.86	0.89	1.10
9Aiii	2009	1.43	1.28	0.38	0.72	0.67	0.76	0.72	0.90	1.17	1.07	0.67	0.99	0.81	0.85	0.90	1.12
	2014	1.44	1.25	0.37	0.67	0.65	0.75	0.69	0.86	1.12	1.01	0.68	0.98	0.81	0.86	0.89	1.10
9Aiv	2009	1.44	1.28	0.36	0.77	0.67	0.77	0.74	0.91	1.17	1.07	0.64	1.06	0.81	0.86	0.92	1.14
	2014	1.44	1.25	0.35	0.71	0.65	0.75	0.71	0.88	1.12	1.01	0.64	1.05	0.81	0.86	0.90	1.12
10i	2009	1.44	1.28	0.31	0.88	0.67	0.77	0.77	0.96	1.17	1.07	0.56	1.21	0.81	0.86	0.96	1.19
	2014	1.45	1.25	0.31	0.83	0.66	0.76	0.74	0.92	1.12	1.01	0.56	1.22	0.81	0.87	0.95	1.18
10ii	2009	1.44	1.28	0.31	0.89	0.67	0.77	0.78	0.96	1.17	1.07	0.56	1.23	0.81	0.86	0.97	1.20
	2014	1.45	1.25	0.31	0.85	0.66	0.76	0.75	0.93	1.12	1.01	0.56	1.24	0.81	0.87	0.96	1.19
10iii	2009	1.44	1.28	0.31	0.91	0.67	0.77	0.78	0.97	1.17	1.07	0.56	1.26	0.81	0.86	0.98	1.21
	2014	1.45	1.26	0.31	0.86	0.66	0.76	0.76	0.94	1.12	1.01	0.56	1.26	0.81	0.87	0.97	1.20
10iv	2009	1.44	1.28	0.32	0.93	0.67	0.77	0.79	0.98	1.17	1.07	0.56	1.29	0.81	0.86	0.99	1.23
	2014	1.45	1.26	0.31	0.89	0.66	0.76	0.77	0.96	1.12	1.01	0.56	1.30	0.81	0.87	0.98	1.22
10Ai	2009	1.44	1.28	0.31	0.88	0.67	0.77	0.77	0.96	1.17	1.07	0.56	1.21	0.81	0.86	0.96	1.19
	2014	1.45	1.25	0.31	0.83	0.66	0.76	0.74	0.92	1.12	1.01	0.56	1.22	0.81	0.87	0.95	1.18
10Aii	2009	1.44	1.28	0.31	0.89	0.67	0.77	0.77	0.96	1.17	1.07	0.55	1.23	0.81	0.86	0.96	1.19
	2014	1.45	1.25	0.30	0.85	0.66	0.76	0.75	0.93	1.12	1.01	0.55	1.24	0.81	0.87	0.95	1.18
10Aiii	2009	1.44	1.28	0.30	0.91	0.67	0.77	0.78	0.97	1.17	1.07	0.54	1.26	0.81	0.86	0.97	1.20
	2014	1.45	1.26	0.30	0.87	0.66	0.76	0.76	0.94	1.12	1.01	0.54	1.26	0.81	0.87	0.96	1.20
10Aiv	2009	1.44	1.28	0.30	0.91	0.67	0.77	0.78	0.97	1.17	1.07	0.53	1.26	0.81	0.86	0.97	1.20
	2014	1.45	1.26	0.29	0.87	0.66	0.76	0.75	0.94	1.12	1.01	0.53	1.26	0.81	0.87	0.96	1.19
11i	2009	1.43	1.28	0.32	0.86	0.67	0.77	0.76	0.94	1.17	1.07	0.56	1.19	0.81	0.86	0.95	1.18
	2014	1.45	1.25	0.31	0.81	0.65	0.76	0.74	0.91	1.12	1.01	0.56	1.19	0.81	0.87	0.94	1.16
11ii	2009	1.43	1.28	0.32	0.84	0.67	0.77	0.76	0.94	1.17	1.07	0.57	1.17	0.81	0.86	0.94	1.17
	2014	1.45	1.25	0.31	0.80	0.65	0.76	0.73	0.91	1.12	1.01	0.57	1.17	0.81	0.87	0.93	1.16
11iii	2009	1.43	1.28	0.33	0.83	0.67	0.77	0.75	0.93	1.17	1.07	0.58	1.15	0.81	0.86	0.94	1.16
	2014	1.45	1.25	0.32	0.78	0.65	0.76	0.73	0.90	1.12	1.01	0.58	1.15	0.81	0.87	0.93	1.15
11iv	2009	1.43	1.28	0.33	0.83	0.67	0.77	0.75	0.93	1.17	1.07	0.58	1.15	0.81	0.86	0.94	1.16
	2014	1.45	1.25	0.32	0.78	0.65	0.76	0.73	0.90	1.12	1.01	0.58	1.15	0.81	0.87	0.93	1.15
12i	2009	1.44	1.28	0.30	1.07	0.67	0.78	0.85	1.06	1.17	1.07	0.53	1.44	0.81	0.86	1.05	1.30
	2014	1.47	1.27	0.30	1.01	0.66	0.77	0.82	1.02	1.12	1.01	0.53	1.45	0.81	0.87	1.04	1.29
12ii	2009	1.44	1.28	0.30	1.02	0.67	0.77	0.83	1.03	1.17	1.07	0.53	1.38	0.81	0.86	1.02	1.27
	2014	1.46	1.26	0.30	0.96	0.66	0.77	0.80	0.99	1.12	1.01	0.53	1.39	0.81	0.87	1.02	1.26
12iii	2009	1.44	1.28	0.30	0.98	0.67	0.77	0.81	1.00	1.17	1.07	0.53	1.33	0.81	0.86	1.00	1.24
	2014	1.46	1.26	0.30	0.92	0.66	0.76	0.78	0.97	1.12	1.01	0.54	1.34	0.81	0.87	0.99	1.23
12iv	2009	1.44	1.28	0.30	0.98	0.67	0.77	0.81	1.00	1.17	1.07	0.53	1.33	0.81	0.86	1.00	1.24
	2014	1.46	1.26	0.30	0.92	0.66	0.76	0.78	0.97	1.12	1.01	0.54	1.34	0.81	0.87	0.99	1.23

Table A-2. Projected adult biomass of bigeye tuna as a proportion of the adult biomass at the end of 2003. S/S_{MSY} represents the ratio of adult biomass in the year indicated to the adult biomass at MSY. R1–R6 denote the six model regions. The definition of projection runs is given in Table 1.

		BH Recruitment								1994-2003 Average Recruitment							
Run	**Year**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	S/S_{MSY}	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	S/S_{MSY}
1	2009	1.79	1.83	0.00	1.18	0.29	1.02	0.97	1.12	1.51	1.55	0.00	1.78	0.64	1.26	1.19	1.37
	2014	1.95	1.80	0.00	0.68	0.10	0.80	0.75	0.86	1.35	1.24	0.00	1.82	0.48	1.18	1.14	1.31
2	2009	1.44	1.56	0.20	0.98	0.76	1.25	0.89	1.02	1.26	1.39	0.32	1.23	0.90	1.38	1.00	1.15
	2014	1.49	1.52	0.19	0.85	0.73	1.23	0.83	0.95	1.16	1.22	0.33	1.24	0.91	1.42	0.97	1.12
3a	2009	1.79	1.83	0.00	1.23	0.29	1.02	0.99	1.14	1.51	1.55	0.00	1.83	0.64	1.26	1.21	1.39
	2014	1.96	1.80	0.00	0.74	0.10	0.81	0.78	0.90	1.35	1.24	0.00	1.89	0.48	1.18	1.17	1.35
3b	2009	1.79	1.83	0.00	1.27	0.29	1.03	1.01	1.17	1.51	1.55	0.00	1.89	0.64	1.26	1.23	1.42
	2014	1.96	1.80	0.00	0.81	0.10	0.81	0.81	0.93	1.35	1.24	0.00	1.96	0.48	1.18	1.20	1.38
3c	2009	1.44	1.56	0.22	1.00	0.76	1.25	0.90	1.04	1.26	1.39	0.37	1.26	0.90	1.38	1.02	1.18
	2014	1.49	1.52	0.21	0.88	0.74	1.24	0.84	0.97	1.16	1.22	0.37	1.27	0.91	1.42	1.00	1.15
3d	2009	1.44	1.56	0.25	1.02	0.76	1.26	0.92	1.06	1.26	1.39	0.42	1.29	0.90	1.38	1.05	1.21
	2014	1.49	1.52	0.24	0.90	0.74	1.24	0.86	0.99	1.16	1.22	0.42	1.30	0.91	1.42	1.03	1.18
4a	2009	1.89	1.97	0.00	1.44	0.66	1.31	1.13	1.30	1.61	1.70	0.00	2.03	1.10	1.56	1.35	1.55
	2014	2.10	1.98	0.00	0.94	0.35	1.10	0.92	1.06	1.47	1.40	0.00	2.11	0.94	1.49	1.32	1.52
4b	2009	1.99	2.12	0.00	1.71	1.21	1.66	1.30	1.50	1.72	1.85	0.00	2.30	1.71	1.91	1.52	1.74
	2014	2.25	2.17	0.00	1.23	0.82	1.44	1.11	1.27	1.60	1.56	0.00	2.43	1.57	1.84	1.52	1.75
4c	2009	1.56	1.70	0.21	1.14	0.97	1.44	1.00	1.15	1.37	1.52	0.34	1.42	1.13	1.57	1.13	1.30
	2014	1.64	1.68	0.20	1.00	0.93	1.41	0.94	1.08	1.27	1.34	0.35	1.44	1.14	1.61	1.10	1.27
4d	2009	1.69	1.86	0.23	1.35	1.25	1.66	1.14	1.31	1.49	1.67	0.37	1.65	1.44	1.81	1.28	1.47
	2014	1.80	1.86	0.22	1.18	1.19	1.62	1.07	1.24	1.39	1.47	0.37	1.68	1.45	1.84	1.26	1.45
5a	2009	1.79	1.83	0.00	1.19	0.29	1.02	0.98	1.12	1.51	1.55	0.00	1.79	0.64	1.26	1.19	1.37
	2014	1.95	1.80	0.00	0.68	0.10	0.80	0.75	0.86	1.35	1.24	0.00	1.82	0.48	1.18	1.14	1.31
5b	2009	1.79	1.83	0.00	1.19	0.29	1.02	0.98	1.13	1.51	1.55	0.00	1.81	0.64	1.26	1.20	1.38
	2014	1.95	1.80	0.00	0.68	0.10	0.80	0.75	0.86	1.35	1.24	0.00	1.83	0.48	1.18	1.14	1.31
5c	2009	1.44	1.56	0.23	0.98	0.76	1.25	0.90	1.03	1.26	1.39	0.38	1.24	0.90	1.38	1.02	1.17
	2014	1.49	1.52	0.22	0.86	0.74	1.24	0.84	0.96	1.16	1.22	0.39	1.24	0.91	1.42	0.99	1.14
5d	2009	1.44	1.56	0.28	0.98	0.76	1.25	0.91	1.05	1.26	1.39	0.46	1.24	0.90	1.38	1.04	1.20
	2014	1.49	1.52	0.27	0.86	0.74	1.24	0.85	0.98	1.16	1.22	0.47	1.25	0.91	1.42	1.02	1.17
6a	2009	1.89	1.97	0.00	1.49	0.67	1.32	1.16	1.33	1.61	1.70	0.00	2.10	1.11	1.56	1.38	1.58
	2014	2.10	1.99	0.00	1.01	0.35	1.10	0.95	1.09	1.47	1.40	0.00	2.19	0.94	1.49	1.36	1.56
6b	2009	1.99	2.12	0.00	1.82	1.23	1.67	1.35	1.56	1.72	1.85	0.24	2.47	1.76	1.92	1.66	1.91
	2014	2.25	2.18	0.00	1.38	0.83	1.45	1.18	1.35	1.60	1.57	0.17	2.79	1.64	1.87	1.73	1.99
6c	2009	1.56	1.70	0.29	1.17	0.97	1.44	1.04	1.19	1.37	1.52	0.47	1.46	1.13	1.57	1.18	1.36
	2014	1.64	1.68	0.27	1.03	0.93	1.41	0.97	1.12	1.27	1.34	0.48	1.48	1.14	1.61	1.16	1.33
6d	2009	1.69	1.86	0.42	1.41	1.26	1.67	1.23	1.41	1.49	1.67	0.68	1.74	1.45	1.81	1.41	1.62
	2014	1.81	1.86	0.40	1.26	1.20	1.63	1.16	1.34	1.39	1.47	0.71	1.80	1.46	1.85	1.41	1.62
7	2009	1.44	1.56	0.40	1.11	0.77	1.26	1.00	1.15	1.26	1.39	0.68	1.41	0.91	1.39	1.18	1.36
	2014	1.50	1.53	0.39	1.01	0.75	1.25	0.96	1.10	1.16	1.22	0.69	1.47	0.92	1.43	1.17	1.35
8	2009	1.44	1.56	0.29	1.05	0.77	1.26	0.94	1.08	1.26	1.39	0.48	1.32	0.90	1.38	1.08	1.25
	2014	1.50	1.53	0.28	0.93	0.74	1.24	0.89	1.02	1.16	1.22	0.49	1.35	0.91	1.42	1.07	1.23
9i	2009	1.44	1.56	0.23	0.98	0.76	1.25	0.90	1.03	1.26	1.39	0.39	1.24	0.90	1.38	1.02	1.17
	2014	1.49	1.52	0.22	0.86	0.74	1.24	0.84	0.96	1.16	1.22	0.39	1.25	0.91	1.42	0.99	1.14
9ii	2009	1.44	1.56	0.23	0.98	0.76	1.25	0.90	1.03	1.26	1.39	0.37	1.24	0.90	1.38	1.02	1.17
	2014	1.49	1.52	0.22	0.86	0.74	1.24	0.84	0.96	1.16	1.22	0.38	1.24	0.91	1.42	0.99	1.14
9iii	2009	1.44	1.56	0.24	0.98	0.76	1.25	0.90	1.03	1.26	1.39	0.39	1.24	0.90	1.38	1.02	1.18
	2014	1.49	1.52	0.23	0.86	0.74	1.24	0.84	0.97	1.16	1.22	0.40	1.25	0.91	1.42	0.99	1.14
9iv	2009	1.44	1.56	0.23	0.98	0.76	1.25	0.90	1.03	1.26	1.39	0.39	1.24	0.90	1.38	1.02	1.17
	2014	1.49	1.52	0.22	0.86	0.74	1.24	0.84	0.97	1.16	1.22	0.39	1.25	0.91	1.42	0.99	1.14

