Agenda Item H.7
Attachment 1
September 2019

National Standard 1 Technical Guidance for Designing, Evaluating, and Implementing Carry-over and Phase-in Provisions within ABC Control Rules

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List of Acronyms

ABC – acceptable biological catch
ACE – annual catch entitlement
ACL – annual catch limit
ACT – annual catch target
AMs – accountability measures
B_{lim} – biomass limit
B_{pa} – precautionary biomass levels
CCSBT - Commission for the Conservation of Southern Bluefin Tuna
CFR – Code of Federal Regulations
CPUE – catch per unit effort
CV – coefficient of variation
DAS – days at sea
FMP – fishery management plan
F_{lim} – fishing mortality limit
FR – Federal Register
GoM – Gulf of Mexico
HMS – highly migratory species
ICCAT – International Commission for the Conservation of Atlantic Tunas
IFQ – individual fishing quota
IPHC – International Pacific Halibut Commission
LAGC – limited access general category
MSA – Magnuson-Stevens Fishery Conservation and Management Act
MSE – management strategy evaluation
MSY – maximum sustainable yield
NE – Northeast
NMFS – National Marine Fisheries Service
NS1 – National Standard 1
OFL – overfishing limit
P* – probability of overfishing
QS – quota share
QP – quota pounds
SSB – spawning stock biomass
SSC – Scientific and Statistical Committee
TAC – total allowable catch
U.S. – United States
WBFT – Western Atlantic bluefin tuna

Abstract

Revisions to the National Standard 1 (NS1) guidelines published in 2016 included two provisions that added flexibility in the process of specifying annual catch limits (ACLs). One provision allowed the unused portion of an ACL to be carried over to the following year. A second provision allowed changes in catch limits to be phased in over a period of time not to exceed 3 years. Both provisions required that overfishing is still prevented. This added flexibility may have a number of benefits including increasing safety and economic performance and reducing social disruptions by creating stability in harvests over time. However, policies that allow acceptable biological catch (ABC) to be set closer to the overfishing limit (OFL) also have the potential to increase biological risk and should be properly analyzed and adopted with caution. This technical memo is meant to support the implementation of the carry-over and phase-in provisions as described within the NS1 guidelines. It provides examples of how carry-over and phase-in provisions have been implemented in fisheries so that we can learn from past experiences, describes acceptable approaches to design and implement carry-over and phase-in provisions, and identifies characteristics of fish stocks, fisheries, and management approaches that may impact the benefits and risks of applying carry-over and phase-in provisions.

1. Introduction

The NS1 guidelines recommend that each Fishery Management Council (Council) establish an acceptable biological catch (ABC) control rule for each managed stock or stock complex. An ABC control rule is an established policy set by the Council in consultation with its Scientific and Statistical Committee (SSC), or by the Secretary of Commerce for Secretarial managed stocks such as Atlantic highly migratory species (HMS). It articulates how the ABC is set compared to the overfishing limit (OFL). ABC control rules take into account scientific uncertainty and each Council's risk policy (e.g., the acceptable probability that catch equal to the ABC would result in overfishing). Because the ABC cannot exceed the OFL estimate, ABC control rules generally specify the amount by which the ABC should be reduced from the OFL[1], based on the level of scientific uncertainty and the probability that such a catch level could result in overfishing. For Council-managed fisheries, the SSC generally applies the Council's ABC control rule when making its ABC recommendation.

In October 2016, the National Marine Fisheries Service (NMFS) published a final rule to revise the National Standard 1 (NS1) guidelines (81 FR 71858; October 18, 2016). One of the objectives of the 2016 revisions was to provide additional flexibility within current statutory limits to address fishery management issues. For example, the revised NS1 guidelines allow for changes in catch limits to be phased in over time, and for some of the unused portion of an acceptable catch limit (ACL) to be carried over from one year to the next. A summary of those provisions, requirements related to them, and the benefits and risks associated with them, is provided in section 1.1 below.

Councils, regions, and stakeholders have expressed considerable interest in using the carry-over and phase-in provisions in ABC control rules. For example, at the time of this writing, the South Atlantic Council is working on a fishery management plan (FMP) amendment to incorporate phase-in and carry-over provisions within their ABC control rule, the Gulf of Mexico Council is working on an FMP amendment to incorporate carry-over provisions within their ABC control rule, and the Pacific Council is starting scoping for the development of phase-in

[1] For some data limited stocks, an OFL proxy is specified or OFL may not specified.

provisions. Recommendations and best practices on how to develop and apply these provisions are lacking. For these reasons, technical guidance on the application of those provisions is provided in this document. This is only technical advice and is nonbinding.

The goal of this technical memo is to: 1) provide examples of how carry-over and phase-in provisions have been implemented in fisheries so that we can learn from past experiences; 2) describe some possible approaches to design and implement carry-over and phase-in provisions; and 3) identify characteristics of fish stocks, fisheries, and management approaches that may impact the benefits and risks of applying carry-over and phase-in provisions. This technical memo is meant to support the implementation of the carry-over and phase-in provisions as described within the NS1 guidelines. We recognize that the collective scientific understanding about these concepts with continue to evolve over time. Councils should consult with their SSCs and NMFS Fisheries Science Center and Regional Office counterparts, and use the best scientific information available to design carry-over and phase-in provisions that are appropriate for their fisheries.

1.1 Carry-over Provisions: Description, Benefits and Risks

Description

The NS1 guidelines include a provision to allow Councils to carry over a portion of the unused ACL in a following year if an underage occurs (i.e., catch is below ACL) in the current year. This provision was added because some fisheries do not catch each stock's full ACL every year. Carrying over unused catch can relieve pressure on fishermen to catch the entire catch limit within a particular year when it may not be practical or economical to do so. This pressure can result in fishing in unsafe situations or harvesting fish during poor market conditions. Further, carry-over provisions can also be used to address situations when fisheries are prematurely closed in season and some amount of ACL remains unused. Prior to the 2016 NS1 revisions, managers had implemented carry-over provisions in several U.S. fisheries, but specific guidance on carry-over did not exist in the NS1 guidelines. Some Councils had expressed interest in carrying over significant levels of catch that could result in the previously specified ACL, and in some cases the ABC, being exceeded. In *Conservation Law Foundation* v. *Pritzker*, the U.S. District Court for the District of Columbia found that Framework 50 of the Northeast Multispecies FMP violated the Magnuson-Stevens Act (MSA) by allowing sectors to carry over unused catch in an amount that would exceed the SSC's recommendation of ABC for several stocks. The court held that MSA section 302(h)(6) requires that carry-over plus ACLs cannot exceed a stock's specified ABC. Consistent with this court decision, NMFS proposed and finalized guidance on carry-over.

Specifically, the NS1 guidelines state at 50 CFR 600.310(f)(2)(ii):

> "… Councils can develop ABC control rules that allow for changes in catch limits to be phased in over time or to account for the carry-over of some of the unused portion of the ACL from one year to the next. The Council must articulate within its FMP when the phase-in and/or carry-over provisions of the control rule can and cannot be used and how each provision prevents overfishing, based on a comprehensive analysis.
>
> (A) …

> (B) *Carry-over ABC control rules.* An ABC control rule may include provisions for the carry-over of some of the unused portion of an ACL (*i.e.*, an ACL underage) from one year to increase the ABC for the next year, based on the increased stock abundance resulting from the fishery harvesting less than the full ACL. The resulting ABC recommended by the SSC must prevent overfishing and must consider scientific uncertainty consistent with the Council's risk policy. Carry-over provisions could also allow an ACL to be adjusted upwards as long as the revised ACL does not exceed the specified ABC. When considering whether to use a carry-over provision, Councils should consider the likely reason for the ACL underage. ACL underages that result from management uncertainty (*e.g.*, premature fishery closure) may be appropriate circumstances for considering a carry-over provision. ACL underages that occur as a result of poor or unknown stock status may not be appropriate to consider in a carry-over provision. In addition, the Councils should evaluate the appropriateness of carry-over provisions for stocks that are overfished and/or rebuilding, as the overriding goal for such stocks is to rebuild them in as short a time as possible."

It is important to note that the NS1 guidelines describe two approaches that Councils, or the Secretary in the case of Secretarial managed species, may use to carry over some portion of the ACL underage into the next fishing year. This technical guidance document will address both approaches. These two approaches are:

- *Utilizing ACL buffer*: If the ACL is lower than the ABC and there is an underage, a Council may account for it by adjusting the next years ACL upwards (by some part of the underage) as long as the new ACL with the underage added does not exceed the pre-specified ABC for the next year. See section 3.1 for more information on this approach.
- *Utilizing a carry-over ABC control rule*: A carry-over ABC control rule establishes a policy that allows Councils to carry over some portion of an ACL underage into the next year by adjusting the ABC upwards to account for the increased stock biomass that results from an ACL underage. The revised ABC cannot exceed the OFL; therefore the degree to which ABC can be adjusted is limited by the OFL. See section 3.2 for more information on this approach.

Benefits of allowing carry-over

Carry-over provisions provide flexibility for fishermen to delay catching the full ACL if weather or economic conditions would allow them to catch the fish more safely or profitably at a later time (Sanchirico et al. 2006).

- *Safety*: One of the motivations to use carry-over provisions is safety. The rationale is that fishermen (or sectors) with unused quota at the end of the year will not face a choice of whether to go fishing in poor conditions or with excessive haste in order to avoid losing access to that catch. Carry-over provisions can also mitigate unforeseen circumstances (e.g., fishing vessel or equipment damage, natural disasters) that prevent safely obtaining the full ACL.
- *Economic stability*: Carry-over provisions can also relieve the pressure to harvest during poor fishery and/or market conditions or avoid creating a market glut by landing a large amount of catch at the end of the fishing year/season.
- *Management stability*: Carry-over provisions could also increase stability in fisheries management measures for both commercial and recreational fisheries. For example, more consistent, multi-year season lengths and ACLs can be set, knowing that some portion of the uncaught ACL can be carried over into the next fishing year or season. Carry-over provisions also can be administratively easier to implement, rather than making fine scale in-season adjustments to season length or possession limits (which could be based on uncertain in-season harvest data) to achieve the full ACL in a fishing year or season.

- *Catch share fisheries*: The ability to carry over quota reduces incentives to fish right up to the maximum allowed, which can lead to overages and discards (Sanchirico et al. 2006). Carry-over may be particularly important in multi-species catch share fisheries since fishermen may have incomplete control over the mix of species they catch, leading to imbalance between their catch and quota. (Sanchirico et al. 2006).

Risks of allowing carry-over

Allowing carry-over has the potential to increase biological risk by allowing overfishing to occur inadvertently, which could lead to depletion or slow rebuilding of stocks. Risks of overfishing may be higher for some species or fisheries based on life-history characteristics, assessment frequency, data quality, and characteristics of the management system. We discuss these risks in more detail in Section 4.

- *Life history characteristics*: Carry-over could significantly impact short-lived stocks with high rates of natural mortality. For such stocks, the rationale of increasing the ABC based on the increased stock biomass that results from an ACL underage may not hold.
- *Jointly targeted and bycatch species*: Carry-over polices that shift harvest of one species over time may coincidentally do the same for other species. If fact, constraints on quota of an incidentally-caught species may be the primary reason for underages and potential carry-over of another species. Further, for stock complexes that have one ABC for the complex as a whole, the application of carry-over could further enhance challenges with ensuring that none of the stocks within the complex experience overfishing.
- *ACL overages and catch uncertainty*: Allowing carry-over provisions to be applied to ACL underages while not requiring corresponding pay-back provisions for ACL overages could lead to catches exceeding the ACL on average, risking overexploitation of the stock over the long term (Powers and Brooks 2008). Further, for stocks with substantial uncertainty in catch estimates, an underage of the ACL may be due to imprecision in the estimate of catch. An underreporting bias undermines the viability of carry-over management.

1.2 Phase-in Provisions: Description, Benefits and Risks

Description

The 2016 revisions to the NS1 guidelines also included a provision to allow changes in catch limits to be phased in over a period of time not to exceed 3 years, as long as overfishing is prevented. NMFS recognized that the previous version of the NS1 guidelines had led managers to adjust ABCs and ACLs in lock-step with assessment results through the use of control rules. Large changes in catch limits due to new scientific information about the status of a stock may have negative effects on the fishing industry and fishing communities. Phasing in changes to catch limits reduces the immediate magnitude of the change, and should help the fishing industry adapt to and plan for the future by creating more stable fisheries over the short term.

