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STAFF RECOMMENDATIONS FOR MANAGEMENT AND DATA COLLECTION, 2020

CONTENTS

A. MANAGEMENT

1. TUNAS

1.1. Conservation of tropical tunas: yellowfin, bigeye, and skipjack

Summary

The staff used the results of a risk analysis for the tropical tuna fishery in the EPO (SAC-11-08) to evaluate the probability of exceeding the reference points specified in the harvest control rule (HCR; Resolution C-16-02). Since these probabilities are estimated to be higher for bigeye, the staff is relying on the risk analysis results for bigeye to determine if any changes are needed to the current duration of the purse-seine fishery closure. According to the overall results of the risk analysis, which takes into consideration the weighted average across all 44 reference models investigated for bigeye, each representing a different hypothetical 'state of nature', there is a 50% probability that F_{MSY} has been exceeded and a 53% probability that S_{cur} is below S_{MSY}. Although the HCR does not specify an acceptable level of probability of exceeding the target reference points, the staff notes that these probabilities are at about a reasonable arbitrary reference level of 50% considering that, at F_{MSY}, S will fluctuate around the target reference point (S_{MSY}) due to interannual recruitment fluctuations. F will also fluctuate around the target reference point (F_{MSY}) under the days of closure management due to interannual fluctuations in catchability and distribution of purse-seine effort among set types.

As specified in the HCR, action needs to be taken only if the probability of exceeding either the F or S limit reference point is greater than 10%. Since the overall results of the risk analysis for bigeye indicate that the probabilities that the F and S limit reference points have been exceeded are less than 10% (5% and 6%,

respectively), the staff is recommending no changes to the current duration of the closure (72 days).

The staff notes that the results of the risk analysis for bigeye are less clear than for yellowfin. The results separate into two distinct states, one 'pessimistic' and the other 'optimistic', which is reflected as a bimodal pattern in the statistical distributions of the management quantities, indicating that the stock is either well below or well above the target reference points. Resolution C-16-02 notes that the 'best available scientific information' is used to operationalize the HCR, and the staff interprets this to mean, in this instance, the overall results of the risk analysis, including all models investigated, regardless of whether they are pessimistic or optimistic. However, because of the bimodal pattern of the distribution of the management quantities, management decisions (*e.g.* closure duration, *etc*.) should consider the consequences of either the pessimistic or the optimistic scenario being correct.

If the results of the group of pessimistic models are taken as the true state of nature, the limit reference points have been exceeded with a probability of, or slightly above, 10%. In addition, most stock status indicators suggest that the fishing mortality of all three species has increased, mainly due to the increase in the number of floating-object sets (SAC-11-05). In summary, both the results of the risk analysis and the stock status indicators support caution in the consideration of management actions.

To prevent fishing mortality increasing beyond the *status quo* conditions associated with maintaining the 72-day closure, the staff is recommending additional precautionary measures to address potential increases in *F* caused by the floating-object fishery. The staff critically reviewed four options that are directly applicable to controlling *F*: 1) limiting the number of floating-object (OBJ) sets; 2) adjusting the limits on daily active FADs; 3) limiting FAD deployments; and/or 4) adjusting the duration of the closure to compensate for increases in OBJ sets. The staff reviewed the advantages and disadvantages of each option, as well as potential solutions to disadvantages (see Document SAC-11 INF-M), and weighed the management benefits against data and infrastructure shortcomings. The conclusion was that a limit on floating-object sets for all purse-seine vessels, combined with individual-vessel daily active FAD limits, would be the best option for maintaining the *status quo* and thus preventing an increase in *F* within a management cycle. How the limit on the number of floating-object sets would be allocated among CPCs or among vessels, or by some other arrangement, is a matter for the Commission to decide.

The staff is recommending a triennial management cycle (2021-2023).

1.1.1. Background

The management advice for tropical tunas in the eastern Pacific Ocean (EPO) provided to the Inter-American Tropical Tuna Commission by its scientific staff has traditionally been based on a 'best assessment' approach. This consisted of defining a single stock assessment model (the 'base case') for each of yellowfin and bigeye which the staff believed represented the most plausible ('best') assumptions and data about the biology and fisheries. The lower of the *F* multipliers[1] estimated in these base case assessments of yellowfin and bigeye have been used as a basis for the staff's recommendations for management measures; specifically, to determine the duration of the seasonal closure of the purse-seine fishery, adjusted for recent changes in fishing capacity. A conventional stock assessment for skipjack is not possible with the currently available data; therefore, stock status indicators (SSIs) have been used to monitor skipjack, and as supplementary information to monitor yellowfin and bigeye.

In 2018 the staff concluded that the results of its stock assessment of bigeye in the EPO were not reliable enough to be used as a basis for management advice to the Commission, and in 2019 extended this conclusion to its assessment of yellowfin (IATTC-94-03). The main problem with both assessments was that their results became overly sensitive to the inclusion of new data, in particular recent observations for the indices of relative abundance from the longline fishery (SAC-09 INF B; SAC-10 INF-F). These and other issues

[1] *F* multiplier = F_{MSY} (the fishing mortality estimated as producing the maximum sustainable yield) divided by F_{cur} (the average fishing mortality for the three most recent years). An *F* multiplier of less than 1 indicates that fishing mortality is above the MSY level.

were addressed in the staff's workplan to improve the stock assessments for tropical tunas, which included external reviews of the assessments for bigeye and yellowfin, and has now been successfully completed. Neither external review singled out a particular model configuration as a replacement for the previous base case models, but both suggested a variety of alternatives for the staff to consider.

New benchmark assessments are available for bigeye and yellowfin (SAC-11-06, SAC-11-07). These assessments represent a fundamental change from the staff's previous 'best assessment' approach: they are the basis for a 'risk analysis', in which a variety of reference models are used to represent plausible alternative assumptions about the biology of the fish, the productivity of the stocks, and/or the operation of the fisheries, thus effectively incorporating assessment uncertainty into the management advice as it is formulated.

The new assessment framework offers the following advantages: 1) it explicitly incorporates the results of all reference models (*model uncertainty*) and the precision of each model's parameter estimates (*parameter uncertainty*) when computing the quantities for management interest; 2) it allows a probabilistic evaluation of whether the target and limit reference points specified in the IATTC harvest control rule for tropical tunas (C-16-02) have been exceeded; 3) it can be integrated into the Management Strategy Evaluation (MSE) framework under development at IATTC as a basis for developing operating models.

