NS1 Technical Guidance Subgroup 3 Tech Memo:
Managing with ACLs for data-limited stocks in federal fishery management plans - Review and recommendations for implementing 50 CFR 600.310(h)(2) flexibilities for data limited stocks

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I. Introduction

Annual catch limits (ACLs) have been effective management tools for preventing overfishing in many fisheries. However, our current ACL-based management has been difficult in certain data-limited fisheries that lack information on stock biomass and in which there is limited ability to monitor and enforce fishery removals. For data limited fisheries, our current ACL-based management has advanced through improved data collection as well as the development of new tools to more effectively use the data that are available and increase understanding of uncertainty in managing these stocks. Nevertheless, situations remain where data limitations challenge our ability to effectively manage with ACLs, as described in the standard approach set forth in the National Standard 1 (NS1) guidelines. To address these concerns, in 2016, the National Marine Fisheries Service (NMFS) amended the NS1 guidelines to clarify that, for certain data-limited stocks, alternative approaches for satisfying statutory requirements other than those set forth in the NS1 guidelines, i.e., "the (h)(2) flexibilities," can apply. 50 CFR 600.310(h)(2).

Consistent with the current NS1 Guidelines, ACLs should be expressed in terms of an amount of fish, but we recognize the need for flexibility to deviate from that standard approach in limited circumstances. This Tech Memo provides guidance relevant to how the flexibilities described in paragraph (h)(2) of the NS1 guidelines can be applied for certain data-limited stocks.

A. Background

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires that federal fishery management plans (FMPs) be consistent with 10 national standards and establish a mechanism for specifying ACLs such that overfishing is prevented, and that they provide for accountability measures (AMs). NMFS has established regulatory guidance, set forth in the NS1guidelines, to assist the eight Fishery Management Councils (Councils) in meeting these requirements. That guidance provides a standard approach for establishing, and managing with, ACLs (hereinafter referred to as the "Standard Approach"). The Standard Approach in the NS1 guidelines is, in brief, an approach for setting limits (e.g., ACLs, overfishing limits (OFLs), and acceptable biological catch (ABC)) and AMs that considers scientific uncertainty and management control of the fishery and is designed to prevent overfishing.

Pursuant to the Standard Approach, "ACL" is defined as "a limit on the total annual catch, which cannot exceed the ABC… that serves as the basis for invoking AMs," and "catch" is defined to mean a "quantity of fish measured in weight or numbers." Thus the Standard Approach characterizes both ABC and ACL as a quantity of fish.

In 2009, when NMFS first published guidance on the Standard Approach, the NS1 guidelines included a provision recognizing that there are "limited circumstances" that may not fit the Standard Approach to specification of reference points and management measures, and allowing Councils flexibility to propose alternative approaches for satisfying the MSA.[1] 50 CFR

[1] Examples of such limited circumstances were listed as "among other things:"

- conservation and management of Endangered Species Act listed species,
- harvests from aquaculture operations, and

600.310(h)(3)(2009). In October 2016, NMFS published revised NS1 guidelines clarifying that these flexibilities could apply to certain data-limited stocks as well. (81 FR 71858; 10/18/2016). The 2016 rule stated a key objective to provide additional flexibilities, within statutory limits, to address the challenge of setting and managing with reference points, such as an ACL, in data-limited situations. The NS1 guidelines do not provide an exemption from any statutory requirements, including the requirement to establish ACLs. However, the guidance anticipates, and provides flexibility, for cases in which limitations impede the ability to set, and manage with, reference points[2] based on MSY or MSY proxies, pursuant to the Standard Approach. (§ 600.310(h)(2)(2016)). Specifically, the NS1 guidelines state:

> *Flexibility in application of NS1 guidelines*. There are limited circumstances that may not fit the standard approaches to specification of reference points and management measures set forth in these guidelines. These include, among other things, …stocks for which data are not available either to set reference points based on MSY or MSY proxies, or to manage to reference points based on MSY or MSY proxies. In these circumstances, Councils may propose alternative approaches for satisfying requirements of the Magnuson-Stevens Act other than those set forth in these guidelines. Councils must document their rationale for any alternative approaches in an FMP or FMP amendment, which will be reviewed for consistency with the Magnuson-Stevens Act. 50 CFR 600.310(h)(2).

When data are sufficient, it is relatively straightforward to set ABCs and ACLs in terms of quantity using the results of traditional stock assessment methods. For data limited stocks, there are various assessment methods that can be used depending on data availability and management needs (Fig. 1). Some data-limited assessment methods support management pursuant to the Standard Approach (i.e., with the use of ACLs expressed in terms of amounts of fish). In other cases, data-limited methods may not support weight/number-based ACLs but could support compliance with the MSA's ACL requirements by using an alternative approach of expressing ACLs in terms of the fishing rate. While weight/numbers-based ACLs should be used for data-limited stocks when adequately supported by data, there are certain data-limited situations where rate-based ACLs are likely a more effective management tool.

B. Overview of Paper

This document identifies recommended practices for managing with ACLs in data-limited fisheries and provides advice on when and how to use the (h)(2) flexibilities for data-limited stocks. This paper does not address the use of the (h)(2) flexibilities in any other context.

While emphasizing that weight/numbers-based ACLs are the standard approach, this Tech Memo (1) identifies current methods for assessing data-limited stocks, (2) explains how to determine which stocks are appropriate for recommendation of an alternative approach under (h)(2), (3)

- stocks with unusual life history characteristics (e.g., Pacific salmon, where the spawning potential for a stock is spread over a multi-year period.

[2] In fisheries management, the term "reference point" means anything that can be used to reference a management objective. For purposes of the ACL Framework, NMFS uses the term "reference points" to refer to ACLs, along with status determination criteria, OY, MSY, and ABC. 50 C.F.R. § 600.310(b)(2)(iv)

describes a potential alternative to the standard approach for ACLs that would express certain reference points for data-limited stocks in terms of fishing rates rather than weights/numbers of fish, and (4) provides considerations for data-limited stocks that may qualify for (h)(2) flexibility, but not be appropriate for rate-based ACLs. Appendix 1 provides examples of how the FishPath decision support tool has been used to help identify appropriate approaches.