Specifically, the NS1 guidelines state at 50 CFR 600.310(f)(2)(ii):

> "… Councils can develop ABC control rules that allow for changes in catch limits to be phased in over time or to account for the carry-over of some of the unused portion of the ACL from one year to the next. The Council must articulate within its FMP when the phase-in and/or carry-over provisions of the control rule can and cannot be used and how each provision prevents overfishing, based on a comprehensive analysis.

(A) *Phase-in ABC control rules.* Large changes in catch limits due to new scientific information about the status of the stock can have negative short-term effects on a fishing industry. To help stabilize catch levels as stock assessments are updated, a Council may choose to develop a control rule that phases in changes to ABC over a period of time, not to exceed 3 years, as long as overfishing is prevented each year (*i.e.,* the phased-in catch level cannot exceed the OFL in any year). In addition, the Councils should evaluate the appropriateness of phase-in provisions for stocks that are overfished and/or rebuilding, as the overriding goal for such stocks is to rebuild them in as short a time as possible."

Benefits of allowing phase-in

- *Stability*: Phasing in changes to a new ACL helps create more stable fisheries. Implementing large changes in ACLs due to new scientific information about the status of a stock may have greater negative effects on a fishing industry than spreading the change out over time. Spreading out the change provides some stability by allowing the fishing industry time to plan for the best ways to adapt to the change.
- *Management uncertainty*: Management uncertainty (which is a function of the ability of managers to control catch) decreases when quotas vary less from year to year (Patrick et al. 2013).

Risks of allowing phase-in:

Allowing phase-in has the potential to increase biological risk by allowing overfishing to occur inadvertently, which could lead to depletion or slow rebuilding of stocks. Risks of overfishing may be higher for some species or fisheries based on life-history characteristics, assessment frequency, data quality, and characteristics of the management system. We discuss these risks in more detail in Section 4.

- *Life history characteristics*: Phase-in could be more risky for short-lived stocks with high rates of natural mortality.
- *Stock structure and spatial dynamics of fish and fisheries*: For species that school or contract their distribution as biomass declines (allowing CPUE to remain high as the stock is depleted), phase-in provisions could increase the risk of overfishing.
- *Assessment variability and frequency*: If stock assessments are infrequent or subject to high uncertainty phasing in decreases in catch may increase risk.
- *Phasing in decreases without phasing in increases*: Phasing in decreases without phasing in increase could increase the risk of inadvertent overfishing and depletion.

1.3 Summary of Core Principles

The core principles of phase-in and carry-over laid out in the NS1 guidelines are:

- *Must prevent overfishing*: When applying either a phase-in or carry-over ABC control rule, the resulting ABC must prevent overfishing (i.e., ABC cannot exceed OFL).
- *Comprehensive analysis:* ABC control rules should be based on a comprehensive analysis that shows how the control rule prevents overfishing (50 CFR 600.310 (f)(2)(i)). Further, if developed, Councils must articulate in their FMPs when phase-in and/or carry-over provisions of ABC control rules can and cannot be used and how each provision prevents overfishing, based on a comprehensive analysis.

- *Overfished and rebuilding stocks*: The impact of phase-in and/or carry-over on a stock's rebuilding progress should be considered, as the overriding management goal for stocks in a rebuilding plan is to rebuild them in as short a time as possible.

2. Example Applications of Carry-over and Phase-in

This section presents a number of short descriptions of carry-over and phase-in policies applied within fisheries in the U.S. and in other countries and illustrates lessons learned from these experiences. Most of the U.S. examples were implemented prior to the 2016 NS1 guideline revisions, which have created additional flexibility. For example, in some U.S. fisheries, carry-over is limited to the difference between the ABC and ACL. The 2016 NS1 guidelines, properly applied and evaluated, could potentially allow for a less restrictive carry-over program where the ABC in year 2 could be adjusted upward to accommodate carry-over as long as the revised ABC is less than the OFL.

Note that, in some of the examples below, different terminology is used to describe carry-over in the event of a catch underage. For example, in some examples, a catch underage is referred to as a "quota surplus," "underharvest," or "unused quota." Also, several of the carry-over examples presented below also include a discussion of polices that address the overharvest of quota (also referred to as: "pay-back" of quota overages, or "quota deficit"). Often times, when a policy regarding carry-over exists for a specific fishery, there is a related policy that addresses overharvest or pay-back. In those cases, we have provided a summary of the overharvest or pay-back policy.

Many of the international examples have characteristics that could make them infeasible under U.S. law. For example, some carry-over programs in other countries allow high percentages of uncaught quota to be carried over. If, when added to the quota for the next year, the combined quota would result in an allowable catch that would exceed the OFL for a stock. Such a policy would not be allowed under the NS1 Guidelines. Similarly, some phase-in programs in other countries that restrict the percentage or frequency of decreases in ACLs in a single year might be in conflict with MSA requirements if they fail to set an ACL at or below the ABC each year. In most cases, these programs could likely be modified or applied in such a way to be consistent with U.S. fisheries law and policy, so these programs still serve as instructive examples.

2.1 Carry-over Examples

2.1.1 U.S. Experience (see also Table 1)

North Pacific Fishery Management Council

The Pacific Halibut and Sablefish Individual Fishing Quota (IFQ) Program includes both carry-over and pay-back provisions. This IFQ program was implemented in 1995 with the primary objectives of eliminating gear conflicts, addressing safety concerns, and improving product quality. Note that Pacific halibut is managed under a treaty between the United States and Canada. The International Pacific Halibut Commission establishes catch limits annually for Pacific halibut fisheries in U.S. and Canadian waters. In Alaska, the North Pacific Council is

responsible for allocating the catch limits among users and user groups fishing off Alaska, and NMFS implements the IFQ program for halibut and sablefish. Within this program, IFQ for Pacific halibut and sablefish is issued to persons that hold quota shares (QS). Holders of QS may harvest their allocation at any time during the eight plus-month season. Regulations related to addressing overages and underages are contained in 50 CFR 679.40(d)-(e). In general, NMFS issues IFQ to individuals based on their QS for halibut and sablefish, and the assigned IFQ are specific to an IFQ regulatory area and vessel category. Individuals are allowed to exceed what is available in their IFQ account at the time of landing by up to 10 percent. That overage will be subtracted the next year, and applied to any person to whom the IFQ is allocated that next year. This small amount of permissible overage is intended to cover the last set or trip in the season, in the event the harvest exceeds remaining IFQ. Similarly, if an individual catches less than their IFQ, up to 10 percent can be carried over to the next fishing year, and will be applied to any person to whom the IFQ is allocated that next year. NMFS applies administrative adjustments at the beginning of each fishing year when annual IFQ accounts are created and IFQ pounds are allocated to QS holders.

The tracking of carry-over and pay-back provisions in the IFQ Program is partially automated through the annual IFQ issuance process. The primary administrative costs related to underage or overage provisions are in reviewing the IFQ permit data to ensure the overage/underage adjustments are calculated correctly, are attributed to the current QS holder and to correct any data errors, and to review IFQ allocations on a case by case basis as requested by permit holders. IFQ holders are subject to a maximum 2 percent cost recovery fee to cover some of the administrative costs of managing the program.

Pacific Fishery Management Council

The Pacific Coast Groundfish Catch Share Program includes a carry-over provision within the shore-based IFQ program. Within this program, the overall quota for non-whiting groundfish stocks is divided into shares controlled by individual fishermen. At the start of each year, NMFS issues the annual form of quota denominated by weight, called quota pounds (QP), to entities based on their QS. A vessel's catch (including discards) must be balanced with an equal amount of QP. If a vessel's catch exceeds its QP, that deficit can be covered by up to 10 percent of the following year's QP, but it must then cease fishing for the year unless it can acquire QP from another QP account. Similarly, if a vessel's catch is less than its QP (i.e., it has a surplus of QP), up to 10 percent of its total cumulative QP can be carried over from that year to the next. The surplus QP may not be carried over for more than one year. If there is a decline in the ACL for a stock in the year in which the carry-over would be applied, the amount of carry-over would be reduced in proportion to the reduction in the ACL. Similar carry-over provisions apply to Pacific halibut individual bycatch quota pounds. NMFS has not allowed carry-over for an IFQ stock when the sum of surplus from year 1 and the ACL in year 2 would exceed the ABC in year 2. Effectively, this does not allow carry-over unless the ACL is set lower than the ABC.

New England Fishery Management Council

The New England Council has carry-over provisions within both the multispecies sector program and the scallop fishery. The Northeast (NE) Multispecies FMP contains a process for forming sectors within the NE multispecies (groundfish) fishery. In general, a "sector" is defined

as a group of three or more distinct persons that hold limited access vessel permits who have voluntarily entered into a contract and agree to certain fishing restrictions for a specified period of time, and have been granted a quota. Sectors in the NE multispecies fishery are intended to provide fishermen with more flexibility and more direct responsibility for managing the resource. In general, the ACL for a groundfish stock is divided into commercial and recreational components, and the commercial ACL is split further into a common pool (vessels not participating in the sector program and fishing under days-at-sea) ACL and sector ACL. Within the sector management system, each sector is allocated a portion of the sector ACL. These sector allocations, known as annual catch entitlements (ACE), are based on the collective fishing history of a sector's members. A sector determines how to harvest its ACEs and may decide to limit operations to fewer vessels. Sectors are allowed to carry over up to 10 percent of their unused ACE for each stock, as long as this amount, plus the total ACL for the upcoming fishing year, does not exceed the ABC of the stock when carry-over from all sectors is considered. If the full 10 percent carry-over would exceed the ABC, then NMFS will limit the available carry-over for each sector to ensure that the ABC is not exceeded for a stock. Carry-over is not allowed for the Georges Bank yellowtail flounder stock, because this stock is jointly managed with Canada. At the start of each fishing year, NMFS typically withholds 20 percent of each sector's ACE until all the catch data from the previous year are finalized. Once catch data are finalized, NMFS accounts for any overages and underages and publishes final ACE allocations.

The Atlantic scallop fishery, managed by the New England Council under the Atlantic Sea Scallop FMP, has carry-over provisions in both the limited access and limited access general category (LAGC) IFQ components of the fishery. The limited access fishery is issued 94.5 percent of the ACL, and the LAGC IFQ fishery is issued 5.5 percent of the ACL. Limited access vessels are assigned days-at-sea (DAS) to use in open areas as well as an allocation of scallops (in pounds) that can be caught in specific controlled access areas. If they have unused open area DAS at the end of a fishing year, they may carry over a maximum of 10 DAS, not to exceed the total open area DAS allocation by permit category, into the next year. The allowance of carry-over DAS is accounted for in setting a sub-annual catch target (ACT) that is less than the sub-ACL for the limited access fleet. LAGC IFQ vessels that have unused IFQ at the end of a fishing year may carry over up to 15 percent of the vessel's IFQ into the next fishing year. For accounting purposes, the combined total of all vessels' IFQ carry-over is added to the LAGC IFQ sub-ACL for the carry-over year. These carry-over provisions allow vessel owners to avoid fishing in bad weather at the end of the fishing year, while retaining some of their unused quota or DAS.

<u>NMFS - Atlantic Highly Migratory Species (HMS)</u>

NMFS, in coordination with international bodies such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), directly manages domestic fisheries for Atlantic highly migratory species, including Atlantic tunas, swordfish, sharks, and billfish, through the Atlantic HMS FMP (MSA 302(a)(3)). In addition, the United States negotiates international fishery management measures for these species through ICCAT. The domestic management measures for sharks can be found at 50 CFR part 635, and include provisions to adjust the base annual commercial quotas for sharks based on overharvests and underharvests. An underharvest of shark stocks that are not overfished or not subject to overfishing may be carried over to the following year, up to 50 percent of the base annual quota. Carry-over is not

allowed if a shark stock or a shark stock within a multi-species shark complex is overfished, subject to overfishing, or has an unknown stock status. If a shark quota is exceeded in a fishing year, NMFS will deduct from the base quota in the following year an amount equivalent to the overharvest. Alternatively, depending on the level of overharvest, NMFS may deduct from the base quota an amount equivalent to the overharvest spread over a number of subsequent fishing years to a maximum of five years. The NMFS Office of Sustainable Fisheries HMS Management Division is reconsidering these and other measures (e.g., ABC control rule and phase-in) as a result of the 2016 NS1 guidelines in Amendment 14 to the 2006 Consolidated HMS FMP.

