HIGHLY MIGRATORY SPECIES MANAGEMENT TEAM REPORT
NORTH PACIFIC ALBACORE PRECAUTIONARY MANAGEMENT FRAMEWORK

1. Introduction

At its September 2011 meeting, the Western and Central Pacific Fisheries Commission (WCPFC) Northern Committee (NC) proposed the development of a precautionary management framework for North Pacific albacore in their work plan. The objectives of the precautionary approach-based management framework include: (1) recommending appropriate reference points; (2) agreeing in advance to actions that will be taken in the event each of the particular limit reference points is breached (decision rules, which the HMSMT believes would include a harvest control rule as discussed below); and (3) recommending any changes to Conservation and Management Measure 2005-03 for North Pacific Albacore. The NC intends to complete these tasks by 2014 when the next North Pacific albacore stock assessment is scheduled.

This Report reviews various concepts that could be used as a basis for Council recommendations to the US delegation at the 9th Regular Session of the Northern Committee, scheduled for September 2-5, 2013, in Fukuoka, Japan. The team was tasked to develop recommendations on the NC's proposed precautionary management framework for North Pacific albacore.

According to advice provided to the WCPFC Science Committee (Berger, et al. 2012), a management framework should ideally contain the following elements:

- management objectives
- target and limit reference points consistent with those objectives
- performance metrics
- consideration of systemic uncertainties
- alternative management options (e.g. types of harvest control measures, data to be used, or stock assessment process)
- candidate harvest control rules

2. Management Objectives

Management objectives need to take into account both the manner in which the benefits from the fishery are to be realized, as well as the possible undesirable outcomes that are to be avoided. It is desirable that both the timeframe and likelihood for achieving the target (or avoiding a limit) is included in the formal specification of each management objective (International Seafood Sustainability Foundation, 2013). The HMSMT reviewed the list of Management Goals and Objectives (Section 2.2) in the Fishery Management Plan for West Coast Fisheries for Highly Migratory Species (July 2011 version) and synthesized them into the following particularly relevant management goals for a precautionary management framework for North Pacific albacore.

1. Maintain the long-term conservation and sustainable use of North Pacific albacore. Implement harvest strategies which achieve optimum yield, prevent overfishing, and rebuild overfished stocks, as needed.
2. Maintain and support long-term economic and social benefits for the Nation's albacore fishing industry, giving due consideration to traditional participants.
3. Provide a long-term, stable supply of high-quality, locally caught fish to consumers.
4. Establish procedures to facilitate rapid and successful implementation of future management actions, as necessary.
5. Implement measures to adequately account for total mortalities, including any discards.
6. Implement harvest strategies that are robust with respect to scientific and management uncertainty.

3. Target and Limit ReferencePoints

Reference points can either be target reference points (used to guide management objectives for achieving a desirable outcome and not to be exceeded on average, or at least 50 percent of the time) or limit reference points (limits beyond which the state of a fishery and/or a resource is not considered desirable and remedial management action is required). In addition, reference points can address growth overfishing – when mortalities by weight exceed weight gains in the population by growth, or recruitment overfishing – fishing mortality above which the recruitment to the exploitable stock becomes significantly reduced. Not all reference points are useful depending upon the stock assessment modeling approach and knowledge of the stock dynamics.

The ISC Albacore Working Group estimated current fishing mortality, or F, ($F_{2006\text{-}2008}$) relative to several F-based reference points used in contemporary fisheries management. In addition to the simulation-based interim reference point, $F_{SSB\text{-}ATHL}$, these included F_{MAX}, F_{MED} and $F_{0.1}$, reference points that are based on yield-per-recruit analysis, and the $F_{20\text{-}50\%}$ reference points that are spawning biomass-based proxies of F_{MSY}. A summary of the results of the 2011 assessment with respect to these reference points and some of the problems identified with using each of the reference points is provided in Table 1. (For description of these reference points see section 7 at the end of this report.)

Table 1. Estimated ratio of Fcurrent to commonly used F reference points, equilibrium spawning biomass and equilibrium yield for the 2011 north Pacific albacore assessment.