Table A-2. (Continued)

Run	Year	BH Recruitment R1	R2	R3	R4	R5	R6	Total	S/S_{MSY}	1994-2003 Average Recruitment R1	R2	R3	R4	R5	R6	Total	S/S_{MSY}
9Ai	2009	1.44	1.56	0.23	0.80	0.76	1.24	0.82	0.94	1.26	1.39	0.39	1.00	0.90	1.37	0.92	1.05
	2014	1.48	1.51	0.22	0.68	0.73	1.22	0.76	0.87	1.16	1.22	0.40	0.99	0.91	1.40	0.88	1.01
9Aii	2009	1.44	1.56	0.23	0.82	0.76	1.24	0.83	0.95	1.26	1.39	0.38	1.03	0.90	1.37	0.93	1.07
	2014	1.49	1.51	0.21	0.69	0.73	1.22	0.76	0.88	1.16	1.22	0.38	1.01	0.91	1.40	0.89	1.02
9Aiii	2009	1.44	1.56	0.24	0.81	0.76	1.24	0.82	0.95	1.26	1.39	0.40	1.01	0.90	1.37	0.92	1.06
	2014	1.49	1.51	0.23	0.67	0.73	1.22	0.75	0.87	1.16	1.22	0.40	0.98	0.91	1.40	0.88	1.01
9Aiv	2009	1.44	1.56	0.23	0.85	0.76	1.25	0.84	0.97	1.26	1.39	0.39	1.06	0.90	1.37	0.94	1.08
	2014	1.49	1.52	0.22	0.70	0.73	1.22	0.77	0.88	1.16	1.22	0.40	1.02	0.91	1.41	0.90	1.03
10i	2009	1.44	1.56	0.20	0.98	0.76	1.25	0.89	1.02	1.26	1.39	0.32	1.23	0.90	1.38	1.00	1.15
	2014	1.49	1.52	0.19	0.85	0.73	1.23	0.83	0.95	1.16	1.22	0.33	1.24	0.91	1.42	0.97	1.12
10ii	2009	1.44	1.56	0.20	0.99	0.76	1.25	0.89	1.03	1.26	1.39	0.32	1.25	0.90	1.38	1.01	1.16
	2014	1.49	1.52	0.19	0.87	0.73	1.24	0.83	0.96	1.16	1.22	0.33	1.26	0.91	1.42	0.98	1.13
10iii	2009	1.44	1.56	0.20	1.01	0.76	1.26	0.90	1.03	1.26	1.39	0.32	1.27	0.90	1.38	1.02	1.17
	2014	1.49	1.52	0.19	0.89	0.73	1.24	0.84	0.97	1.16	1.22	0.33	1.28	0.91	1.42	0.99	1.14
10iv	2009	1.44	1.56	0.20	1.04	0.76	1.26	0.91	1.05	1.26	1.39	0.33	1.31	0.90	1.38	1.04	1.19
	2014	1.49	1.52	0.19	0.93	0.74	1.24	0.86	0.99	1.16	1.22	0.33	1.34	0.91	1.42	1.02	1.17
10Ai	2009	1.44	1.56	0.20	0.98	0.76	1.25	0.89	1.02	1.26	1.39	0.32	1.23	0.90	1.38	1.00	1.15
	2014	1.49	1.52	0.19	0.85	0.73	1.23	0.83	0.95	1.16	1.22	0.33	1.24	0.91	1.42	0.97	1.12
10Aii	2009	1.44	1.56	0.19	0.99	0.76	1.25	0.89	1.03	1.26	1.39	0.32	1.25	0.90	1.38	1.01	1.16
	2014	1.49	1.52	0.18	0.87	0.73	1.24	0.83	0.96	1.16	1.22	0.32	1.26	0.91	1.42	0.98	1.13
10Aiii	2009	1.44	1.56	0.19	1.01	0.76	1.26	0.90	1.03	1.26	1.39	0.31	1.28	0.90	1.38	1.02	1.17
	2014	1.49	1.52	0.18	0.89	0.73	1.24	0.84	0.97	1.16	1.22	0.32	1.29	0.91	1.42	0.99	1.14
10Aiv	2009	1.44	1.56	0.18	1.01	0.76	1.26	0.90	1.03	1.26	1.39	0.30	1.27	0.90	1.38	1.01	1.16
	2014	1.49	1.52	0.17	0.89	0.73	1.24	0.84	0.96	1.16	1.22	0.30	1.29	0.91	1.42	0.99	1.13
11i	2009	1.44	1.56	0.21	0.92	0.76	1.25	0.86	0.99	1.26	1.39	0.34	1.16	0.90	1.38	0.97	1.12
	2014	1.49	1.52	0.20	0.80	0.73	1.23	0.80	0.93	1.16	1.22	0.34	1.16	0.91	1.42	0.94	1.09
11ii	2009	1.44	1.56	0.22	0.89	0.76	1.25	0.85	0.98	1.26	1.39	0.35	1.12	0.90	1.38	0.96	1.11
	2014	1.49	1.52	0.20	0.77	0.73	1.23	0.80	0.91	1.16	1.22	0.36	1.13	0.91	1.42	0.93	1.07
11iii	2009	1.44	1.56	0.23	0.86	0.76	1.25	0.84	0.97	1.26	1.39	0.38	1.09	0.90	1.38	0.95	1.10
	2014	1.49	1.52	0.22	0.75	0.73	1.23	0.79	0.91	1.16	1.22	0.38	1.09	0.91	1.41	0.92	1.06
11iv	2009	1.44	1.56	0.23	0.86	0.76	1.25	0.84	0.97	1.26	1.39	0.38	1.09	0.90	1.38	0.95	1.10
	2014	1.49	1.52	0.22	0.75	0.73	1.23	0.79	0.91	1.16	1.22	0.38	1.09	0.91	1.41	0.92	1.06
12i	2009	1.44	1.56	0.17	1.49	0.76	1.26	1.10	1.27	1.26	1.39	0.28	1.81	0.90	1.39	1.24	1.43
	2014	1.51	1.54	0.16	1.30	0.74	1.26	1.02	1.17	1.16	1.22	0.28	1.85	0.91	1.43	1.23	1.41
12ii	2009	1.44	1.56	0.17	1.33	0.76	1.26	1.04	1.19	1.26	1.39	0.28	1.64	0.90	1.39	1.17	1.34
	2014	1.50	1.53	0.16	1.16	0.74	1.25	0.96	1.10	1.16	1.22	0.28	1.67	0.91	1.42	1.15	1.32
12iii	2009	1.44	1.56	0.18	1.21	0.76	1.26	0.98	1.13	1.26	1.39	0.29	1.50	0.90	1.38	1.11	1.27
	2014	1.50	1.53	0.17	1.05	0.74	1.24	0.91	1.05	1.16	1.22	0.29	1.52	0.91	1.42	1.08	1.25
12iv	2009	1.44	1.56	0.18	1.21	0.76	1.26	0.98	1.13	1.26	1.39	0.29	1.50	0.90	1.38	1.11	1.27
	2014	1.50	1.53	0.17	1.05	0.74	1.24	0.91	1.05	1.16	1.22	0.29	1.52	0.91	1.42	1.08	1.25

Table A-3. Projected exploitable abundance of bigeye tuna for selected fisheries (F1, F2, etc. – see Annex II for definitions) as a proportion of the exploitable abundance at the end of 2003. The definition of projection runs is given in Table 1.

