PACIFIC FISHERY MANAGEMENT COUNCIL RECOMMENDATIONS FOR THE NORTH PACIFIC ALBACORE PRECAUTIONARY MANAGEMENT FRAMEWORK PROPOSED BY THE WESTERN AND CENTRAL PACIFIC COMMISSION NORTHERN COMMITTEE

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 combines material in reports provided by the Pacific Fishery Management Council's (Council's) Highly Migratory Species Management Team (HMSMT) and Scientific and Statistical Committee (SSC). It is further tailored to include the intent of the Council regarding the title of this paper. It serves as the 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, 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). Using the list of Management Goals and Objectives in the Fishery Management Plan for West Coast Fisheries for Highly Migratory Species (HMS FMP) as a starting point, the Council proposes the following particularly relevant, slightly edited FMP management goals towards consideration of 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 albacore fishing industry, including both commercial and recreational fishery participants, giving due consideration to traditional participants.
3. Provide a long-term, stable supply of high-quality 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. Biological Reference Points

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).

Reference points can be defined in terms of fishing mortality (F) or stock biomass (B). F-based reference points can be related to catch or effort metrics for the purpose of management. In addition, F-based 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. Biomass-based reference points define critical thresholds in terms of stock status (depletion) and can be used to determine when remedial action is needed to rebuild a stock to a more productive size (by reducing F). The Magnuson-Stevens Fishery Conservation and Management Act requires the identification of both biomass reference points (B-limit and B-target) and F reference points. Not all reference points are useful depending upon the stock assessment modeling approach and knowledge of the stock dynamics.

The International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (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 in 2012 the NC directed the ISC to evaluate more closely.[1] Therefore, it seems reasonable to conclude that the NC has narrowed the range of F-based reference points for consideration to this list. The Council recommends that 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.

The Council recommends the use of one of the $F_{SPR\%}$ proxies (Level 2 reference points), which do not depend on knowledge of a stock recruitment relationship as a potential F_{MSY} proxy for North Pacific albacore. For tuna management, and albacore in particular, which are considered quite productive, $F_{20\%}$ may be a reasonable limit reference point. Reference points expressed relative to stock biomass, like the current, interim F-based reference point ($F_{SSB\text{-}ATHL}$), are problematic given the high uncertainty associated with biomass estimates for this species. 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 US 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 only recommends 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 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).

The Council's HMS FMP identifies B-limit reference points set lower than B_{MSY} (or B_{MSY} proxy). Until an assessment-derived maximum sustainable yield is provided, a level 2 reference point, such as some fraction of unfished B, could be considered.

The ISC Albacore Working Group is most knowledgeable about the productivity of the stock and the impacts of the fisheries on it, and is expected to recommend reference points to the ISC Plenary at its July 2013 meeting.

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 Council's 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 graphs shown in Figure 1 visualize the relationship between stock status (B) and control measures such as F, catch, or effort. Although the graphs were intended only to conceptualize these functional forms, it is important to distinguish between F and catch- or effort-based measures. Thus an HCR would perform differently if the vertical axis is defined in terms of F, catch, or fishing effort.

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). For example, the HMS FMP framework includes a minimum biomass flag, set above the level at which a stock is considered overfished, as a warning that a manage response should be implemented to allow biomass to increase.