Reference Point	$F_{2006\text{-}2008}/F_{ref}$	SSB (t)	Equilibrium Yield (t)	Drawbacks
$F_{SSB\text{-}ATHL}$	0.71	346,382	101,426	Not useful when there is a declining biomass trend because the lowest biomasses during the end of the time series will be contributing to the average of the 10 historic lowest biomass levels (ATHL).
F_{MAX}	0.14	11,186	185,913	Difficult to estimate when Y/R curve is asymptotic, as for the 2011 assessment.
$F_{0.1}$	0.29	107,130	170,334	Not useful for recruitment overfishing; estimates highly sensitive to changes in M.
F_{MED}	0.99	452,897	94,080	Assumes a stock recruitment relationship; may not be robust if number of recruits are estimated from narrow range of SSB.
$F_{20\%}$	0.38	171,427	156,922	Difficult to specify which %SPR is an appropriate proxy; advice in literature based on assumptions about stock productivity; not robust to changes in selectivity; does not consider impacts of environmental change on productivity.
$F_{30\%}$	0.52	257,140	138,248	
$F_{40\%}$	0.68	342,854	119,094	
$F_{50\%}$	0.91	428,567	99,643	

This list also encompasses the reference points that the NC directed the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC) to evaluate more closely as an outcome of their 2012 meeting (see Attachment to the Summary Report of the Eighth Regular Session).[1] Therefore, it seems reasonable to narrow the range of F-based reference points for consideration to this list. The HMSMT recommends that the Council's position with respect to reference points for international management of North Pacific albacore be consistent with the reference points selected for domestic management. Specifically, F_{MSY} (a Level 1 reference point, see box below) should be the fishing mortality limit reference point of choice, if it can be well-estimated with the stock assessment model. However, because of the lack of understanding about the relationship between spawners and recruits (i.e., steepness, a measure of the productivity of the stock), F_{MSY} is not well-estimated in the current assessment and is therefore not recommended as a reference point for management at this time. (In the above table the quantities associated with F_{MAX} are equivalent to F_{MSY}. for the 2011 assessment because of the lack of a stock-recruitment relationship.) For this reason, in the short term at least, a proxy would have to be used for F_{MSY}. Like F_{MSY}/F_{MAX}, F_{MED} requires knowledge of a stock recruitment relationship, so it is not an appropriate choice for a proxy either. The interim reference point, $F_{SSB\text{-}ATHL}$, appears to be reasonably precautionary given the current assessment time series, as the projected simulated median yield and spawning stock biomass (SSB) fall close to the equilibrium yield and SSB for $F_{40\%}$. However, since this reference point is based on historical minimum stock biomass values, it would become progressively less precautionary if stock biomass is on a declining trend.

[1] The NC request additionally included $F_{10\%}$.

Categorizing Biological Reference Points

The WCPFC Scientific Committee has discussed classifying biological reference points into three categories based on the biological information available about the stock in question. (Preece, et al. 2011, p. 18): **Level 1**: If steepness is well-estimated, then F_{MSY} and B_{MSY} are appropriate limit reference points; **Level 2**: If the steepness is not well-estimated (and essentially unknown) and if the relevant life-history and fishery information (natural mortality, selectivity, maturity) are both available and reliably estimated, then $F_{SPRx\%}$ and γSSB_0 are appropriate candidate F and SSB limit reference points, respectively (with an appropriately justified rationale for the selection of the fractions x and γ); **Level 3**: If the relevant life-history and fishery information are not reliably estimated then only use the SSB-based limit reference point, γSSB_0 is appropriate.

A better choice may be to use one of the $F_{SPR\%}$ proxies (Level 2 reference points), which do not depend on knowledge of a stock recruitment relationship. In their June 2012 report, the SSC agreed with the ISC Albacore Working Group's recommendation that "spawning potential ratio (SPR) reference points be considered as potential F_{MSY} proxies for albacore." For tuna management, and albacore in particular, which are considered quite productive, $F_{20\%}$ may be a reasonable limit reference point. SPR-based reference points are more directly related to stock productivity.

For a target reference point to be precautionary, it should be set lower than the limit reference point. This reduces the likelihood that the limit reference point will be breached. Such a precautionary reduction could be determined in several different ways:

- Similar to domestic annual catch limit (ACL)-based management, it could be selected by taking into account uncertainty in stock assessments. Based on the most recent north Pacific albacore assessment, sources of uncertainty include the lack of understanding about the relationship between spawners and recruits, potential regional differences in growth, conflicts between indices of abundance for fisheries with the same size selectivity, a lack of stockwide indices, and uncertainty about stock structure.
- If an SPR-based F limit is chosen, a more precautionary SPR reference point could be chosen as the target, e.g. $F_{20\%}$ as the limit and $F_{30\%}$ as the target.
- The HMS FMP identifies a 25% reduction from MSY or its proxy for setting the limit reference point for vulnerable stocks. Analogously, such a percentage reduction from the limit reference point could be chosen to determine the target F reference point.