Gulf of Mexico Fishery Management Council

The Gulf of Mexico Council's Red Snapper and Grouper-Tilefish IFQ programs both have a landing overage provision allowing IFQ shareholders to land 10 percent over their remaining allocation on the last fishing trip of the year as long as the amount does not exceed the amount of catch held in the account. Any overage will be subtracted from the shareholder's allocation at the start of the next fishing year. For example, if 100 pounds of red snapper are in an IFQ vessel's account on the last fishing trip of the year, the shareholder may land 110 pounds of red snapper. However, 10 pounds will be subtracted from the shareholder's allocation on January 1, the following year. Because overages need to be subtracted from the shareholder's allocation at the start of the following year, share transfers will not be allowed that would reduce the shareholder's IFQ shares to less than the amount needed to pay back the overage.

The Gulf Council is currently developing a draft generic amendment on ACL carry-over provisions and framework modifications. If approved, this amendment would change the FMPs for reef fish and coastal migratory pelagics to allow for carry-over under specified circumstances. A January 2019 version of a draft public hearing amendment is available on the Council's website[2]. As stated in the draft amendment, "The purpose of this action is to incorporate provisions to allow carry-over of portions of ACLs that were uncaught due to landings uncertainty[3] and management limitations, and to modify the framework procedure to allow carry-over and other changes to operate in a timely manner." The January 2019 draft amendment has three independent but related proposed actions:

- Action 1 – Eligibility for a Carry-over Provision for Managed Reef Fish and Coastal Migratory Pelagic Stocks in the Gulf of Mexico
- Action 2 – Adjustment in the Carry-over Provision Accounting for Management Uncertainty
- Action 3 – Modify the Framework Procedures for Gulf Council FMPs

South Atlantic Fishery Management Council

The South Atlantic Council is developing a Comprehensive ABC Control Rule Amendment that would modify the FMPs for snapper-grouper, dolphin, wahoo, golden crab, sargassum, and coral. A January 2019 version of an options paper is available on the Council's

[2] http://gulfcouncil.org/wp-content/uploads/E-8-Draft-Public-Hearing-Generic-Amendment-for-Quota-Carry-over-and-Framework-Modification-011619_508.pdf

[3] In this case, the term "landings uncertainty" includes examples such as when inseason fishery closures are implemented based on preliminary landings data and effort estimates, and subsequently some amount of the ACT or ACL may ultimately not be harvested in the given fishing year.

website for scoping.[4] As stated in the paper: "The purpose of this amendment is to revise the acceptable biological catch control rule; simplify incorporation of scientific uncertainty; modify the approach used to determine the acceptable risk of overfishing; and address flexibility in specifying catch levels." The paper has 5 proposed actions:

- Action 1 – Modify the ABC control rules
- Action 2 – Specify an approach for determining the acceptable risk of overfishing.
- Action 3 – Specify an approach for determining the probability of rebuilding success for overfished stocks
- Action 4 – Allow phase-in of acceptable biological catch changes
- Action 5 – Allow carry-over of unharvested catch

The South Atlantic Council conducted scoping for this amendment on January 23 and 24, 2019. Six comments were submitted by the public and can be viewed on the Council's website.[5]

2.1.2 International Experience

International Commission for the Conservation of Atlantic Tunas (ICCAT)

In 1993, ICCAT introduced a carry-over provision for Western Atlantic Bluefin Tuna (WBFT). This early provision simply stated that "unused quota in 1994 can be carried over to the 1995 quota" (Recommendation 93-05), and did not specify any restrictions on the amount of underharvest which could be carried over from one year to the next. However, in 1998, it became increasingly clear that the WBFT stock was declining, and a 20-year rebuilding plan was established (Rec. 98-07). In 2006, the carry-over of quota underharvest was limited and could not exceed 50 percent of the total allowable catch (TAC) for the year in which the underage occurred. If an overage occurred, the next year's quota would be reduced by 100 percent of that overage. In 2008, the carry-over amount was further limited and was not to exceed 10 percent of the original TAC allocation[6]. The 10 percent carry-over limit remains in place today; however, it is unclear what effect this carry-over allowance has had on the rebuilding trajectory of the WBFT stock.

Commission for the Conservation of Southern Bluefin Tuna (CCSBT)

In 2011, CCSBT adopted a limited carry-over provision for the Southern Bluefin Tuna stock[7]. This provision enabled member nations to carry over[8] an underage in an amount not to exceed 20 percent of the TAC from the year in which the underage occurred. The provision was established after considering how the additional flexibility provided by the carry-over provision would benefit the fishery with no negative effect on the operation of the current management procedure for setting global TACs. An interesting and unusual aspect of this provision is that it is voluntary, in recognition of the potentially burdensome administrative complexities that carry-over may present for some member nations. For example, member nations would need to have a

[4] http://safmc.net/download/ABCCR-Jan2019-ScopingReview.pdf
[5] https://safmc.wufoo.com/reports/abc-control-rule-report/
[6] Note: this language was added in 2008, but went into effect in the 2010 fishing season
[7] Report of the Eighteenth Annual Meeting of the Commission, Attachment 13 (https://www.ccsbt.org/userfiles/file/docs_english/meetings/meeting_reports/ccsbt_18/report_of_CCSBT18.pdf)
[8] Note: The CCSBT uses the term "carry forward," but we used to term "carry over" here to be consistent with the terminology used throughout this paper.

system in place which can accurately quantify total catches, document how carry-over is to be accrued and distributed, limit any incentives or opportunities for mis-reporting of catch, report catch against allocations, and establish the circumstances under which carry-over would not be allowed. Members must inform the Secretariat at the end of each fishing year whether they intend to carry over an underage of the TAC to the following year (CCSBT 2017)[9]. The provision also lays out four circumstances when carry-over shall not be permitted: (1) if the Extended Scientific Committee provides advice that exceptional circumstances exist and additional management actions are necessary, and the CCSBT reduces global TAC within a three-year quota block, (2) if the Commission reduces the three-year quota block for one or more members, (3) if the Global TAC is reduced, and (4) if a member exceeds its TAC in the 2017 season or later seasons without paying back its excess catch for those seasons, then carry-over shall not be applied until those catches have been paid back (CCSBT 2017).

New Zealand

Most of New Zealand's fisheries have been managed under an IFQ system since 1986. In 1998 and 1999 the New Zealand Fisheries Act of 1996 was amended to include mechanisms to increase flexibility through a catch-quota balancing system that included provisions for underages or overages in a given year. New Zealand requires fishermen to pay a 'deemed value,' which is a fee per kilogram of catch above their allotted ACE. This can allow catches to exceed the TAC without payback, but deemed values are ramped up on the individual within the year and may be increased over time for all fishermen to strengthen incentives to stay within the TAC. To account for underage, a provision was added in a 1999 amendment to the Fisheries Act (clause 67A) to enable IFQ holders to carry over uncaught quota not to exceed 10 percent of their quota, or ACE, for the year in which the underage occurred. The carry-over provision does not apply to stocks whose TAC is reduced in the following year. When disallowing carry-over was being considered for Southern Bluefin tuna (SBT), fishermen argued that not allowing for carry-over would actually increase the risk of overfishing. Without the carry-over allowance, fishermen would rush to catch their full ACE early in the season fearing conditions would worsen later on. Consequently, any fish caught later in the season as bycatch may lead to overshooting the TAC for the year, payment of deemed values, which could be quite high, and dumping or underreporting catches.

Australia

Australia first introduced the carry-over provision in the south east trawl fishery in 1994-1995 to help smooth the transition to the individual vessel quota system. The provision was later extended to most fisheries up to a level of 20 percent. In 2003, after consultation with key stakeholders, a policy[10] was established for managing carry-over and overharvests of quota. The policy describes five principles to reinforce economic efficiency, including: (1) correctly set a

[9] Resolution on Limited Carry-forward of Unfished Annual Total Available Catch of Southern Bluefin Tuna (https://www.ccsbt.org/sites/default/files/userfiles/file/docs_english/operational_resolutions/Resolution_Limited_Carry_forward.pdf)

[10] The policy is referred to as Fisheries Management Paper 10. This policy uses the terms "undercatch" and "overcatch," while we use the terms carry-over and overharvest here. https://www.afma.gov.au/about/fisheries-management-policies/managing-undercatch-overcatch-quota

sufficiently precautionary TAC as the primary management tool for pursuing sustainability and economic efficiency; (2) recognize that carry-over/pay-back arrangements may provide flexibility in the fishery, but are also likely to constrain the efficient operations of the quota market and may impact negatively on sustainability; (3) reflect the characteristics of the species/fishery when setting the parameters for carry-over and overharvests, but generally allow for minimal or zero levels of carry-over and overharvests to minimize quota market distortions; (4) take into account the level of carry-over/overharvest when setting a TAC; and (5) set carry over/overharvest arrangements in conjunction with TACs for a fishing year and not vary these arrangements once in place. Several reviews of the carry-over/overharvest system have been carried out since the establishment of the 2003 principles, the most recent conducted in 2015[11]. The review identified the main challenge or issue facing the carry-over provision as the potential distortion of the quota market. The carry-over/overharvest system removes the incentives for quota to be bought and sold within or between seasons, which reduces market efficiency and the ability of more efficient fishermen to obtain quota from less efficient fishermen. This, along with conservation concerns, is one of the main motivations for setting low levels for the allowable percentage of quota (less than 10 percent) that can be transferred between years.

Canada

The ability to carry over uncaught quota from one year to the next was first introduced in Canadian fisheries management in 1996, around the time that many Canadian fisheries moved to an ITQ system. However, in 1997, Canada decided that carry-over could not be implemented until there was 100 percent observer coverage and the accuracy of catch data could be assured (Proceedings of the Fisheries Management Subcommittee Meeting, July 1997). This was achieved for the British Columbia groundfish trawl fishery, and the carry-over provision was implemented as a 'catch-quota balancing' mechanism in the ITQ system. The ITQ system was implemented due to concerns with overages, discards, and stock management challenges under the previous system for managing the multi-species groundfish fishery. The carry-over provision was established to develop a flexible, innovative system that accounts for different species and different fishing business models (Bonzon et al. 2010). The carry-over amount allowed differs by species, ranging from 10 to 30 percent, and can be eliminated or reduced in a given year due to conservation concerns (Sanchirico et al. 2006). When setting limits for specific species in the fishery, the risk of overrun in the next year, the increased or decreased risk of discards or underreporting of catches, and administrative burdens were important considerations.

Iceland

Iceland first introduced the carry-over/pay-back provision as a way to improve the success of the total discard ban established in 1989 (Clucas 1997). These provisions were intended to provide incentives to fishermen to retain and land all fish caught and reduce the incidence of discards. Currently, Iceland allows for carry-over of uncaught quota up to 20 percent of an individual's quota holdings for that year. The carry-over provision does not allow the accumulation of carried-over quota for more than one year, reducing the risk, as any overage would only be temporary.

[11] https://www.afma.gov.au/undercatch-and-overcatch-provisions-fishing-quota-continue

2.1.3 Summary of carry-over design features

For the examples above, when carry-over is allowed, there are typically limits to the percentage of total quota that can be carried over or back (i.e., borrowed from next year's quota). This limit is imposed as a means of reducing the risk of overfishing in the following season. The majority of catch share fisheries with carry-over provisions limit carry-over to a maximum of 10 percent of a fisherman's quota (e.g., New England sector system, U.S. Pacific Coast groundfish trawl IFQ, New Zealand quota management system). The groundfish ITQ in British Columbia has the most liberal carry-over policy, allowing carry-over or carry-back of up to 30 percent of an individual's annual quota allocation. An important difference between U.S. fisheries and these international examples is that, in general, other countries are not required to keep catch below a predetermined OFL. For U.S. fisheries managed under the MSA, consistent with the Act and NS1 guidelines, the carry-over percentages or amounts would have to be restricted to ensure that overfishing is prevented, ABC does not exceed OFL, and ACL does not exceed ABC. In most of the examples above, the carry-over of a catch underage or unused quota is applied in the next fishing year. In IFQ systems, unused quota carried over is typically used first and expires at the end of the year.