With respect to expressing ACLs for data-limited stocks in terms of rate, the memo explains that the key difference between a rate-based ACL and a weight/numbers-based ACL is the metric being monitored and used for triggering AMs (i.e., rate versus and an amount of fish). It also provides details on how this alternative approach could use traditional concepts of indicators and control rules, and how rate-based ACLs could be derived and implemented in a fashion similar to the Standard Approach.

II. Guidance

Since NMFS's initial interpretation of the MSA's ACL requirements through the 2009 NS1 guidelines, the agency has improved its analytical techniques for producing assessments. New methods of conducting stock assessments for data-limited stocks have been developed. Some use measurable aspects of a fishery (such as lengths or catch-per-unit-effort (CPUE)) to generate estimates of the fishing rate (F) and the maximum fishing mortality rate (MFMT). In some cases, data-limited assessment methods can support management pursuant to the Standard Approach (i.e., with the use of ACLs expressed in terms of amounts of fish). In other cases, data-limited methods may support compliance with the MSA's ACL requirements by using an alternative approach that expresses ACLs for data-limited stocks in terms of the fishing rate. This section provides information and recommendations on these topics.

A. Overview of Standard Approach to ACLs under the NS1 Guidelines

In applying the Standard Approach to ACLs as set forth in the NS1 guidelines, the OFL, expressed as an amount of fish, is a key reference point, from which ABCs and ACLs are derived. Pursuant to the Standard Approach, the OFL is the best estimate of the maximum annual amount of fish that can be taken from a stock without resulting in overfishing. OFL calculations typically require the estimation of the exploitable population in biomass (B_{EX}) or numbers (N_{EX}) and the estimation or proxy specification of the fishing mortality rate at MSY (F_{MSY}). B_{EX} incorporates the scale (i.e., absolute amount) of available individuals for capture; F_{MSY} is defined by the productivity (i.e., life history) of the stock and the selectivity of the fishery(ies). The fishing rate at MSY can also be represented as an overall exploitation rate (U_{MSY}) where $U_{MSY} = OFL/B_{EX}$. This leads to a simple representation of the OFL as $OFL = U_{MSY}*B_{EX}$. If B_{EX} is unknown or inestimable, F_{MSY} would then reflect the overfishing limit measured as a rate instead of in biomass or numbers.

Pursuant to the Standard Approach, the ABC cannot exceed OFL, and is generally lower than the OFL to account for scientific uncertainty around the OFL estimate and the Council's risk policy. Calculations of ABC often employ harvest control rules that respond to stock status and the amount of scientific uncertainty by adjusting the ABC downward from the OFL. The ACL may, but does not have to be, reduced from the ABC. Reductions may be made based on management or other uncertainty.

Each of the eight Councils has developed a tiered approach to their ABC control rules to describe how ABC will be specified based on different levels of data availability and/or the status of the stock. The details of each tier vary by Council, but generally ABC control rules have three or more tiers, which represent data rich and various levels of more data-limited stocks. As uncertainty becomes higher, stock metrics such as F, B, and M cannot be calculated directly, and catch numbers become less reliable or are missing for significant time periods. Generally, the more data-limited tiers utilize larger buffers between OFL and ABC to reduce the risk of overfishing occurring. Some Councils divide tiers up further to allow greater flexibility in setting ABC and OFL depending on uncertainty level, and the Scientific and Statistical Committee's (SSC) expert opinion.

B. Data-limited Assessment Methods

There are various data-limited assessment methods that can be used depending on data availability and management needs (Fig. 1). Some assessment methods can be used as a basis for determining biomass or number based OFLs in accordance with the Standard Approach to setting ACLs. Other data-limited assessment methods can only provide management advice that would support the use of an alternative ACL defined in terms relative to F_{MSY}. Data availability informs the type of analytical method that could be used to determine the OFL and in what units. This Tech Memo offers information and recommendations pertaining to the potential use of different data-limited methods.

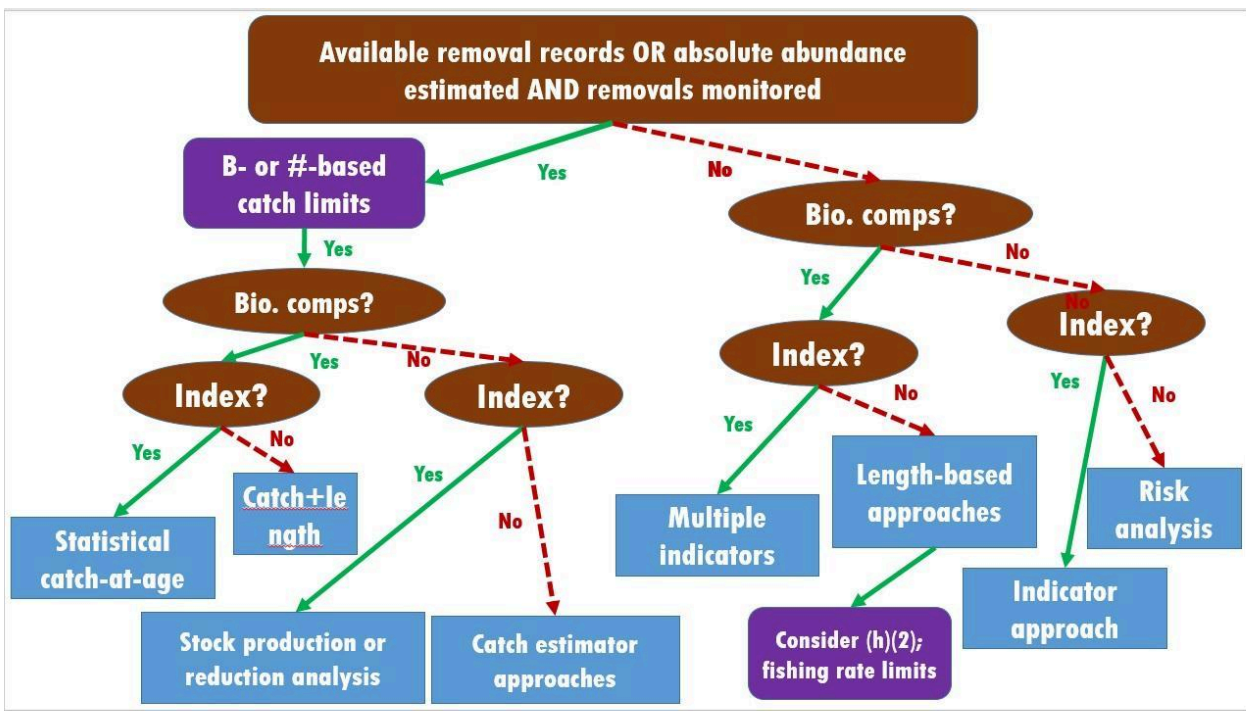


Figure 1. The suite of analytical options and considerations in determining OFL. Data availability informs the type of analytical method that could be used. "Bio. Comps" refers to biological (length or age) compositions. "Index" refers to a relative abundance index. "Indicator" also refers to

indicator approaches that use indices of abundance. Multiple indicators use both lengths and abundance indices as indicators.

