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# RISK POLICY and MANAGING FOR UNCERTAINTY
## ACROSS THE REGIONAL FISHERY MANAGEMENT COUNCILS

**An Updated Report**
**2012**

**Fisheries Leadership & Sustainability Forum**

**Prepared in support of the**
**New England Fishery Management Council Risk Policy Workshop**
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## INTRODUCTION

The 2006 reauthorized Magnuson-Stevens Fishery Conservation and Management Act (MSRA) instructs the eight regional fishery management councils (councils) to prevent overfishing while achieving optimum yield (OY) from U.S. fisheries. To achieve this mandate, the MSRA requires councils to establish annual catch limits (ACLs) for all managed fisheries and ensure adherence to those limits through the use of accountability measures (AMs). Through the significant effort of councils, council staff, scientific and statistical committees (SSCs), NOAA Fisheries scientists and managers, and other management partners, ACLs were first implemented for all federally managed fisheries by the 2011 deadline. The achievement of this ambitious mandate was supported by considerable developments on both scientific and management fronts. Diverse policies, processes, and tools are used to set reference points, account for scientific and management uncertainty, establish ACLs, and provide accountability. Reflecting on their experience during the first few years of utilizing ACLs and AMs, councils are revisiting their approach to risk policy and refining their policies and processes for setting catch levels.

This report was developed as a resource for fishery managers and to provide a platform for sharing progress and lessons learned across council regions. The body of the report consists of eight regional profiles, which provide a high-level overview of the different approaches adopted by each of the eight regional councils and their SSCs to manage risk and account for uncertainty in their specification processes. These regional profiles build on the original "Risk Policy and Managing for Uncertainty Report" published by the Fisheries Leadership & Sustainability Forum in 2010. Each regional profile has been informed through direct communication and phone interviews with council members, council staff, SSC members, NOAA Fisheries staff, and other experts during the summer and fall of 2012 (see Resources at the end of this report for a list of interviewees). Because each council's risk policy and specification processes are complex and continually evolving, these profiles are not intended to be comprehensive. Each profile reflects regional differences and includes the information and insights interviewees found most relevant to share for the purposes of this report, current as of late 2012.

The regional profiles are prefaced by background information and a discussion section. Included in the background section are a review of National Standard 1 guidelines for establishing ACLs and a general overview of the approaches councils have taken to comply with the ACL mandate and account for scientific and management uncertainty. The discussion section captures some of the high-level themes across regional risk policies. This report is not intended to compare the effectiveness of risk policy approaches across council regions; rather, it aims to highlight innovations and continuing challenges to addressing risk and uncertainty. This updated report is also meant to support discussions at the New England Fishery Management Council workshop on risk policy in March 2013.

## ACRONYMS

| | |
|---|---|
| AM | Accountability measure |
| ABC | Acceptable biological catch |
| ACL | Annual catch limit |
| ACT | Annual catch target |
| AFSC | Alaska Fisheries Science Center |
| ASMFC | Atlantic States Marine Fisheries Commission |
| $B_{MSY}$ | Biomass associated with MSY |
| BSAI | Bering Sea/Aleutian Islands |
| CFMC | Caribbean Fishery Management Council |
| CNMI | Commonwealth of the Northern Mariana Islands |
| CPS | Coastal pelagic species |
| CV | Coefficient of variation |
| DB-SRA | Depletion-based stock reduction analysis |
| DCAC | Depletion-corrected average catch |
| EEZ | Exclusive economic zone |
| F | Fishing mortality |
| $F_{ABC}$ | Fishing mortality level/rate associated with ABC |
| $F_{MSY}$ | Fishing mortality level/rate associated with MSY |
| FEP | Fishery Ecosystem Plan |
| FMP | Fishery Management Plan |
| GHL | Guideline harvest level |
| GMFMC | Gulf of Mexico Fishery Management Council |
| HMS | Highly migratory species |
| IATTC | Inter-American Tropical Tuna Commission |
| ITQ | Individual Transferable Quota |
| M | Natural mortality |
| MAFMC | Mid-Atlantic Fishery Management Council |
| MPS | Migratory pelagic species |
| MRIP | Marine Recreational Information Program |
| MSE | Management strategy evaluation |
| MSRA | Magnuson-Stevens Fishery Conservation and Management Act (reauthorized) |
| MSST | Minimum stock size threshold |
| MSY | Maximum sustainable yield |
| NEFMC | New England Fishery Management Council |
| NEFSC | Northeast Fisheries Science Center |
| NERO | Northeast Regional Office |
| NGO | Non-governmental organization |
| NMFS | National Marine Fisheries Service |
| NPFMC | North Pacific Fishery Management Council |
| NWFSC | Northwest Fisheries Science Center |
| NS1 | National Standard 1 |

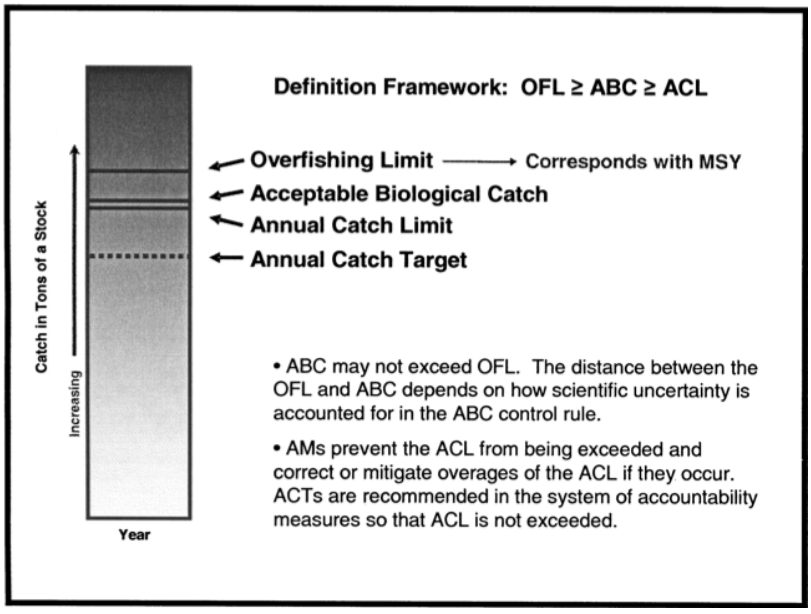
| | |
|---|---|
| OFL | Overfishing limit |
| ORCS | Only reliable catch stocks |
| OY | Optimum yield |
| P* | Probability of overfishing |
| PDF | Probability distribution function |
| PDT | Plan Development Team |
| PFMC | Pacific Fishery Management Council |
| PIFSC | Pacific Islands Fisheries Science Center |
| PIRO | Pacific Islands Regional Office |
| PRIA | Pacific Remote Island Areas |
| PSA | Productivity susceptibility analysis |
| SAFMC | South Atlantic Fishery Management Council |
| SEDAR | Southeast Data, Assessment, and Review |
| SEEM | Social, Economic, Ecological and Management (Analysis) |
| SEFSC | Southeast Fisheries Science Center |
| SRA | Stock reduction analysis |
| SSC | Scientific and Statistical Committee |
| SWFSC | Southwest Fisheries Science Center |
| TAC | Total allowable catch |
| TAL | Total allowable landings |
| USVI | United States Virgin Islands |
| WCPFC | Western Central Pacific Fishery Commission |
| WPFMC | Western Pacific Fishery Management Council |