Several countries that had allowed both carry-over of a quota underage and overharvest of quota later eliminated the ability to overharvest quota (Sanchirico et al. 2006). These provisions were not used frequently in fisheries where they had been allowed and removing them was noncontroversial. When these provisions were used, some of them were somewhat punitive, requiring multiple units of quota for each unit of overharvest.

Managers in New Zealand and British Columbia can reduce or eliminate carry-over if they have conservation concerns (Marchal et al. 2016; Sanchirico et al. 2006). In New Zealand, quota carried over is automatically forfeited if the TAC is reduced. This reduces the possibility of catches exceeding the new TAC when the stock has declined. In U.S. fisheries to date, carry-over has been restricted to ensure that it could not allow total catch to exceed the ABC for a given year. For example, in the New England multispecies fishery sector program, the aggregate unused sector ACE plus the overall ACL for the following fishing year cannot exceed the ABC for the fishing year in which the carry-over may be harvested. If this total exceeds the ABC, NMFS adjusts the maximum amount of unused ACE that a sector may carry over (down from 10 percent) to an amount equal to the ABC of the following fishing year. Any adjustments made are applied to each sector based on its total unused ACE.

2.2 Phase-in Examples

In federally managed U.S. fisheries to date, phasing in changes in ABCs and ACLs has been done on an ad hoc basis in response to particular situations. This generally required an analysis of the phase-in plan for each specific situation to ensure that the OFL would not be exceeded, and, in cases where stocks had been declared overfished, that rebuilding timeline requirements would be met. We provide examples below, though there are many other cases where Councils have phased in changes to ABC in rebuilding plans. The new NS1 guidelines provide more flexibility to create ABC control rules that are designed in advance to phase in changes in ABC over a period of up to three years rather than adjusting an ABC immediately based on the results of a new stock assessment. Control rules of this type are widely used outside the United States, and generally are evaluated with management strategy evaluation (MSE) in advance to assess

risk. An MSE that accounts for multiple types of uncertainty (e.g., process error, observation error, implementation error) in a closed-loop simulation model may be the best way to test robustness of a carry-over or phase-in policy, particularly with multiple sources of uncertainty and interacting factors. As we discuss below, these rules generally require more conservative harvest strategies to offset the additional risk that can be created by slower reaction to stock declines.

2.2.1. U.S. Experience

Mid-Atlantic Fishery Management Council

The Mid-Atlantic Council proposed a phase-in of a required reduction of ABC for summer flounder for fishing years 2016-2018 (80 FR 69181; November 9, 2015). Based on the 2015 stock assessment update for this stock, in addition to the Council's standard risk policy and ABC control rule, the 2016 ABC should have been 30 percent below the OFL. Instead, the Council and NMFS proposed to phase in a reduction of the ABC over three years by increasing the buffer by a third each year (i.e., 10 percent buffer in 2016, 20 percent buffer in 2017, and 30 percent buffer in 2018). This phase-in approach was expected to reduce the economic impact of having a large reduction in a single year's catch limits. The SSC calculated a less than 50 percent chance of overfishing in any of the three years. NMFS approved the proposed phase-in approach and finalized the catch limit specifications in December 2015 (80 FR 80689; December 28, 2015).

A stock assessment update for summer flounder was completed in 2016, which indicated a downward trend in stock biomass, and 2017 and 2018 OFL levels that were reduced from those previously calculated. The SSC recommended abandoning the previously approved phase-in approach, and instead following the Council's standard risk policy. The SSC recommended revised 2017 and 2018 ABCs that were lower than the previously recommended ABCs. The SSC cited among its reasons for departing from the previously approved phase-in approach the continual overestimation of biomass and recruitment and underestimation of fishing mortality, emphasizing that continuing to overharvest in a period of consistently poor recruitment represents a substantial risk to the stock. The Council recommended and NMFS approved reductions in catch limits based on SSC's revised ABC recommendations (81 FR 93842; December 22, 2016).

Western Pacific Fishery Management Council

The Western Pacific Council and NMFS implemented a three-year phase-in approach to reductions in the ABC and ACL of the main Hawaiian Islands Deep 7 bottomfish complex (a complex of 7 stocks). Based on a 2011 bottomfish stock assessment updated in 2015, the OFL for this complex was approximately eight percent less than the previous OFL. Applying the Council's ABC control rule would have resulted in a significant drop in the ABC from the previous year. Instead, the SSC recommended lowering the ABC gradually over three years so that in the final year, the ABC was at 306,000 lb. The ACL was set equal to the ABC over each of the three years. The Council recommended and NMFS specified an ACL of 326,000 lb for the 2015-16 fishing year, lowered it to 318,000 lb in fishing year 2016-17, and finally to 306,000 lb in fishing year 2017-18. The final specifications for the 2017-2018 fishing year were published

in June 2017 (82 FR 29778; June 30, 2017). For this complex, landings data are updated weekly and in-season accountability measures (AMs) are in place which would close the fishery in season if the ACL were to be reached. The fishery has not caught the specified limit in any year since 2011.

South Atlantic Fishery Management Council

As mentioned above, the South Atlantic Council is developing a comprehensive ABC control rule amendment that would modify the Council's ABC control rule to enable carry-over as well as develop phase-in provisions. The South Atlantic Council conducted scoping for this amendment on January 23 and 24, 2019.[12] Six comments were submitted by the public and can be viewed on the Council's website.[13]

North Pacific Fishery Management Council

The SSC of the North Pacific Fishery Management Council has used a stair-step approach for increasing the ABC over multiple years (e.g. for Gulf of Alaska pollock). The SSC applies an increase to ABC on an ad hoc basis over multiple years, as a precautionary measure in response to scientific uncertainty associated with the OFL (e.g., new data, model changes, uncertainties regarding population dynamics and environment). For example, the SSC had concerns about the 2016 Bering Sea and Aleutian Islands (BSAI) Greenland turbot assessment. This assessment showed a large increase in female spawning biomass from recent years, a declining trend in overall abundance, high uncertainty regarding the pulsed nature of recruitment, and high environmental uncertainty. In recommending harvest specifications, the SSC used a precautionary approach of increasing the ABC over a two-year period by stepping from an ABC of 3,462 mt for 2016, to 6,644 mt in 2017, instead of the maximum permissible ABC of 9,825 mt. The ABC was set equal to the maximum ABC (10,864 mt) for 2018.

The ABC control rule for the BSAI and Gulf of Alaska Groundfish FMPs has six tiers that relate to various levels of information availability. There is some flexibility in specifying ABC, in that the control rule prescribes only an upper bound (i.e., maxABC). The FMPs specifically authorize the Plan Development Team and SSC to recommend decreasing an ABC below the maxABC. For example, the FMPs state that the Plan Team and SSC should "determine whether conditions exist that warrant setting ABC at a value lower than the maximum permissible value (such conditions may include—but are not limited to—data uncertainty, recruitment variability, and declining population trend) and, if so: a) document those conditions; b) recommend an ABC lower than the maximum permissible value; and c) explain why the recommended value is appropriate."

2.2.2 International Experience

Outside the United States, a number of fisheries use control rules that automatically phase in increases or decreases to catch limits, generally for the purposes of creating more stability in

[12] http://safmc.net/download/ABCCR-Jan2019-ScopingReview.pdf
[13] https://safmc.wufoo.com/reports/abc-control-rule-report/

harvest levels over time. A commonly employed mechanism for limiting annual variability in TACs is to limit the amount that the TAC can be increased or decreased from one year to the next. North Sea cod management, carried out jointly between the European Commisson and Norway, is an example of such a management mechanism. In 2004, North Sea cod spawning stock biomass (SSB) fell below B_{lim} and the fishing mortality rate was above F_{lim}. A recovery plan was instituted to bring SSB above precautionary biomass levels (B_{pa}) by limiting F to less than 0.65, and year-to-year changes to TAC were limited to 15 percent. In 2008, stock levels increased above B_{lim} and a new management plan was put in place that allowed a 20 percent change in TAC year-to-year from 2010 to 2014. Allowing fishing pressure to increase by no more than 20 percent each year enabled SSB to continue to rebuild above B_{pa} (EU Council Regulation 1342/2008).

Another example is a clause that Iceland added in 2000 to the catch rule for the cod fishery, which stated that the total TAC should not vary by more than 30,000 mt from one year to the next (Sanchirico et al. 2006). CCSBT (2011) also adopted a management procedure in which TAC was limited to a minimum change of 100 mt and a maximum change of 3000 mt year-to-year. TACs were set for three-year periods and would be calculated the year prior to the start date of the management procedure.

In some cases, phase-in rules are focused more strongly on reducing risk of overexploitation, and implement increases slowly but decreases more quickly. For example, a "Slow Up Fast Down" policy was officially adopted in 1999 by the International Pacific Halibut Commission (IPHC) to help normalize large fluctuations in recommended quotas resulting from model estimations of biomass and MSY. A recommended reduction would be carried out over two years (50 percent each year) (i.e., fast down), and a recommended increase would be carried out over three years (33 percent each year) (i.e., slow up) (Hare 2011). After years of steady biomass decline, a new policy of "Slow Up Full Down" was instituted to allow for the full recommended reduction in quotas to be implemented immediately. The "Slow Up Full Down" approach is no longer formally a part of the IPHC's harvest policy. However, the MSE process the IPHC uses does contain many different management procedures that incorporate a constraint to limit inter-annual variability in the mortality limit.

In some cases, decision rules that determine the TAC are designed in such a way as to make TAC changes less frequent. For example, some management procedures that base the TAC on a catch-per-unit-effort (CPUE) index include a "flat region" in the decision rule (i.e., where a change in CPUE between certain values does not trigger any change in the TAC). Only when CPUE falls below (or above) that flat region is a decrease (or increase) in the TAC triggered. Management procedures with flat regions in the decision rule are in place in the South African sardine fisheries (DeMoor and Butterworth 2016) and several New Zealand rock lobster fisheries (NLRMG 2016). To reduce the biological risk associated with maintaining a TAC over a large range of CPUEs (and presumably biomass), the decision rules must set TACs that are more conservative than would be possible if the TAC were allowed to move in proportion to CPUE changes. The South African sardine decision rule also requires a very steep drop off in the TAC when CPUE falls below the flat region. However, it also allows large changes in the TAC at high CPUE values to take advantage of resource booms that would otherwise be forgone due to high natural mortality of sardines. Whether stability is increased with a flat region in the decision rule or with restrictions on the frequency or percentage change in TAC, there is inevitably a trade-off with lower yield. However, industry stakeholders in these fisheries have generally been willing

to accept lower yield in return for lower variability in harvests[14]. It should be noted that the lower average catch targeted under these decision rules also means a higher average biomass level which can mean lower harvest costs. These management procedures were all tested with MSEs prior to implementation to evaluate the risks associated with limiting changes in TACs.

2.2.3 Summary of Phase-in Design Characteristics

As with carry-over policies, countries outside the United States are generally not required to avoid exceedance of a predetermined OFL. However, MSEs were often conducted to evaluate these policies and to select control rules and harvest strategies that limit the risk of overfishing or depletion over some period of years. In general, control rules that limited the frequency or percentage of TAC changes required more conservative harvest strategies (lower average mortality and harvest) to offset risk associated with limiting or slowing the response to stock declines. NS1 guidelines for U.S. fisheries may be more restrictive (e.g., by not allowing the ABC to exceed the OFL) and may require more conservative policies that limit both short-term overages and longer-term overexploitation.