		BH Recruitment										1994-2003 Average Recruitment									
Run	Year	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19
1	2009	1.74	1.78	0.00	1.01	0.43	0.98	0.00	0.78	0.01	0.00	1.42	1.48	0.00	1.57	0.72	1.17	0.00	1.17	0.01	0.00
	2014	1.85	1.73	0.00	0.72	0.28	0.84	0.00	0.75	0.01	0.00	1.31	1.24	0.00	1.58	0.63	1.12	0.00	1.17	0.01	0.00
2	2009	1.48	1.58	0.23	0.91	0.73	1.13	0.54	0.79	0.30	0.22	1.24	1.36	0.41	1.23	0.88	1.26	0.99	1.15	0.50	0.36
	2014	1.50	1.54	0.23	0.85	0.71	1.11	0.54	0.78	0.28	0.21	1.16	1.23	0.41	1.24	0.88	1.27	0.99	1.15	0.51	0.36
3a	2009	1.74	1.78	0.00	1.05	0.43	0.98	0.00	0.80	0.01	0.00	1.42	1.48	0.00	1.61	0.72	1.18	0.00	1.19	0.01	0.00
	2014	1.85	1.73	0.00	0.77	0.28	0.85	0.00	0.77	0.01	0.00	1.31	1.24	0.00	1.63	0.63	1.13	0.00	1.19	0.01	0.00
3b	2009	1.74	1.78	0.00	1.08	0.43	0.98	0.00	0.81	0.01	0.00	1.42	1.48	0.00	1.65	0.72	1.18	0.00	1.20	0.01	0.00
	2014	1.85	1.74	0.00	0.82	0.28	0.85	0.00	0.78	0.01	0.00	1.31	1.24	0.00	1.68	0.63	1.13	0.00	1.20	0.01	0.00
3c	2009	1.48	1.58	0.26	0.93	0.73	1.13	0.58	0.80	0.32	0.25	1.24	1.36	0.46	1.26	0.88	1.26	1.05	1.16	0.56	0.40
	2014	1.50	1.54	0.26	0.87	0.71	1.11	0.57	0.79	0.31	0.23	1.16	1.23	0.46	1.27	0.88	1.27	1.05	1.16	0.56	0.41
3d	2009	1.48	1.58	0.30	0.96	0.73	1.13	0.62	0.82	0.36	0.28	1.24	1.36	0.52	1.29	0.88	1.26	1.13	1.18	0.61	0.46
	2014	1.50	1.54	0.29	0.89	0.71	1.11	0.61	0.81	0.34	0.26	1.16	1.23	0.52	1.30	0.88	1.27	1.13	1.18	0.62	0.47
4a	2009	1.82	1.89	0.00	1.16	0.65	1.15	0.00	0.80	0.01	0.00	1.50	1.58	0.00	1.71	0.97	1.35	0.00	1.18	0.01	0.00
	2014	1.96	1.87	0.00	0.88	0.49	1.03	0.00	0.78	0.01	0.00	1.40	1.36	0.00	1.74	0.89	1.30	0.00	1.18	0.01	0.00
4b	2009	1.90	2.00	0.00	1.31	0.93	1.34	0.00	0.81	0.01	0.00	1.58	1.69	0.00	1.86	1.25	1.53	0.00	1.19	0.01	0.00
	2014	2.08	2.02	0.00	1.06	0.76	1.23	0.00	0.80	0.01	0.00	1.50	1.48	0.00	1.92	1.20	1.50	0.00	1.19	0.01	0.00
4c	2009	1.57	1.69	0.24	1.01	0.83	1.23	0.55	0.80	0.31	0.24	1.32	1.46	0.42	1.35	1.00	1.36	0.99	1.16	0.52	0.38
	2014	1.61	1.66	0.24	0.94	0.81	1.21	0.54	0.80	0.29	0.22	1.24	1.32	0.42	1.36	1.00	1.38	0.99	1.16	0.53	0.39
4d	2009	1.67	1.80	0.25	1.13	0.96	1.35	0.55	0.82	0.32	0.26	1.41	1.56	0.43	1.49	1.15	1.49	0.99	1.17	0.54	0.41
	2014	1.74	1.79	0.25	1.05	0.94	1.33	0.55	0.81	0.31	0.24	1.34	1.42	0.44	1.50	1.15	1.50	0.99	1.17	0.54	0.42
5a	2009	1.74	1.78	0.00	1.02	0.43	0.98	0.00	0.79	0.01	0.00	1.42	1.48	0.00	1.57	0.72	1.17	0.00	1.17	0.01	0.00
	2014	1.85	1.73	0.00	0.72	0.28	0.84	0.00	0.75	0.01	0.00	1.31	1.24	0.00	1.58	0.63	1.12	0.00	1.17	0.01	0.00
5b	2009	1.74	1.78	0.00	1.02	0.43	0.98	0.00	0.79	0.01	0.00	1.42	1.48	0.00	1.59	0.72	1.18	0.00	1.18	0.01	0.00
	2014	1.85	1.73	0.00	0.72	0.28	0.84	0.00	0.75	0.01	0.00	1.31	1.24	0.00	1.58	0.63	1.12	0.00	1.17	0.01	0.00
5c	2009	1.48	1.58	0.27	0.92	0.73	1.13	0.58	0.79	0.34	0.27	1.24	1.36	0.46	1.24	0.88	1.26	1.05	1.15	0.57	0.43
	2014	1.50	1.54	0.26	0.85	0.71	1.11	0.57	0.78	0.32	0.25	1.16	1.23	0.47	1.24	0.88	1.27	1.05	1.15	0.57	0.44
5d	2009	1.48	1.58	0.31	0.92	0.73	1.13	0.62	0.80	0.38	0.33	1.24	1.36	0.53	1.24	0.88	1.26	1.12	1.15	0.64	0.51
	2014	1.50	1.54	0.30	0.86	0.71	1.11	0.61	0.79	0.36	0.30	1.16	1.23	0.53	1.25	0.88	1.27	1.12	1.15	0.65	0.53
6a	2009	1.82	1.89	0.00	1.20	0.66	1.15	0.00	0.81	0.01	0.00	1.50	1.58	0.00	1.77	0.97	1.35	0.00	1.20	0.01	0.00
	2014	1.96	1.88	0.00	0.94	0.49	1.03	0.00	0.79	0.01	0.00	1.40	1.36	0.00	1.80	0.89	1.31	0.00	1.20	0.01	0.00
6b	2009	1.90	2.00	0.00	1.40	0.94	1.34	0.00	0.84	0.01	0.00	1.58	1.69	0.37	2.02	1.28	1.54	1.03	1.26	0.46	0.28
	2014	2.08	2.02	0.00	1.16	0.76	1.24	0.00	0.83	0.01	0.00	1.50	1.49	0.28	2.17	1.24	1.51	0.92	1.26	0.38	0.20
6c	2009	1.57	1.69	0.32	1.04	0.83	1.23	0.62	0.82	0.39	0.33	1.32	1.46	0.54	1.39	1.00	1.36	1.13	1.18	0.65	0.52
	2014	1.62	1.66	0.31	0.97	0.82	1.22	0.62	0.81	0.37	0.30	1.24	1.32	0.55	1.40	1.00	1.38	1.13	1.18	0.66	0.53
6d	2009	1.67	1.81	0.43	1.19	0.97	1.35	0.72	0.84	0.52	0.49	1.41	1.56	0.73	1.57	1.15	1.49	1.29	1.21	0.86	0.76
	2014	1.75	1.80	0.42	1.12	0.95	1.34	0.71	0.84	0.50	0.46	1.34	1.42	0.74	1.60	1.15	1.51	1.29	1.21	0.88	0.80
7	2009	1.48	1.58	0.48	1.05	0.73	1.13	0.83	0.87	0.53	0.44	1.24	1.36	0.85	1.43	0.89	1.26	1.50	1.25	0.92	0.73
	2014	1.51	1.55	0.48	1.00	0.72	1.12	0.82	0.86	0.52	0.42	1.16	1.23	0.86	1.45	0.89	1.28	1.50	1.25	0.93	0.76
8	2009	1.48	1.58	0.34	0.98	0.73	1.13	0.67	0.83	0.40	0.32	1.24	1.36	0.60	1.33	0.88	1.26	1.22	1.20	0.69	0.52
	2014	1.50	1.54	0.34	0.92	0.72	1.12	0.66	0.82	0.39	0.30	1.16	1.23	0.60	1.34	0.88	1.28	1.22	1.20	0.70	0.54
9i	2009	1.48	1.58	0.28	0.92	0.73	1.13	0.59	0.79	0.34	0.26	1.24	1.36	0.49	1.24	0.88	1.26	1.07	1.15	0.58	0.43
	2014	1.50	1.54	0.27	0.85	0.71	1.11	0.58	0.79	0.33	0.25	1.16	1.23	0.49	1.24	0.88	1.27	1.07	1.15	0.59	0.44
9ii	2009	1.48	1.58	0.27	0.92	0.73	1.13	0.59	0.79	0.33	0.25	1.24	1.36	0.47	1.24	0.88	1.26	1.08	1.15	0.57	0.41
	2014	1.50	1.54	0.26	0.85	0.71	1.11	0.59	0.79	0.32	0.24	1.16	1.23	0.47	1.24	0.88	1.27	1.08	1.15	0.57	0.42
9iii	2009	1.48	1.58	0.29	0.92	0.73	1.13	0.64	0.79	0.35	0.27	1.24	1.36	0.50	1.24	0.88	1.26	1.17	1.15	0.60	0.43
	2014	1.50	1.54	0.28	0.85	0.71	1.11	0.64	0.78	0.33	0.25	1.16	1.23	0.50	1.24	0.88	1.27	1.17	1.15	0.60	0.44
9iv	2009	1.48	1.58	0.28	0.92	0.73	1.13	0.57	0.79	0.34	0.26	1.24	1.36	0.49	1.24	0.88	1.26	1.04	1.15	0.58	0.43
	2014	1.50	1.54	0.27	0.85	0.71	1.11	0.57	0.79	0.32	0.25	1.16	1.23	0.49	1.24	0.88	1.27	1.04	1.15	0.58	0.44

Table A-3. (Continued)