1. Data-limited Methods that Support ACLs developed through the Standard Approach

Some data-limited methods are designed to determine biomass/numbers-based OFLs under particular data requirements (Fig. 1). The majority of these "catch estimator" (or "catch only") methods rely on a time series of historical fishery removals and some idea of the life history parameters, productivity and relative stock abundance (i.e., stock depletion) for a given stock. Some of the more common approaches have included Only Reliable Catch Stocks (ORCS; Berkson et al. 2011; Free et al. 2017), Depletion-Corrected Average Catch (DCAC; MacCall, 2009), Depletion-Based Stock Reduction Analysis (DB-SRA, Dick and MacCall, 2011), Simple Stock Synthesis (SSS, Cope 2013), Catch-MSY (Martell and Froese 2013), among several other recently developed data-limited assessment methods (Rosenberg et al. 2014; Walsh et al. 2018).[3]

Currently, there are certain stocks for which Councils set ACLs based on data from "average catch" or "catch-scalar" methods, which are types of "catch estimators." Concerns with using catch-scalar methods are well known and well founded. Numerous studies using simulation testing on known population life histories and removal time series have shown catch-scalar methods perform poorly at defining sustainable catch rates (Carruthers et. al., 2014; Newman et. al., 2014; Berkson and Thorson, 2014; Anderson et al. 2017), often leading to recommended removal levels above MSY, though sometimes leading to very low yields. Carruthers et al. (2014) used six simulated life history types in a management strategy evaluation framework and found that data-limited methods for setting weight/numbers-based catch limits based on only historical removals led to high probabilities of overfishing (i.e., fishing above sustainable rates as established in the simulated population) at high and even moderate levels of stock depletion. Free et al. (2017) describe the sensitivity of the catch-scalar approach ORCS to setting weight/numbers-based catch limits depending on what part of the removal history is used for a given life history and inferred stock depletion, and developed a refined version of that approach to address such weaknesses. Anderson et al. (2017) compared scalar and non-scalar based catch-estimators and observed that inherent variability of the data led to an increased chance of fisheries being classified as collapsed, even when they are still developing. Berkson and Thorson (2014) offered the general recommendation that given the weaknesses in estimating weight/numbers-based ACLs based on methods using only removal histories, simple management procedures using other data may be more suitable for some stocks. These studies support the conclusion that relying on catch-scalar methods to identify an OFL can lead to poor management results, and thus should be used with extreme caution, or bypassed altogether and

[3] As an example, the DB-SRA method was recently applied to determine an OFL distribution for Cowcod (Sebastes levis) in central California. Fifty years of removal data were available, and knowledge of the history and development of the fishery was sufficient to develop a prior distribution for stock depletion at the end of the catch time series. Additional information such as age at maturity, natural mortality (M), and the ratios F_{MSY}/M and B_{MSY}/B_0, was available from a full stock assessment of the same species in southern California. An ABC and ACL were then derived from the OFL through application of the Pacific Fishery Management Council's (PFMC) harvest control rule for data-limited stocks. This derivation of reference point recommendations was accepted by the PFMC's Scientific and Statistical Committee for management of this stock. Numerous other applications of data-limited techniques have been applied in similar ways to determine catch limits for FMP stocks (Newman et al. 2014; Newman et al. 2015).

instead use a suite of other methods to specify ACLs. While NMFS is aware of weaknesses with catch-scalar approaches, nevertheless, in some cases these methods may represent BSIA and therefore may be the most appropriate methods to use.

Recommendations When Using Data-limited Methods that Support Weight/Numbers-Based ACLs

The following recommendations are based on the examples and peer-reviewed studies mentioned above:

- Identify data gaps and make recommendations about research priorities.
- Seek to improve and increase data quality and collection, including increasing effort on reconstructing removal histories.
- Explore the uncertainty in method inputs in order to robustly characterize uncertainty in the outputs of any method being used. This includes sensitivity to the bias and imprecision in inputs.
- Be explicit about the uncertainty buffer between OFL and ABC.
- Review implementation of control rules to ensure that the buffer between OFL and ABC increases as scientific uncertainty increases. A Productivity Susceptibility Analysis (PSA) is a useful tool for assessing the vulnerability of a stock to fishing pressure (Patrick et al. 2009) and can inform the size of the buffer, as does the calculated uncertainty in the OFL (Ralston et al. 2011).
- If results are driven by weakly justified expert opinion, poorly known parameters, or severely limited data, consider using one of the methods described in sections II.B.2 (discussion of other data limited methods) and II.C. (discussion of managing with alternative ACLs in data-limited fisheries) of this Tech Memo.
- Regarding catch-estimator methods for data-limited stocks:
    - Avoid "average catch" and "catch scalar" approaches when data are available to apply other data-limited methods.
    - If data are not available to use methods other than "average catch" or "catch scalar" approaches, then:
        - Consider whether use of an alternative ACL under (h)(2) may be appropriate.
        - Due to the high uncertainty with catch scalar methods, appropriate buffers should be used.
        - Make a plan to transition to another approach.