3.0 Implementing and evaluating carry-over and phase-in provisions

3.1 Carry-over and phase-in without changing the ABC

Carry-over and phase-in provisions are already used in some U.S. fisheries and were permissible under prior NS1 guidelines. For example, is some U.S. fisheries, ACLs are set lower than the ABC to account for management uncertainty or for other reasons. In such cases, if there is a catch underage in one year, the ACL in the next year can be increased, as long as the revised ACL does not exceed ABC in that next year. Similarly, changes to an ACL can be phased in (e.g., by reducing or increasing the normal gap between the ABC and ACL). Implementing such policies does not require any particular additional analysis or an ABC control rule. However, if the gap between the ABC and ACL was in place due to management uncertainty associated with a lack of control over catch, carry-over should be considered with extra caution. In such cases, carry-over has the potential to lead to overfishing if overages are not accounted for but underages are carried forward (Section 4). Carry-over provisions should not be used to address issues of chronic underages; in such situations, the Council should explore the underlying reason why the full ACL is not being caught. A phase-in program that allows for phasing in ACL reductions more slowly than would be prescribed by existing control rules also has the potential to increase the risk of overfishing, and should be considered carefully based on the factors discussed in Section 4.

3.2 Carry-over requiring ABC adjustments

There are two basic approaches to evaluating and implementing carry-over actions that enable changes in ABCs. As provided for in the NS1 guidelines, the first approach described below is to develop a carry-over provision within the ABC control rule. Different approaches could also be taken to evaluate and implement individual carry-over actions on a case-by-case

[14] Personal Communication, Doug Butterworth, January 17, 2018)

basis (described below in Approach 2). Table 2 summarizes this guidance on evaluating and implementing carry-over provisions within ABC control rules, and on a case-by-case basis.

Approach 1. ABC Control Rule to Accommodate Carry-over

The NS1 guidelines allow ABC control rules to include provisions for the carry-over of some of the unused portion of the ACL (i.e., ACL underage) from one year to increase the ABC for the next year, based on the increased stock abundance resulting from harvesting less than the full ACL. Such an ABC control rule would need to limit carry-over such that the new ABC with carry-over does not exceed the OFL. As described in the NS1 guidelines, Councils must articulate within their FMPs when carry-over provisions of the control rule can and cannot be used and how the provisions prevent overfishing, based on a comprehensive analysis (50 CFR 600.310(f)(2)(ii)). Further, when considering carry-over provisions, Councils should consider the likely reason for ACL underages, and evaluate whether any carry-over is appropriate for stocks that are overfished and/or rebuilding (see 50 CFR 600.310(f)(2)(i)(B)). In addition to the guidance provided in the NS1 guidelines, the following paragraphs provide some additional considerations and guidance for developing carry-over provisions with an ABC control rule.

Additional issues to address when developing a carry-over provision within an ABC control rule include: which stocks are eligible for carry-over; how ACL underages will be determined; how underages will be accounted for when there are multiple fishery sectors (e.g., commercial, recreational, or specific gear types); a minimum buffer between ABC and OFL; limits on the amount of unharvested ACL that can be carried over; and a process for making changes to the ABC and ACL. Consideration should be given to identifying circumstances or thresholds where precautionary measures should be used and/or additional simulation analysis is required before applying the carry-over provision to ensure overfishing is prevented.

A Council and its SSC, or the Secretary, can develop carry-over provisions within ABC control rules that apply to individual stocks or stock complexes, or a comprehensive provision that applies to multiple stocks and/or FMPs. If the provision applies to multiple stocks (e.g., a Council/SSC has a "programmatic" ABC control rule), the SSC or relevant scientific advisory body should evaluate and approve the use of the carry-over provision for each individual stock or stock complex to ensure that it will prevent overfishing. Once a carry-over provision is established in the FMP and approved, it is possible that SSC or scientific review of each individual carry-over action may not be needed. Each Council and SSC will need to determine the appropriate steps needed in order for the SSC to fulfill its obligation of providing an ABC recommendation per MSA section 302(g)(1)(B).

Restrepo et al. (1998) recommend that control rules should be tested by simulation. Accordingly, carry-over provisions within ABC control rules should also be evaluated using simulation testing to ensure that carry-over will prevent overfishing in accordance with any established risk policy. Such simulation testing is commonly referred to as a management strategy evaluation (MSE; Punt et al. 2016, Edwards and Dankel 2016). Recent studies using MSEs to evaluate ABC control rules demonstrate the insights provided by MSEs when evaluating the trade-offs between management strategies (Wetzel and Punt 2017, Wiedenmann et al. 2017). Councils should consult with their SSCs as well as the applicable NMFS Science Centers to determine how best to design and evaluate carry-over provisions using MSE.

Evaluation of an ABC control rule that incorporates carry-over does not necessarily require a full MSE that accounts for all types of uncertainty, but it does require a comprehensive

analysis to ensure it will not result in overfishing. Because the NS1 guidelines require that ABC control rules are described within FMPs (50 CFR 600.310(c)(3)), revising an ABC control rule to incorporate a carry-over provision would require an FMP amendment, thus also requiring a review of biological, social, and economic impacts. This assessment of impacts could be the vehicle for conducting the comprehensive analysis. Further, any efforts to revise an ABC control rule would benefit from a review of the baseline performance of the current control rule. An ABC control rule that enables adjustment of ABCs to accommodate carry-over should be reviewed by the SSC to ensure that it will prevent overfishing and account for scientific uncertainty.

Approach 2. Case-by-case Carry-over

In the absence of specified carry-over provision within the ABC control rule, ABC adjustments can be considered on a case-by-case basis. For assessed stocks, a simple approach to revising ABCs is to rerun the stochastic projections (i.e., forecasts that have some inherent randomness) that were used in the last stock assessment with revised catch estimates. In other words, scientists could run the same projection model with the same data, except that the actual observed catch data from the most recent projection year is used instead of the projected ACL catch. In such cases, rerunning the projections can establish the total amount of increased catch that can be allowed as a result of the prior year's under-harvest in cases where the observed catch was less than the ACL. This method is currently used in some fisheries. For example, Alaska groundfish fisheries do not use a carry-over ABC control rule, but instead review and reset the ABC each year.

In some cases, a deterministic projection analysis may be sufficient to evaluate carry-over on a case-by-case basis. In deterministic projections analysis, the output is fully determined by the parameter values, while stochastic projections incorporate randomness. For example, Goethel and Smith (2016) investigated the possible impacts of a carry-over measure on the red snapper rebuilding plan in the Gulf of Mexico (GoM). They created two sets of projections for recreational and commercial fleets using the Stock Synthesis 3 base model from the 2014 Southeast Data, Assessment, and Review (SEDAR) 31 GoM red snapper assessment and a 20 percent underage that would be carried over once from the 2015 to 2017 season. Catches for the remainder of the rebuilding time series (2018-2032) were fixed at base projection values. They found that the carry-over resulted in a biomass approximately 3 million lb higher than the biomass projected by the base model. The difference was attributed to growth exceeding natural mortality for the uncaught fish over the period between when they would theoretically have been caught and when they actually were caught. After the 2017 landings, the model projected almost no difference over the long term, and spawning potential ratio levels remained equal to those of the base rebuilding plan. Goethel and Smith cautioned that such results would not be expected if an opposite approach was taken (i.e., overages should not be expected to be paid back on a one-for-one basis). They noted that overages would require subsequently greater underages to account for the loss of potential growth in biomass removed early. A follow-up study by Smith and Goethel (2017) simulated several carry-over scenarios that allowed ABCs to be adjusted to accommodate carry-over for GoM red snapper. They also evaluated a policy that set a cap on carry-overs that would always maintain a gap between ABC and OFL such that the adjusted ABC could not exceed 95 percent of the OFL. Scenarios implementing the cap rebuilt the stock faster due to the heavily reduced carry-over adjusted yields, but scenarios without the cap that

allowed carry-over up to the OFL still rebuilt the stock on schedule. Caution may be warranted in using deterministic projections if it appears that uncaught quota was due to declining catch rates and declining stock size. In such cases uncertainty about stock size and productivity should be taken into account before allowing carry-over.

Instead of retroactively rerunning projections when there is an ACL underage, carry-over could be proactively addressed using scenario planning within a stock assessment. For example, the assessment model and any projections based off that model could be used to evaluate a wide range of ACL underages (or the maximum carry-over levels possible), resulting in ranges of OFL and ABC recommendations for each year within each scenario. This analysis could be summarized within the assessment report, and once actual catch levels are known, the SSC could use that information to make or revise its ABC recommendation.

3.3 Phase-in of ABC Changes in Response to Updated Assessments

ABC control rules used in federally managed fisheries generally adjust ABCs and ACLs when new scientific information indicates a change in the OFL. This can sometimes result in large changes in ACLs from one year to the next, which can have adverse social and economic consequences. In some cases, these changes could reflect imprecise assessments rather than a true change in the stock. The 2016 revisions to the NS1 guidelines allow for implementation of ABC control rules with provisions that allow changes in ABCs to be phased in to create more stability in catch. These control rules must still prevent overfishing on an annual basis by maintaining ABCs below the OFL, and changes must be phased in fully within three years. Here we describe two basic approaches to evaluating and implementing phase-in. As provided for in the NS1 guidelines, the first approach described below is to evaluate and implement an ABC control rule that directly incorporates phase-in provisions as an integral part of the rule and that have been evaluated in advance to ensure that operation of the control rule will not result in overfishing. Different approaches could also be taken to evaluate and implement individual phase-in actions on a case-by-case basis (described below in Approach 2). Table 3 summarizes this guidance.

<u>Approach 1: ABC Control Rule to Accommodate Phase-in</u>

The NS1 guidelines state that Councils may develop a control rule that phases in changes to the ABC over a period of time, not to exceed three years, as long as overfishing is prevented each year (i.e., the phased-in catch level cannot exceed the OFL in any year). A phase-in provision within the ABC control rule is set forth within the FMP that prescribes how phase-in should be applied. As described within the NS1 guidelines, Councils must articulate within an FMP when the phase-in provisions of the control rule can be used and how the provision prevents overfishing, based on a comprehensive analysis (50 CFR 600.310(f)(2)(ii)). Further, Councils should evaluate whether phase-in is appropriate for stocks that are overfished and/or rebuilding as the goal for such stocks is to rebuild in as short a time as possible (see 50 CFR 600.310(f)(2)(i)(A)). In addition to the guidance provided in the NS1 guidelines, the following paragraphs provide some additional considerations and guidance to consider when developing phase-in provisions with an ABC control rule.

Many FMPs define a tiered approach to ABC control rules. Phase-in provisions may be incorporated into the existing tiered system. Data-rich, frequently updated "Tier 1" assessments have different opportunities than data-limited situations for implementing phase-in.

The expected performance of the ABC control rule with phase-in needs sufficient analysis to account for scientific and management uncertainty. Ideally, an MSE will be carried out to test the ABC control rule and will account for multiple types of uncertainty including process error, observation error, and implementation error. The scope of this MSE is very similar to the scope of an MSE designed to evaluate the impact of carry-over, so it may be advisable to evaluate carry-over and phase-in simultaneously.

As noted in section 2.2, low variability in ACLs is often important to industry even though it may require a reduction in average catch to offset risk. MSEs can be used to test specific ABC control rules that phase in or limit the annual change in the ABC to ensure that the rule will not increase the risk of overfishing and depletion. Generally, rules that phase in or limit ABC reductions require reductions in average fishing mortality (i.e., a lower target harvest rate at any given biomass) to offset risk associated with slower reactions to stock declines. Note that phasing in decreases in ACL, but not increases, will effectively change the average buffer size. If such an asymmetric policy is considered, the impact on average buffer size should be evaluated and may need to be increased to maintain an acceptable probability of overfishing. NS1 guidelines for U.S. fisheries require that ABC may not exceed OFL, which may preclude large degrees of phase-in for ABC reductions.

An MSE can be particularly useful in cases where there is considerable uncertainty in assessments that leads to large changes in ABC driven by uncertainty in assessment results rather than true changes in stock levels. Similarly, MSEs are useful for stocks that are assessed infrequently. If there is a large gap in time between assessments, a control rule based on a survey index or standardized CPUE can be used to adjust ABCs between assessments.

Some additional issues to consider when developing phase-in provisions within ABC control rules include: which stocks are eligible for phase-in; phasing in increases as well as decreases in ABC; generation time of the stock, assessment precision, and length of time between stock assessments; whether phase-in is appropriate for stocks without assessments; a minimum buffer between the ABC and OFL; allowing phase-in only when stock biomass exceeds a certain level; and monitoring the stock over the phase-in period by updated projections. Managers should identify circumstances or thresholds where precautionary measures should be used and/or additional simulation analysis is required before applying the phase-in provision to ensure that overfishing is prevented. For example, caution should be applied if there has been a significant or unexpected change in stock abundance and biomass that could be due to rapidly changing marine conditions or there are significant or unexpected changes in the ecosystem that undermine the ability to project stock biomass and abundance going forward. In such case, phasing in catch reductions would be inappropriate.