This new approach to formulating management advice for tropical tunas includes the following elements:

- Two **benchmark stock assessment reports**, for bigeye (SAC-11-06) and yellowfin (SAC-11-07), presenting the results from all reference models for each species (model fits, diagnostics, derived quantities and estimated parameters that define stock status);
- A **risk analysis** (SAC-11-08) specific for tropical tunas, using the methods described in SAC-11 INF-F, which assesses current stock status and quantifies the probability (risk) of exceeding target and limit reference points specified in the IATTC harvest control rule, as well as the expected consequences of alternative management measures in terms of closure days;
- **Stock status indicators** (SAC-11-05) for all three tropical tuna species (yellowfin, bigeye, and skipjack); and;
- The following **recommendations** by the staff for the conservation of tropical tunas, based on the above.

1.1.2. Rationale for staff recommendations

The technical rationale underlying the staff's recommendations for the conservation of tropical tunas after the current resolution (C-17-02) expires at the end of 2020 is summarized below.

1.1.2.a Stock status

Yellowfin and bigeye: The overall results of the risk analysis, expressed in terms of the probabilities of exceeding the reference points specified in the HCR, are presented in **Table A**.

Table A. Stock status[2] of yellowfin, bigeye and skipjack tunas, expressed in terms of the probabilities[3] of exceeding the reference points specified in the HCR.

	Probability (%) of exceeding RP		
Target RP	**Yellowfin**	**Bigeye**	**Skipjack[4]**
$F_{cur}>F_{MSY}$	9	50	<50
$S_{cur}<S_{MSY}$	12	53	<53
Limit RP			
$F_{cur}>F_{LIMIT}$	0	5	<5
$S_{cur}<S_{LIMIT}$	0	6	<6

For **yellowfin**, the overall results of the risk analysis, which include all 48 reference models, indicate only a 9% probability that the fishing mortality corresponding to the maximum sustainable yield (F_{MSY}) has been exceeded[5] (**Figure 1a**). There is a 12% probability that the spawning stock biomass corresponding to the maximum sustainable yield (S_{MSY}) has been breached. The probability that the F and S limit reference points have been exceeded is zero.

For **bigeye**, the overall results of the risk analysis, which include 44[6] models, indicate a 50% probability that F_{MSY} has been exceeded and a 53% probability that S_{cur} is below S_{MSY} (**Figure 1b**). The probabilities that the F and S limit reference points have been exceeded are not negligible ($P(F_{cur}>F_{LIMIT})$ = 5%; $P(S_{cur}<S_{LIMIT})$ = 6%).

Skipjack: Due to the high and variable productivity of skipjack (*i.e.* annual recruitment is a large fraction of the total biomass, and is strongly environmentally driven), it is difficult to detect the effect of fishing on the population with standard fisheries data and stock assessment models. The last attempt at evaluating the stock status of skipjack in the EPO was by Maunder (2012), in which a variety of methods were applied (fishery and biological indicators, analysis of tagging data, a length-structured stock assessment model, and a Spatial Ecosystem and Population Dynamic Model (SEAPODYM)). The key results of the assessment were that: 1) there is uncertainty about the status of skipjack in the EPO; 2) there may be spatial difference in the status of the stock among regions; 3) there is no evidence indicating a credible risk to the skipjack stock(s). One of the major uncertainties is to whether the catch per unit effort (CPUE) of the purse-seine fisheries is a reliable index of abundance for skipjack. The CPUE data are problematic because it is difficult to identify the appropriate unit of effort, in particular when the fish are associated with fish-aggregating devices (FADs). Without greatly improved age-composition and tag-recovery data, skipjack in the EPO will remain particularly difficult to assess, thus making any evaluation relative to traditional reference points (*e.g.* MSY-based) a challenge.

[2] Defined as the spawning biomass (S) at the start of 2020 or the average fishing mortality (F) during the most recent three years (2017-2019).

[3] These results are based on the 'current' status, and thus relate to fleet capacity during 2017-2019. As of 10 May 2020, the capacity of the purse-seine fleet operating in the EPO, 262,213 cubic meters (m^3) of well volume, is 1% less than the "current" (2017-2019) average of 223,923 m^3. If this reduction is taken into account, the results for bigeye change slightly: $P(F_{cur}>F_{MSY})$ = 0.49. Adjustments for capacity are not available for stock status based on spawning biomass.

[4] A conventional stock assessment is not available for skipjack. Results inferred from PSA analysis indicate that the status of skipjack should be more optimistic than bigeye (see skipjack section below). Therefore, the probability of exceeding the reference points for skipjack should be lower than for bigeye.

[5] In this report, the terms "overfished" and "overfishing" are not used, because the Commission has not defined the threshold probabilities associated with those terms.

[6] Four of the 48 models did not converge for bigeye.