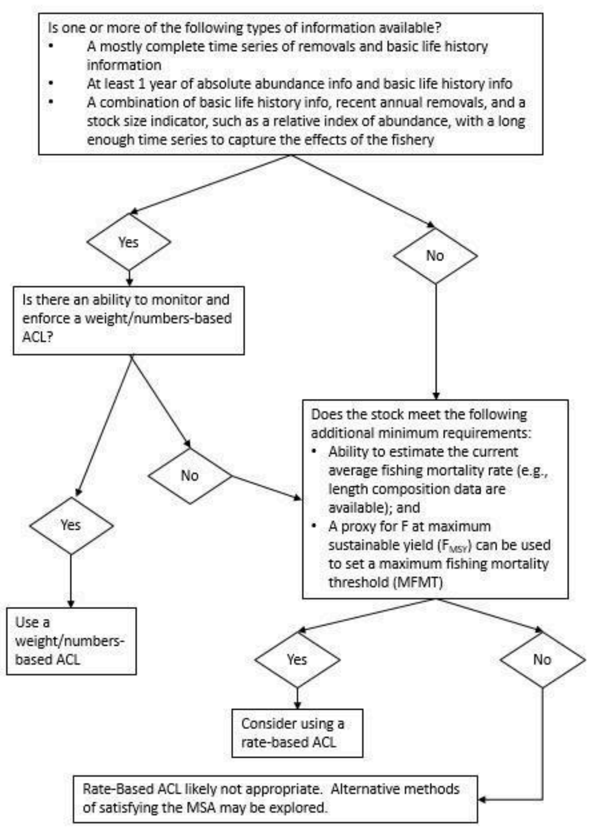
2. Other Data-limited Methods that Provide Management Advice

Ideally, there are sufficient data to manage effectively in terms of removals in weight or numbers. However, in some instances, data are limited to sparse removal time series, and limited length compositions or relative measures of abundance. Under these data conditions, the most commonly encountered assessment approaches include length-based (Fig. 1; Hordyk et al. 2016; Rudd and Thorson 20) and indicator methods (Geremont and Butterworth 2015; Carruthers and Hordyk 2019), with even more data-limited approaches being used to evaluate vulnerability to overfishing in order to prioritize stocks for data collection and more advanced assessment methods (Patrick et al. 2009, 2010; Zhou et al. 2012, Zhou et al. 2016). While limited in the ability to define a removal target in weight or numbers, these methods do provide alternative science-based metrics and reference points to support fisheries management (Ault et al. 2018; Babcock et al. 2013; Hordyk et al. 2015), including preventing overfishing in compliance with the MSA's ACL requirements. The next section outlines how such methods can support an alternative approach to ACLs.

C. Managing with Alternative ACLs in Data-limited Fisheries

While NMFS's Standard Approach to ACLs is based on setting catch limits in terms of weights or numbers of fish, some of the data-limited methods described above can support alternative management strategies for complying with the MSA's mandate when data are not available to support the Standard Approach. A Council's determination of whether to propose an alternative approach to ACLs for a data-limited stock should be based on the best scientific information available and implementation capability. The flow chart below illustrates how the available information should inform the decision of whether to propose an alternative ACL. A Council must document its rationale for an alternative approach in an FMP or FMP amendment, which NMFS will review for consistency with the MSA.

Considerations for ACLs in Data-Limited Fisheries



1. When to Consider Proposing an Alternative Approach for Data-Limited Stocks under (h)(2)

For data-limited stocks, a Council's decision to utilize the flexibilities in (h)(2) should be based on consideration of the best scientific information available about the fishery. As (h)(2) states, the flexibilities for data-limited stocks may be utilized for "stocks for which data are not available either to set reference points based on MSY or MSY proxies, or to manage to reference points based on MSY or MSY proxies."

Key factors are whether the stock is so data-limited that: (1) we lack the biological information to determine weight/numbers-based reference points based on MSY or MSY proxies (as prescribed by the Standard Approach), and/or (2) a weight/numbers-based ACL cannot effectively be managed pursuant to the Standard Approach.

The answers to the following questions will help inform whether it is appropriate to apply the (h)(2) flexibilities:

a. Data needed to effectively specify a weight/numbers based ACL that is based on MSY or an MSY proxy.

Is one or more of the following types of information available:

- o A mostly complete time series of removals and basic life history information
- o At least 1 year of absolute abundance info and basic life history info
- o A combination of basic life history info, recent annual removals, and a stock size indicator, such as a relative index of abundance, with a long enough time series to capture the effects of the fishery

Lack of data availability may arise from either a general lack of data quantity or quality (e.g., no reliable removal or life history data) or high intrinsic variability in the data (e.g., incomplete time removal series), making calculation of a reliable biomass/numbers-based management target (i.e., an ACL based on a number or weight of fish) impracticable. Assessment models frequently assume that time series of total removals are complete and known with reasonable accuracy and precision. For data-limited stocks with large uncertainty in removal data, these assumptions can invalidate the use of such stock assessment methods.

There are many situations in fisheries management that may contribute to uncertainty in removals. While the existence of any such circumstance in a fishery would not necessarily qualify a data-limited stock for use of an (h)(2) alternative, examples of causes of uncertainty include: unknown removals by fishery sectors (e.g., undocumented recreational or subsistence removals); rare or bycatch species, where infrequent and sporadic catches may lead to high variation in a given year and skew management results; significant discards and poorly estimated discard mortality rates; species misidentification, especially in a species complex. Any consideration of the applicability of (h)(2) flexibility due to inability to set weights/numbers-based reference points would need to examine and vet the severity and context of such uncertainties, as well as of what data and methods are available for that particular stock.

b. Monitoring and Enforcement

Being able to calculate an ACL is only the first step for effective ACL-based management. For ACLs to be effective at limiting removals and preventing overfishing, management bodies need to be able to monitor and enforce limits and apply AMs when limits are reached or exceeded. If a lack of capacity exists to monitor removals and enforce limits, then actual removals can exceed the limits by large or unknown amounts (Copes 1986, Salas et al. 2007, Purcell et al. 2013). There are many situations in fisheries management where capacity to monitor and manage may be challenging. While the existence of any such circumstance in a fishery would not necessarily qualify a data-limited stock for use of an (h)(2) alternative, examples of situations that may be challenging in these ways include: artisanal, small-scale and recreational fisheries with many fishers and many points of landings; lack of enforcement resources (financial and technical) needed to monitor removals and deter illegal fishing; numerous market pathways that make tracking removals difficult; geographically dispersed fishing activity; targeting of multiple fish stocks (i.e., mixed-stock fisheries); lack of stakeholder buy-in, cooperation, and trust. Any consideration of the applicability of (h)(2) flexibility due to management challenges would need to examine and vet the severity and context of such challenges for that particular stock.

c. Determination

A detailed examination and vetting of the best scientific information available is required to determine if minimum data requirements exist for a weight/number based ACL. Additionally managers need to carefully consider implementation capabilities (i.e., the ability to monitor and enforce weight/number ACLs). If adequate data or management capacity does not exist, then it may be appropriate to consider developing an alternative recommendation under (h)(2).