		BH Recruitment										1994-2003 Average Recruitment									
Run	**Year**	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19
9Ai	2009	1.48	1.58	0.28	0.74	0.73	1.12	0.59	0.71	0.34	0.26	1.24	1.36	0.49	1.00	0.88	1.25	1.07	1.03	0.58	0.43
	2014	1.49	1.53	0.27	0.68	0.71	1.10	0.58	0.70	0.32	0.24	1.16	1.23	0.49	1.00	0.88	1.26	1.07	1.03	0.59	0.44
9Aii	2009	1.48	1.58	0.27	0.76	0.73	1.12	0.60	0.70	0.33	0.26	1.24	1.36	0.48	1.03	0.88	1.25	1.09	1.01	0.57	0.42
	2014	1.49	1.53	0.26	0.69	0.71	1.10	0.59	0.68	0.32	0.24	1.16	1.23	0.48	1.02	0.88	1.26	1.09	1.01	0.58	0.42
9Aiii	2009	1.48	1.58	0.29	0.74	0.73	1.12	0.65	0.65	0.35	0.27	1.24	1.36	0.50	1.00	0.88	1.25	1.19	0.95	0.60	0.44
	2014	1.49	1.53	0.28	0.67	0.71	1.10	0.64	0.64	0.34	0.25	1.16	1.23	0.51	0.98	0.88	1.26	1.19	0.95	0.61	0.45
9Aiv	2009	1.48	1.58	0.28	0.78	0.73	1.12	0.57	0.74	0.34	0.26	1.24	1.36	0.49	1.05	0.88	1.25	1.05	1.07	0.58	0.43
	2014	1.49	1.53	0.27	0.70	0.71	1.10	0.57	0.73	0.32	0.24	1.16	1.23	0.49	1.03	0.88	1.27	1.05	1.07	0.58	0.44
10i	2009	1.48	1.58	0.23	0.91	0.73	1.13	0.54	0.79	0.30	0.22	1.24	1.36	0.41	1.23	0.88	1.26	0.99	1.15	0.50	0.36
	2014	1.50	1.54	0.23	0.85	0.71	1.11	0.54	0.78	0.28	0.21	1.16	1.23	0.41	1.24	0.88	1.27	0.99	1.15	0.51	0.36
10ii	2009	1.48	1.58	0.23	0.93	0.73	1.13	0.54	0.80	0.30	0.22	1.24	1.36	0.41	1.25	0.88	1.26	0.99	1.16	0.51	0.36
	2014	1.50	1.54	0.23	0.86	0.71	1.11	0.54	0.79	0.28	0.21	1.16	1.23	0.41	1.26	0.88	1.27	0.99	1.16	0.51	0.37
10iii	2009	1.48	1.58	0.24	0.95	0.73	1.13	0.54	0.82	0.30	0.22	1.24	1.36	0.41	1.28	0.88	1.26	0.99	1.19	0.51	0.36
	2014	1.50	1.54	0.23	0.88	0.71	1.11	0.54	0.81	0.28	0.21	1.16	1.23	0.41	1.28	0.88	1.27	0.99	1.19	0.51	0.37
10iv	2009	1.48	1.58	0.24	0.98	0.73	1.13	0.54	0.82	0.30	0.23	1.24	1.36	0.41	1.32	0.88	1.26	0.99	1.19	0.51	0.36
	2014	1.50	1.54	0.23	0.92	0.71	1.11	0.54	0.81	0.29	0.21	1.16	1.23	0.41	1.34	0.88	1.27	0.99	1.19	0.51	0.37
10Ai	2009	1.48	1.58	0.23	0.91	0.73	1.13	0.54	0.79	0.29	0.22	1.24	1.36	0.40	1.23	0.88	1.26	0.99	1.15	0.50	0.36
	2014	1.50	1.54	0.23	0.85	0.71	1.11	0.54	0.78	0.28	0.21	1.16	1.23	0.41	1.24	0.88	1.27	0.99	1.15	0.51	0.36
10Aii	2009	1.48	1.58	0.23	0.93	0.73	1.13	0.54	0.80	0.29	0.22	1.24	1.36	0.40	1.25	0.88	1.26	0.98	1.16	0.50	0.35
	2014	1.50	1.54	0.23	0.86	0.71	1.11	0.53	0.79	0.28	0.21	1.16	1.23	0.40	1.26	0.88	1.27	0.98	1.16	0.50	0.36
10Aiii	2009	1.48	1.58	0.23	0.95	0.73	1.13	0.53	0.82	0.29	0.22	1.24	1.36	0.39	1.28	0.88	1.26	0.96	1.19	0.49	0.35
	2014	1.50	1.54	0.22	0.88	0.71	1.11	0.52	0.81	0.27	0.20	1.16	1.23	0.39	1.29	0.88	1.27	0.96	1.19	0.49	0.35
10Aiv	2009	1.48	1.58	0.22	0.95	0.73	1.13	0.53	0.82	0.28	0.21	1.24	1.36	0.37	1.28	0.88	1.26	0.96	1.19	0.48	0.33
	2014	1.50	1.54	0.21	0.88	0.71	1.11	0.52	0.81	0.27	0.19	1.16	1.23	0.38	1.29	0.88	1.27	0.96	1.19	0.48	0.34
11i	2009	1.48	1.58	0.24	0.88	0.73	1.12	0.54	0.79	0.30	0.23	1.24	1.36	0.42	1.19	0.88	1.26	0.99	1.14	0.52	0.38
	2014	1.50	1.53	0.23	0.82	0.71	1.11	0.54	0.78	0.29	0.22	1.16	1.23	0.42	1.19	0.88	1.27	0.99	1.14	0.52	0.38
11ii	2009	1.48	1.58	0.25	0.86	0.73	1.12	0.54	0.79	0.31	0.24	1.24	1.36	0.43	1.16	0.88	1.25	0.99	1.14	0.53	0.39
	2014	1.50	1.53	0.24	0.80	0.71	1.11	0.54	0.78	0.29	0.23	1.16	1.23	0.43	1.17	0.88	1.27	0.99	1.14	0.53	0.40
11iii	2009	1.48	1.58	0.26	0.84	0.73	1.12	0.55	0.78	0.32	0.26	1.24	1.36	0.44	1.14	0.88	1.25	1.00	1.13	0.54	0.42
	2014	1.50	1.53	0.25	0.78	0.71	1.11	0.54	0.77	0.31	0.24	1.16	1.23	0.45	1.14	0.88	1.27	1.00	1.13	0.55	0.42
11iv	2009	1.48	1.58	0.26	0.84	0.73	1.12	0.55	0.78	0.32	0.26	1.24	1.36	0.44	1.14	0.88	1.25	1.00	1.13	0.54	0.42
	2014	1.50	1.53	0.25	0.78	0.71	1.11	0.54	0.77	0.31	0.24	1.16	1.23	0.45	1.14	0.88	1.27	1.00	1.13	0.55	0.42
12i	2009	1.48	1.59	0.22	1.20	0.73	1.13	0.54	0.82	0.28	0.20	1.24	1.36	0.37	1.57	0.88	1.26	0.98	1.17	0.47	0.31
	2014	1.52	1.55	0.21	1.11	0.72	1.13	0.54	0.81	0.27	0.19	1.16	1.23	0.37	1.59	0.88	1.28	0.98	1.17	0.48	0.32
12ii	2009	1.48	1.59	0.22	1.13	0.73	1.13	0.54	0.82	0.28	0.20	1.24	1.36	0.37	1.48	0.88	1.26	0.98	1.17	0.47	0.32
	2014	1.51	1.55	0.21	1.04	0.72	1.12	0.54	0.81	0.27	0.18	1.16	1.23	0.37	1.50	0.88	1.28	0.98	1.17	0.48	0.32
12iii	2009	1.48	1.58	0.22	1.06	0.73	1.13	0.54	0.81	0.28	0.20	1.24	1.36	0.38	1.41	0.88	1.26	0.98	1.17	0.48	0.32
	2014	1.51	1.54	0.21	0.98	0.72	1.12	0.53	0.80	0.27	0.19	1.16	1.23	0.38	1.41	0.88	1.27	0.98	1.17	0.48	0.33
12iv	2009	1.48	1.58	0.22	1.06	0.73	1.13	0.54	0.81	0.28	0.20	1.24	1.36	0.38	1.41	0.88	1.26	0.98	1.17	0.48	0.32
	2014	1.51	1.54	0.21	0.98	0.72	1.12	0.53	0.80	0.27	0.19	1.16	1.23	0.38	1.41	0.88	1.27	0.98	1.17	0.48	0.33

Table A-4. Projected total biomass of yellowfin tuna as a proportion of the biomass at the end of 2003. B/B_{MSY} represents the ratio of total biomass in the year indicated to the total biomass at MSY. R1–R6 denote the six model regions. The definition of projection runs is given in Table 1.