## BACKGROUND

The 2009 revised National Standard 1 (NS1) Guidelines to the 2006 reauthorized Magnuson-Stevens Fishery Conservation and Management Act (MSRA) outline the process for regional fishery management councils (councils) and scientific and statistical committees (SSCs) to follow when specifying annual catch limits (ACLs.) Each region's SSC is instructed to set overfishing limits (OFLs) for all managed stocks in a fishery. The OFL represents the upper limit of catch that can be harvested from current biomass and is calculated by applying a limit to the fishing mortality rate (F) that is typically set by maximum sustainable yield (MSY) or its proxy (Shertzer et al. 2010). Following the establishment of OFL values, SSCs develop acceptable biological catch (ABC) recommendations for each stock. The ABC is a catch limit that is calculated downward from the OFL on the basis of the councils' ABC control rules to account for scientific uncertainty: the greater the degree of scientific uncertainty, the greater the difference between the OFL and ABC (see Figure 1).

Based upon the SSCs' ABC recommendation, councils establish ABC levels and adopt annual catch limits (ACLs), which are required under MSRA as a tool to prevent the OFL from being exceeded. ACLs must be set less than or equal to ABCs and represent the level of annual catch that can be harvested from a stock or stock complex. ACLs also serve as the basis for invoking accountability measures (AMs) in a fishery. AMs are management controls that prevent ACLs from being exceeded and include measures such as annual catch targets (ACTs), time/area closures, and payback mechanisms in response to ACL overages.

Figure 1. Relationship of OFL >/= ABC >/= ACL >/= ACT.




*Source:* Federal Register. "Magnuson-Stevens Act Provisions; Annual Catch Limits; National Standard Guidelines." 16 January 2009. pg. 3180. "Relationship between OFL, ABC, ACL, and ACT."

*Scientific Uncertainty and ABCs*

Scientific uncertainty is the first critical factor SSCs and councils consider when setting catch limits. Scientific uncertainty reflects uncertainty around the determination of stock status and projections of how a stock will respond to different harvest strategies in the future. This uncertainty stems from imperfect understanding of biological and ecological information such as assessment parameter estimates, abundance, productivity, vulnerability, trophic interactions, bycatch in other fisheries, changing states of nature, and other factors.

SSCs account for scientific uncertainty in the specification of ABCs through the application of ABC control rules. ABC control rules are procedures set by councils with input from their SSCs, which guide SSCs in characterizing scientific uncertainty and incorporating appropriate buffers from the OFL when recommending ABC levels to the councils. While control rules account for varying levels of scientific uncertainty, they are also a function of councils' risk tolerance. Resource needs, data availability, stock assessment frequency, management history and capacity, and SSC guidance all inform a council's control rule selections. Typically, more scientific uncertainty regarding a stock corresponds with a more risk-averse ABC control rule and thus a larger buffer from OFL to ABC. Ultimately, control rules reflect policy decisions made by councils and express their preferred level of risk tolerance for overfishing a stock.

The ABC control rules currently in place are diverse and vary across council regions; they reflect different interpretations of the MSRA statute and NS1 guidelines, a range of information availability, and the unique ecological and management context of each region's managed fisheries. Many councils use a tiered ABC control rule, in which stocks are categorized into tiers depending on the availability and quality of scientific data. For each tier, the control rule outlines the processes and parameters for specifying ABCs. The use of tiered ABC control rules provides SSCs and managers with valuable guidance, and the first few years of ACL implementation have provided councils with additional applied experience. Some councils have expressed concern that the ABC resulting from the approach specified by a certain tier is overly precautionary or not precautionary enough, and in some cases have been reluctant to utilize a particular tier. Many councils lack the data to apply their upper-level tiers; thus some tiers are only minimally utilized, if at all. Managers have also expressed that the tiered systems may be too rigid in practice and that councils would benefit from additional flexibility to respond on a case-by-case basis.

The National Standard 1 guidelines specify that ABCs must be set at a level such that there is no more than a 50% probability that overfishing will occur. The majority of councils specify an acceptable probability of overfishing (P*) when establishing ABCs for at least one stock in their region. Although P* can be articulated for any stock, P* can only be applied to stocks with enough information to determine a probability distribution around the OFL. Several councils apply P* within their tiered control rules, whereby the selection of P* is informed and/or bounded by data availability and scientific uncertainty. Specifying acceptable probabilities of overfishing is a way for councils to communicate their risk tolerance, though this approach focuses more on the probability than on the consequences of overfishing a stock.

Councils use a number of approaches to incorporate estimates of scientific uncertainty when establishing ABCs. Some councils incorporate variables during the specifications process to represent estimates of scientific uncertainty. These variables can be used to structure control rules in several ways, such as informing reductions in the maximum allowable P*, adjusting the OFL downward before a P* is applied, or informing a percentage reduction applied to the OFL to arrive at an ABC. For stocks without sufficient information to produce OFL estimates, direct reductions or scalars can be applied to other reference points such as $F_{MSY}$ or a proxy. A number of methods have been developed to estimate uncertainty and inform ABC specification of "data-poor" stocks. For the most data-poor stocks—ones for which proxies cannot be established—ABCs are commonly determined by applying straight percentage reductions to estimates of historic catch.

*Management Uncertainty, ACLs, ACTs, and AMs*

In addition to accounting for scientific uncertainty, managers must also account for management uncertainty when establishing ACLs and AMs. Management uncertainty describes the accuracy and precision with which management measures limit catch to allowable levels and is largely a function of the existing monitoring, reporting, and enforcement mechanisms in place for a fishery. Monitoring programs, including surveys, trip reporting, dealer reporting, and observer coverage, play an important role in reducing sources of management uncertainty by helping managers compare estimated and actual catch relative to ACLs. These data collection programs can also provide data such as fishing mortality, bycatch estimates, size-at-age data, and other information that can help capture scientific uncertainty and improve stock assessments.