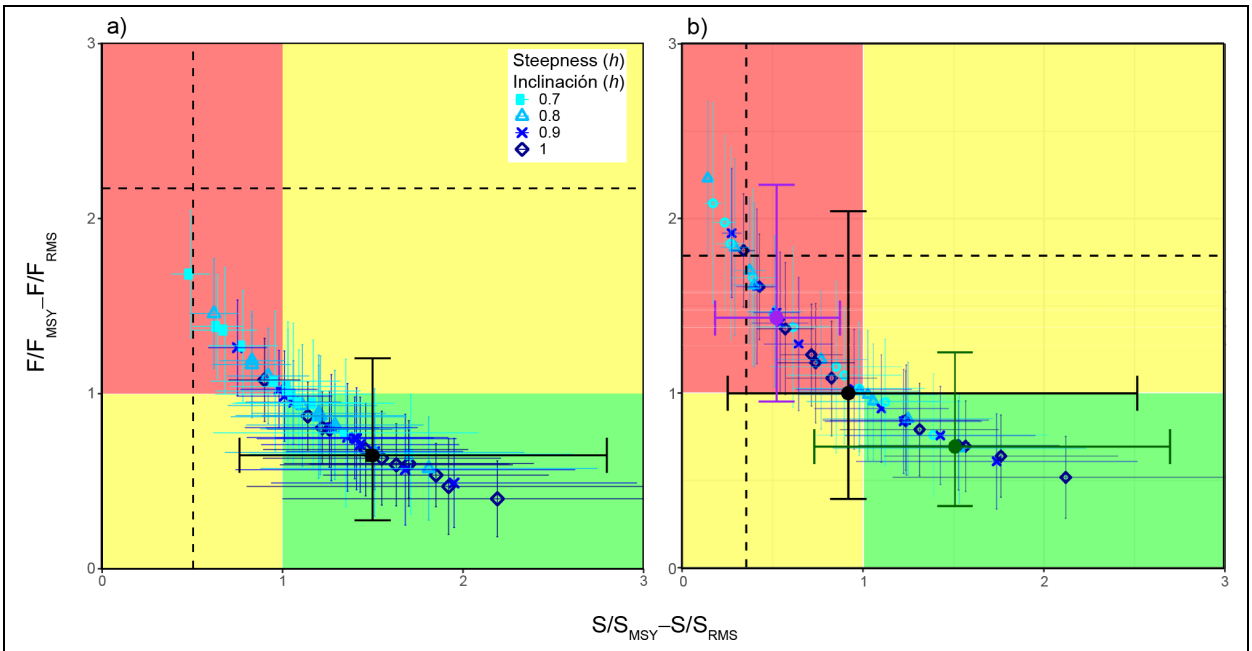

FIGURE 1. Kobe (phase) plot showing the current estimates of spawning stock size (S) and fishing mortality (F) of **(a) yellowfin** and **(b) bigeye tuna** relative to their MSY reference points. The colored panels are separated by the target reference points (S_{MSY} and F_{MSY}) and limit reference points (dashed lines). The center point for each model indicates the current stock status, based on the average fishing mortality (F) over the last three years. The solid black circle represents all models combined. For bigeye (b), the purple and green solid circles represent, respectively, the stock status for the 'pessimistic' and 'optimistic' states related to the bimodal pattern in the risk analysis (see section 1.1.2.c). The lines around each estimate represent its approximate 95% confidence interval.

Nevertheless, inferences can be made about the stock status of skipjack in 2019, based on the new and improved stock assessment results for bigeye. In particular, Productivity and Susceptibility Analysis (PSA; Duffy *et al*. 2019) for the tropical tuna fishery in the EPO indicated that skipjack and bigeye have about the same susceptibility to purse-seine fishing gear, and that skipjack is much more productive than bigeye. Taking the risk analysis results for bigeye as reference (SAC-11-08), the staff infers the following about the skipjack stock status in the EPO (**Table A**):

1. There is less than 50% probability that F_{MSY} has been exceeded ($P(F>F_{MSY})<50\%$), and a less than 53% probability that S_{cur} is below S_{MSY} ($P(S<S_{MSY})<53\%$),
2. There is less than 5% probability that F_{LIMIT} has been exceeded ($P(F>F_{LIMIT})<5\%$), and less than 6% probability that S_{LIMIT} has been breached ($P(S>S_{LIMIT})<6\%$).

These inferences about skipjack stock status from the PSA analysis are interim: direct advice from a skipjack assessment is still needed. The staff is currently conducting a multi-year tagging study of tropical tunas in the EPO aimed at obtaining data that will contribute to, and reduce uncertainty in, tuna stock assessments, particularly for skipjack (Project E.4.a). In addition, an MSE process for tropical tunas, which includes skipjack, is ongoing at IATTC.

As a supplementary means to monitor the stock status of tropical tunas, the staff has used stock status indicators (SSIs) to compare current and historical values of these indicators. For skipjack in particular, the SSIs show recent catches at high historical levels, while catch per set and the average size of the fish in the catch are at low historical levels (SAC-11-05). The continuation of these recent trends raises concerns about increasing exploitation rates, which are mainly due to the increase in the number of floating-object sets,

and their future impact on the sustainability of the skipjack stock.

1.1.2.b Duration of the temporal closure of the purse-seine fishery

At the core of the conservation measures for tropical tunas in the EPO is the temporal closure of the purse-seine fishery, which currently lasts 72 days, either during July-October or November-January (Resolution C-17-02). In order to evaluate the consequences of alternative management actions, specifically through different durations of the closure, the staff conducted a risk analysis (SAC-11-08), which quantifies the probability (risk) of exceeding the reference points specified in the harvest control rules for tropical tunas in the EPO established in Resolution C-16-02.

Paragraph 3a of Resolution C-16-02 specifies that "***the scientific recommendations*** *for establishing management measures in the fisheries for tropical tunas, such as closures, which can be established for multiple years,* ***shall attempt to prevent the fishing mortality rate (F) from exceeding*** *the best estimate of* ***the rate corresponding to the maximum sustainable yield (F_{MSY}) for the species that requires the strictest management***."

The staff's determination about whether the duration of the closure needs to change is based on the overall results[7] of the risk analysis for bigeye, which requires the strictest management of the three species. The overall results (Figure 2) take into account 44 reference models (alternative hypotheses) and their assigned relative weights in the combined distributions for the management parameters.

In 2020, the staff is not recommending changes in the number of closure days, for two reasons.

1. The overall results of the risk analysis indicate a 50% probability that F_{MSY} has been exceeded, and a 53% probability that S_{cur} is below S_{MSY}. Although Resolution C-16-02 does not specify the acceptable level of probability of exceeding the target reference points, these probabilities are at about a reasonable arbitrary reference level of 50%, considering that, at F_{MSY}, S will fluctuate around the target reference point (S_{MSY}) due to interannual recruitment fluctuations. F will also fluctuate around the target reference point (F_{MSY}) under the days of closure management due to interannual fluctuations in catchability and distribution of purse-seine effort among set types.
2. The overall results of the risk analysis for bigeye indicate that, although the probabilities that the F and S limit reference points have been exceeded are not negligible ($P(F_{cur}>F_{LIMIT})$ = 5%; $P(S_{cur}<S_{LIMIT})$ = 6%), they are below the 10% threshold for triggering an action specified in Resolution C-16-02 .