Recommendation When Proposing to utilize the (h)(2) flexibilities for a data-limited stock

When a Council wants to consider proposing an (h)(2) alternative approach for ACLs, the following conditions for use should be considered:

- Data limitations should be clearly described by means of a thorough review of the best scientific information available and documentation of data quantity and quality, a synthesis of historical and existing collection-reporting programs, and other relevant anecdotal information.
- Councils should evaluate which data-limited methods are appropriate for their applicable stocks to ensure that management is consistent with the best scientific information available.
- As required by NS1 guidelines, Councils must document their rationale for proposing an alternative approach to ACLs than that set forth in NMFS's Standard Approach for ACLs, and how the alternative approach will be consistent with MSA requirements such as preventing overfishing and rebuilding overfished stocks.
- When weight/numbers-based catch limits are not advisable given data and implementation limitations, Councils should investigate alternative approaches under (h)(2).

- A data improvement plan should be developed and data collection should be strongly encouraged to enable data-limited stock assessment methods and move priority stocks into more robust tiers (e.g., data sufficient to support stock status determinations and weight/number based ACLs). For example, collection of length samples every year could enable length-based approaches and move a stock into a higher tier.
- Alternative approaches for ACLs should be revisited frequently (e.g., every few years).

Appendix 1I presents several case studies illustrating how a stock could be identified for potential applicability of an alternative ACL approach. These case studies feature the use of the FishPath decision support tool (https://www.fishpath.org) as an example of a tool with the capacity to support each of the above recommendations.

2. Potential Use of Rate-Based ACL as an (h)(2) Alternative for Data-limited Stocks

This section provides a description and examples of how a rate-based ACL could work as an alternative to the Standard Approach for ACLs, including establishing the ACL, and monitoring and managing to prevent overfishing.

a. Considering Whether to recommend a Rate-Based ACL

The decision to recommend a rate-based ACL for a data-limited stock should be based on whether:

i. The stock qualifies for use of the (h)(2) flexibilities for data-limited stocks (See Section 1 above);
ii. There are sufficient data to estimate the current average fishing mortality rate, or a proxy for F at MFMT; and
iii. It is possible to manage with/enforce a rate-based approach

If these conditions are met, then a Council could consider a rate-based ACL as an alternative to the Standard Approach. Such a recommendation would need to be proposed as an FMP amendment with a robust record documenting the rationale for the proposed approach and its consistency with the MSA and other applicable law.

b. How a Rate-Based ACL Could Work

i. Applicability and Description of Standard Indicator, Reference Points, and Control Rule Approach

Managing fisheries using an ACL expressed in terms of rate could follow the same basic steps that are used in the standard weights/numbers-based approach. Managing to a fishing rate involves using a system of indicators, reference points and control rules. This approach requires monitoring stock status using the best scientific information available and available analytical methods, then applying management measures to maintain the stocks within prescribed reference points. (Geromont and Butterworth 2015).

Indicators -- such as an abundance index (Geromont and Butterworth 2015), mean length (Gedamke and Hoenig 2006; Klaer et al 2012; Nadon et al. 2015; Ault et al. 2018), proportion mature (Cope and Punt 2009; McDonald et al. 2017), or Spawning Potential Ratio (SPR, Hordyk et al. 2015; Rudd and Thorson 2017) -- can support the use of fishing mortality or relative biomass as management metrics. Reference points for some of these metrics (SPR, mean length, proportion mature and sustainable fishing rates) are often determined through life history theory (Clark 2002; Klaer et al 2012, Hordyk et al. 2015), while reference points for an abundance index would need to be determined through expert opinion (including using vulnerability scores; Cope et al. 2011) if the reference index is not available for the unfished population or indicative of a sustainable fishing level. In these scenarios, simulation testing should be used where feasible to establish a reference level for a given data source and method.

Once a reference point is established, a control rule can express what change in fishing effort is needed to maintain the indicator near the reference point. Such a control rule is conceptually the same as some rules currently used to modify standard catch limits (e.g., 40-10 rule of the Pacific Fishery Management Council[4]), and should be likewise predetermined and pre-agreed upon in order to maintain the integrity of the rule (Dowling et al. 2015). The control rule can then determine how much fishing effort would need to change (as a percent of current effort) to achieve the management objective. Management could then implement the desired change in effort through any of the effort control means currently available (e.g., time-area closures). Such indicator-based management procedures are commonly used in data-limited fisheries, as well as with extremely short-lived stocks or stocks that demonstrate enormous variability in population dynamics (Geromont et al. 1999, Geromont and Butterworth 2015).

Translating percent effort change into a particular or a suite of effort controls needs specific thought and attention, and is often best designed using simulation testing (Carruthers et al. 2014, Carruthers et al. 2016; Sagarese et al. 2018). Performance evaluation, via performance metrics (e.g., probability of overfishing), provides the most direct link demonstrating whether a particular system of indicators, reference points, and control rules (i.e., the management procedure) fulfills the MSA requirements of preventing overfishing while maintaining relative stock status near the target. Simulation testing the management procedure is the same concept used to determine harvest control rules for setting ACLs under the Standard Approach. The main difference is the metric (weight, numbers or effort) that is being used to accomplish the same management objectives (i.e., prevent overfishing). Thus, for data-limited stocks qualified to use the (h)(2) flexibilities, it might be possible to express the ACL as a relative measure of rate that has been demonstrated through simulation testing to effectively reach management objectives.

This basic management approach can be expanded to include more than one indicator and reference pairing. These approaches are commonly referred to as "traffic light approaches" (Caddy 1998, 2004), "multi-indicator trigger systems" (Dowling et al. 2008), or "decision trees" (Wilson et al. 2010). As an example of such approaches, Dowling et. al., (2008)[14] described three case studies where trigger systems (i.e., a trigger being the reference point that "triggers" a management response (Dowling et al. 2015)) were applied to data-limited Australian fisheries.

[4] This is a threshold control rule that applies automatic effort controls based on reductions in biomass. The restrictions become greater as you drop below the target (40% relative biomass).