At the international level, biomass reference points have not been explicitly discussed for North Pacific albacore. Biomass reference points are useful for specifying a different, or more precautionary, management response when biomass declines are encountered (e.g., implementation of a stock rebuilding plan). At this stage, the Council may wish to simply recommend that biomass reference points be taken into account as part of the North Pacific albacore precautionary management framework. The Council's SSC noted that B_{MSY} had been proposed as a potential limit reference point internationally and stated that "while B_{MSY} may be an appropriate target reference point, it is not an appropriate limit reference point. If used as a limit reference point, one would expect the stock to be overfished approximately half the time due to assessment uncertainties and management imprecision when fishing at F_{MSY}" (Agenda Item E.2.b, June 2012). Alternatively, consistent with the HMS Fishery Management Plan (FMP) framework, a biomass limit reference between B_{MSY} and $0.5B_{MSY}$ could be identified. The management framework could implement a steeper linear reduction in the F limit when biomass falls below this biomass threshold (i.e., such that F is reduced to zero before B equals 0) in the harvest control rule (which we assume is equivalent to the "decision rules" identified by the NC).

4. Harvest Control Rules

Harvest control rules (HCRs) identify a pre-agreed course of action which results from reaching stock status benchmarks (e.g., triggers, thresholds or buffers) or some established economic or environmental conditions relative to reference points. Evaluation of alternative HCRs is best done in consultation with stakeholders and managers.

The HMSMT reviewed six HCR forms outlined in Berger, et al. (2012): constant, threshold (or knife-edge), stair step, and three types of sliding scale HCRs (simple linear, complex linear, and non-linear). Sliding HCRs reduce harvest along a continuum when the stock falls below a threshold, while a constant HCR does not adjust with changes in stock status. Figure 1 shows the simple and complex sliding scale HCRs. The HMS FMP specifies a simple linear HCR with a linear reduction in F when biomass falls below B_{MSY}. A complex sliding scale form can include one or more regions where the fishing mortality rate remains constant across a range of biomass levels.

For fishery management purposes, it may be desirable to build buffers into HCRs such that stakeholders and managers have some indication that reference points are being approached. Buffers allow for both the stochastic elements (e.g., recruitment) and the deterministic elements (e.g., harvest) of the stock to co-occur within some "comfort zone." For example, stock status could be allowed to fall within some range below a threshold for a period of time before triggering a linear reduction in F, catch, or effort (the vertical axis in the figures below). The buffer could be visualized as some form of the complex linear form.

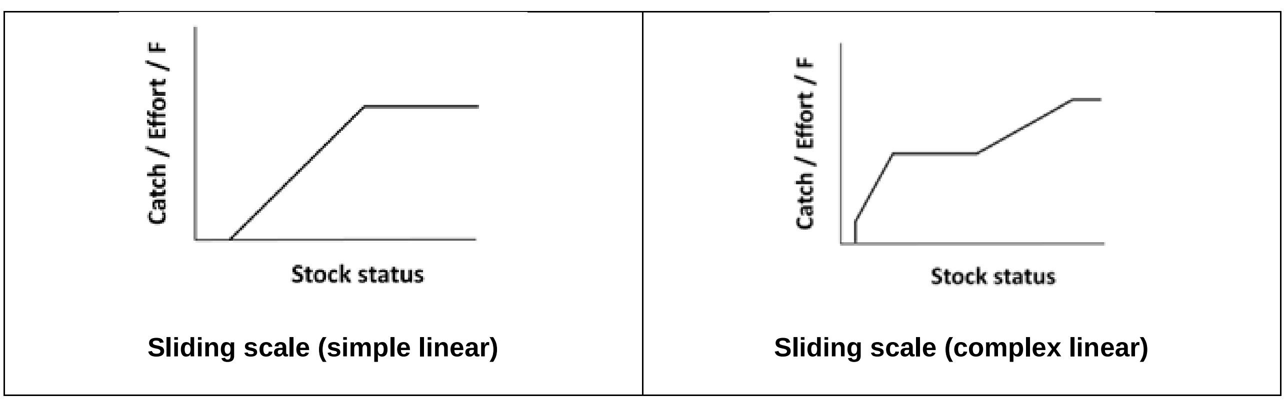

Figure 1. General form of simple and complex sliding scale HCRs. The horizontal axis, "stock status," is relative stock biomass. The vertical axis represents the management response. (Source: Berger, et al. 2012)

In examining the range of HCR forms described in Berger, et al. (2012) the HMSMT recommends the sliding scale form be considered as an appropriate candidate family for a North Pacific albacore HCR. Either the simple or complex form could be appropriate. By changing the reference biomass levels at which adjustments are made, as well as the desired slope (rate) of the change, the complex form is considered more adaptable. Such an HCR would reduce the frequency of management adjustments by including a "plateau" in the region around B_{MSY} (or the target B) but well-above a biomass level that might trigger more aggressive measures to rebuild the stock.