1.1.2.C Additional precautionary measures to prevent further increases in fishing mortality

As mentioned above, the staff based its determination that no changes are needed in the current duration of the temporal closure of the purse-seine fishery on the overall results of the risk analysis for bigeye. However, the distribution of the management quantities for bigeye is bimodal (Figures 7-10, SAC-11-08), with marked differences in the management quantities estimated by two distinct groups of models (the 'pessimistic' and 'optimistic' states), unlike the unimodal distribution of yellowfin (Figures 1-4, SAC-11-08). This bimodal pattern indicates that the stock is either well below or well above the target reference points (Figure 14, SAC-11-08), and the staff urges caution in interpreting these results for management purposes.

[7] The "overall results" of the risk analysis include the results of all the models (hypotheses) used in the analysis, and are obtained by computing the weighted average of the combined probability distributions of the management quantities.

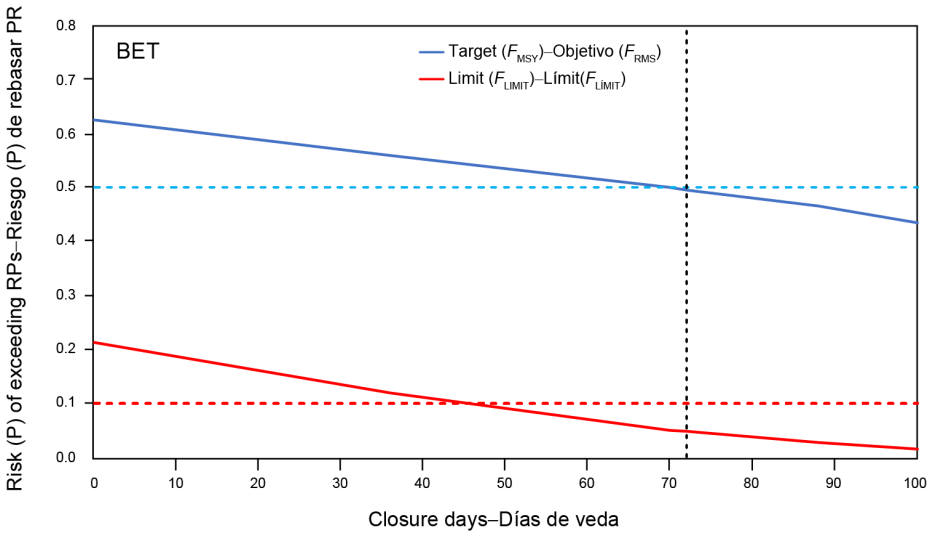

FIGURE 2. Risk curves for bigeye, showing the probability of exceeding the target (solid blue line) and limit (solid red line) *F* reference points (RPs) for different durations of the temporal closure. The blue dashed line represents an arbitrary 50% probability of exceeding the target, and the red dashed line a 10% probability of exceeding the limit, specified in the harvest control rule. The dashed black line indicates the current 72-day closure.

The duration of the closure is based on the average of all models, pessimistic and optimistic, but the possibility that either the pessimistic or the optimistic scenario reflects reality needs to be considered. In particular, if the pessimistic scenario is correct, the probability of exceeding the limit reference points with the current closure is 10%, or slightly higher (Figure 15, SAC-11-08).

As noted above, the staff also considered stock status indicators (SSIs; SAC-11-05) in the formulation of its management advice for tropical tunas.

For precautionary reasons, the staff is recommending that fishing mortality (*F*) not be increased beyond current levels (*status quo*), for three reasons:

a. If the pessimistic scenario from the bigeye risk analysis (SAC-11-08) reflects the true state of nature, the probability that the limit reference points are being breached is 10%, or slightly higher.
b. Most stock status indicators based on the floating-object fishery suggest that the fishing mortality has increased, mainly due to the increase in the number of floating-object sets.
c. Given the lack of a stock assessment or an evaluated harvest strategy for skipjack, fishing mortality should not be increased beyond current levels

The staff is recommending additional precautionary measures to ensure that the *status quo* fishing mortality is not exceeded (see Document SAC-11 INF-M). The following four options, all directly applicable to controlling *F*, and/or already implemented in some form, were investigated:

1. limiting the number of floating-object (OBJ) sets;
2. adjusting the limits on daily active FADs;
3. limiting FAD deployments; and/or
4. adjusting the duration of the closure to compensate for increases in OBJ sets.

The staff reviewed the advantages and disadvantages of each option, as well as potential solutions to disadvantages (see Document SAC-11 INF-M). The staff weighed the management benefits against data and infrastructure shortcomings, which led it to conclude that a limit on floating-object sets for all purse-seine vessels, combined with individual-vessel daily active FAD limits, would be the best option for maintaining the *status quo* and thus preventing an increase in *F* within a management cycle. How the limit

on the number of floating-object sets would be allocated among CPCs or among vessels, or by some other arrangement, is a matter for the Commission to decide.

1.1.2.d Triennial management cycle

SAC-10 Recommendation 1.b states:

> *"The SAC recognizes that the current schedule of annual benchmark or update assessments of bigeye and yellowfin tunas makes it difficult for the IATTC staff to perform the necessary research to improve those assessments, as well as to develop assessments for other stocks requested by the Commission. Indicators are available every year to make any needed adjustments.*
>
> *Therefore, the SAC recommends that the IATTC staff develop, and present to the SAC, an alternative assessment schedule, with benchmark or update assessments scheduled in coordination with the management schedule, and indicator analyses in the intervening years to assess whether additional management measures are required."*

The staff is recommending a triennial management cycle (2021-2023) for the new measures, for the following reasons:

a. Conducting annual risk analyses is an inefficient use of staff time; a three-year management cycle would increase the time available to improve existing assessments and the risk analysis, develop assessments for other stocks, and particularly to focus on the ongoing MSE process;
b. Stock status indicators, computed annually, can be used as a basis for any needed adjustments within the management cycle;
c. Major changes in the management recommendations are unlikely within the management cycle, since this would require substantial new data, research and improvements in the assessments and risk analysis.
d. The Scientific Advisory Committee supports transitioning to a multi-year assessment cycle.

1.1.3. Management advice

Based on the above, in 2020 the staff makes the following recommendations for the conservation of tropical tunas:

RECOMMENDATIONS:

1. Establish a triennial management cycle for the tropical tuna fishery in the EPO (2021-2023).
2. Maintain the provisions of the current resolution (C-17-02), except paragraph 8.
3. Establish an annual limit for all purse-seine vessels on the total number on floating-object sets[8], combined with individual-vessel daily active FAD limits[9].