A Council and its SSC, or the Secretary, can develop phase-in ABC control rules that apply to individual stocks or stock complexes, or a comprehensive provision that applies to multiple stocks and/or FMPs. If the provision applies to multiple stocks (e.g., a Council/SSC has a "programmatic" ABC control rule), the SSC or relevant scientific advisory body should evaluate and approve the use of phase-in for each individual stock or stock complex to ensure that the framework will prevent overfishing.

<u>Approach 2. Case-by-case Phase-in Actions</u>

In the absence of a phase-in provision within an ABC control rule, phasing in ABC changes may be considered on a case-by-case basis. As described within the NS1 guidelines, an SSC may recommend an ABC that differs from the result of the ABC control rule calculation, based on factors such as data uncertainty, recruitment variability, declining trends in population variables, and other factors, but must provide an explanation for the deviation (50 CFR 600.310 (f)(3)). These factors and others could provide reasons to phase in changes to ABC on a case-by-case basis. For assessed stocks, a simple approach to evaluating phased in reductions to ABCs is to run stochastic projections (i.e., forecasts) based on the most recent stock assessment with the proposed ABCs. The projections can establish whether phasing in a reduction in the ABC can be done safely without undue risk of overfishing (e.g., the risk of overfishing cannot exceed 50 percent). In the case of an overfished stock, a phased in reduction must still meet requirements for rebuilding timelines, which is likely to require greater ABC reductions later to offset slower reductions early in the rebuilding period. As noted above for carry-over, the existence of a retrospective pattern should be considered and will affect the calculated ABC.

While stochastic projections are preferred, a deterministic projection analysis may be sufficient to evaluate a phased in ABC change on a case-by-case basis. However, caution is warranted in using deterministic projections when an ABC reduction was triggered by a decline in the stock and there is reason to believe that stock productivity may remain lower than average. If a reduced ABC was triggered by a management failure that allowed an ACL to be exceeded, then phasing in ABC reductions would be unwise without correcting the problems that led to the management failure.

4. Characteristics of fish stocks, fisheries, and management approaches that impact both the benefits and risks of carry-over and phase-in

The benefits and risks of carry-over and phase-in provisions depend on the technical (e.g., selectivity) and economic characteristic of the fishery, the biological characteristics of the species being managed, the frequency and precision of assessments, and the management approach. These characteristics of fisheries may act jointly to increase or mitigate benefits and risk. Thus, a determination of whether carry-over or phase-in provisions are desirable and how they should be designed and evaluated should involve a holistic look at the fishery.

There are two modeling papers that explicitly evaluate the risks and benefits of carry-over provisions. Powers and Brooks (2008) used an MSE framework with a biological model patterned after a stock with low productivity, similar to bluefin tuna, to evaluate the implications of alternative decision rules regarding payback of TAC overages on sustainability objectives and rebuilding time frames. Decision rules allowing overages and payback were found to prolong rebuilding (compared with perfect implementation or more precautionary TACs), especially if monitoring is biased (catches misreported) or imprecise. When overages were penalized and underages not rewarded, recovery was achieved earlier. Weidenmann and Holland (2019) used an MSE framework adapted from Wiedenmann et al. (2017) to evaluate a variety of carry-over policies assuming different life histories and under different causes of catch underages. They find that carry-overs can increase yield to the fishery but can also increase the risk of overfishing and becoming overfished, the risk of low catch, and the interannual variability in catch. However, results vary with policies and fishery characteristics, as noted in the discussion below. Wiedenmann and Holland (2019) found that, in general, the additional risk of overfishing and

depletion associated with carry-over was small as long as carry-over was limited to 15 percent of the ABC. There are a number of modeling studies that address similar questions such as the risks associated with catches temporarily exceeding TACs which we also draw on here.

Model-based evaluations of phase-in provisions of various types are more common. We review several studies that provide insights into the risks and benefits of harvest strategies that limit or delay changes in TACs in response to changes in biomass. Most of these are tests of management procedures that limit the percentage change or frequency of adjustments to TACs. We also review literature that describes how carry-over and phase-in rule design is tailored to meet objectives including mitigating risk.

4.1 Life history characteristics

As noted above, carry-over provisions may pose increased risk based on the life history characteristics of the species being managed. In particular, carry-over could significantly impact short-lived stocks with high rates of natural mortality where a large fraction of the stock is caught each year. For such stocks, the rationale of increasing an ABC based on the increased stock biomass that results from an ACL underage may not hold.

Wiedenmann et al. (2017) used an MSE framework to evaluate the performance of alternative ABC control rules given imperfect information about stock status and productivity. They considered how performance varied with different life history characteristics (e.g., with short-lived, medium-lived, and long-lived species), as well as alternative assumptions about recruitment variability and assessment uncertainty. Although the study did not evaluate the consequences of catch deviating from the ABC, the study's inclusion of error in setting the ABC due to scientific uncertainty provides some insights into what might occur if catch varied from a "correctly" set ABC. The ABC control rules evaluated include common approaches used by regional SSCs such as setting the ABC at 75 percent of the F_{lim}, and approaches under which the ABC is set by selecting a target probability of overfishing (P*). The study evaluates control rule performance under a variety of assumptions about the source and nature of scientific uncertainty and stochasticity of biological processes. Across the range of scenarios and parameter assumptions explored, for all control rules that accounted for uncertainty (where the ABC was less than the OFL), the model rules limited the probability of overfishing to less than 0.5, and, for most control rules, fewer than 25 percent of the simulation repetitions resulted in frequent overfishing. Higher recruitment variability increased the frequency of overfishing across control rules, while autocorrelation in recruitment had no effect. The median probability of overfishing increased going from the long-lived to the short-lived life history characteristics, but the probability of overfishing exceeded 0.5 in more than 25 percent of the runs only for the short-lived species with the least conservative P* scenario (fixed P* of 0.40 with an assumed coefficient of variation (CV) of 0.37).

Wiedenmann and Holland (2019) adapted the model of Wiedenmann (2017) to explicitly consider carry-over policies. They found that carry-over can lead to lower yield compared to smaller or no carry-overs when the stock had poor productivity (low recruitment and high natural mortality), and when stock assessments overestimated biomass, especially for the short-lived life history.

The rate of growth of the exploitable fish stock relative to natural mortality is an important characteristic to consider when deciding on the appropriate level of carry-over (e.g., one-to-one vs. limited percentage of TAC). For example, in an analysis of the impact of carry-

over on GoM red snapper, researchers found that a catch underage in one year resulted in older and heavier fish to be available in the 3rd year, resulting in an increase in the weight of landed fish available to be caught in year 3 compared to a scenario with no catch underages (Goethel and Smith 2016). On the other hand, if natural mortality exceeds population growth rate, then one-for-one carry-over is not appropriate, as it will increase overall mortality. Managers and scientists should evaluate life history and technical characteristics of the fishery to understand the potential effect of carry-over on a stock.

Some life history characteristics can increase risk of depletion regardless of whether carry-over and phase-in provisions are applied. Life histories presenting particular risks include species which reach sexual maturity after they become vulnerable to fishing, species with life stages or behavior that make them highly vulnerable to fishing (e.g., species that form large and predictable spawning aggregations), and species with low-frequency variability in recruitment (e.g., long periods of low or high recruitment) or with rare large recruitments (Restrepo et al 1998). In these cases, Restrepo et al. (1998) called for more conservative precautionary management approaches. Carry-over and phase-in policies have the potential to increase biological risk of already risk-prone species, requiring an even more conservative harvest strategy to offset this risk. However, fishery managers may be able to mitigate this risk with gear or spatial regulations, though this may be more effective for avoiding growth overfishing than mitigating recruitment failures. In addition, short-lived species with high natural mortality rates may present particular risks if the target exploitation rates represent a large fraction of SSB. Risks of overfishing when following common ABC control rules are already higher for short-lived species even without implementation error (Wiedenmann et al. 2017). An overly optimistic assessment in conjunction with carry-over or a delay in the reduction of the ABC could exacerbate the risk, suggesting that more caution is called for in applying carry-over or phase-in for short-lived species.

4.2 Stock structure and spatial dynamics of fish and fisheries

The risk associated with some of the life history characteristics noted above is closely related to technical, economic, and management characteristics of the fisheries. For example, spawning aggregations may exacerbate risk if they are profitable to target, but may not if they are not or cannot be targeted, e.g., due to poor condition and quality of the fish, distance from ports, or protection within a marine protected area. For species that school or species known to contract their distribution as biomass declines, CPUE may remain high as the stock is depleted. This may exacerbate risk similar to that experienced by spawning aggregations. However, where CPUE declines in proportion to biomass for a species, declining profitability may reduce effort and risk of overfishing. Thus, an understanding of how spatial dynamics of fish and fisheries relate is important to evaluate risk of harvest strategies including carry-over and phase-in policies.

Metapopulation structure also may have implications for the risk of depletion of metapopulation components. Failure to manage catch at the same scale as the true population structure can lead to extirpation of discrete subpopulations and to declines in the productivity of the larger metapopulation. However, it may be difficult and costly to assess and manage stocks at a finer spatial scale, and there is likely to be greater uncertainty about the size of substocks than about the aggregate stock. Holland and Herrera (2010, 2012) show that the relative benefits of finer-scale management, in terms of profits and risks of depleting subpopulations, depend on a

number of biological, technical, and economic factors. In some cases, when there is less certainty about the status of subpopulations than the overall metapopulation, it may be both less risky and more profitable to manage the fishery with a single TAC, even when there are actually biologically separate fish populations in the two areas. This occurs as effort tends to move off the weaker subpopulations where CPUE is lower and toward the stronger subpopulations. Nevertheless, metapopulation structure could pose a risk if fishing remains profitable on depleted subcomponents of the larger population.

4.3 Jointly targeted and bycatch species

Additional issues may arise when species are targeted jointly, result in bycatch of another species, or are taken as bycatch while targeting another species. In these cases, carry-over and phase-in policies that shift harvest of one species over time may coincidentally do the same for other species. In fact, constraints on quota of an incidentally-caught species may be a primary reason for underages and potential carry-over of another species (e.g., Holland and Jannot 2012). Whether this creates additional risk or concerns is likely to vary case by case, but when joint production is known to occur, it is important to evaluate implications of carry-over or phase-in for jointly caught species. Notably, carry-over may also be relatively more economically beneficial in such cases. If bycatch is highly variable and uncertain, an individual or even a fleet might be forced to stop fishing as a result of an accidental bycatch event leaving unused quota of the target species. The ability to carry over a portion of the remaining target species quota to the next year may mitigate the risk of an unexpected bycatch event resulting in forgone target catch (assuming the bycatch quota does not restrict the fishery that year). It may also reduce incentives to illegally discard catch. Chronic underages leading to substantial carry-over year after year may indicate an imbalance in TACs for which carry-over may not be a good solution. However, it may still be useful for individual quota holders in an IFQ system since some quota holders may be constrained even when quota is not utilized in aggregate.

Holland and Herrera (2006) evaluated risks and benefits of flexible catch balancing policies modeled on deemed value policies used in New Zealand which allow fishermen to land catch for which they do not hold quota and pay a fine per pound in lieu of balancing catch with quota. Deemed values can result in TAC overages. The policy is designed to incentivize fishermen to land species taken incidentally rather than discard them illegally. The policy has resulted in total catches of some species exceeding the TAC. While the study does not explicitly evaluate carry-over or phase-in, it provides insights into the implications of temporary TAC overages that are offset with later catch reductions only if the stock declines and the TAC is reduced. Holland and Herrera use a simulation model to evaluate two cases with different life history characteristics. The first case models orange roughy (*Hoplostethus atlanticus*) as the target species, and smooth oreo (*Pseudocyttus maculatus*) as the bycatch species for which catches sometimes exceed the TAC, resulting in the need to pay deemed values. This case is illustrative of a fishery with two jointly caught species that are both very long-lived and slow growing, with highly variable recruitment. The target exploitation rate for orange roughy is also higher than that for smooth oreo, increasing the risk that smooth oreo will be overexploited. The second case models red cod (*Pseudophycis bachus*) as the target species and elephantfish (*Callorhinchus milii*) as the bycatch. This case is of particular interest because the bycatch species is considerably less productive than the target species, so the former's viability may be threatened if exploited at rates appropriate for the target stock. The study found that allowing

TACs to be exceeded through a deemed value system generally will not create substantial risks of depletion as long as (1) deemed values are progressively increased to a maximum of twice the ex-vessel price in response to TACs being exceeded, and (2) TACs are reduced in response to stock declines.