Management uncertainty arises from difficulty in accurately accounting for total catch, common in fisheries with a large recreational or subsistence component, and in multispecies fisheries where not all catch is landed. Councils employ a number of measures to account for management uncertainty and help to avoid exceeding an ACL. Many councils buffer against management uncertainty by establishing ACTs below the ACL. ACTs act as "target" reference points in a fishery and can reduce the possibility that the "limit" reference point, the ACL, is exceeded. These reductions can be incorporated on an ad hoc basis or informed by an ACT control rule. In addition to ACTs, managers employ a number of other AMs to prevent and/or mitigate ACL overages including in-season area closures, reductions in trip or bag limits, and reductions to a subsequent year's ACL. Several councils rely on the input from various committees or advisory groups to help characterize management uncertainty and determine appropriate mechanisms to ensure ACLs are not exceeded.

## DISCUSSION

Following the 2006 MSRA, councils and their management partners responded rapidly to comply with the ACL mandate by drafting FMP amendments, developing methods to characterize and account for scientific and management uncertainty, and establishing specifications processes to meet the implementation deadline. Now, with ACLs established for all managed fisheries subject to the ACL mandate, federal fishery managers are transitioning to a new phase in thinking about risk policy. Councils are learning from their own experience and the experiences of other regions, and evaluating which approaches are most effective for integrating and communicating their risk preferences. Looking ahead, councils are exploring opportunities to advance and refine their decisions about risk.

In this second phase of risk policy development, the discussion between councils and their management partners is evolving to encompass a more strategic, long-term perspective on risk. Councils are finding that they can use their risk policies and control rules as a pathway to explore broader management objectives, including consideration of social, economic, ecological, and biological factors as well as achievement of optimum yield. The specification of catch limits through the application of control rules provides a platform for structuring and communicating these tradeoff decisions. Moreover, the development and application of control rules can help make tradeoffs more systematic and transparent. The initial applications of, and subsequent revisions to control rules demonstrate that risk policies are not static and will continue to evolve over time. Rather than a product to be finalized, risk policies are a pathway for ongoing conversations among the councils, SSCs, and their management partners.

*Balancing Structure and Flexibility*

The control rules employed across council regions all impart some structure to the specification of ABCs and ACLs, reflecting the value that councils place on consistency, transparency, and administrative record-building. However, even within the more structured tiered approaches, councils often preserve some flexibility, recognizing that stocks for which data availability is similar may warrant different levels of precaution. For example, tiers 1 and 2 of the South Atlantic Fishery Management Council's (SAFMC's) ABC control rule examine vulnerability, stock status, uncertainty, and data availability to determine the maximum allowable P* for each stock within these tiers.

In some cases, councils have developed control rules with tiers that are rarely or never used. Although these tiers can provide a frame of reference, the limited application of data-rich tiers poses the question of whether tiered structures guide or constrain councils in managing for risk and uncertainty. One perspective is that unused tiers demonstrate the need to better align a risk policy with information availability. Another perspective suggests that the articulation of tiered classifications can communicate the council's thinking about what constitutes a higher or lower risk scenario and their respective risk tolerances. A tiered approach, with or without unused categories, can also provide a frame of reference for improving information availability and prioritizing stocks for assessment, as is evident from the language used to describe some tiers; for example, the Mid Atlantic Fishery Management Council (MAFMC) uses the terms "ideal,"

"preferred," "acceptable," and "unreliable" to characterize the quality of assessments and batch stocks into one of four tiers.

As councils move into this second phase of risk policy, there is momentum for risk policies to be more inclusive of the social, economic, ecological, and biological dimensions of risk and optimum yield considerations. The flexibility currently built into structured control rules is often used to adjust catch levels to account for these dimensions and considerations. For example, parrotfish play an important ecological role as coral reef grazers and also have an important social and economic role in parts of the U.S. Caribbean. The Caribbean Fishery Management Council's (CFMC's) specification of ACLs for parrotfish incorporated a buffer that acknowledges this species' vital ecological role and susceptibility to overfishing, while also recognizing the region's social and economic dependence on this species.

*Managing Risk*

While identifying, quantifying, and clearly communicating risk is an ongoing challenge, councils have taken steps to recognize specific types of risks. Several councils incorporate measures of biological risk when specifying catch limits by evaluating characteristics such as the vulnerability, susceptibility, and life history characteristics of a stock. These metrics can guide the council's risk policy and directly inform management measures, particularly when there is some flexibility within a tiered control rule. For example, MAFMC groups stocks into "typical" and "atypical" categories on the basis of their life history characteristics; atypical stocks are subject to an increased level of precaution. To prevent stocks from becoming overfished and to maintain stock biomass near levels that support MSY, the Pacific Fishery Management Council (PFMC) employs harvest control rules for stocks managed under the Groundfish FMP. The harvest control rules recommend progressive reductions to ACLs relative to the ABC as biomass drops below $B_{MSY}$ toward the minimum stock size threshold (MMST).

Recognizing and managing risk is an evolving process built on the collective experience of managers and scientists across regions. Although scientific information can help inform risk determinations, complex marine ecosystems are difficult to predict, and managers are challenged to account for ecosystem-level risks that are not yet well understood. In some cases, managers have taken an early precautionary approach by developing FMPs for as-yet undeveloped fisheries. For example, the North Pacific Fishery Management Council (NPFMC) developed an Arctic FMP to establish management authority over fisheries that could develop as Arctic ice recedes. Managers and scientists have been paying particular attention to rebuilding groundfish stocks and to the role of forage fish in the Pacific, Mid-Atlantic, and New England regions. Integrating biological and ecological considerations, balancing rebuilding requirements with social and economic considerations, preserving predator-prey relationships, and anticipating the risks posed by habitat changes and regime shifts are likely to become central components of ecological risk discussions.

*Accommodating Data Limitations*

The process for specifying ACLs outlined in the NS1 guidelines is extremely data intensive. Councils have made significant progress specifying ACLs for data-poor stocks, despite data limitations and high levels of uncertainty. Control rules and tiered approaches account for the

quality of assessments, the availability of information, and the level of scientific uncertainty, and recommend corresponding levels of precaution. Scientists and managers have made considerable advances in developing and applying data-poor methods. Ongoing efforts to enhance management of stocks for which only catch data are available ("only reliable catch stocks," ORCS) continue to advance our ability to manage data-poor stocks. Managers have also formalized processes to utilize local knowledge and incorporate the expert judgment of fishers, scientists, and managers.

The management of data-poor stocks can be particularly challenging when an entire fishery or stock complex is constrained by high uncertainty around one or more individual stocks. Particularly for multispecies fisheries and reef complexes, bycatch of data-poor stocks can result in management to the "lowest common denominator," in which precautionary catch limits for data-poor stocks constrain utilization of other stocks. Councils are taking steps to avoid unnecessarily constraining target fisheries. For example, in the Caribbean and Western Pacific, area-based management is used to address the differences in catch composition and localized stock status across a region. Several councils have grouped stocks into family complexes and set complex-level ACLs to avoid managing and accounting for a multitude of small, individual ACLs in reef fish complexes. Other councils, including those in the Caribbean and South Atlantic regions, have removed non-target or rarely caught stocks from management units and reclassified them as ecosystem component species, or in some cases have delegated management responsibility to state agencies, to focus their efforts on stocks for which there are active federal fisheries.