		BH Recruitment								1994-2003 Average Recruitment							
Run	Year	R1	R2	R3	R4	R5	R6	Total	B/B_{MSY}	R1	R2	R3	R4	R5	R6	Total	B/B_{MSY}
1	2009	1.29	1.35	0.02	0.72	0.71	1.63	0.51	0.59	1.66	1.35	0.02	1.08	0.75	1.17	0.60	0.70
	2014	1.27	1.32	0.02	0.67	0.68	1.60	0.49	0.56	1.66	1.36	0.02	1.08	0.74	1.16	0.60	0.69
2	2009	1.63	1.39	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.41	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.43	0.84	1.07	1.14	1.31
3a	2009	1.29	1.35	0.02	0.76	0.72	1.63	0.52	0.60	1.66	1.35	0.02	1.12	0.75	1.17	0.61	0.71
	2014	1.28	1.33	0.02	0.71	0.69	1.60	0.50	0.57	1.66	1.36	0.02	1.11	0.74	1.16	0.61	0.70
3b	2009	1.30	1.36	0.02	0.80	0.72	1.64	0.53	0.61	1.66	1.36	0.02	1.15	0.75	1.17	0.62	0.72
	2014	1.28	1.33	0.02	0.75	0.69	1.61	0.51	0.59	1.66	1.36	0.02	1.15	0.74	1.16	0.61	0.71
3c	2009	1.64	1.40	0.83	1.13	0.82	1.49	1.00	1.15	2.03	1.36	1.03	1.46	0.85	1.07	1.17	1.35
	2014	1.64	1.40	0.83	1.14	0.82	1.49	1.00	1.15	2.03	1.37	1.03	1.47	0.85	1.07	1.17	1.36
3d	2009	1.66	1.40	0.88	1.17	0.82	1.49	1.03	1.19	2.05	1.36	1.09	1.50	0.85	1.07	1.21	1.40
	2014	1.66	1.41	0.88	1.18	0.82	1.50	1.03	1.20	2.05	1.37	1.09	1.52	0.85	1.07	1.21	1.40
4a	2009	1.29	1.35	0.02	0.74	0.73	1.67	0.52	0.60	1.66	1.36	0.02	1.10	0.77	1.20	0.61	0.71
	2014	1.28	1.33	0.02	0.70	0.70	1.64	0.50	0.58	1.66	1.36	0.02	1.10	0.76	1.19	0.61	0.70
4b	2009	1.30	1.36	0.02	0.77	0.75	1.70	0.53	0.61	1.66	1.36	0.02	1.12	0.79	1.23	0.62	0.72
	2014	1.28	1.34	0.02	0.72	0.72	1.68	0.51	0.59	1.67	1.36	0.02	1.12	0.77	1.22	0.62	0.71
4c	2009	1.61	1.40	0.71	1.14	0.83	1.54	0.95	1.10	1.99	1.37	0.88	1.47	0.86	1.11	1.11	1.28
	2014	1.61	1.41	0.71	1.15	0.82	1.54	0.95	1.10	1.99	1.37	0.88	1.48	0.85	1.10	1.11	1.28
4d	2009	1.61	1.41	0.71	1.17	0.85	1.60	0.96	1.11	1.99	1.37	0.88	1.49	0.87	1.15	1.12	1.30
	2014	1.62	1.41	0.71	1.17	0.84	1.60	0.96	1.11	1.99	1.37	0.88	1.51	0.87	1.14	1.12	1.30
5a	2009	1.29	1.35	0.02	0.73	0.72	1.63	0.51	0.59	1.66	1.35	0.02	1.09	0.75	1.17	0.60	0.70
	2014	1.27	1.32	0.02	0.67	0.68	1.60	0.49	0.56	1.66	1.36	0.02	1.08	0.74	1.16	0.60	0.69
5b	2009	1.29	1.35	0.02	0.73	0.72	1.64	0.51	0.59	1.66	1.36	0.02	1.11	0.76	1.17	0.61	0.70
	2014	1.27	1.32	0.02	0.67	0.68	1.60	0.49	0.56	1.66	1.36	0.02	1.08	0.74	1.16	0.60	0.69
5c	2009	1.65	1.40	0.85	1.12	0.82	1.49	1.00	1.16	2.04	1.36	1.05	1.44	0.85	1.07	1.18	1.36
	2014	1.65	1.40	0.85	1.12	0.82	1.49	1.00	1.16	2.04	1.37	1.05	1.45	0.85	1.07	1.18	1.36
5d	2009	1.68	1.40	0.92	1.14	0.83	1.49	1.05	1.21	2.07	1.36	1.14	1.46	0.86	1.07	1.23	1.42
	2014	1.68	1.41	0.92	1.15	0.83	1.50	1.05	1.21	2.08	1.37	1.14	1.48	0.86	1.07	1.23	1.42
6a	2009	1.30	1.36	0.02	0.79	0.74	1.67	0.53	0.61	1.67	1.36	0.02	1.15	0.77	1.20	0.62	0.72
	2014	1.28	1.34	0.02	0.74	0.71	1.64	0.51	0.59	1.66	1.36	0.02	1.14	0.76	1.19	0.62	0.71
6b	2009	1.32	1.38	0.02	0.90	0.77	1.72	0.57	0.65	1.79	1.37	0.26	1.41	0.84	1.23	0.81	0.94
	2014	1.29	1.35	0.02	0.80	0.73	1.69	0.53	0.61	1.67	1.36	0.02	1.21	0.78	1.22	0.64	0.74
6c	2009	1.67	1.40	0.91	1.18	0.84	1.54	1.05	1.22	2.06	1.37	1.12	1.51	0.87	1.11	1.23	1.42
	2014	1.68	1.41	0.91	1.18	0.84	1.55	1.05	1.22	2.06	1.37	1.12	1.53	0.87	1.10	1.23	1.43
6d	2009	1.73	1.41	1.07	1.27	0.87	1.60	1.16	1.34	2.12	1.37	1.31	1.61	0.90	1.15	1.35	1.56
	2014	1.73	1.43	1.07	1.28	0.87	1.61	1.16	1.34	2.12	1.38	1.31	1.64	0.90	1.14	1.36	1.57
7	2009	1.65	1.40	0.82	1.17	0.82	1.49	1.00	1.16	2.04	1.36	1.02	1.51	0.85	1.07	1.18	1.36
	2014	1.65	1.40	0.82	1.17	0.82	1.49	1.00	1.16	2.04	1.37	1.02	1.52	0.85	1.07	1.18	1.36
8	2009	1.66	1.40	0.87	1.19	0.82	1.49	1.03	1.19	2.05	1.36	1.08	1.53	0.85	1.07	1.21	1.40
	2014	1.66	1.41	0.87	1.20	0.82	1.50	1.03	1.20	2.05	1.37	1.08	1.55	0.85	1.07	1.21	1.40
9i	2009	1.63	1.39	0.79	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.98	1.42	0.85	1.07	1.14	1.32
	2014	1.63	1.40	0.79	1.10	0.81	1.49	0.97	1.13	2.02	1.37	0.98	1.43	0.84	1.07	1.14	1.32
9ii	2009	1.63	1.39	0.79	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.98	1.42	0.85	1.07	1.14	1.32
	2014	1.63	1.40	0.79	1.10	0.81	1.49	0.97	1.12	2.02	1.37	0.98	1.43	0.84	1.07	1.14	1.32
9iii	2009	1.63	1.39	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.42	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.43	0.84	1.07	1.14	1.31
9iv	2009	1.63	1.39	0.79	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.98	1.42	0.85	1.07	1.14	1.32
	2014	1.63	1.40	0.79	1.10	0.81	1.49	0.97	1.12	2.02	1.37	0.98	1.43	0.84	1.07	1.14	1.32

Table A-4. (Continued)

		BH Recruitment								1994-2003 Average Recruitment							
Run	Year	R1	R2	R3	R4	R5	R6	Total	B/B_{MSY}	R1	R2	R3	R4	R5	R6	Total	B/B_{MSY}
9Ai	2009	1.66	1.39	0.85	0.91	0.82	1.49	0.96	1.11	2.06	1.36	1.06	1.17	0.85	1.07	1.12	1.29
	2014	1.66	1.40	0.85	0.91	0.81	1.49	0.96	1.11	2.06	1.36	1.06	1.18	0.85	1.07	1.12	1.30
9Aii	2009	1.63	1.39	0.86	0.87	0.82	1.49	0.95	1.10	2.03	1.36	1.07	1.12	0.85	1.07	1.11	1.28
	2014	1.63	1.40	0.86	0.87	0.81	1.49	0.95	1.10	2.03	1.36	1.07	1.13	0.85	1.07	1.11	1.28
9Aiii	2009	1.64	1.39	0.89	0.74	0.82	1.48	0.94	1.08	2.04	1.36	1.11	0.95	0.85	1.07	1.09	1.26
	2014	1.64	1.39	0.89	0.74	0.81	1.48	0.93	1.08	2.04	1.36	1.11	0.96	0.85	1.07	1.09	1.26
9Aiv	2009	1.65	1.39	0.82	0.93	0.82	1.49	0.95	1.10	2.04	1.36	1.03	1.19	0.85	1.07	1.11	1.28
	2014	1.65	1.40	0.82	0.93	0.81	1.49	0.95	1.09	2.04	1.36	1.03	1.20	0.85	1.07	1.11	1.28
10i	2009	1.63	1.39	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.41	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.43	0.84	1.07	1.14	1.31
10ii	2009	1.63	1.39	0.78	1.11	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.43	0.85	1.07	1.14	1.31
	2014	1.63	1.40	0.78	1.11	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.44	0.84	1.07	1.14	1.32
10iii	2009	1.63	1.39	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.42	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.43	0.84	1.07	1.14	1.31
10iv	2009	1.63	1.40	0.78	1.14	0.81	1.49	0.98	1.13	2.02	1.36	0.97	1.47	0.85	1.07	1.15	1.32
	2014	1.63	1.40	0.78	1.14	0.81	1.49	0.98	1.13	2.02	1.37	0.97	1.48	0.84	1.07	1.15	1.33
10Ai	2009	1.63	1.39	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.41	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.78	1.10	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.43	0.84	1.07	1.14	1.31
10Aii	2009	1.63	1.39	0.78	1.11	0.81	1.49	0.97	1.12	2.01	1.36	0.96	1.43	0.84	1.07	1.14	1.31
	2014	1.63	1.40	0.78	1.12	0.81	1.49	0.97	1.12	2.02	1.37	0.96	1.45	0.84	1.07	1.14	1.32
10Aiii	2009	1.63	1.40	0.77	1.15	0.81	1.49	0.97	1.13	2.01	1.36	0.95	1.49	0.84	1.07	1.14	1.32
	2014	1.63	1.40	0.77	1.16	0.81	1.49	0.97	1.13	2.01	1.37	0.95	1.50	0.84	1.07	1.15	1.32
10Aiv	2009	1.62	1.40	0.76	1.18	0.81	1.49	0.98	1.13	2.01	1.36	0.95	1.52	0.84	1.07	1.15	1.33
	2014	1.62	1.40	0.76	1.18	0.81	1.49	0.98	1.13	2.01	1.37	0.95	1.54	0.84	1.07	1.15	1.33
11i	2009	1.63	1.39	0.78	1.09	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.40	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.78	1.09	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.42	0.84	1.07	1.13	1.31
11ii	2009	1.63	1.39	0.78	1.09	0.81	1.49	0.97	1.12	2.02	1.36	0.97	1.40	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.78	1.09	0.81	1.49	0.97	1.12	2.02	1.37	0.97	1.41	0.84	1.07	1.13	1.31
11iii	2009	1.63	1.39	0.79	1.08	0.81	1.49	0.97	1.12	2.02	1.36	0.98	1.39	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.79	1.08	0.81	1.49	0.97	1.12	2.02	1.37	0.98	1.40	0.84	1.07	1.13	1.31
11iv	2009	1.63	1.39	0.79	1.08	0.81	1.49	0.97	1.12	2.02	1.36	0.98	1.39	0.85	1.07	1.13	1.31
	2014	1.63	1.40	0.79	1.08	0.81	1.49	0.97	1.12	2.02	1.37	0.98	1.40	0.84	1.07	1.13	1.31
12i	2009	1.63	1.40	0.78	1.12	0.81	1.49	0.97	1.12	2.01	1.36	0.96	1.44	0.85	1.07	1.14	1.31
	2014	1.63	1.40	0.78	1.12	0.81	1.49	0.97	1.12	2.01	1.37	0.96	1.46	0.84	1.07	1.14	1.32
12ii	2009	1.63	1.40	0.77	1.15	0.81	1.49	0.97	1.12	2.01	1.36	0.95	1.47	0.84	1.07	1.14	1.32
	2014	1.63	1.40	0.77	1.15	0.81	1.49	0.97	1.12	2.02	1.37	0.95	1.49	0.84	1.07	1.14	1.32
12iii	2009	1.63	1.39	0.77	1.14	0.81	1.49	0.97	1.12	2.01	1.36	0.96	1.46	0.85	1.07	1.14	1.31
	2014	1.63	1.40	0.77	1.14	0.81	1.49	0.97	1.12	2.02	1.37	0.96	1.48	0.84	1.07	1.14	1.32
12iv	2009	1.63	1.39	0.77	1.14	0.81	1.49	0.97	1.12	2.01	1.36	0.96	1.46	0.85	1.07	1.14	1.31
	2014	1.63	1.40	0.77	1.14	0.81	1.49	0.97	1.12	2.02	1.37	0.96	1.48	0.84	1.07	1.14	1.32

Table A-5. Projected adult biomass of yellowfin tuna as a proportion of the adult biomass at the end of 2003. S/S_{MSY} represents the ratio of adult biomass in the year indicated to the adult biomass at MSY. R1–R6 denote the six model regions. The definition of projection runs is given in Table 1.