1.1.4. Future research

Future research should focus on: 1) continuing to improve the risk analysis and the stock assessment models, which also involves their data inputs, and 2) evaluate management strategies that are shown to be robust to the main uncertainties, including the bigeye bimodality, using MSE.

1.1.4.A Improving the risk analysis and the stock assessment models

Matters that require investigation and/or improvement include the bimodal pattern in the risk analysis of bigeye, more objective and transparent scoring in the risk analysis, continuing the collaborative work to improve the longline indices of abundance, the ability to estimate yellowfin absolute abundance, the two-stock hypothesis for yellowfin, estimates of growth, selectivity, and natural mortality through tagging data,

[8] Equal to the average total number of OBJ sets made by the purse-seine fleet during the most recent three-year period (2017-2019). The annual average during 2017-2019 was 15,987 OBJ sets (SAC-11-03).
[9] See SAC-11 INF-M for details.

a skipjack assessment based on tagging data, and a stronger involvement of industry stakeholders in the tagging program (*e.g.* facilitating access to tagging operations in offshore areas, aggregations on FADs, etc.)

1.1.4.b Management Strategy Evaluation

The staff acknowledges that there may always be unresolved issues in knowledge, their impact on taking appropriate management action, and the inherent limits of modelling complex and changing natural systems and their fisheries. Management Strategy Evaluation for tropical tunas should focus on including additional sources of uncertainty (implementation uncertainty, management/institutional uncertainty, sampling uncertainty, projection uncertainty) and refining elements of the current strategy, along with alternatives (types and estimation of reference points, specificity of the current HCR, performance metrics, etc.), that are important for evaluating the robustness of the management advice and the likelihood of strategies achieving desired management objectives. The models and their weighting developed in the risk analysis could be used to inform the development of operating (simulation) models for MSE. The MSE process could be used to evaluate setting management actions based on simpler models or empirical HCRs that rely on trends in data, as an alternative or complement to the recent (best-assessment) or current (risk analysis) approaches, while both data and stock assessments are improved. An MSE workplan is already ongoing at IATTC (see recent Workshops), and the staff has developed a proposal for continuing this research, pending funding.

RECOMMENDATIONS:

In collaboration with CPCs and relevant stakeholders:

1. Continue improving stock assessments and risk analysis for tropical tunas.
2. Continue support for MSE for tropical tunas, following guidelines from C-16-02 and C-19-07.

1.2. Pacific bluefin tuna

The Pacific bluefin tuna working group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) completed a new benchmark assessment of the species in 2020. Projections in which Resolution C-18-01 was extended into the future predict that, even under a low-recruitment scenario up to the first rebuilding target, the stock will rebuild to the interim rebuilding targets. The optimistic results are due to the above-average 2016 recruitment, which is now better estimated in the stock assessment. Projections predict that catch could be increased while still maintaining a high probability of meeting the rebuilding targets. However, it should be noted that the projections assume that recruitment reverts to average after the first rebuilding target is met.

The assessment includes several catch scenarios, with different increases in catch and different distributions of the catch between small and large fish, which follow the harvest strategy prepared by the joint t-RFMO working group. In most scenarios, catching larger fish increases the total catch in weight for a given level of rebuilding. The staff considers that the most precautionary approach is to maintain the catch limits and other provisions of Resolution C-18-01 through 2021-2022; however, some increases are possible without posing a danger to the rebuilding of the stock, as described in Resolution C-18-02. If one of the scenarios is chosen as the basis for future catch limits, the choice should take into account both the desired rebuilding rate and the distribution of catch between small and large bluefin.

RECOMMENDATIONS:

1. Extend the provisions of Resolution C-18-01 through 2021-2022;
2. Increased catches based on the scenarios analyzed are possible under the harvest strategy prepared by the joint tRFMO working group. The choice of catch scenario should take into account the desired rebuilding rate and the distribution of catch between small and large bluefin.

1.1. North Pacific albacore tuna

A new benchmark stock assessment was completed in 2020 by the Albacore Working Group (ALBWG) of the

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC).-The spawning biomass was at 46% of the dynamic virgin spawning biomass in 2018, the last year in the assessment, and the fishing mortality during 2015-2017 ($F_{2015\text{-}2017}$) is below the level corresponding to the maximum sustainable yield ($F_{2015\text{-}2017}/F_{MSY}$ =0.60) Ten-year projections with either constant catch (2013-2017 average, 69,000 t) or constant fishing mortality (at the $F_{2015\text{-}2017}$ level) predicted an increase in the female spawning biomass. The Working Group noted that there was no evidence that fishing had reduced the spawning stock biomass below thresholds associated with most potential biomass-based reference points. The Working Group concluded that the north Pacific albacore stock is healthy, and that the productivity was sufficient to sustain recent exploitation levels, assuming average historical recruitment in both the short and the long term.

The Working Group is currently undertaking a Management Strategy Evaluation (MSE) for the North Pacific albacore stock. The first round was reported in March 2019 (ISC/19/ANNEX/06), and a second round should be completed during 2020. In the context of the MSE process, management and conservation objectives were agreed[10].

The current conservation and management measures for North Pacific albacore (IATTC Resolutions C-05-02, C-13-03 and C-18-03; also WCPFC CMM 2005-03) are based on maintaining the fishing effort below the 2002-2004 levels. The effort levels in eastern Pacific Ocean for 2017-2019 are 72% and 69% of those in 2002-2004, for vessel-days and number of vessels, respectively.

Given the relative stability in the biomass and fishing mortality in recent years, and in view of the ongoing MSE, the staff considers that the current resolutions should be continued.

RECOMMENDATIONS:

1. CPCs should continue to implement Resolutions C-05-02, C-13-03, C-18-03, presently in force.
2. Endorse the management objectives for North Pacific albacore tuna developed and agreed by the ISC MSE process, ensuring their prioritising, ranking and weighting in the context of that ongoing process.