Given the limited resources for stock assessments and the large number of managed stocks in the United States exclusive economic zone (EEZ), data availability and scientific uncertainty will always be a challenge. While managers and scientists continue to develop and refine data-poor methods, progress in managing data-poor stocks is also the product of leveraging existing information and clarifying tradeoffs in the face of high uncertainty.

*Characterizing and Responding to Management Uncertainty*

The requirement to adhere to ACLs and utilize accountability measures has elevated the role of management uncertainty as metric for management success. Improving management certainty, like improving scientific certainty, takes considerable time and resources and is a stepwise, longer-term goal. Councils have made significant progress in recognizing and accounting for management uncertainty within their specifications processes. Strategies include the use of ACTs, buffers to account for bycatch and differences between observed and reported landings, adjustments to bag limits and seasons in recreational fisheries, and payback mechanisms to subtract ACL overages from the subsequent fishing year.

Councils have also drawn on the expertise of their management partners to help characterize and respond to management uncertainty. For example, the MAFMC relies on the expertise of its Species Monitoring Committees to develop ACT control rules and provide recommendations to the Council on ACTs and other management measures to ensure adherence to catch limits. Likewise, the Gulf of Mexico Fishery Management Council (GMFMC) employs its Socioeconomic Committee to help set ACT buffers and provide analysis of the social and economic impacts of potential ACT buffers. The Western Pacific Fishery Management Council (WPFMC) established a

Social, Economic, Ecological, and Management (SEEM) Working Group, which scores a series of factors, including management uncertainty, and recommends percentage reductions from the ABC and ACL during their specifications process.

*Building on Relationships, Processes, and Tools*

Risk policy discussions to date have tended to focus on specifying acceptable probabilities of overfishing without explicit consideration of the social, economic, ecological, and biological tradeoffs surrounding those decisions. As councils embrace this second phase in risk policy and move toward a broader perspective on risk, managers can learn from the innovative ways councils have already begun to structure, consider, and communicate risk.

Councils have developed a number of tools to evaluate tradeoffs, structure decisions, and communicate about the consequences of risk. For example, the NEFMC employs an innovative approach to manage its scallop fishery. The Council's SSC and Scallop Plan Development Team present managers with a decision table that illustrates the potential tradeoffs in yield that correspond to different P* choices. This approach allows the Council to incorporate precaution in response to uncertainty while also optimizing yield in this high-value fishery. Similarly, the NPFMC's SSC and Crab Plan Team examined the economic tradeoffs in forgone yield associated with setting ABCs for crab, evaluating how small changes in the P* applied during the specifications process could have significant impacts on revenue. While the scallop and crab fisheries are high value, data-rich fisheries, councils have also developed tools to support the specification of catch limits for stocks in their most data-limited fisheries. The SAFMC and their SSC employ a decision tree, consisting of a set of questions regarding the characteristics and trends for a particular stock, which guides the case-by-case evaluation of OFL and ABC recommendations for their data-poor stocks.

In addition to developing tools, councils have adopted processes to guide risk considerations and catch level recommendations in a systematic way. The WPFMC established the SEEM Working Group, comprised of social scientists, economists, Council staff, and fishers to evaluate region-specific considerations to inform the Council's selection of management buffers when specifying ACTs. The GMFMC relies on guidance from its ABC Control Rule Working Group to support the application and refinement of its ABC control rules. Consisting of a Council member, SSC members, and NMFS staff, the Working Group supports the Council and SSC in the review and refinement of their control rule.

Central to the tools and processes described above are the relationships that support them. Councils rely on the input and expertise of their management partners and advisors at almost every step in the management process. Leveraging these relationships to explore tradeoffs and evaluate the implications of different risk approaches will continue to be an important part of this collaborative and ongoing process.

## NORTH PACIFIC FISHERY MANAGEMENT COUNCIL

The North Pacific Fishery Management Council (NPFMC) oversees six fishery management plans, including Bering Sea/Aleutian Islands (BSAI) Groundfish, Gulf of Alaska Groundfish, BSAI Crabs, Sea Scallops, Alaska Salmon, and the Arctic. The NPFMC uses a tiered system to set ABCs that incorporate either a probabilistic (P*) approach or a fixed buffer below the OFL for both groundfish plans and the crab plan, and a fixed buffer approach for scallops. At present, the BSAI Crab, Alaska Salmon, and Sea Scallop FMPs defer authority to the state of Alaska to set precautionary guideline harvest levels (GHLs) or total allowable catches (TACs), but the Council ensures that these levels are within ACLs and OFLs. Alaskan salmon and Pacific halibut are exempt from specifications because they are managed by the state of Alaska and the Pacific Salmon Treaty and the Pacific Halibut Commission, respectively. The operating framework for setting crab and scallop ABCs and groundfish TACs is applied on an annual basis as described below:

Overfishing Limit (OFL) $\geq$ Acceptable Biological Catch (ABC)

ABC = Annual Catch Limit (ACL)

ACL $\geq$ Annual Catch Target (ACT)

$\geq$ Total Allowable Catch (TAC) or Guideline Harvest Level (GHL)

The NPFMC uses TACs for both groundfish FMPs as catch targets, like ACTs. ABC levels are specified by the SSC based on Plan Team review and other input prior to adoption by the Council. TACs are set equal to ACLs or adjusted downward by the Council for conservation, bycatch, social, economic, and other considerations.

**Scientific Uncertainty**

The SSC examines multiple sources of scientific uncertainty in the ABC specification process, including observation error and other "within" assessment uncertainty sources, errors in proxy definition, parameterization errors in models, choice of methodology for assessments, and choice of which assessment data to include or omit. The North Pacific SSC acknowledges that estimates of "within" model uncertainty do not fully capture the true extent of scientific uncertainty associated with stock status. As a result, it incorporates considerations of additional uncertainties such as errors in estimating $F_{MSY}$ or $B_{MSY}$ or their proxies, parameterization estimation errors for such factors as the catchability quotient (q), and choice of appropriate assessment methodologies. Sigma ($\sigma$), a random variable used as a proxy to represent scientific uncertainty, accounts for all these sources of scientific uncertainty under the P* approach used for crab stock specifications in the North Pacific. The SSC and Plan Teams continue to assess methods for characterizing scientific uncertainty in OFL calculations.