		BH Recruitment								1994-2003 Average Recruitment							
Run	**Year**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	S/S_{MSY}	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	S/S_{MSY}
1	2009	0.44	1.67	0.00	0.68	0.96	2.62	0.53	0.62	0.57	1.67	0.00	1.06	1.00	1.85	0.62	0.73
	2014	0.43	1.63	0.00	0.61	0.90	2.56	0.49	0.58	0.57	1.67	0.00	1.05	0.97	1.80	0.61	0.72
2	2009	0.73	1.71	0.66	1.18	1.11	2.19	0.97	1.14	0.91	1.68	0.81	1.50	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.66	1.18	1.10	2.20	0.97	1.14	0.91	1.68	0.81	1.53	1.14	1.57	1.12	1.33
3a	2009	0.44	1.67	0.00	0.73	0.96	2.63	0.54	0.64	0.57	1.67	0.00	1.11	1.00	1.85	0.63	0.74
	2014	0.43	1.63	0.00	0.66	0.91	2.57	0.51	0.60	0.57	1.67	0.00	1.10	0.97	1.80	0.62	0.74
3b	2009	0.44	1.67	0.00	0.78	0.96	2.64	0.56	0.66	0.57	1.67	0.00	1.16	1.00	1.85	0.65	0.76
	2014	0.44	1.64	0.00	0.71	0.91	2.58	0.52	0.62	0.57	1.67	0.00	1.15	0.97	1.80	0.64	0.75
3c	2009	0.75	1.72	0.72	1.23	1.11	2.20	1.01	1.19	0.93	1.68	0.90	1.56	1.15	1.59	1.17	1.38
	2014	0.75	1.73	0.72	1.23	1.11	2.20	1.01	1.20	0.93	1.68	0.90	1.59	1.15	1.57	1.18	1.39
3d	2009	0.77	1.72	0.80	1.28	1.12	2.20	1.06	1.25	0.95	1.68	0.99	1.63	1.16	1.59	1.23	1.45
	2014	0.77	1.73	0.80	1.29	1.12	2.21	1.06	1.26	0.95	1.69	0.99	1.65	1.15	1.57	1.24	1.46
4a	2009	0.44	1.67	0.00	0.72	1.00	2.71	0.54	0.64	0.57	1.67	0.00	1.09	1.03	1.93	0.63	0.75
	2014	0.43	1.64	0.00	0.65	0.94	2.65	0.51	0.61	0.57	1.68	0.00	1.09	1.00	1.88	0.63	0.74
4b	2009	0.45	1.68	0.00	0.75	1.03	2.79	0.56	0.67	0.57	1.68	0.00	1.13	1.07	2.00	0.65	0.77
	2014	0.44	1.65	0.00	0.69	0.98	2.74	0.53	0.63	0.57	1.68	0.00	1.12	1.04	1.96	0.65	0.76
4c	2009	0.71	1.73	0.58	1.24	1.14	2.32	0.96	1.13	0.88	1.68	0.72	1.58	1.17	1.68	1.10	1.30
	2014	0.71	1.74	0.58	1.24	1.13	2.33	0.96	1.13	0.88	1.69	0.72	1.60	1.16	1.66	1.11	1.31
4d	2009	0.71	1.73	0.59	1.27	1.17	2.46	0.98	1.16	0.88	1.69	0.72	1.62	1.20	1.78	1.12	1.33
	2014	0.71	1.74	0.59	1.28	1.16	2.47	0.98	1.16	0.88	1.70	0.72	1.65	1.20	1.76	1.13	1.34
5a	2009	0.44	1.67	0.00	0.69	0.96	2.63	0.53	0.62	0.57	1.67	0.00	1.07	1.00	1.85	0.62	0.73
	2014	0.43	1.63	0.00	0.61	0.90	2.56	0.49	0.58	0.57	1.67	0.00	1.05	0.97	1.80	0.61	0.72
5b	2009	0.44	1.67	0.00	0.70	0.97	2.63	0.53	0.63	0.57	1.67	0.00	1.10	1.01	1.85	0.63	0.74
	2014	0.43	1.63	0.00	0.61	0.90	2.56	0.49	0.58	0.57	1.67	0.00	1.06	0.97	1.80	0.61	0.72
5c	2009	0.76	1.72	0.73	1.21	1.12	2.20	1.01	1.19	0.93	1.68	0.90	1.54	1.16	1.59	1.17	1.38
	2014	0.76	1.73	0.73	1.21	1.11	2.20	1.01	1.19	0.94	1.69	0.90	1.56	1.15	1.57	1.17	1.39
5d	2009	0.78	1.72	0.81	1.24	1.13	2.20	1.05	1.25	0.97	1.68	1.00	1.57	1.17	1.59	1.22	1.45
	2014	0.79	1.73	0.81	1.25	1.12	2.21	1.06	1.25	0.97	1.69	1.00	1.60	1.16	1.57	1.23	1.45
6a	2009	0.45	1.68	0.00	0.78	1.00	2.72	0.56	0.67	0.57	1.67	0.00	1.17	1.04	1.93	0.66	0.78
	2014	0.44	1.65	0.00	0.70	0.95	2.66	0.53	0.63	0.57	1.68	0.00	1.14	1.01	1.88	0.64	0.76
6b	2009	0.46	1.70	0.00	0.94	1.07	2.83	0.62	0.74	0.69	1.69	0.12	1.52	1.16	2.00	0.83	0.98
	2014	0.44	1.67	0.00	0.80	0.99	2.77	0.57	0.67	0.57	1.68	0.00	1.25	1.05	1.96	0.68	0.81
6c	2009	0.78	1.73	0.81	1.29	1.16	2.32	1.08	1.28	0.96	1.69	1.00	1.64	1.20	1.68	1.25	1.48
	2014	0.78	1.74	0.81	1.30	1.15	2.34	1.08	1.28	0.96	1.69	1.00	1.67	1.19	1.66	1.26	1.48
6d	2009	0.84	1.74	1.02	1.42	1.21	2.47	1.22	1.44	1.03	1.69	1.25	1.80	1.25	1.78	1.41	1.67
	2014	0.84	1.76	1.02	1.44	1.21	2.49	1.23	1.45	1.03	1.70	1.25	1.84	1.25	1.76	1.42	1.68
7	2009	0.75	1.72	0.65	1.25	1.11	2.19	0.99	1.17	0.93	1.68	0.81	1.60	1.15	1.59	1.14	1.35
	2014	0.75	1.73	0.65	1.26	1.11	2.20	0.99	1.17	0.93	1.69	0.81	1.62	1.15	1.57	1.15	1.36
8	2009	0.77	1.72	0.77	1.31	1.12	2.20	1.05	1.24	0.95	1.68	0.95	1.66	1.16	1.59	1.22	1.44
	2014	0.77	1.73	0.77	1.32	1.12	2.21	1.06	1.25	0.95	1.69	0.95	1.69	1.15	1.57	1.23	1.45
9i	2009	0.73	1.71	0.66	1.18	1.11	2.19	0.97	1.15	0.91	1.68	0.82	1.51	1.15	1.59	1.12	1.33
	2014	0.73	1.72	0.66	1.19	1.10	2.20	0.97	1.15	0.91	1.68	0.82	1.53	1.14	1.57	1.13	1.33
9ii	2009	0.74	1.71	0.66	1.18	1.11	2.19	0.97	1.15	0.91	1.68	0.82	1.51	1.15	1.59	1.12	1.33
	2014	0.74	1.72	0.66	1.19	1.10	2.20	0.97	1.15	0.91	1.68	0.82	1.53	1.14	1.57	1.13	1.33
9iii	2009	0.74	1.71	0.63	1.18	1.11	2.19	0.96	1.13	0.91	1.68	0.78	1.51	1.15	1.59	1.11	1.31
	2014	0.74	1.72	0.63	1.19	1.10	2.20	0.96	1.13	0.91	1.68	0.78	1.53	1.14	1.57	1.11	1.32
9iv	2009	0.73	1.71	0.66	1.18	1.11	2.19	0.97	1.15	0.91	1.68	0.82	1.51	1.15	1.59	1.12	1.33
	2014	0.73	1.72	0.66	1.19	1.10	2.20	0.97	1.15	0.91	1.68	0.82	1.53	1.14	1.57	1.13	1.33

Table A-5. (Continued)

		BH Recruitment								1994-2003 Average Recruitment							
Run	**Year**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	S/S_{MSY}	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**Total**	S/S_{MSY}
9Ai	2009	0.78	1.71	0.76	0.93	1.12	2.19	0.95	1.12	0.96	1.68	0.95	1.18	1.16	1.59	1.09	1.29
	2014	0.78	1.72	0.76	0.92	1.11	2.20	0.95	1.12	0.96	1.68	0.95	1.19	1.15	1.57	1.10	1.29
9Aii	2009	0.74	1.71	0.76	0.87	1.12	2.19	0.93	1.10	0.92	1.68	0.95	1.11	1.16	1.59	1.07	1.27
	2014	0.74	1.72	0.76	0.87	1.11	2.19	0.93	1.10	0.92	1.68	0.95	1.12	1.15	1.57	1.08	1.27
9Aiii	2009	0.75	1.71	0.80	0.72	1.11	2.19	0.91	1.07	0.93	1.68	1.00	0.92	1.15	1.59	1.04	1.23
	2014	0.75	1.71	0.80	0.72	1.10	2.19	0.91	1.07	0.94	1.68	1.00	0.93	1.15	1.57	1.04	1.23
9Aiv	2009	0.76	1.71	0.73	0.94	1.11	2.19	0.94	1.11	0.94	1.68	0.90	1.19	1.15	1.59	1.08	1.27
	2014	0.76	1.72	0.73	0.93	1.10	2.19	0.93	1.10	0.94	1.68	0.90	1.20	1.15	1.57	1.08	1.27
10i	2009	0.73	1.71	0.66	1.18	1.11	2.19	0.97	1.14	0.91	1.68	0.81	1.50	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.66	1.18	1.10	2.20	0.97	1.14	0.91	1.68	0.81	1.53	1.14	1.57	1.12	1.33
10ii	2009	0.73	1.71	0.66	1.19	1.11	2.19	0.97	1.15	0.91	1.68	0.81	1.52	1.15	1.59	1.12	1.33
	2014	0.73	1.72	0.66	1.19	1.10	2.20	0.97	1.15	0.91	1.68	0.81	1.54	1.14	1.57	1.13	1.33
10iii	2009	0.73	1.71	0.66	1.17	1.11	2.19	0.96	1.14	0.91	1.68	0.81	1.49	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.66	1.17	1.10	2.20	0.96	1.14	0.91	1.68	0.81	1.51	1.14	1.57	1.12	1.32
10iv	2009	0.73	1.72	0.66	1.23	1.11	2.19	0.98	1.16	0.91	1.68	0.82	1.57	1.15	1.59	1.14	1.34
	2014	0.73	1.73	0.66	1.24	1.10	2.20	0.98	1.16	0.91	1.68	0.82	1.60	1.14	1.57	1.14	1.35
10Ai	2009	0.73	1.71	0.66	1.18	1.11	2.19	0.97	1.14	0.91	1.68	0.81	1.50	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.66	1.18	1.10	2.20	0.97	1.14	0.91	1.68	0.81	1.53	1.14	1.57	1.12	1.33
10Aii	2009	0.73	1.71	0.65	1.20	1.11	2.19	0.97	1.15	0.90	1.68	0.81	1.53	1.15	1.59	1.12	1.33
	2014	0.73	1.72	0.65	1.20	1.10	2.20	0.97	1.15	0.91	1.68	0.81	1.55	1.14	1.57	1.13	1.33
10Aiii	2009	0.73	1.72	0.64	1.25	1.11	2.19	0.98	1.16	0.90	1.68	0.80	1.59	1.14	1.59	1.13	1.34
	2014	0.73	1.73	0.64	1.25	1.10	2.20	0.98	1.16	0.90	1.68	0.80	1.62	1.14	1.57	1.14	1.35
10Aiv	2009	0.72	1.72	0.63	1.30	1.11	2.19	0.99	1.17	0.89	1.68	0.79	1.66	1.14	1.59	1.15	1.35
	2014	0.72	1.73	0.63	1.31	1.10	2.20	0.99	1.17	0.90	1.69	0.79	1.69	1.14	1.57	1.15	1.36
11i	2009	0.73	1.71	0.66	1.17	1.11	2.19	0.97	1.14	0.91	1.68	0.82	1.49	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.66	1.17	1.10	2.20	0.97	1.14	0.91	1.68	0.82	1.51	1.14	1.57	1.12	1.32
11ii	2009	0.73	1.71	0.66	1.16	1.11	2.19	0.97	1.14	0.91	1.68	0.82	1.48	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.66	1.17	1.10	2.20	0.97	1.14	0.91	1.68	0.82	1.51	1.14	1.57	1.12	1.33
11iii	2009	0.73	1.71	0.67	1.15	1.11	2.19	0.97	1.14	0.91	1.68	0.84	1.46	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.67	1.15	1.10	2.20	0.97	1.14	0.91	1.68	0.84	1.48	1.14	1.57	1.12	1.32
11iv	2009	0.73	1.71	0.67	1.15	1.11	2.19	0.97	1.14	0.91	1.68	0.84	1.46	1.15	1.59	1.12	1.32
	2014	0.73	1.72	0.67	1.15	1.10	2.20	0.97	1.14	0.91	1.68	0.84	1.48	1.14	1.57	1.12	1.32
12i	2009	0.73	1.72	0.65	1.22	1.11	2.19	0.97	1.15	0.90	1.68	0.80	1.55	1.15	1.59	1.13	1.33
	2014	0.73	1.72	0.65	1.22	1.10	2.20	0.98	1.15	0.90	1.68	0.80	1.58	1.14	1.57	1.13	1.34
12ii	2009	0.73	1.72	0.63	1.26	1.11	2.19	0.98	1.16	0.90	1.68	0.79	1.60	1.14	1.59	1.13	1.34
	2014	0.73	1.73	0.63	1.27	1.10	2.20	0.98	1.16	0.91	1.68	0.79	1.63	1.14	1.57	1.14	1.35
12iii	2009	0.73	1.72	0.64	1.24	1.11	2.19	0.98	1.15	0.90	1.68	0.79	1.58	1.15	1.59	1.13	1.33
	2014	0.73	1.72	0.64	1.25	1.10	2.20	0.98	1.15	0.91	1.68	0.79	1.61	1.14	1.57	1.14	1.34
12iv	2009	0.73	1.72	0.64	1.24	1.11	2.19	0.98	1.15	0.90	1.68	0.79	1.58	1.15	1.59	1.13	1.33
	2014	0.73	1.72	0.64	1.25	1.10	2.20	0.98	1.15	0.91	1.68	0.79	1.61	1.14	1.57	1.14	1.34