Under these multi-indicator management procedures, metrics used included changes in species composition, changes in spatial fishing patterns, and changes in fishery CPUE, with each having associated trigger levels. When a trigger is reached (i.e., the reference point is crossed), management responses are invoked. Subsequent simulation testing assessed the performance for two of the three fisheries described in Dowling et al., (2008). As an example, the multi-indicator management for the Bass Strait Central Zone Scallop Fishery performed well based on the performance metrics of reducing fishing mortality as stock size declined (i.e., avoiding overfishing) and preventing the stock from falling below the limit reference point 94% of the time (i.e., avoiding an overfished state).

Whether using one or multiple indicators, and whether sequentially or simultaneously evaluated, the effectiveness of these approaches at satisfying MSA requirements can be determined via performance metrics evaluated through simulation testing. This approach is principled and consistent with managing stocks under weight/numbers-based catch limits, which also typically use effort management controls to manage fishing and prevent overfishing. The question then becomes how to evaluate options (limits on removals or effort-based controls of fishing mortality) and determine which are best suited for any particular fishery in order to establish the best way to fulfill MSA requirements.

As stated in the NS1 guidelines, the use of weight/numbers-based ACLs is the standard approach, and should be used for data-limited stocks when adequately supported by data.

ii. General Rate-Based ACL Concept for Data-Limited Stocks

The MSA defines "overfishing" as a "*rate or level of fishing mortality* that jeopardizes the capacity of a fishery to produce the [MSY] on a continuing basis." MSA § 3(34)(emphasis added). Thus, while weight/numbers-based ACLs are the standard approach, expressing an ACL in terms of the rate of fishing mortality, and monitoring the actual fishing mortality level against that reference point, could provide an alternative means of monitoring to ensure that overfishing does not occur. The same management tools that are available for use as accountability measures for weight/numbers-based ACLs would be available to control effort and prevent overfishing in a rate-based ACL fishery. For example, time-area closures, trip limits, and size limits are all potential management tools that could be used as AMs for a rate-based ACL. The difference would be in the metric being monitored and used for triggering AMs (i.e., the fishing rate as opposed to an amount of fish).

iii. Establishing Rate-Based Reference Points

A key question regarding the potential use of rate-based ACLs is how to ensure that the ACL is preventing overfishing. That answer depends on what data are available. Managers will need to ask: "What aspect of the fishery can be measured, and what data-limited methods exist to utilize that information?"

For example, some measurable aspects of a fishery (e.g., lengths or age compositions), even if only a snap-shot, may provide a measure of stock status. Length-based methods are the major data-limited methods for utilizing such data sources. These methods can estimate the current average F as compared to an MFMT (e.g., F_{OFL} based on life history information. While these methods often use average measures of fishing rate, and therefore incorporate a time lag, they may provide better information than a weight/number based ACL that isn't supported by adequate data.

Terminology in this Example. For ease of description, this document describes how a rate-based ACL could be developed pursuant to the same system of reference points and buffers set forth in the Standard Approach, only expressed in terms of a different metric (rate versus amount of fish). For purposes of this discussion, we label the substitute reference points for ABC and ACL as F_{ABC} and F_{ACL}, respectively. The MFMT is the rate-based expression of the overfishing threshold, and is thus the rate-based equivalent of the OFL (i.e., an F_{OFL}).

Calculating the ACL. Once the stock assessment method has identified the F and the MFMT, the Council's SSC could review the results and apply a buffer to the MFMT to account for scientific uncertainty. This could produce an F_{ABC}. The Council could then review the F_{ABC}, and apply a buffer to account for other uncertainty, such as management uncertainty, to identify an F_{ACL}.

Option to Identify Indicators. If there is benefit to using an indicator, the SSC and the Science Center could determine if and how a particular indicator could be correlated to the rate-based reference points. For example, it may be possible to correlate particular mean lengths to the MFMT, the F_{ABC}, and F_{ACL}. This information could potentially be useful for monitoring as well as in the design of AMs.

iv. Monitoring and Management to Ensure Overfishing is Prevented

A Council recommending an (h)(2) alternative for a data-limited fishery would need to describe how the fishery would be monitored to ensure compliance with the rate-based reference points. Two options to consider would be (1) annually run the data-limited model to determine the current F and compare it to the F_{ACL} (and MFMT if wanted for annual monitoring); or (2) monitor the indicator to compare the F to the F_{ACL} (and/or MFMT if wanted for annual monitoring). The FMP must include AMs to be triggered if the annual F rate (as estimated from the length-based assessment approach) meets or exceeds the $F_{ACL.}$ Various management tools would be available to support management based on a rate-based ACL including size limits, time-area closures, and trip limits.

Recommendations When Use of Rate-Based ACLs is Proposed for a Data-Limited Stock under (h)(2)

- Weight/numbers-based ACLs are the standard approach when supported by data.
- Strong buffers should be used in data-limited situations due to increased uncertainty.
- Rate-based ACLs must comply with MSA and other applicable law and be adopted through an FMP amendment.
- Performance metrics evaluated through simulation testing can determine the effectiveness of rate-based approaches at satisfying MSA requirements.
- Simulation testing can effectively translate rate-based approaches into effort controls to reach management objectives.

- Various management tools would be available to support management based on a rate-based ACL including size limits, time-area closures, and trip limits.
- The choice of data-limited methods should be based on what aspect of the fishery can be measured.
- Indicators can support management metrics and be useful for monitoring and designing AMs.

3. Data-limited Stocks that may Qualify for (h)(2) flexibility but Lack Data for Use of Rate-Based Approach

There are some data-limited fisheries which might qualify to use the (h)(2) flexibilities, but which also lack data to effectively use rate-based ACLs. For these stocks, we have the following recommendations.

Recommendations for Data-limited Stocks that may Qualify for (h)(2) but Lack Data for Use of Rate-Based Approach

- In accordance with priorities, seek out opportunities to collect data to facilitate future use of a rate, or ideally numbers/biomass-based approach.
- If there is no reasonable alternative to using a catch-scalar technique, employ cautionary buffers and recommendations as described in section II.B.1. of this paper.

III. Summary of Recommendations and Conclusion

In conclusion, managing data-limited stocks continues to present challenges. However, great improvements have been made in data-limited assessment methods. It is important to analyze current data available for data-limited stocks and align the appropriate assessment method with the available data. Additional improvements are still needed in terms of data collection and assessments for these stocks.