Specifications in the North Pacific region are supported by expertise from the Alaska Fisheries Science Center (AFSC). The frequency of stock assessments and the extensive review process adds scientific rigor to advice provided for fisheries management in the North Pacific region. Further, this enhances the ability of the SSC to account for scientific uncertainty within the stock assessment models and trends in recruitment or other population parameters in a timely manner.

The Council has also been proactive in establishing ABCs for non-target species, such as sharks, skates, and octopus to ensure that potential fisheries development occurs based on sound information and data collection programs.

**Six-Tiered Approach**

The North Pacific Council employs a six-tiered approach to setting ABCs for the groundfish fisheries; each tier corresponds to the level of information available for a particular stock. ACLs are set equal to ABCs in the North Pacific region. The SSC establishes $B_{MSY}$ or a proxy for current biomass, calculates a fishing mortality rate (F) associated with the ABC ($F_{ABC}$) on the basis of assessment information, and sets a buffer to capture scientific uncertainty from its proxy modeling. These calculations are capped by overfishing proxies based on biomass levels and stock status. For a stock to be categorized in a tier, there must be specific information available to inform its stock status, as summarized below:

Tier 1: Require reliable point estimates of B, $B_{MSY}$, and PDF of MSY;
- 1a) $F_{ABC} \leq$ the harmonic mean of the probability distribution function (PDF)
- 1b) $F_{ABC} \leq$ the harmonic mean of the PDF x stock biomass estimate
- 1c) $F_{ABC} = 0$

Tier 2: Require reliable point estimates of B, $B_{MSY}$, $F_{MSY}$, $F_{35\%}$, and $F_{40\%}$;
- 2a) $F_{ABC} \leq F_{MSY}$ x estimated fishing mortality
- 2b) $F_{ABC} \leq F_{MSY}$ x estimated fishing mortality x stock biomass estimate
- 2c) $F_{ABC} = 0$

Tier 3: Require reliable point estimates of B, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$;
- 3a) $F_{ABC} \leq F_{40\%}$
- 3b) $F_{ABC} \leq F_{40\%}$ x stock biomass estimate
- 3c) $F_{ABC} = 0$

Tier 4: Require reliable point estimates of B, $F_{35\%}$, and $F_{40\%}$; $F_{ABC} = \leq F_{40\%}$

Tier 5: Require reliable point estimates of B and M; $F_{ABC} = 0.75$ x M

Tier 6: Require reliable catch history from 1978 to 1995; ABC = 0.75 x OFL

The maximum ABC derived from the formula in the tier system can be further adjusted downward by the SSC to account for additional unquantifiable uncertainty; the guidelines above represented maxima in each tier. Operationally, the Groundfish Plan Team provides input on OFLs and ABCs on a species-by-species basis. The SSC reviews these recommendations to create Council options for additional buffers from OFLs to ABCs.

**TAC Specification Tradeoffs**

In contrast to the six-tiered approach used for groundfish specification, crab stocks in tiers 1–3 utilize a P* approach that is adjusted on an *ad hoc* basis for individual stocks. Operationally, use of the P* approach results in setting ABCs equal to OFLs for most stocks, or provides a larger buffer

as desired by the Council. Sigma is a variable used in the P* approach to account for sources of scientific uncertainty; by informing P* values, sigma adjusts the ABC downward from the OFL. In 2011, the North Pacific SSC and Crab Plan Team spent considerable effort examining the tradeoffs of forgone yield in terms of discounted revenues and net present values inherent in setting annual ABCs for crab (Punt et al. 2012). The NPFMC was provided a full decision analysis of the crab fishery centered on both components of risk: probability and potential consequences of overfishing. While many councils utilize a P* approach to quantify the probability of overfishing, the analysts looked at how small changes in P* values could potentially have large consequences for fishery revenue by leaving harvestable crab in the ocean.

Punt et al. (2011) discovered that the economic benefits of managing for stability in long-term catches are not fully offset by the short-term costs of reductions in P* values (and thus, revenue) due to discounting for Alaskan crab. This academic study highlights a method to incorporate and quantify potential dollar losses to a fishery due to a particular P* choice during the ACL/TAC specification process that can be employed for many fisheries.

**Management Uncertainty and Accountability Measures**

Given the high level of management certainty in North Pacific fisheries, NPFMC does not include additional buffers below the established TACs. TACs are used by NMFS in-season managers as catch limits and also serve as real-time accountability measures, which are only rarely exceeded (and in most cases when exceeded, catches remain below the ABCs and well below OFL). Comprehensive at-sea observer coverage, near real-time electronic catch monitoring systems, partial and total fishery closures, and other in-season measures all contribute to the region's management certainty. For example, crab stocks are managed with a federal catch-shares program, and fishery closures are utilized if catch nears the TAC in a fishing season, without regard for individual carryovers. The scallop fishery, on the other hand, operates as a voluntary catch-shares program. This fishery in the North Pacific is for weathervane scallops only, and the state of Alaska oversees implementation of the 100% voluntary observer coverage, catch reporting, and shutdown of subareas when catch is projected to reach the GHL in a fishing season. As a result, the scallop ABC is set at 90% of the OFL; the Council does not anticipate establishing an additional buffer between the ABC and the OFL for these stocks. The use of state-set GHLs and AMs also provides support for a 10% carryover provision currently in place for the sablefish and halibut fisheries.

**Continuing Challenges**

Scientists involved in North Pacific fisheries management are working on evaluating the current groundfish ABC specification process through management strategy evaluations (MSEs). MSEs are an effective way to develop robust practices that prevent overfishing while achieving optimum yield. Additional MSE efforts in the region include evaluating the impact of bycatch species and the probability of exceeding a set ACL.

## PACIFIC FISHERY MANAGEMENT COUNCIL

The Pacific Fishery Management Council (PFMC) administers four FMPs: Coastal Pelagic Species (CPS), Highly Migratory Species (HMS), Groundfish, and Salmon. For stocks within the Groundfish and CPS FMPs, a P* approach is used to determine ABCs during the ACL specification process. HMS stocks are exempted from ACL specification because they are managed by international fisheries management organizations, such as the Inter-American Tropical Tuna Commission (IATTC). Management of salmon in the Pacific is complex; salmon have unique life histories and are also subject to management under international and tribal treaties. As a result, salmon runs in the Pacific region are co-managed by the Council, Pacific Northwest tribes, the Pacific Salmon Commission, and the states of Washington, Oregon, and California. Although most salmon runs are exempt from ACL specification, the Council still determines catch limits for these stocks. Given the challenges associated with managing such diverse stocks, the PFMC utilizes different approaches for specifying catch limits and quotas across their FMPs. The PFMC and SSC have made significant advances in identifying, quantifying, and incorporating scientific uncertainty into the establishment of ACLs for non-exempted stocks under their jurisdiction, especially for stocks within the Groundfish FMP.