2. NON-TARGET SPECIES

2.1. Silky sharks

The indices for large silky sharks, based on data from the purse-seine fishery on floating objects, have been updated through 2019 for the north and south EPO (BYC-10 INF-A). Previous analyses (SAC-08-08a(i)) identified a correlation between north EPO indices, particularly those for small and medium silky sharks, and interannual variability in oceanographic conditions, and thus the indices for those size categories, and for all silky sharks, were not updated because of concerns about bias. Because of recent increases in the live release of silky sharks, two sets of indices for large silky sharks were computed, one including live release data and the other not. Taken together, the two sets of indices likely bracket the trend that would have resulted in both the north and south EPO if "finning"[11], shark handling, and data recording practices had continued unchanged since 1994. The real trend is considered to be closer to the index based on dead + live releases because sharks recorded as released alive in recent years would probably have been recorded as dead previously, and thus the dead + live release is likely a more consistent indicator. The terminal point

[10] The following management objectives for North Pacific albacore tuna were developed in the context of the MSE process, given the overarching objective of maintaining the viability and sustainability of the current North Pacific albacore stock and fisheries, agreed upon in the process:

- Maintain spawning biomass above the limit reference point.
- Maintain total biomass, with reasonable variability, around the historical average depletion of total biomass.
- Maintain harvest ratios by fishery (fraction of fishing impact with respect to SSB) at historical average.
- Maintain catches by fishery above average historical catch.
- If a change in total allowable effort and/or total allowable catch occurs, the rate of change should be relatively gradual.
- Maintain *F* at the target value with reasonable variability.

[11] Cutting the fins off sharks and discarding the carcass.

of these indices suggests a relatively stable abundance level for over a decade, with the 2019 values at, or slightly below, the 2018 values, and thus no changes to management measures are recommended. However, the stock status is uncertain, and an assessment has not been possible due to the paucity of data, especially for the longline fleets of coastal nations, which are believed to have the greatest impact on the stock (SAC-05-11a). The staff has made recommendations for data collection as part of its work plan for addressing the stock assessments of sharks (see Section 4.1).

Paragraph 7 of Resolution C-19-05 requires CPCs to implement a three-month prohibition on the use of steel leaders in certain longline fisheries, and paragraph 8 requires the IATTC staff to present, at the SAC meeting in 2021, an analysis of the available data, including the shark fishery sampling program in Central America, with recommendations for improvement of the resolution, including adjustment of the prohibition period in paragraph 7.

Resolution C-19-05 also directs the staff to consider the adequacy and effectiveness of the limits established by the resolution and if necessary, recommend revisions. However, the improved species-level catch and composition data required for this analysis are not yet fully available, so the staff could not perform the analysis for SAC-11. However, significant progress has been made in recent years in developing a sampling program for shark fisheries, in particular in Central America (see Section 4.1, SAC-11-13); if continued, and expanded to other regions in the EPO, both data collection and stock assessments for sharks in the EPO should improve.

RECOMMENDATIONS:

CPCs should enhance their compliance with the following provisions of Resolution C-19-05:

1. Paragraph 7, prohibiting the use of steel leaders during a period of three consecutive months of each year for the relevant portions of their national fleets.
2. Paragraphs 11 and 12, requiring notifying the Commission of the period of the prohibition, the number of vessels subject to the prohibition, and how compliance with the prohibition will be monitored.

2.2. Seabirds

Resolution C-11-02 should be revised consistent with the current state of knowledge regarding seabird mitigation techniques, as described in document SAC-08-INF-D. The two-column menu approach in C-11-02 should be replaced by a requirement to use at least two of three mitigation methods (line weighting, night setting, and bird-scaring lines) in combination, in a way that will meet the minimum standards recommended by ACAP and Birdlife International. Other mitigation methods should not be approved until their effectiveness is proven.

RECOMMENDATION:

Revise Resolution C-11-02 consistent with the current state of knowledge regarding seabird mitigation techniques.

B. DATA COLLECTION

3. DATA FOR PURSE-SEINE VESSELS WITHOUT ON-BOARD OBSERVERS

The catch information of the portion of the purse-seine fleet that operates without observers aboard, consistent with the rules and procedures adopted by the Commission and the rules of the AIDCP and related instruments, is essential to ensure full compliance with Resolution C-03-05 and the assembling of the best scientific evidence needed to inform the consideration and adoption of conservation and management measures. In this respect, it should be recalled also that, as established in the Resolution, CPCs are directly responsible for the collection of the catch information specified in the resolution and its submission to the Director. In the interests of obtaining complete and timely data, the staff considers that the best way forward

would be for each CPC to ensure that its competent authority collect this information (mainly logbook data, but also any other relevant data) at the end of each fishing trip, and provide it to the IATTC staff as soon as possible thereafter, without prejudging its further compilation and provision to the Director on an annual basis.

RECOMMENDATION:

Each CPC should ensure that its competent authority collects the logbook and other pertinent data from every fishing trip made without an observer aboard at the end of the trip, and provides them to the IATTC staff as soon as possible afterwards.

4. SHARKS AND RAYS

4.1. Improving data collection and stock assessments for sharks

Paragraph 1 of Resolution C-16-05 requires the IATTC staff to develop a workplan for completing full stock assessments for silky and hammerhead sharks. As noted in SAC-05 INF-F, SAC-05-11a, and SAC-07-06b(iii), improving shark fishery data collection in the EPO is an essential prerequisite.

There are continuing data deficiencies for three fishery components that catch silky and/or hammerhead sharks in the EPO: 1) coastal (*i.e.* 'artisanal') longline and gillnet fisheries (SAC-07-06b(iii); SAC-08-07e); 2) high-seas longline fisheries (SAC-08-07b; SAC-08-07e); and 3) small[12] purse-seine vessels (SAC-08-06a). In particular, without data from a properly designed long-term sampling program of Mexican, Central American, and South American artisanal fisheries (a significant part of component (1)), the IATTC staff will not be able to meet this requirement of Resolution C-16-05.

As a first step toward developing sampling designs for catch and size composition in artisanal fisheries, and for size composition in industrial longline fisheries, a wealth of information has been collected in five Central American countries under Project C.4.a, funded by FAO-GEF through March 2019, and through March 2020 by the IATTC capacity-building fund (SAC-11-13). A total of 676 artisanal landing sites for shark catches were identified in five countries, and information on fishing effort and on catch rates by species and life stage were obtained in interviews with fishers. The data were used to make order-of-magnitude estimates of shark catches by site, and for the region, which will be used to inform decisions on resource allocation for future sampling programs. In addition, exhaustive sampling data on catch size composition, by species and taxon, were collected from 90 unloadings by longline vessels in Costa Rica and Panama. Simulations were conducted with those data to determine parameters for size composition sampling protocols that will be tested in 2020, and further simulations are currently being conducted.