In some multispecies fisheries, several species frequently caught together are combined into a stock complex for management purposes, with one quota allocation for the whole group. For example, in the Pacific groundfish trawl IFQ fishery, there are quotas for "other flatfish," "minor slope rockfish," and "minor shelf rockfish" that include multiple species. When grouping stocks into a stock complex, the NS1 guidelines advise that the stocks should have similar life history characteristics and similar vulnerabilities to fishing pressure (see 50 CFR 600.310(d)(2)(i)). However, if the stocks within the complex do not have similar vulnerabilities, then the stocks with relatively higher vulnerability could be at increased risk if carry-over were allowed. Managers should consider if the application of carry-over will increase the risks on stock complexes.

4.4 Assessment availability and frequency

Projections (i.e., model-derived estimates of future stock biomass) from the most recent stock assessment reflect the most up-to-date prediction of future stock dynamics, including recruitment, age structure, selectivity, and biomass trajectory. Accordingly, more precaution may be needed as a stock assessment gets older or if there is no stock assessment information available (Wiedenmann et al. 2017). As described above, Wiedenmann et al. (2017) conducted a simulation analysis to evaluate the performance of alternative ABC control rules. In most simulations, assessments were assumed to occur every 2 years and some simulations were run with an assessment interval of 5 years (though this was done only for the medium-lived life history assumptions). The study considered policies aimed at creating less variability in ABCs whereby the ABC was set based on an average of the ABC from the current assessment and ABC from the previous assessment or, in the case of a 5-year interval, assuming the ABC was adjusted over the interval before the next assessment according to the stock projection. Setting a fixed ABC based on the last assessment reduced the probability of overfishing, and had comparable yield and lower variability in yield compared with using projections, both for the 2- and 5-year assessment intervals. The frequency of overfishing was higher and yield was lower for the longer (5-year) assessment interval, regardless of whether the ABC was fixed or based on projection. Using a weighted average of ABC reduced variability in catch but resulted in a higher rate of overfishing and lower yield than other methods.

Carry-over provisions that are applied to stocks without a recent stock assessment and/or projections may require more precaution unless the carry-over ABC control rule has been tested for robustness using simulation testing (Wiedenmann 2017). Furthermore, if there is reason to believe stock and fishery dynamics have deviated substantially from those assumed in the simulations, additional analyses should be used to evaluate using carry-over. Possible reasons for these deviations include changes to management that impact selectivity (e.g., changes to size limits, gear regulations), unexpected events (e.g., oil spill), and major environmental fluctuations (e.g., storms, algal blooms).

However, in their adaptation of this MSE to explore carry-over policies, Weidenmann and Holland (2019) found the length of the interval between assessments (between 3 and 5 years)

did not have a consistent impact on the performance of carry-over polices across scenarios and life histories for the different amounts of carry-overs allowed. For example, in some scenarios, the risk of overfishing and of becoming overfished was higher for an assessment interval of 3 years, whereas in other scenarios it was higher for an interval of 5 years. There was no consistency in the relative differences between 3 and 5-year intervals across scenarios for the medium- and short-lived life histories. This does not suggest that longer intervals between assessments don't increase risk, just that the addition of carry-over does not necessarily aggravate that risk systematically.

Wiedenmann and Jensen (2018) conducted a retrospective evaluation of how alternative strategies for setting catch targets would have performed for nine New England stocks. They chose to examine stocks for which target catches have recently been set above overfishing levels. Among other things, they examined the performance of the following strategies that attempted to smooth catch targets: allowing only a +/- 20 percent change in catch targets based on the most recent assessment, using a weighted average of the catch target from the current and previous assessment, and a status quo, no-smoothing approach where target catches were based on the most recent assessment. They found that the smoothing methods resulted in target catches that were comparable to or higher than the unsmoothed catch values, which would have exacerbated overfishing conditions. They concluded that caution is needed when using catch-smoothing approaches, especially for stocks for which assessments tend to overestimate abundance.

It is useful to consider the following factors when evaluating usefulness of phase-in: (a) the mean generation time (or turnover rate) of the stock, which affects the fraction of the catch that is young fish, (b) precision with which the assessment estimates ABC for upcoming year, (c) time between assessments, and (d) time for assessment, which is the time lag between collecting data and revising the ABC. Various studies have elucidated some of the interplay between these factors, but stock-specific MSEs are advised to understand representative situations in each FMP. For example, Liu et al. (2016) found that as assessments became less frequent, relative yields were reduced and the risk of stock depletion and interannual variation in yield increased. They found that the effects of less-frequent assessments were ameliorated with more productive populations. However, the effects of assessment frequency were largely insensitive to changes in recruitment variation or the quality of assessment data. Although populations with low productivity were the most sensitive to changes in assessment frequency and the lag between data collection and assessment, the management of those populations benefited to a greater extent from implementation of an appropriate target mortality rate than from more-frequent assessments or removal of the 1-year lag. Although Liu et al.'s work did not directly evaluate phase-in and carry-over, their results contribute to understanding of factors that would affect phase-in and carry-over.

If a high turnover stock is assessed infrequently, then each assessment and associated ABC setting is nearly independent from the previous assessment and ABC. If the new assessment is precise and timely, then it should be used as the new basis for management with no phase-in. But if the new assessment is imprecise, then averaging with the previous (and probably equally imprecise) result may be advisable to get a better estimate of the long-term average ABC.

If a short generation time (high turnover) stock is assessed annually, then the focus is on the precision with which it can project the upcoming year's ABC accurately. Generally, this means that the assessment must have very timely information of the relative magnitude of current and anticipated recruitment levels. Without such forecasting capability, the ABC changes

will frequently be out of sync with actual population changes. Here phasing in seems advisable so that the ABC does not change too much.

Stocks with a long generation time (low turnover) have high inertia, so the true ABC is not expected to change much from year to year, even if there is moderate recruitment variability because the wide age-structure of the stock buffers the recruitment variability. Here carry-over works well because fish not caught last year are still mostly available to be caught this year, with suitable adjustments for expected mortality. If precise assessments are conducted nearly annually, then year-to-year changes in ABC should be small, so phase-in is not necessary. If the assessments are not precise, then phase-in is a good idea because it helps achieve a better long-term average ABC without so much year-to-year variation in ABC.

A more challenging situation is when a low-turnover stock is assessed infrequently. Because the assessment is infrequent, there is enough time for the true stock and the true ABC to accumulate substantial change since the previous ABC was set. Here phasing in an ABC decrease but not phasing in an ABC increase could substantially increase the risk of overfishing, because some of the change may be due to uncertainty and there may not be another assessment for several years to provide an update on the situation. If the stock is on a long-term decline, then infrequent step-down of the ABC can lead to overfished stocks, as it did for some west coast groundfish stocks during the 1990s, and phasing in the new estimates will only make the problem worse. On the other hand, phasing in new estimates for increasing stocks will provide the desired ABC stability, but may reduce the long-term average catch. Given these considerations, NMFS recommends that if a stock seems fairly stable from the current assessment but the assessment has high uncertainty, then it could be appropriate to phase in the new ABC. But if a stock is on a declining trajectory or if the new assessment indicating decline has increased precision because of new information, then more caution should be applied when allowing phase-in, or perhaps phase-in should not be allowed.

4.5 ACL overages and catch uncertainty

For stocks where the fishery is expected to exceed its ACL in some years, allowing carry-over provisions to be applied to ACL underages while not requiring corresponding provisions to address ACL overages (e.g., pay-backs) could lead to catches exceeding the ACL on average, increasing the risk of overexploitation of the stock over the long term (Powers and Brooks 2008). Powers and Brooks (2008) used an MSE framework to evaluate the implications of alternative decision rules regarding carry-over of undercaught TACs and pay-back of TAC overages on conservation and sustainability objectives and rebuilding time frames. The study assumed TACs were set with perfect knowledge of the stock status and productivity, but that catch varied randomly around the TAC with a coefficient of variation of 20 percent. The carry-over/pay-back in the study was delayed such that an underage/overage in year 1 was added to/deducted from the TAC in year 3. A sensitivity analysis also was conducted to examine scenarios with an underreporting bias of 20 percent. The study found that as long as there was one-for-one payback of both overages and underages and no bias in reporting, sustainability objectives and rebuilding time frames were comparable to perfect TAC implementation. When overages were paid back and underages not carried over, recovery was achieved earlier. Conversely, a policy under which overages were ignored and underages were carried over did not maintain or rebuild the stock to target level on average. Possible methods for accounting for ACL overages include requiring

pay-back AMs, deducting overages from subsequent ACLs, or delaying the application of carry-over until later in the year when the previous year's catch is more certain.

For stocks with substantial uncertainty in the estimate of the catch, ACL underages may be caused by underestimation of the catch. Power and Brooks (2008) found that an underreporting bias undermined the viability of carry-over management. In Wiedenmann and Holland's 2019 study, allowing carry-over when catch was underreported led to the highest probability and magnitude of overfishing, as well as the highest risk of becoming overfished, of the scenarios they explored. In such circumstances, NMFS recommends that overages and underages be addressed through AMs, as opposed to carry-over provisions, in order to average out the fluctuations in the estimated catch. The NS1 guidelines suggest that AMs could be based on a comparison of average catch to average ACL over a three-year period (NS1 Guidelines paragraph 50 CFR 600.310(g)(5)). If a Council or the Secretary wants to apply carry-over ABC control rules, the NS1 guidelines advise that managers consider the reason for a catch underage prior to implementing carry-over. For stocks with substantial uncertainty in catch data, additional precautionary measures such as triggers to prohibit carry-over in risky circumstances may be needed to ensure that catches do not exceed ACLs on average.

4.6 The broader fishery management context

The benefits and risks of carry-over and phase-in provisions should be evaluated in the context of the broader fishery management approach. As mentioned earlier, carry-over policies may be particularly useful in multispecies fisheries managed with individual quotas. They can be an important part of catch-balancing regimes that reduce the need for individuals to fish right up to their quota (and potentially discard overages), and make it easier to balance catch with quota portfolios in multispecies fisheries without having to buy or sell quota. Carry-over may be useful in derby fisheries with short seasons and in fisheries that rely on indirect measures to control total catch. This includes recreational fisheries, which may rely on indirect methods such as bag limits, and for which catch estimates may not be available in a timely fashion. The ability to carry over unused quota may reduce pressure on managers to set longer season lengths or laxer fishing rules if fishermen know that uncaught fish can be carried over to the next season. Many fisheries have multiple sectors that may be regulated separately and be allocated portions of the ACL. Examples include sectors using different gears, sectors with different classes of vessels (small vs. large, catcher vs. catcher-processor), and fisheries with commercial and recreational components. Allowing carry-over in one sector in these cases may be more problematic since it may impact other sectors. Different fishing fleets (or sectors) may preferentially target or select different ages or sizes of fish based on gear type, or area fished. In an analysis of the impact of carry-over on the rebuilding progress of GoM red snapper, Smith and Goethel (2017) noted that reassigning carry-over to sectors other than the one that originally observed an underage may lead to unexpected impacts. Thus, sector selectivity is an important consideration when designing carry-over control rules. Further, different sectors may have divergent interests in whether or how to phase in changes to ABC.

Additionally, the administrative cost of developing new policies and procedures should not be overlooked in implementing carry-over and phase-in provisions. A simple cost-benefit analysis should be considered to determine whether the potential realized benefits in terms of catch increases, profit margins, industry stability, etc. are substantial enough to justify the additional administrative work to establish and implement these provisions.