**Scientific Uncertainty**

The SSC incorporates scientific uncertainty buffers between the OFL and the ABC according to the tiered-classification system for species in the Groundfish FMP as described in the next section. The variable sigma ($\sigma$) is used to characterize estimates of scientific uncertainty and is applied along with P* to an OFL distribution to determine a buffer from OFL to ABC. The SSC's selection of sigma adjusts the OFL downward to account for scientific uncertainty: the greater the uncertainty, the larger the buffer from OFL to ABC. The default sigma for data-rich stocks has been set using a meta-analytical approach that looks at variability in biomass estimates across assessments and at assessment model uncertainty such as data limitations, model uncertainty, parameterization error, and assessor bias (Ralston et al. 2011). For data-poor stocks, scientific uncertainty is difficult to characterize, and OFLs are set by applying limits of fishing mortality estimates (F) to proxies of MSY on the basis of "catch-only" methods described in MacCall (2010), Dick and MacCall (2011), and Cope (2012). In practice, the SSC sets a sigma value for stocks in Tier 1, and uses a two- and four-fold increase to assign sigma values to stocks in Tier 2 and Tier 3, respectively.

The Northwest and Southwest Fisheries Science Centers and state fisheries management agencies provide stock assessments to the Pacific Council that help inform specification of catch limits. New and updated stock assessments can provide additional data on stock status and biomass reference points to support management. However, they do not necessarily improve the certainty around those estimates: measures of scientific uncertainty may actually increase in response to new assessments.

**Three-Tiered Approach**

The Pacific Council employs a three-tiered approach for the Groundfish FMP harvest specifications process on the basis of level and type of information available. Stocks in Tier 1 are considered data-rich, whereas stocks in Tiers 2 and 3 are increasingly data-poor. Groundfish stocks that are most commonly targeted tend to fall into Tiers 1 and 2; the remaining stocks, representing

the majority of the 90-plus managed groundfish species, fall into Tier 3. In addition to application of the sigma variable described above, stocks are assigned either a P* value or a straight reduction from the OFL. A summary of the Pacific Council's ABC control rules under the three-tiered approach is provided below:

Tier 1: data-rich stocks; Council specifies a P* based on SSC input, maximum P* is 0.45

Tier 2: less data reliability; Council chooses P* or straight reduction from OFL

Tier 3: data-poor stocks; Council chooses P* or straight reduction from OFL

Before passage of Amendment 23 for the Groundfish FMP in 2012, ABCs were set on the basis of straight reductions of 25%, 50%, and 75% from the OFL for the above three tiers, respectively. The inclusion of the sigma variable accounts for differences in scientific uncertainty across tiers (previously characterized by the different percentage reductions above), and the Council selects P* values based on their preferred level of risk tolerance. With a few exceptions, the Council has the flexibility to choose a P* on a stock-by-stock basis within each tier but is exploring application of a single P* value for each tier. The default maximum P* is set at 0.45, though the Council can adopt more conservative values. For example, at the June 2012 PFMC meeting, the Council adopted precautionary P* values of 0.4 for sablefish to improve chances that sablefish abundance would increase over the short term, and 0.3 for spiny dogfish because the $F_{MSY}$ proxy for dogfish was flagged as inappropriate for the species' life history.

Sigma and P* values are applied during the Council's biennial harvest specifications process. With the establishment of the P*-based ABC control rule, the SSC recommends default sigma values of 0.36 for Tier 1, 0.72 for Tier 2, and 1.44 for Tier 3. The default sigma can be overridden by species-specific sigma estimates if they exceed the default value. For example, a sigma value of 0.41 instead of 0.36 was used for Widow rockfish for the 2013–2014 ABC specification. The Council decided under its preferred ABCs for 2011–2014 to use the P* approach for stocks in Tiers 1–3. To assist the Council in choosing the appropriate buffer for all tiers, the SSC provided a table that maps potential P* values to corresponding buffer fractions from OFL to ABC. The Council can then determine its preferred level of risk and use the table to select the appropriate buffer and calculate the ABC for the stock.

**40:10 / 25:5 Harvest Control Rules**

The Pacific Council employs two harvest control rules for the explicit purpose of quickly rebuilding stocks managed under the Groundfish FMP to biomass levels that support MSY. The 40:10 and 25:5 ABC harvest control rules are applied independently of OFL to ABC buffers so that scientific uncertainty is separated. These strategies are typically used when a stock's biomass is below the proxy $B_{MSY}$ value but above the minimum stock size threshold (MSST) set by the Council. The 40:10 rule applies to all groundfish stocks in the FMP except flatfish, which are instead managed with the 25:5 control rule. The "40" and "25" refer to their respective proxy $B_{MSY}$ values of $B_{40\%}$ and $B_{25\%}$, or 40% and 25% of unfished biomass, respectively. Before 2011, all groundfish were managed to $B_{40\%}$. The flatfish proxy $B_{MSY}$ was revised in response to the 2009 petrale sole assessment and further consideration of flatfish life history characteristics. The 40:10

and 25:5 control rules reduce the ACL relative to the ABC if a groundfish stock's biomass drops below $B_{MSY}$ levels, with the purpose of returning the stock to $B_{MSY}$ more quickly. The reduction becomes progressively larger as biomass drops towards the MSST.

**Management Uncertainty and Accountability Measures**
Conservation concerns and management uncertainty considerations are blended together on a flexible, ad hoc basis during the ACL specification process. To ensure ACLs are not exceeded, the Council employs a suite of measures, including additional buffers below the ACL, reductions in bag limits for the recreational sector, depth closures, monthly fishing opportunity allocations, and other time or area closures. There is significant management certainty in the region's groundfish fishery as a result of reporting requirements and 100% observer coverage required under the groundfish ITQ program. While AMs are triggered if an ACL is overshot more than once in four years, the Council is proactive in avoiding ACL overages and responds to overages even within a single year. AMs for PFMC fisheries include seasonal, gear, and fishery closures; increased monitoring; and ACL-overage reductions from future ACLs.

**Continuing Challenges**
The PFMC continues to struggle with the difficult task of setting ACLs for stock complexes that include species of varying life histories and updating assessments for the 90-plus stocks within its Groundfish FMP. The Council and SSC continue to investigate the challenges of managing multispecies fisheries and hope that revisions to the NS1 guidelines will provide direction. The PFMC is also seeking approval from NMFS for a 10% carryover provision for its sablefish fishery to provide additional flexibility and management certainty. The Council and SSC are still discussing whether the sigma and P* values provide the appropriate amount of precaution; some view them as too precautionary, while others view them as insufficiently precautionary. Without a clear process for reconsideration of these buffers, the Council is interested in exploring a more coherent risk framework that incorporates more specific examination of consequences. Finally, the Pacific Council is working on how to deal with the challenging consequences of rebuilding long-lived rockfish stocks as mandated under the MSRA; the Council would benefit from additional guidance on how to weigh social and economic factors with the directive to rebuild as quickly as possible.