With funding from the European Union, in April 2020 the staff initiated Phase 1 of the long-term sampling project (Project C.4.b). To date, sampling technicians have been hired and plans have been developed to implement the sampling designs. The data collected in Project C.4.a has been invaluable for informing decisions on sampling priorities and allocation of resources. Field testing of the sampling methodology developed as part of Project C.4.a has been delayed due to the COVID-19 pandemic, but it is hoped that sampling technicians will begin this work in late summer 2020. It will include sampling designs for estimating the composition of shark catches by coastal longline and gillnet fisheries and by the industrial longline fisheries of EPO coastal nations.

/sampling data from shark landings in that region (SAC-07-06b(iii)), the staff reiterates the following recommendation:

RECOMMENDATION:

Establish an IATTC field office in Central America near some of the ports where most shark landings occur.

As regards fishery component (2), Resolution C-12-07 requires that vessel captains record all shark catches transshipped, but not by species. Species data are needed for accurate estimates of species-specific catches,

[12] IATTC classes 1-5; carrying capacity ≤ 363 t.

so the staff recommends that vessel captains record transshipments of sharks by species.

RECOMMENDATION: Require all vessel captains to complete the transshipment declaration forms of Resolution C-12-07 by species, for all shark catches.

Previous recommendations by the staff on data collection by observers on longline vessels and Class 1-5 purse-seine vessels are reiterated in Section 8.

4.2. Additional research on Mobulids

Mobulid rays are among the most vulnerable bycatch species caught by the purse-seine fishery for tropical tunas, and are of special concern because of their low rates of reproduction and growth. There is also great uncertainty about many aspects of their life-history (*e.g.* stock structure, migratory patterns) and their post-release mortality rates. A quantitative ecological risk assessment of *Mobula mobular* by IATTC staff (BCWG-09-01) explored various conservation and management measure scenarios to reduce the species' vulnerability to the fishing. Improved handling practices were shown to be the most promising means of reducing post-release mortality and, as a result, vulnerability.

The long-term sampling project for shark fisheries in Central America (Project C.4.b) has begun to collect information on Mobulids from these fisheries. If maintained, the program will continue to collect information from these fisheries and will provide data on the early life stages of these species.

RECOMMENDATION: In collaboration with CPCs and relevant stakeholders, conduct additional research on Mobulids, including genetics, population studies, and a post-release survival tagging pilot study in all purse-seine set types, following the guidelines in Annex I of Resolution C-15-04.

5. ECOSYSTEM CONSIDERATIONS

5.1. Development of a fishery-dependent ecological sampling program for EPO tuna fisheries

Accurate depictions of trophic connections, based on data from trophic ecology studies, are fundamental to the ecosystem models that the IATTC staff has begun to use to assess the ecological impacts of fishing, and to forecast potential changes in ecosystem structure due to fishing and/or climate change. However, the most recent trophic data used in the current version of the ecosystem model of the EPO (Olson and Watters 2003) were collected in the early 1990s. Since then some of the strongest El Niño events on record have occurred, with potentially significant effects on the diets and abundance of key predators, and the subsequent trophic pathways throughout the ecosystem. This program may also help meet the data needs of other IATTC projects, such as the collection of revised length-weight, length-length, and other morphometric relationships.

RECOMMENDATION:

In collaboration with CPCs and relevant stakeholders, develop a fishery-dependent ecological sampling program to collect stomach and tissue samples from key predators for ecological analyses of contents, stable isotopes and fatty acids.

6. FISH-AGGREGATING DEVICES (FADs)

The recommendations in this section are based on document FAD-03 INF-A; some of them were endorsed by the *ad-hoc* working group on FADs, SAC-09 and SAC-10.

6.1. Timely provision of FAD data

Resolution C-19-01 requires that CPCs provide data on FADs recorded by captains of purse-seiners without observers aboard for the previous calendar year "*no later than 90 days prior to each regular meeting of the SAC*", and that the IATTC staff present a preliminary analysis of that information to the SAC. However, given the variety of formats received and many other tasks required of the staff in preparation for SAC meetings, this does not allow sufficient time for a thorough analysis of the data, and therefore more timely

provision of data is desirable.

RECOMMENDATION:

CPCs should provide the FAD data from each fishing trip without an observer aboard to the IATTC staff as soon as possible after the trip terminates.

6.2. Standard reporting format

Resolution C-19-01 requires all CPCs "*to ensure their vessel owners and operators record and report to the appropriate national authorities any interaction with FADs, using a standard format to be developed by the Commission staff*". Since 1 January 2020, on purse-seine vessels without an observer aboard, the captain is responsible for recording FAD data, and it is important that all captains use only the form developed by the IATTC staff (FAD form 9/2018; available here in pdf or MS Excel format), to ensure that all necessary data are collected in a standard format.

RECOMMENDATION:

For purse-seine vessels without an observer aboard, data related to interactions with FADs should be recorded exclusively on the standard form developed by the IATTC staff (FAD form 9/2018).

6.3. Provision of detailed buoy data

Under Resolution C-17-02, CPCs are required to provide "daily information" on their active FADs, which is interpreted to mean a single data point per FAD per day, the selection criteria for which are unclear (*e.g.* no acoustic biomass information is required by the Resolution). This combination of low resolution and uncertain selection criteria means that these data are of limited scientific utility. Also, CPCs can report data in different formats, sometimes highly summarized (without any information on FAD identification or trajectory), which again are of little use for science. Moreover, Resolution C-19-01 allows CPCs to use different methods for marking and identifying FADs. As a result, the data currently provided are inadequate even for analyses to determine the level of data resolution required for an assessment of the FAD fishery, since the various FAD-related IATTC datasets cannot be matched and combined. As noted by voluntary pilot studies using raw buoy data, including both trajectories and acoustic biomass information, at regional (*e.g.* FAD-05) and global (*e.g.* IOTC-2020-WPTT20-14, SCRS/2019/075) level, scientific studies require high-resolution, standardized data, and the staff therefore recommends that CPCs provide the raw buoy data in order to conduct the appropriate scientific analyses.