Berger, et al. (2012) recommend a management strategy matrix to convey management advice and trade-offs associated with different decisions. The matrix is a way to convey the probability of achieving given objectives within a certain timeframe when alternative HCRs are applied. Short of a full management strategy evaluation (MSE), the HMSMT recommends such an approach for evaluating candidate HCRs for the North Pacific albacore precautionary management framework. Because of uncertainty in the fishery system, such as biases in the data, incorrect population assumptions (e.g., growth rates, fecundity) and other aspects, it will be important to more fully test different reference points and control rules through a MSE. The HMSMT may expound more fully on these methods in a supplemental report.

5. Management Measures to Reduce Fishing Mortality

Once a control rule is established, management measures are needed to achieve any required fishing mortality reduction in response to declines in biomass below the target or limit. Catch-based and effort-based measures are used as proxies for mortality reduction. Effort-based measures limit fishing mortality indirectly based on a presumed positive correlation between a given effort measure and catch; effort-based measures would need to relate the effort measure used for regulation to the expected reduction in catch mortality. Potential effort-based measures include time-and-area closures, capital controls (e.g. restrictions on numbers of lines, vessel size, hold capacity or other technological constraints on fishing power), or limits on numbers of vessels permitted to fish or on days fished. Catch-based management measures typically involve establishing a Total Allowable Catch (TAC) in concurrence with the control rule, which may be allocated by season, by sector, or by fishery based on gear selectivity for different age classes of fish.

The HMSMT discussed issues which arise with implementing mortality-reduction measures. Days fished or numbers of vessels fishing are conceptually simple, but create incentives to increase fishing power, for example due to changes in vessel capital. In principle, this could be addressed by also imposing gear or other vessel capital restrictions, though such capital restrictions would be difficult to verify, and might also restrict vessels from the most economically efficient fishing methods. Another possibility would be to require a larger-than-proportional reduction in effort compared to the desired reduction in fishing mortality, in anticipation of an offsetting increase in fishing power. Limiting the number of vessels in a fishery would be easier to implement and verify than days fished. Given heterogeneity of fishing power across a fleet, attention would need to be paid to the relative fishing power of vessels which stopped fishing versus those which remained active.

Monitoring, control and surveillance needs pose a challenge to reducing mortality in an international management context, with respect to costs, feasibility and reciprocal verification. High observer costs might potentially be reduced by using a vessel monitoring system or other electronic surveillance technology as a substitute. Placing observers on board may not be feasible for some vessels. Self-reporting of catch or effort creates incentives for underreporting, suggesting the possible need for reciprocal verification to prove the effectiveness of mortality reduction measures.

TACs would need to reflect total catch, not just landings. Limiting catch might lead to high-grading or unreported discards, resulting in the need for additional monitoring. The measure of mortality for monitoring and reporting would need to be in comparable terms across fleets and national fisheries, whether by weight, number of fish, economic yield, or population impacts based on fleet selectivity and age structure. A standardized measure of population impacts based on age selectivity for the different methods used and locations fished could provide flexibility in how different national fleets achieve a required mortality reduction.

Allocations could be made flexible by making them transferable or tradable, allowing an overage in one season to be balanced by a reduced allocation the next, or averaging catch over several seasons. The uncaught portion of one sector's allocation could be reallocated to others later in the season.

In establishing management measures, the HMSMT recognized that it is important for fishery managers to have the greatest understanding of whether particular reference points are appropriate for management and to assess the impacts of the fisheries on the stock dynamics. Therefore, in order to be most useful, assessment results should include: 1) an F-at-age matrix; 2) Y/R analysis by fishery; and 3) a fishery impact analysis. With such information, allocations can be applied by fishery or by life history stage, if needed.

The HMSMT did not have sufficient time to develop recommendations on general types of management measures that would be the most appropriate as part of a precautionary management framework. Such recommendations may be included in a supplemental report.

6. References and Materials Consulted for this Report

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WCPFC Northern Committee. 2012. Eighth Regular Session Summary Report, Attachment D: North Pacific Albacore Catch and Effort Data.

WCPFC Northern Committee. 2012. Eighth Regular Session Summary Report, Attachment E: North Pacific Albacore Reference Points, Requests to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

7. Description of Candidate Reference Points

Reference Point	**Description**
$F_{SSB\text{-}ATHL}$	Fishing mortality rate that maintain the spawning stock biomass (SSB) above the average level of its ten historically lowest points (ATHL) with a probability greater than 50%
F_{MAX}	F corresponding to maximum yield per recruit
$F_{0.1}$	F at which slope of Y/R is 10% of value at origin
F_{MED}	Fishing mortality rate corresponding to the median observed recruit/SSB ratio
$F_{x\%}$	F that reduces SSB/R to x% of unfished state

Source: ISC. 2010. A Review of Candidate Biological Reference Points for Northern Stocks of Highly Migratory Species in the North Pacific Ocean. ISC/10/Plenary/04.