## WESTERN PACIFIC FISHERY MANAGEMENT COUNCIL

The Western Pacific Fishery Management Council (WPFMC) administers four area-based Fishery Ecosystem Plans (FEPs): Hawaii, Marianas (which includes Guam and the Commonwealth of the Northern Mariana Islands [CNMI]), American Samoa, and the Pacific Remote Island Areas (PRIAs). The WPFMC utilizes an area-specific approach to management with ecosystem boundaries defined by the exclusive economic zones (EEZs) of the island areas under its jurisdiction. This arrangement is intended to reflect the biological isolation of the island regions and the social, cultural, and biological differences of each region. The Council also manages pelagic fisheries through the Pelagics FEP; this FEP is not archipelago specific and covers the entire Western Pacific Region. The four archipelagic FEPs encompass multiple types of species, including precious corals, bottomfish, groundfish, reef fish, and crustaceans; the Pelagics FEP includes tunas, billfish, and other open-ocean species.

The Council uses a qualitative, risk-based approach to establishing the OFL, ABC, ACL, and ACT values for managed stocks. The WPFMC establishes ACLs for all stocks, except those managed under the Pelagics FEP that are exempt from the ACL requirement because they are subject to international management or have an annual life cycle. The Western and Central Pacific Fishery Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC) are responsible for managing pelagic stocks with ACL exemptions.

**Scientific Uncertainty**
Given the large number of data-poor and unassessed stocks, scientific uncertainty associated with WPFMC-managed fisheries is significant. The region has a biennial bottomfish stock assessment cycle that alternates assessments between Hawaii and the other islands; currently, only two or three stocks are assessed in each cycle. For unassessed stocks, WPFMC often relies on catch data to establish ACLs. Where catch data are not comprehensive, catch estimates are based on raising small survey sample sizes to account for the entire fishery and thus introduce error around point estimates of total catch. The Council has adopted conservative risk policies to deal with significant scientific and management uncertainties. For example, it recommended and NMFS imposed a total moratorium on the harvest of gold coral given high uncertainty associated with its age and growth.

**Five-Tiered Strategy**
The Western Pacific SSC adopted a five-tiered system as an overarching approach to derive OFLs and ABCs on the basis of the South Atlantic Council's model. As the tier increases, the level of information available for ABC determinations decreases, and the buffer between OFL and ABC increases as a result. The five-tiered specifications approach is as follows:

> Tiers 1 and 2: ABC = P* percentile of the probability distribution of OFL x OFL
>
> Tier 3: ABCs are determined on the basis of catch-only methods such as depletion-corrected average catch (DCAC), stock reduction analysis (SRA), or biomass-based surplus production models that incorporate estimates of stock resilience
>
> Tier 4: ABC = 0.70 x $F_{MSY}$

Tier 5: Three potential scenarios to choose from based on stock status:
ABC = 1.0 x median catch if biomass is > $B_{MSY}$
ABC = 0.67 x median catch if biomass is < $B_{MSY}$ but > MSST (Minimum Stock Size Threshold)
ABC = 0.33 x median catch if biomass is < MSST (considered overfished)

For stocks in Tiers 1, 2, and 3 that have data and associated biological reference points such as MSY estimates or proxies to support such determinations, the Council seeks SSC advice on risk levels and scientific uncertainty to be incorporated into ABC calculations. The P* approach can only be applied to stocks in Tiers 1 and 2, and the SSC qualitatively (and quantitatively, where possible) evaluates assessment quality, scientific uncertainty, stock status, and vulnerability/susceptibility analysis for stocks to present a range of potential P* values for the Council's consideration. The stocks in Hawaii's "Deep Seven" bottomfish complex fall into Tiers 1 and 2 and currently utilize the P* approach. The Deep Seven species complex is very culturally important in Hawaii and is significantly more data rich than other fish stocks. The P* approach was applied to bottomfish stock complexes in American Samoa, Guam, and CNMI on the basis of a new assessment completed in 2012.

Tier 4 applies to stocks for which MSY has been calculated but there are no active fisheries. For these stocks, such as unharvested crustaceans and precious corals, ABC is set at 0.70 $F_{MSY}$. Tier 5 stocks are the most data-poor, and therefore managers rely on long-term catch data, where available, to make harvest determinations.

For reef fish stocks throughout the region, the SSC relies on catch data and applies the Tier 5 control rule to inform ABC decisions. Due to the high number of reef fish species in the region, ACLs are set for family groupings rather than on a species-by-species basis. This approach offers a practical solution for the Western Pacific region as approximately 20 reef fish families account for 99% of total finfish catch in each island area.

**Management Uncertainty**
The Western Pacific region has a high degree of management uncertainty. Hawaii's Deep Seven bottom complex is the only fishery with a well-developed, reliable catch reporting system in place. The Council proposed mandatory catch accounting and reporting requirements for all fisheries in 2010; however, the resources to support this proposal are lacking.

The Council and SSC rely on three options for translating the ABC determinations into ACLs. These options incorporate buffers for management uncertainty and can also take additional factors into account through Social, Economic, Ecological, and Management (SEEM) analysis (described below).

1. ACL = ABC as reduced by SEEM analysis
2. ACL = ABC as reduced by a percentage buffer on the sole basis of management uncertainty
3. ACL = ABC as reduced by SEEM Analysis; ACT established below ACL

Hawaii's Deep Seven complex is the only fishery with sufficient information to support SEEM analysis, using Option 3. For all other stocks, the Council reviews the SSC's ABC choice for each stock, then recommends an ACL while taking into account management uncertainty as described in Option 2.

**SEEM Analysis**
During the 2011 specifications process, the Council established a framework to explicitly consider social and economic input during ACL specification for the Deep Seven complex. They established a Social, Economic, Ecological, and Management (SEEM) Working Group, comprised of social scientists, economists, Council staff, and fishers to evaluate region-specific considerations in specifying ACTs lower than ACLs. During SEEM analysis, a dozen Working Group members individually scored, on a scale of -2 to 2, specific factors in each consideration such as a stock's symbolic/cultural importance and the financial security of and number of fishers engaged in a fishery. The averaged results of the SEEM analysis were vetted through the SSC and presented to the Council. After finding positive scores for social, economic, and ecological considerations, but a negative score for the management uncertainty component, the Working Group recommended and the Council adopted a precautionary 6% reduction of the ACL to an ACT for the Deep Seven stock complex during the 2012–2013 specification cycle.