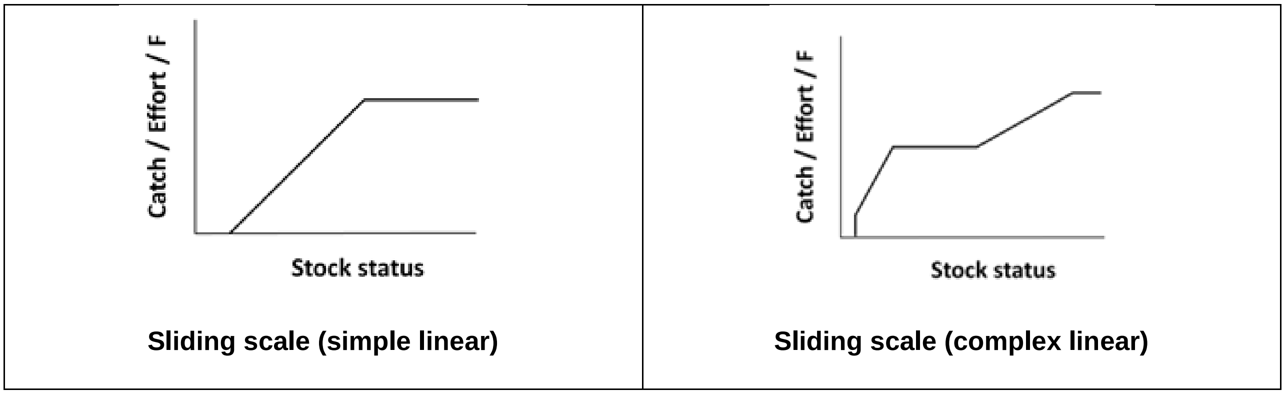

Figure 1. General form of simple and complex sliding scale HCRs. The horizontal axis, "stock status," is relative stock biomass. The vertical axis represents the management response. (Source: Berger, et al. 2012)

In examining the range of HCR forms described in Berger, et al. (2012) the Council recommends the simple linear sliding scale form be considered as a North Pacific albacore HCR. Although either the simple or complex linear forms could be used in a precautionary framework for the management of albacore, with management based on either F or catch, the Council recommends against considering the complex linear sliding scale harvest control rule, because the high uncertainty associated with this stock's parameter estimates and status do not support implementation of a more complex HCR. Nonetheless, a complex linear form could 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.

Reference points chosen as HCR thresholds should consider all factors that explain variability in assessed stock levels including not only fishing mortality, but natural environmental variation and assessment uncertainty. HCRs should balance the biological risks of overfishing or overfished stocks against the costs of lost fishing opportunity or unnecessary management.

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 Council 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.

5. Management Measures to Reduce Fishing Mortality

Despite not having an HCR for North Pacific albacore, the fishery has operated under conservation measures since the adoption of international measures to limit effort to 2002-04 levels (WCPFC CMM 2005-03, IATTC Resolution C-05-02). The NC has begun compiling statistics on catch and effort for fisheries targeting North Pacific albacore. The NC has also been monitoring fishing effort with respect to 2002-2004 levels by collecting information by gear type on days fished and number of vessels fishing for North Pacific albacore. At the June 2013 Inter-American Tropical Tuna Commission (IATTC) meeting, a new resolution on North Pacific albacore was adopted, which requires comparable reporting.

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.

Each type of mortality-reduction measure has advantages and disadvantages. 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.

Such effort-based measures serve to limit fishing mortality indirectly based on the relationship between effort and catch. While some nations fishing for North Pacific albacore, including the U.S., have demonstrated the ability to manage based on effort, it has become apparent at the international level that managing all North Pacific albacore fisheries based on effort has been problematic for a number of reasons. There has been little appetite by most nations to agree on a common effort metric, and even the most basic form of data, such as vessels fishing or days fished, has been slow in coming. Furthermore, the submitted data have not been independently verified. The challenge with managing effort under the current resolutions is one of the reasons for the NC work plan to establish a precautionary management framework for NP albacore.

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. If it is necessary to consider fishery selectivity in allocation decisions, stock 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. 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.

Using the simple linear HCR introduced as an example, if B is shown to be some level below the B-target, international managers could apply a catch limit to bring the catch level down to an associated level along the slope of the linear HCR or to some level that is considered sustainable based on the historical B time series. Catch limits could be adjusted iteratively based on the B trajectories of future assessments until annual B estimates remain around the B-target (i.e. the probability of B falling below B-target is approximately 50 percent). Similarly, if F is shown to be at some level above the F-target, catch restrictions could be imposed and adjusted iteratively until future assessments show that F estimates center around the F-target. Catch restrictions, in the form of quotas or total allowable catches could be applied equitably across fleets or may be more appropriately directed toward fleets having the greatest impact on the stock based on their patterns of selectivity. Likewise, the same example could be used for effort-based measures.

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.

The current interim reference point, $F_{SSB-ATHL}$, is effort-based and provides a status quo reference point that assumes that the current mix of gear types remains constant. The definition of effort is key to any reference point based on fishing effort, and some effort metrics may be more informative than others (e.g., number of vessels or vessel-days vs. number of hooks in the water). Currently, fishing effort for this species is not measured to the degree needed to support reference points based on fishing effort.

In conclusion, given that the effort information submitted to the NC is incomplete and the challenges with managing effort, it may be preferable to develop catch-based measures at the international level.

6. References and Materials Consulted for this Report

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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.