4.7 Limitations on ABC adjustments

As described above, an ABC control rule is a policy set by the Council, in consultation with its SSC, or by the Secretary for Secretarial managed stocks, that articulates how the ABC will be set compared to the associated OFL. ABC control rules account for scientific uncertainty as well as the Council's risk policy (e.g., the acceptable probability that catch equal to the ABC would result in overfishing). Because the ABC cannot exceed the OFL, ABC control rules generally specify the amount by which the ABC should be reduced from the OFL[15], based on the level of scientific uncertainty and the preferred probability that such a catch level could result in overfishing. Most of the Councils have established a tiered ABC control rule, where different approaches are used to specify OFL and ABC depending on the data that is available for a given stock. In many of the higher data quality tiers, P* will be applied to the probability distribution of OFL to generate ABC. In general, when there is a large buffer between the OFL and the ABC, there is more room to account for carry-over and to adjust the ABC upwards. The amount of carry-over that can be applied is limited by the difference between the OFL and the ABC. Stock assessments with more uncertainty will have larger buffers and thus more room to accommodate ABC adjustments upward to allow for carry-over or phase-in.

5.0 Conclusions and Recommendations

Revisions to the National Standard 1 (NS1) guidelines that allow some portion of ACL underages to be carried over to the following year and phase-in of ABC changes over a period of up to three years can have benefits including increasing safety and economic performance. Phase-in of ABC changes can reduce social disruptions by creating stability in harvests over time. However, these policies may also increase risk of overfishing and depletion, and should be properly analyzed and adopted with caution. Carry-over and phase-in policies that limit changes in the ACL to the gap between the ACL and the ABC do not necessarily require any additional analysis or changes to FMPs. Policies that allow the ABC to be adjusted to accommodate carry-over or phase-in require comprehensive evaluation in advance and/or provisions for SSCs to evaluate and approve changes to ABCs on a case-by-case basis.

There are two alternative acceptable approaches by which carry-over or phase-in could be implemented. The first approach is to evaluate carry-over or phase-in actions on a case-by-case basis. For assessed stocks, this might entail re-running the projections used in the last stock assessment with revised catch estimates adjusted to accommodate proposed carry-over or phase-in of ABC changes. Ideally, these projections should incorporate uncertainty and should take retrospective patterns into account. Deterministic projections may be acceptable but should be used with caution when assessments are imprecise or when there is reason to believe a stock is declining. It may be possible to run catch projection scenarios in advance that allow for a range of actual catches and carry-over to ensure that they do not result in overfishing. Then, if the actual adjustments to the ABC for carry-over and phase-in fall with the scenarios tested, it is possible they can be approved without further analysis.

The second, and preferred, approach is to incorporate carry-over and phase-in provisions within ABC control rules by first conducting a comprehensive evaluation (preferably an MSE) of

[15] Note: For some data limited stocks, OFL is not specified.

these policies before adopting them as revised ABC control rules in the respective FMPs. An MSE can test a range of scenarios that may occur under a given control rule and account for how various types of uncertainty and error affect the probability of overfishing occurring. An MSE may also be useful for understanding how these control rules will impact the average catch and stability of the catch over time. MSEs may be particularly useful for stocks that are not frequently assessed, as they can inform how managers can use indicators, such as survey indices or commercial CPUE, to adjust ABCs in the years between assessments. It may not always be feasible to undertake a full MSE to evaluate phase-in or carry-over ABC control rules. However, the NS1 guidelines require that a comprehensive analysis showing how the provisions prevent overfishing be included when carry-over or phase-in provisions are incorporated within an ABC control rule. Because it is the SSC's responsibility to recommend ABCs, an ABC control rule that enables adjustment of ABCs to accommodate carry-over or phase-in should be reviewed by the SSC to ensure that it will prevent overfishing and to account for scientific uncertainty.

When designing a carry-over or phase-in policy, fishery managers should account for a number of factors that influence the risk of such policies. Care should be taken when implementing these policies for fish stocks with life history characteristics that make them more vulnerable to overfishing, such as short-lived stocks or stocks that aggregate as their biomass declines, allowing catch rates to remain high even when stocks are depleted. When species are targeted jointly, increasing the ABC on one species may result in increased catch of jointly caught species. This may be particularly important when ABCs are set for stock complexes rather than individual species, as carry-over could enable overfishing of a component species even though the ABC of the stock complex is not exceeded. Extra caution should also be taken for stocks that are not frequently assessed or for which catch or the assessment itself is highly uncertain.

NS1 guidelines clearly state that ABC cannot exceed OFL. This means that increases in the ABC based on phase-in or carry-over provisions cannot exceed the margin between the ABC and OFL. Ironically, this generally allows for increases in the ABC for stocks subject to relatively high scientific uncertainty because those stocks are likely to have a large margin between the OFL and ABC in the first place. In such cases, when considering carry-over, it may still be appropriate to allow ABC increases, but managers should consider the reasons for the underage. If there is reason to believe the underage was due to a decline in the stock, it may be unwise to allow carry-over. However, there may be cases where assessment results are uncertain but carry-over serves an important purpose with limited risk. A key example is in multispecies IFQ programs that include species taken incidentally and with highly variable and uncertain catch rates. Allowing individuals to carry over quota may help individuals or the industry to balance incidental catches that vary substantially year-to-year. In contrast, when the undercaught species is a target species and it appears that failure to catch the ACL was due to low catch rates, the possibility that the stock size is lower than presumed should be considered and caution exercised before allowing carry-over.

6.0 Acknowledgements

This paper was improved by the review and comments provided by: John DeVore, Jane DiCosmio, Kari Fenski, Travis Ford, Jason Gasper, Dana Hanselman, Sandra Lowe, Sarah McLaughlin, Nikhil Mehta, Peggy Mundy, Caroline Park, Sean Roberts, Brett Schumacher, and Cindy Tribuzion.

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Table 1. Carry-over Provisions in Domestic U.S. Fisheries

Council	FMP	Fishery component	Carry-over provision	Regulatory citation
North Pacific Council	Groundfish of the Bering Sea/Aleutian Island FMP/Groundfish of the Gulf of Alaska FMP	Pacific Halibut and Sablefish	NMFS issues individual fishing quota (IFQ) to individuals based on their quota share (QS) for halibut and sablefish. An individual's catch must be matched by their IFQ. Individuals are allowed to exceed what is available in their IFQ account by up to 10 percent, and that overage will be subtracted from their IFQ in the next year. Similarly, if an individual catches less than their IFQ, up to 10 percent of a person's total annual IFQ can be carried over to the next fishing year.	50 CFR 679.40(d)-(e)

Pacific Council	Pacific Coast Groundfish FMP	Share-based IFQ program: within this program, the overall catch or quota for non-whiting groundfish stocks is divided into shares controlled by individual fishermen.	At the start of each year, NMFS issues quota pounds (QP) to entities based on their quota share (QS). A vessel's catch (including discards) must be matched by an equal amount of quota pounds. Up to 10 percent of a vessel's QP can be carried over from one year to the next. Similarly, an overage in one year can be covered by up to 10 percent of the following year's QP.	50 CFR 660.140(e)(5)
New England	Northeast Multispecies FMP	Sectors, which are generally defined as a group of three or more distinct persons who hold limited access vessel permits, who have voluntarily entered into a contract and agree to certain fishing restrictions for a specified period of time, and who have been granted a quota (referred to as an Annual Catch Entitlement).	Sectors are allowed to carry over up to 10 percent of their ACE for each stock that is unused, as long as this amount, plus the total ACL for the upcoming fishing year, does not exceed the ABC of the stock.	50 CFR 648.87(b)(1)(C)
New England	Atlantic Sea Scallop FMP	1) Limited access vessels, which are assigned days at sea (DAS) to use in open areas as well as an allocation of scallops (in pounds) that can be caught in specific controlled access areas. 2) Limited access general category (LAGC) individual fishing quota (IFQ) vessels.	1) Limited access vessels may carry over a maximum of 10 DAS, not to exceed the total open area DAS allocation by permit category, into the next year. 2) LAGC IFQ vessels may carry over up to 15 percent of the vessel's IFQ into the next fishing year.	50 CFR 648.53 (d) and (v)

NMFS	Atlantic HMS	Shark fishery	Base annual commercial quotas can be adjusted based on over- or underharvests. An underharvest of "healthy" sharks (those that are not overfished, not subject to overfishing, and do not have an unknown status) may be carried over to the following year, up to 50 percent of the base annual quota. Carry-over is not allowed for if a shark stock or a stock within a management group is overfished, subject to overfishing, or has an unknown stock status. If a quota is exceeded in a fishing year, NMFS will deduct from the base quota an amount equivalent to the overharvest in the following year or, depending on the level of overharvest, NMFS may deduct from the base quota an amount equivalent to the overharvest spread over a number of subsequent fishing years to a maximum of five years.	50 CFR 635.27(b)(2)

Gulf Council	Reef Fish Resources of the Gulf of Mexico	Gulf of Mexico IFQ Programs for Red Snapper and Grouper-Tilefishes	IFQ shareholders can land 10 percent over their remaining allocation on the last fishing trip of the year as long as the amount does not exceed the amount of shares held in the account. Any overage will be subtracted from the shareholder's allocation at the start of the next fishing year. Because overages need to be subtracted from the shareholder's allocation at the start of the following year, share transfers will not be allowed that would reduce the shareholder's IFQ shares lower than the amount needed to pay back the overage.	50 CFR 622.21 (b)(3)(ii) and 622.22 (b)(3)(ii)

Table 2. Summary of guidance on carry-over provisions

NS1 guideline requirements for developing carry-over provisions within an ABC control rule: ● Describe within an FMP when the carry-over provision can and cannot be used, and how the provision prevents overfishing based on a comprehensive analysis. ● Consider the reason for the ACL underage. ● Evaluate appropriateness of carry-over provisions for stocks that are overfished and/or rebuilding, as the overriding goal for such stocks is to rebuild them in as short a time as possible.
Additional considerations and guidance to consider when developing carry-over provisions with an ABC control rule: ● Consider how ACL underages will be determined. ● Consider how underages will be accounted for when there are multiple fishery sectors. ● Consider having a minimum buffer between OFL and ABC. ● Consider establishing limits on the amount of unharvested ACL that can be carried over. ● Consider identifying circumstances where precautionary measures should be used. ● Establish process for making changes to the ABC and ACL. ● Consider using simulation testing to ensure that carry-over will prevent overfishing in accordance with any established risk policy, preferably using a closed-loop management strategy evaluation. ● Consult with Scientific and Statistical Committee as well as the applicable NMFS Fisheries Science Center.
Implementing and evaluating carry-over on a case-by-case basis: ● Rerun the stochastic projections that were used in the last stock assessment with revised catch estimates. ● Conduct a deterministic projection analysis with revised catch estimates. ● Use scenario planning within an assessment to evaluate a wide range of ACL underages, resulting in ranges of OFL and ABC recommendations for each year within each scenario.

Table 3. Summary of guidance on phase-in provisions

NS1 guideline requirements for developing phase-in provisions within an ABC control rule: ● Describe within an FMP when the phase-in provision can and cannot be used, and how the provision prevents overfishing based on a comprehensive analysis. ● Phase-in period may not exceed three years. ● Must prevent overfishing each year (i.e., the phased-in catch level cannot exceed OFL). ● Evaluate appropriateness of phase-in provisions for stocks that are overfished and/or rebuilding, as the overriding goal for such stocks is to rebuild them in as short a time as possible.
Additional considerations and guidance to consider when developing phase-in provisions with an ABC control rule: ● Consider typical frequency and uncertainty of stock assessments. ● Consider phasing in increases as well as decreases in ABC. ● Consider whether the stock assessments have retrospective bias. ● Consider whether phase-in is appropriate for stocks without assessments. ● Consider having a minimum buffer between ABC and OFL. ● Consider phase-in only when stock biomass exceeds a certain level. ● Consider monitoring the stock over the phase-in period with updated projections. ● Consider using simulation testing to ensure that the phase-in plan is robust to uncertainty, preferably using a closed-loop management strategy evaluation. ● If phasing in ACL increases, but not decreases, consider evaluating impact on average buffer size. ● Consult with Scientific and Statistical Committee as well as the applicable NOAA Fisheries Science Center.
Implementing and evaluating phase-in on a case-by-case basis: ● Run stochastic projections based on most recent stock assessment with proposed ABCs to evaluate risk of overfishing. ● Conduct a deterministic projection analysis to evaluate a phased-in ABC.