For certain data-limited stocks that lack the data necessary to effectively specify or manage with Standard ACLs, an alternative approach, as authorized under 50 CFR 600.310(h)(2) could be considered. One potential approach that may be appropriate for such data-limited stocks is the use of a rate-based ACL.

NMFS is ultimately responsible for ensuring compliance with MSA and NS2.

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Appendix 1. Case Studies Demonstrating How to Identify Stocks for Alternative ACL Consideration

It is important to apply transparent and replicable protocols when identifying which stocks would benefit from alternative ACL considerations. This section provides examples from three case studies in various U.S. regions that demonstrate an example of one such approach, using a web-based decision-support tool named FishPath (https://www.fishpath.org/).[5] These case studies are not intended to endorse the use of FishPath for these or other fisheries, suggest that FishPath is the only approach to identifying stocks for alternative ACLs, or make official agency recommendations for these fisheries, but they provide examples of one way the process of identifying stocks that might qualify for alternative ACL consideration under (h)(2) can be done.

FishPath is designed to help scientists, managers, and stakeholders use an objective rationale to evaluate local conditions and available information and technical capacity (among other things) to identify the best matches for data collection, assessment, and management measures specific to any stock and/or fishery (Dowling et al. 2016). FishPath contains a comprehensive repository of techniques for data collection, stock assessment, and management measures, and, in particular, it outlines a variety of alternative options for constructing harvest strategies when resources are limited. NMFS is not making a blanket endorsement of FishPath as constituting the best scientific information available. Whether conservation and management measures for a fishery are consistent with National Standard 2 and other MSA requirements is a fact-specific determination.

The first step for using FishPath is to fill out a diagnostic questionnaire to assess the available data and characteristics of the fishery. The FishPath tool then produces reports of possible approaches to data collection, assessment methods, and management actions best suited for the specific details of the given stock and fishery specifics. For purposes of assessing whether use of an alternative ACL may be warranted, the FishPath tool offers a way to gauge the viability of estimating and managing to weight/numbers-based catch limits in the following ways:

- Identifies whether and how well "catch estimation" method criteria (i.e., the inputs needed to apply a particular method) are met;
- Outlines how well the assumptions of all assessment methods are matched to the fishery and stock;
- Identifies and explains whether management measures based on weight/numbers-based catch limits are advisable; and
- Specifies data and parameters gaps and improvements needed to move strategically toward better or more workable "catch estimation" methods.

The first two bullets above can be used to provide an objective rationale for invoking (h)(2) and using methods other than "catch estimation" methods to manage a stock. The third bullet establishes when alternative ways to manage fishing rate beyond weight/number-based catch limits (such as through effort controls) is warranted in order to prevent overfishing. The final

[5] FishPath, which provides an online decision-support tool, as well as a system for constituent engagement, was developed by The Nature Conservancy with support and input from NOAA and other experts from around the world.

bullet highlights specific data and input needs to encourage progress toward improving information to ultimately support the use of "catch estimator" methods (if possible) and bracket uncertainty in those estimates.

The following three case studies first present an overview of the fishery, then describe the way the FishPath decision support tool was applied to evaluate weight/number-based vs alternative ACL options.

St. Croix stoplight parrotfish case study:
Fishery overview: In the U.S. Caribbean, stock units are defined by species or species group and by island (Puerto Rico, St. Thomas/St. John, and St. Croix), leading to a combination of roughly 170 stocks requiring assessment according to management units in the Island-Based FMPs. The St. Croix parrotfish fishery presently lands seven parrotfish species, including stoplight parrotfish (landings of three additional parrotfish species are prohibited). This fishery accounts for about 85% of commercial trips and is the primary fishery targeting parrotfish. A stock assessment for stoplight parrotfish in St. Croix was conducted in 2016 and highlighted severe data limitations for the stock. Available time series of species-specific removals were short and highly variable, due in part to changing market demands and modifications to reporting forms throughout the available time-series.

FishPath application and results: A preliminary FishPath exercise was completed by scientists at the NMFS Southeast Fisheries Science Center for the St. Croix stoplight parrotfish diving fishery. Data collection activities for which FishPath showed positive results included interviews, market surveys, and port-landing site monitoring. The relatively small spatial areas and known landing sites, the subsistence-artisanal nature of the fishery, and the willingness of fishermen to be interviewed aided the data collection efforts and contributed to the assumed reliability. For assessment options, FishPath indicated "catch-only" methods are not recommended, due to large uncertainty associated with removals, for reasons stated above (variable time series of landings); misreporting, which has been attributed to fishers' fears of reaching ACLs; and a lack of information input into catch-only methods to inform stock status as an input to those methods.[6] Alternative assessment options recommended by FishPath included abundance indicators (e.g., based on CPUE), empirical reference points (triggers), and length-based approaches. Based on the results from FishPath, an example of an alternative to a weight- or number-based ACL for this fishery could be an ACL expressed as an F_{MSY} proxy reference point derived from life history. A rate-based ACL could be monitored via estimates of fishing rate derived from length-based stock assessment approaches (Ault et al. 2018; Appendix 3).

FishPath's results pertaining to management measures identified negative caveats for number/weight-based catch limits, and identified positive attributes (i.e., those indicating positive aspects of an option) suggesting that potential viable management measures include effort limits (by area, season, or daily limits) and spatial management.[7] Overall results,

[6] Note that the reference points in the island-based FMPs recognize these sources of uncertainty and account for them in setting the management reference points or their proxies based on best available scientific information.
[7] Note that the island-based FMPs currently rely on recreational bag limits and seasonal and area closures as part of their management, and allow for additional closed seasons in the event of an AM trigger (exceedance of the

particularly the lack of long-term and reliable removal data, support the use of alternatives to standard approach to ACLs.[8]

Hawaii parrotfish case study:
Fishery overview: There are a multitude of data-limited fisheries across the Pacific Islands Region that are under US management jurisdiction. One prominent example in the Hawaiian Islands is the parrotfish fishery, which is widespread across the islands (mostly spearfish with some trap gear) and has a large non-commercial component, estimated to be at ~85% of total spearfish landings. Commercial landings are tracked to a certain extent, but non-commercial activity is only sporadically surveyed (creel surveys, phone surveys). While a variety of regulations are in place to protect certain species, the total fishing effort is largely unknown and difficult to regulate. The spearfish fishery is also complicated by the use of multiple types of gears ranging from simple single and multi-prong spears to pneumatic and band-powered spearguns while free-diving or while SCUBA diving.