RECOMMENDATION:

CPCs should provide to the IATTC staff the same raw buoy data received by original users (*i.e.* vessels, fishing companies), including both trajectories and acoustic biomass information.

7. FISHING GEAR CONFIGURATIONS

Describing changes in gear configurations is important for monitoring changes over time in fishing strategies, to improve stock assessments and management advice (Strategic Science Plan, Target J.1).

RECOMMENDATION:

Require that vessels submit the purse-seine and longline gear description forms appended to Document SAC-05-05. Any significant modifications made to the gear subsequently should be reported on these forms prior to departing port with the modified gear.

8. OBSERVER COVERAGE

8.1. Purse-seine fishery

8.1.1. Observer coverage of purse-seine vessels of less than 363 t carrying capacity

Trips by small[13] purse-seine vessels are rarely sampled by observer programs (SAC-08-06a), and vessel log-books and cannery unloading records are the principal sources of data on the activities of these vessels. However, they generally do not contain information on tuna discards, and the data are less complete and detailed that those collected by observers. In addition, bycatch information is not always recorded in logbooks, which hampers efforts to conduct assessments for such species. Electronic monitoring (EM) for this fleet component is currently being explored (Project D.2.a; SAC-10-12), and some capabilities of EM detected in the pilot study are detailed in Appendix 2 of SAC-11-11; however, a proposal for an EM data collection program cannot be developed until the analysis of the data from Project D.2.a has been completed. Therefore, a fleet-wide observer program is needed to obtain the data necessary for estimating the quantity and species composition of bycatches by these vessels and understanding the strategies and dynamics of their operations. Based on a previous study of EPO data for Class-6 vessels fishing on floating objects (IOTC Proceedings WPDCS-01-09, 4: 48–53), an initial sampling coverage of 20% of all trips of the small-vessel fleet component is recommended.

RECOMMENDATION:

Establish a fleet-wide observer program for purse-seine vessels of less than 363 t carrying capacity, with a sampling coverage of 20%.

8.2. Longline fishery

8.2.1. Observer coverage

Resolution C-19-08 requires that at least 5% of the fishing effort by longline vessels greater than 20 m length overall (LOA) carry a scientific observer. However, preliminary analyses undertaken by IATTC staff on the new operational-level data collected by observers on large longline vessels showed that the data are not representative of the fishing activities of the entire fleet. Therefore, the staff concludes that 5% coverage is too low for calculating accurate estimates of the total catches of species caught by these vessels, particularly those species caught infrequently, such as sea turtles, seabirds and some sharks of conservation concern. 20% coverage is considered the minimum level required for such estimates. Both the staff and the SAC have recommended that this level of coverage be adopted for longline vessels over 20 m LOA (SAC-10 INF-H).

RECOMMENDATION:

The staff maintains its recommendation of at least 20% observer coverage of longline vessels over 20 m length overall.

8.2.2. Data standards and reporting

In 2019, the de la In 2019, the Commission replaced Resolution C-11-08 on scientific observers on longline vessels with Resolution C-19-08. Annex B to C-19-08 also formalizes the minimum data standards for longline observer data collection approved by SAC-08 in 2017. Under these measures, all CPCs with qualifying longline vessels fishing in the EPO are required to report all operational data collected by their respective observer programs since 2013. However, several CPCs have not yet reported data for all years, nor responded to the Director's letter of February 2020 requesting information on the status of the missing data.

[13] Carrying capacity ≤ 363 t.

RECOMMENDATIONS:

1. CPCs should submit all operational longline observer data collected from 1 January 2013 to present, consistent with the minimum data standards contained in Annex B of C-19-08, or provide a clear and complete explanation why the missing data sets have not been submitted.

9. ELECTRONIC MONITORING

9.1. Implementing an electronic monitoring system for the tuna fisheries

Electronic monitoring (EM) is increasingly being used worldwide to record the activities of fishing vessels, to complement human observer programs, and where on-board observer coverage is too low or non-existent. Resolution C-19-08 requires the IATTC staff, in consultation with CPCs, to "*prepare a draft proposal for the development of minimum standards for the implementation of an [electronic monitoring system] for the longline fleets, taking into account the experience of CPCs that are implementing EMS on longline vessels and progress made in other tuna RFMOs, to be submitted to the SAC meeting of 2020*". The resolution also requires that the SAC, in consultation with the IATTC staff, "*present recommendations on this proposal to the Commission for its consideration at its annual meeting in 2020*". The IATTC staff has developed, in consultation with experts on the matter, document SAC-11-11, which outlines the objectives and standards for an EM system for the tuna fisheries in the EPO.

The IATTC staff has also developed two EM-related proposals, on remote identification of FADs and implementation of EM on vessels other than purse-seiners, both of which will contribute to improved data for management. Given the potential benefits of EM, and that one of the goals of the Commission's Strategic Science Plan (SSP) is to "*investigate the use of new technologies to improve data quality*", in 2018 a pilot study (Project D.2.a) was initiated in Ecuador, in which cameras were installed on four purse-seine vessels and tested at sea (SAC-10-12). One of the lessons learned from that project was that, although FAD deployments and retrievals are clearly detectable with current EM technology, sensors are not capable of remotely identifying satellite buoys attached to FADs[14]. This information would be very useful for scientific purposes, including establishing science-based FAD limits, a management priority, and the proposal has been added to the SSP, pending funding. Also, despite the importance of longline fisheries in the EPO (SAC-11-03) and the current very low levels of observer coverage of those fisheries (see 7.2.1 above), the staff has not conducted any EM studies on longline vessels. It could also provide information on the size composition of catches of target species, which would be useful given the differences in observer and fisher measurements recently identified (SAC-11 INF-K; SAC-11 INF-L). A proposal for a pilot study of EM on longline vessels has been added to the SSP (Project C.2.b), pending funding.

RECOMMENDATIONS:

1. Conduct a pilot study to test electronic monitoring on longline vessels operating in the eastern Pacific Ocean (Project C.2.b).
2. Evaluate technologies for identifying FADs remotely and automatically.
3. Consider and discuss the objectives and standards described in document SAC-11-11, particularly those related to technical aspects of the EM system.

[14] Satellite buoys are used by the purse-seine fleet to identify FADs, as per Resolution C-19-01.