Table A-6. Projected exploitable abundance of yellowfin tuna for selected fisheries (F1, F2, etc. – see Annex II for definitions) as a proportion of the exploitable abundance at the end of 2003. The definition of projection runs is given in Table 1.

		BH Recruitment										1994-2003 Average Recruitment									
Run	Year	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19
1	2009	0.52	1.34	0.00	0.66	0.95	2.39	0.00	0.71	0.08	0.00	0.67	1.34	0.00	1.03	0.99	1.69	0.00	1.03	0.11	0.00
	2014	0.51	1.31	0.00	0.60	0.90	2.33	0.00	0.70	0.08	0.00	0.67	1.35	0.00	1.03	0.96	1.65	0.00	1.03	0.11	0.00
2	2009	0.86	1.37	0.66	1.13	1.09	2.04	0.88	0.93	0.77	0.70	1.06	1.35	0.82	1.44	1.13	1.48	1.09	1.22	0.95	0.87
	2014	0.86	1.39	0.66	1.13	1.09	2.04	0.88	0.93	0.77	0.70	1.07	1.36	0.82	1.46	1.13	1.46	1.09	1.22	0.96	0.87
3a	2009	0.53	1.34	0.00	0.71	0.95	2.39	0.00	0.73	0.08	0.00	0.67	1.34	0.00	1.08	0.99	1.69	0.00	1.05	0.11	0.00
	2014	0.51	1.32	0.00	0.65	0.90	2.34	0.00	0.72	0.08	0.00	0.67	1.35	0.00	1.07	0.96	1.65	0.00	1.05	0.11	0.00
3b	2009	0.53	1.35	0.00	0.76	0.95	2.40	0.00	0.75	0.08	0.00	0.67	1.34	0.00	1.12	0.99	1.69	0.00	1.06	0.11	0.00
	2014	0.52	1.32	0.00	0.70	0.90	2.35	0.00	0.74	0.08	0.00	0.67	1.35	0.00	1.12	0.96	1.65	0.00	1.06	0.11	0.00
3c	2009	0.89	1.37	0.73	1.17	1.10	2.04	0.92	0.95	0.82	0.78	1.09	1.35	0.90	1.50	1.14	1.48	1.14	1.25	1.01	0.97
	2014	0.89	1.39	0.73	1.18	1.09	2.05	0.92	0.95	0.82	0.78	1.10	1.36	0.90	1.52	1.13	1.46	1.14	1.25	1.02	0.97
3d	2009	0.91	1.37	0.80	1.22	1.11	2.05	0.96	0.97	0.88	0.88	1.13	1.35	0.99	1.56	1.14	1.48	1.19	1.27	1.08	1.08
	2014	0.92	1.40	0.80	1.23	1.10	2.05	0.96	0.97	0.88	0.88	1.13	1.36	0.99	1.58	1.14	1.46	1.19	1.27	1.08	1.08
4a	2009	0.53	1.35	0.00	0.70	0.98	2.45	0.00	0.72	0.08	0.00	0.67	1.34	0.00	1.06	1.02	1.75	0.00	1.03	0.11	0.00
	2014	0.51	1.33	0.00	0.64	0.93	2.40	0.00	0.70	0.08	0.00	0.67	1.35	0.00	1.06	0.99	1.71	0.00	1.03	0.11	0.00
4b	2009	0.53	1.36	0.00	0.73	1.01	2.52	0.00	0.72	0.08	0.00	0.67	1.35	0.00	1.09	1.05	1.82	0.00	1.03	0.11	0.00
	2014	0.52	1.34	0.00	0.67	0.97	2.48	0.00	0.71	0.08	0.00	0.67	1.36	0.00	1.09	1.03	1.78	0.00	1.03	0.11	0.00
4c	2009	0.84	1.38	0.59	1.19	1.12	2.15	0.81	0.96	0.72	0.63	1.03	1.35	0.73	1.51	1.15	1.55	1.00	1.26	0.89	0.78
	2014	0.84	1.40	0.59	1.19	1.11	2.15	0.81	0.96	0.72	0.63	1.03	1.36	0.73	1.53	1.15	1.54	1.00	1.26	0.89	0.78
4d	2009	0.84	1.39	0.59	1.22	1.15	2.26	0.81	0.97	0.72	0.64	1.03	1.36	0.73	1.55	1.18	1.64	1.00	1.26	0.89	0.79
	2014	0.84	1.41	0.59	1.22	1.14	2.27	0.81	0.97	0.72	0.64	1.04	1.37	0.73	1.57	1.18	1.62	1.00	1.26	0.89	0.79
5a	2009	0.52	1.34	0.00	0.67	0.95	2.39	0.00	0.71	0.08	0.00	0.67	1.34	0.00	1.04	0.99	1.69	0.00	1.03	0.11	0.00
	2014	0.51	1.31	0.00	0.60	0.90	2.33	0.00	0.70	0.08	0.00	0.67	1.35	0.00	1.03	0.96	1.65	0.00	1.03	0.11	0.00
5b	2009	0.53	1.35	0.00	0.68	0.96	2.39	0.00	0.71	0.08	0.00	0.68	1.34	0.00	1.06	1.00	1.69	0.00	1.03	0.11	0.00
	2014	0.51	1.31	0.00	0.60	0.90	2.33	0.00	0.70	0.08	0.00	0.67	1.35	0.00	1.03	0.96	1.65	0.00	1.03	0.11	0.00
5c	2009	0.89	1.37	0.73	1.15	1.10	2.04	0.95	0.95	0.85	0.81	1.10	1.35	0.91	1.47	1.14	1.48	1.17	1.24	1.05	1.00
	2014	0.90	1.39	0.73	1.16	1.10	2.05	0.95	0.95	0.85	0.81	1.11	1.36	0.91	1.49	1.14	1.46	1.17	1.24	1.05	1.00
5d	2009	0.93	1.37	0.81	1.18	1.11	2.05	1.02	0.96	0.94	0.94	1.15	1.35	1.00	1.51	1.15	1.48	1.27	1.25	1.16	1.16
	2014	0.94	1.40	0.81	1.19	1.11	2.05	1.02	0.96	0.94	0.94	1.15	1.36	1.00	1.53	1.15	1.46	1.27	1.25	1.16	1.16
6a	2009	0.53	1.36	0.00	0.75	0.99	2.46	0.00	0.74	0.08	0.00	0.68	1.35	0.00	1.12	1.03	1.75	0.00	1.05	0.11	0.00
	2014	0.52	1.33	0.00	0.69	0.94	2.41	0.00	0.72	0.08	0.00	0.67	1.36	0.00	1.10	1.00	1.71	0.00	1.05	0.11	0.00
6b	2009	0.55	1.38	0.00	0.90	1.05	2.56	0.00	0.77	0.08	0.00	0.81	1.36	0.14	1.45	1.14	1.82	0.34	1.19	0.30	0.09
	2014	0.52	1.35	0.00	0.77	0.98	2.50	0.00	0.75	0.08	0.00	0.68	1.37	0.00	1.20	1.04	1.78	0.00	1.08	0.11	0.00
6c	2009	0.93	1.38	0.81	1.23	1.14	2.15	0.99	0.97	0.91	0.92	1.14	1.36	1.00	1.57	1.18	1.55	1.23	1.26	1.13	1.13
	2014	0.93	1.41	0.81	1.24	1.14	2.16	0.99	0.97	0.91	0.92	1.15	1.37	1.00	1.59	1.17	1.54	1.23	1.26	1.13	1.13
6d	2009	1.01	1.39	1.00	1.35	1.19	2.27	1.13	1.01	1.11	1.23	1.24	1.37	1.23	1.71	1.23	1.64	1.38	1.31	1.36	1.51
	2014	1.02	1.43	1.00	1.37	1.19	2.28	1.13	1.01	1.11	1.24	1.25	1.38	1.23	1.74	1.23	1.62	1.38	1.31	1.36	1.52
7	2009	0.87	1.37	0.68	1.20	1.10	2.04	0.96	1.01	0.75	0.64	1.07	1.35	0.84	1.54	1.14	1.48	1.20	1.32	0.94	0.80
	2014	0.87	1.39	0.68	1.21	1.09	2.05	0.96	1.01	0.75	0.65	1.08	1.36	0.84	1.56	1.14	1.46	1.20	1.32	0.94	0.80
8	2009	0.91	1.37	0.77	1.25	1.10	2.05	0.97	0.99	0.85	0.82	1.12	1.35	0.95	1.59	1.14	1.48	1.20	1.29	1.05	1.01
	2014	0.91	1.40	0.77	1.26	1.10	2.05	0.97	0.99	0.85	0.82	1.12	1.36	0.95	1.62	1.14	1.46	1.20	1.29	1.05	1.01
9i	2009	0.86	1.37	0.67	1.13	1.09	2.04	0.90	0.94	0.77	0.70	1.06	1.35	0.83	1.45	1.13	1.48	1.12	1.22	0.95	0.86
	2014	0.86	1.39	0.67	1.14	1.09	2.04	0.90	0.94	0.77	0.70	1.07	1.36	0.84	1.47	1.13	1.46	1.12	1.22	0.95	0.86
9ii	2009	0.87	1.37	0.67	1.13	1.09	2.04	0.90	0.94	0.77	0.69	1.07	1.35	0.83	1.45	1.13	1.48	1.11	1.23	0.95	0.86
	2014	0.87	1.39	0.67	1.14	1.09	2.04	0.90	0.94	0.77	0.70	1.07	1.36	0.83	1.47	1.13	1.46	1.11	1.23	0.95	0.86
9iii	2009	0.86	1.37	0.65	1.13	1.09	2.04	0.90	0.94	0.75	0.66	1.07	1.35	0.80	1.45	1.13	1.48	1.12	1.23	0.93	0.82
	2014	0.86	1.39	0.65	1.14	1.09	2.04	0.90	0.94	0.75	0.66	1.07	1.36	0.80	1.47	1.13	1.46	1.12	1.23	0.93	0.82
9iv	2009	0.86	1.37	0.67	1.13	1.09	2.04	0.90	0.94	0.77	0.69	1.06	1.35	0.83	1.45	1.13	1.48	1.11	1.23	0.95	0.86
	2014	0.86	1.39	0.67	1.13	1.09	2.04	0.90	0.94	0.77	0.69	1.07	1.36	0.83	1.47	1.13	1.46	1.11	1.23	0.95	0.86