FishPath application and results: A FishPath exercise was completed for the Hawaii parrotfish spearfish fishery with expert advice solicited from scientists at the Pacific Islands Fisheries Science Center (PIFSC), University of Hawaii at Manoa, Western Pacific Regional Fishery Management Council (WPFMC), and State of Hawaii Division of Aquatic Resources. Due to much uncertainty associated with total amounts of fish caught and effort, the opportunistic nature of the fishery, a high level of fisher targeting, and the challenges of an extremely diverse catch base, FishPath indicated "catch-only" methods are not recommended for developing ACLs. To address some of these issues, PIFSC has focused on data-limited assessment approaches relying on length data. Assessment scientists originally focused on the mean-length model and have recently moved to the growth-type-group length-based SPR model (GTG-LBSPR, Hordyk et al., 2016). This general approach generates an FMSY proxy that can be used to estimate an MFMT. However, to derive a weight- or number-based OFL and ACL, it is necessary to scale this harvest rate with a biomass estimate derived either from diver surveys or removal data. This typically leads to very uncertain values for the OFLs and ACLs, which can fail to pass independent review. For example, a recent assessment of Guam reef fish successfully passed review for stock status (F/FMSY, SPR) for 12 species, but only 5 out of the 12 species passed review for OFL determination, due to the uncertainty in biomass estimates. This supports the use of alternatives to the numbers or weight-based ACL framework for this fishery.[9] For example, Nadon (2017) presented an alternative approach to specifying MFMT as a fishing rate, not an OFL, by calculating reference points using population simulation, then using mean length data to establish whether overfishing was occurring and length-based estimates of SPR measures to consider overfished status for 27 Hawaiian reef fishes. This approach successfully passed independent review and could be used to inform various types of fishing effort controls. Other types of assessment methods indicated by FishPath such as abundance indicators (e.g., CPUE) and empirical reference points (triggers), could also be explored.

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weight-based ACL). The island-based FMPs, including the weight-based ACLs, have been certified as reflecting the best available scientific information.

[8] We note that, pursuant to the (h)(2) the determination of whether to recommend an alternative ACL is up to the Council, and must be recommended through an FMP or FMP amendment.

[9] We note that, pursuant to the (h)(2) the determination of whether to recommend an alternative ACL is up to the Council, and must be recommended through an FMP or FMP amendment.

Alaskan Shark Complexes Case Study:

Fishery overview: Sharks in Alaskan waters are managed in two separate areas within federal waters: The Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BSAI). The shark complex has the same four components in each area: spiny dogfish, Pacific sleeper shark, salmon shark, and a catch-all of "other/unidentified" sharks. However, the primary shark species, the fisheries that catch those species, and the available data differ between the two areas. The OFL and ABC are estimated in metric tons for the complex as a whole, based on the OFLs and ABCs for individual shark species, thus there is no species-specific management. Also, within Alaskan waters, sharks are caught in state-managed fisheries, primarily fisheries targeting salmon. All sharks caught in both state and federal waters are discarded at-sea. The amount of shark caught in the federal fisheries of the GOA and BSAI is estimated by at-sea observations with high levels of coverage in the BSAI, but variable coverage in the GOA. Sharks caught in state-managed fisheries are mostly unobserved and unreported. Thus, there are three primary challenges for the shark complexes: 1) unobserved/unreported sharks caught (impacts spiny dogfish and salmon shark); 2) spatial mismatch between location of effort ad sharks caught, versus observer coverage (impacts Pacific sleeper shark and spiny dogfish); and 3) unreliable estimation of weights of fish caught by longline vessels, where observers are unable to access the animals to directly measure weight or electronic monitoring systems (EM) are used (impacts Pacific sleeper shark and "other/unidentified" sharks).

FishPath application and results: Scientists at the Alaska Fisheries Science Center have initiated a FishPath process for the three primary species in the complex, with each of the species having different data availability and collection and management capacity challenges. Given species management is at the stock complex level, data collection or management measure options were considered at that level, while assessment options were reviewed for each species using species-specific life history and data.

FishPath recommended using local and expert knowledge to estimate the volume of sharks caught (either weight or numbers) in unobserved/unreported fisheries and/or incorporating sharks into existing logbook programs or instituting logbook programs. At a minimum, these approaches could provide an idea of the magnitude of shark removals in the unobserved/unreported fisheries (i.e., state managed fisheries). The spatial mismatch of at-sea human observer coverage could be addressed by EM, which is currently being examined in several Alaskan fisheries. However, deployments in the current EM program for fixed gear (i.e., longline and pot) fisheries are randomized by fishing trips, not space, and the programs being explored for future use are for a specific fishing sector and for compliance monitoring, not estimation of removals. The issue of weight underestimation is both a data collection and a management challenge because the size of the sharks precludes obtaining length or weight measure and management measures are based on total weight, which is likely underestimated. Improved data collection through either onboard observers/EM estimating weight (or length to be converted to weight), or expanded logbooks may be able to improve estimates of the size of fish caught. However, with megafauna such as these, a potential management measure presents itself, which is not included in FishPath: managing counts of sharks caught, instead of weight.[10]

[10] Note that expressing reference points in terms of numbers of fish falls within the standard approach in the NS 1 guidelines.

Assessment options suggested by the FishPath analysis varied by species, due to the variable nature of data available, but ranged from length-based and CPUE-based abundance indices (spiny dogfish) to changes in removals and or effort (Pacific sleeper shark and salmon shark). Approaches that directly provide measures of OFL are not strongly supported by data for any of the species, thus supporting the consideration of alternative options for this fishery.

Synthesis of FishPath results

These above examples cover differences in management areas, fisheries, and stocks, but share similar challenges pertaining to historical removal records, collecting removal data, and/or management. As demonstrated above, FishPath can help identify relevant issues with ACLs for a fishery (setting or enforcing ACLs, or both), some specific reasons why the barriers exist, and impediments to improving either data collection to enhance assessment options or governance and socio-economic characteristics that undermine effective management.