Table A-6. (Continued)

		BH Recruitment										1994-2003 Average Recruitment									
Run	**Year**	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19	F1	F2	F4	F7	F10	F12	F14	F16	F18	F19
9Ai	2009	0.92	1.37	0.76	0.89	1.10	2.04	0.93	0.83	0.85	0.83	1.13	1.34	0.94	1.14	1.14	1.48	1.15	1.09	1.05	1.03
	2014	0.92	1.38	0.76	0.89	1.09	2.04	0.93	0.83	0.85	0.83	1.14	1.35	0.94	1.15	1.14	1.46	1.15	1.09	1.05	1.03
9Aii	2009	0.88	1.37	0.76	0.85	1.10	2.04	0.94	0.80	0.85	0.83	1.09	1.34	0.95	1.08	1.14	1.48	1.17	1.05	1.05	1.03
	2014	0.88	1.38	0.76	0.85	1.09	2.04	0.94	0.80	0.84	0.83	1.09	1.35	0.95	1.09	1.14	1.46	1.17	1.05	1.05	1.03
9Aiii	2009	0.89	1.37	0.80	0.70	1.10	2.04	0.98	0.69	0.87	0.86	1.10	1.34	1.00	0.89	1.14	1.48	1.23	0.91	1.08	1.06
	2014	0.89	1.38	0.80	0.70	1.09	2.04	0.98	0.69	0.87	0.86	1.11	1.35	1.00	0.90	1.14	1.46	1.23	0.91	1.08	1.06
9Aiv	2009	0.90	1.37	0.73	0.91	1.10	2.04	0.91	0.85	0.82	0.79	1.11	1.34	0.91	1.15	1.14	1.48	1.13	1.11	1.02	0.98
	2014	0.90	1.38	0.73	0.90	1.09	2.04	0.91	0.85	0.82	0.79	1.11	1.35	0.91	1.16	1.13	1.46	1.13	1.11	1.02	0.98
10i	2009	0.86	1.37	0.66	1.13	1.09	2.04	0.88	0.94	0.77	0.70	1.06	1.35	0.82	1.44	1.13	1.48	1.09	1.22	0.95	0.87
	2014	0.86	1.39	0.66	1.13	1.09	2.04	0.88	0.94	0.77	0.70	1.07	1.36	0.82	1.46	1.13	1.46	1.09	1.22	0.96	0.87
10ii	2009	0.86	1.37	0.66	1.14	1.09	2.04	0.88	0.94	0.77	0.70	1.06	1.35	0.82	1.46	1.13	1.48	1.09	1.23	0.95	0.87
	2014	0.86	1.39	0.66	1.14	1.09	2.04	0.88	0.94	0.77	0.70	1.07	1.36	0.82	1.48	1.13	1.46	1.09	1.23	0.96	0.87
10iii	2009	0.86	1.37	0.66	1.12	1.09	2.04	0.88	0.96	0.77	0.70	1.06	1.35	0.82	1.44	1.13	1.48	1.09	1.25	0.95	0.87
	2014	0.86	1.39	0.66	1.12	1.09	2.04	0.88	0.96	0.77	0.70	1.07	1.36	0.82	1.46	1.13	1.46	1.09	1.25	0.96	0.87
10iv	2009	0.86	1.37	0.66	1.18	1.09	2.04	0.88	0.97	0.77	0.71	1.07	1.35	0.82	1.51	1.13	1.48	1.09	1.27	0.96	0.87
	2014	0.86	1.39	0.67	1.18	1.09	2.04	0.88	0.97	0.77	0.71	1.07	1.36	0.83	1.53	1.13	1.46	1.09	1.27	0.96	0.87
10Ai	2009	0.86	1.37	0.66	1.13	1.09	2.04	0.88	0.94	0.77	0.70	1.06	1.35	0.82	1.44	1.13	1.48	1.09	1.22	0.95	0.87
	2014	0.86	1.39	0.66	1.13	1.09	2.04	0.88	0.94	0.77	0.70	1.07	1.36	0.82	1.46	1.13	1.46	1.09	1.22	0.95	0.87
10Aii	2009	0.86	1.37	0.66	1.15	1.09	2.04	0.87	0.95	0.77	0.70	1.06	1.35	0.82	1.47	1.13	1.48	1.09	1.24	0.95	0.87
	2014	0.86	1.39	0.66	1.15	1.09	2.04	0.87	0.95	0.77	0.70	1.07	1.36	0.82	1.49	1.13	1.46	1.09	1.24	0.95	0.87
10Aiii	2009	0.86	1.37	0.65	1.19	1.09	2.04	0.86	0.98	0.76	0.69	1.06	1.35	0.81	1.53	1.13	1.48	1.07	1.28	0.94	0.86
	2014	0.86	1.39	0.65	1.20	1.09	2.04	0.86	0.98	0.76	0.69	1.07	1.36	0.81	1.55	1.13	1.46	1.07	1.28	0.94	0.86
10Aiv	2009	0.85	1.37	0.64	1.24	1.09	2.04	0.87	0.98	0.75	0.68	1.05	1.35	0.80	1.58	1.13	1.48	1.08	1.28	0.94	0.84
	2014	0.85	1.39	0.64	1.24	1.09	2.05	0.87	0.98	0.75	0.68	1.06	1.36	0.80	1.61	1.12	1.46	1.08	1.28	0.94	0.84
11i	2009	0.86	1.37	0.67	1.12	1.09	2.04	0.88	0.93	0.77	0.71	1.07	1.35	0.83	1.43	1.13	1.48	1.09	1.22	0.96	0.88
	2014	0.86	1.39	0.67	1.12	1.09	2.04	0.88	0.93	0.77	0.71	1.07	1.36	0.83	1.45	1.13	1.46	1.09	1.22	0.96	0.88
11ii	2009	0.86	1.37	0.67	1.11	1.09	2.04	0.88	0.93	0.78	0.72	1.07	1.35	0.83	1.43	1.13	1.48	1.09	1.22	0.96	0.89
	2014	0.86	1.39	0.67	1.12	1.09	2.04	0.88	0.93	0.78	0.72	1.07	1.36	0.83	1.44	1.13	1.46	1.09	1.22	0.96	0.89
11iii	2009	0.86	1.37	0.68	1.10	1.09	2.04	0.88	0.93	0.78	0.73	1.07	1.35	0.84	1.41	1.13	1.48	1.10	1.22	0.97	0.90
	2014	0.86	1.39	0.68	1.10	1.09	2.04	0.88	0.93	0.78	0.73	1.07	1.36	0.84	1.42	1.13	1.46	1.10	1.22	0.97	0.91
11iv	2009	0.86	1.37	0.68	1.10	1.09	2.04	0.88	0.93	0.78	0.73	1.07	1.35	0.84	1.41	1.13	1.48	1.10	1.22	0.97	0.90
	2014	0.86	1.39	0.68	1.10	1.09	2.04	0.88	0.93	0.78	0.73	1.07	1.36	0.84	1.42	1.13	1.46	1.10	1.22	0.97	0.91
12i	2009	0.86	1.37	0.66	1.16	1.09	2.04	0.88	0.94	0.76	0.69	1.06	1.35	0.82	1.48	1.13	1.48	1.09	1.22	0.95	0.86
	2014	0.86	1.39	0.66	1.17	1.09	2.04	0.88	0.94	0.76	0.69	1.06	1.36	0.82	1.51	1.13	1.46	1.09	1.22	0.95	0.86
12ii	2009	0.86	1.37	0.64	1.20	1.09	2.04	0.87	0.94	0.75	0.67	1.06	1.35	0.80	1.53	1.13	1.48	1.09	1.23	0.93	0.83
	2014	0.86	1.39	0.64	1.20	1.09	2.04	0.87	0.94	0.75	0.67	1.07	1.36	0.80	1.55	1.13	1.46	1.09	1.23	0.93	0.83
12iii	2009	0.86	1.37	0.65	1.18	1.09	2.04	0.87	0.94	0.76	0.68	1.06	1.35	0.80	1.51	1.13	1.48	1.08	1.23	0.94	0.84
	2014	0.86	1.39	0.65	1.19	1.09	2.04	0.87	0.94	0.76	0.68	1.07	1.36	0.80	1.53	1.13	1.46	1.08	1.23	0.94	0.84
12iv	2009	0.86	1.37	0.65	1.18	1.09	2.04	0.87	0.94	0.76	0.68	1.06	1.35	0.80	1.51	1.13	1.48	1.08	1.23	0.94	0.84
	2014	0.86	1.39	0.65	1.19	1.09	2.04	0.87	0.94	0.76	0.68	1.07	1.36	0.80	1.53	1.13	1.46	1.08	1.23	0.94	0.84