**Accountability Measures**
The Hawaiian Deep Seven complex is the only fishery with sufficient information to support in-season AMs. Other fisheries rely on post-season AMs. Specifically, if a fishery exceeds its ACL in a fishing year, the Council must correct the operational issue that caused the ACL overage. This may include a recommendation that NMFS implement a downward adjustment to the ACL in the subsequent fishing year, or other measures as appropriate.

**Continuing Challenges**
The WPFMC and the SSC share significant trust and cooperation, which is partly due to the long tenure of many of the Council staff and Council members and the collaborative effort of establishing the region's first catch limits. The majority of fishing in the region occurs for subsistence purposes and is conducted by small-scale "lifestyle" fishers. Fish stocks in the Western Pacific historically have not been managed on the basis of enforceable catch limits (with the notable exception of spiny lobster and precious corals); it remains to be seen how fishers will react to the Council's new catch limits now in place for the first time for many stocks. The Council is still examining, with its SSC and SEEM Working Group, the appropriateness of only allowing downward adjustments of ACLs to ACTs despite the significant social and economic importance of the Deep Seven fishery.

Setting catch limits for data-poor stocks is an ongoing challenge, given the large number of managed stocks and limited stock assessment resources. The five FEPs were established to take an ecosystem approach to management and thus include hundreds of species, some of which are not presently harvested. The Council, with the support and advice of the SSC, could remove species from the FEPs that are not currently "in the fishery" or reclassify them as "ecosystem component" stocks within the FEP (for which an ACL is not required).

## GULF OF MEXICO FISHERY MANAGEMENT COUNCIL

The Gulf of Mexico Fishery Management Council (GMFMC) administers seven FMPs: Aquaculture, Spiny Lobster, Reef Fish, Shrimp, Migratory Pelagics, Corals and Red Drum. The GMFMC has taken a proactive step in establishing its Aquaculture FMP before any aquaculture development in the region's EEZ. The Gulf and South Atlantic Councils cooperate to manage joint FMPs for Corals, Migratory Pelagics, and Spiny Lobster. Recently, several GMFMC FMPs have been updated to remove management of certain stocks to better coordinate co-managed FMPs, allow for state management of certain species, and enable the Council to focus more fully on its active fisheries. The GMFMC applies a flexible tiered-approach control rule on basis of the amount of available data.

**Scientific Uncertainty**
The GMFMC explicitly addresses scientific uncertainty by setting the ABC below the OFL as usually determined by an ABC control rule. Stocks in Tier 1 of the current ABC control rule rely on SSC expert judgment and use of a spreadsheet for stock categorization to address scientific uncertainty as described in the three-tiered approach section. For the remaining tiers, the Council largely relies on SSC expert opinion, subject to Council approval, to capture varying degrees of risk and scientific uncertainty. The Council recognizes that its current approach is not inclusive of both probability and potential impacts of overfishing, and is in the process of revising its ABC control rule. An ABC Control Rule Working Group seeks to address the issue of explicitly dealing with risk and uncertainty through a straightforward and transparent process supported by Council members, the SSC, Council staff, and stakeholders alike.

**Process for Developing and Revising ABC Control Rule**
In 2009, the GMFMC formed the ABC Control Rule Working Group, which consists of a Council member, SSC members, and NMFS staff, to develop a decision-making framework that would assess scientific uncertainty and appropriate P* levels for its specifications process. The ABC control rule resulting from that process was adopted in 2012. The Working Group makes recommendations to the SSC on the appropriate approaches to use. Informed by the Working Group's recommendation and SSC expert judgment, the SSC makes recommendations to the Council on specific revisions to the ABC control rule. Given that the Council has not explicitly articulated its risk preference, the Council, along with the Working Group and SSC, continues to re-visit appropriate P* values for specifying ABCs and revising methods for setting ABCs for data-poor stocks where a P* approach cannot be applied. The Control Rule Working Group is in the process of discussing and developing species-specific risk levels that incorporate the costs (e.g., forgone yield, overfishing a stock) of different management approaches on an ad hoc basis; to date no standardized procedure is in place to incorporate these considerations.

**Three-Tiered Approach**
The ABC Control Rule Working Group looked at frameworks from other regions and decided, like the Western Pacific Council, to model its specifications approach after that of the South Atlantic Council. They adopted a framework that employs a series of dimensions and tiers based on the level of information available to quantify scientific uncertainty and establish appropriate buffers between OFLs and ABCs. For Tier 1, the most data-rich tier, the Council has delegated the setting

of the P* value within a range of 0.30 to 0.50 to the SSC. The remaining tiers have default risk levels, but the Council may choose to adopt a higher or lower level of risk on a case-by-case basis. The current default ABC control rules are provided below.

> Tier 1: ABC = yield at P*; 0.30 </= P* </= 0.50; P* is determined by a spreadsheet that is used by the SSC to evaluate elements of uncertainty within stock assessments.
>
> Tier 2: ABC = yield at P* of 0.30 as a default. Council may choose to substitute a P* of 0.40 or 0.50 on the basis of available information. Assessments do not provide an estimate of MSY or its proxy but instead provide a measure of OFL based on alternative methodology.
>
> Tier 3a: ABC = mean landings + 1 Standard Deviation as default. Council may choose to substitute the mean of recent landings, or 0.5 or 1.5 standard deviations above mean landings on the basis of the time series of data. This tier is used when landings data, but no assessment, are available, and if the expert opinion of the SSC suggests the stock is unlikely to undergo overfishing.
>
> Tier 3b: ABC = 75% of OFL as default, where OFL = mean landings; based on expert judgment of landings data. Council may choose to substitute multipliers of 65%, 85%, or 100% of OFL. This tier is used when landings data but no assessment is available, and if the expert opinion of the SSC suggests recent landings may be unsustainable.

For data-rich species in Tier 1, the control rule considers the type of assessment (biomass, proxies, etc.), within-model uncertainty, past performance of models, and bias of previous assessors. These considerations are used to determine a specific P* that falls within the specified range of 0.30 to 0.50. For stocks in Tier 2, the framework incorporates reliability of catch history and data-poor methods such as scalar and natural mortality approaches, depletion-corrected average catch (DCAC), and depletion-based stock reduction analysis (DB-SRA) into the specification of OFLs and recommendation of ABCs as described in Berkson et al. (2011). For stocks in Tier 3, the specification of OFL and recommendation of ABC is based on mean recent landings multiplied by a scalar. The decision about whether to use a less risk-averse approach (Tier 3a) or a more risk-averse approach (Tier 3b) relies heavily on the expertise and judgment of the SSC.

Within this control rule framework, the Gulf Council is making some adjustments to address the complexity and implementation challenges posed by the original approach. (For example, Tier 2 has been judged unsatisfactory in its current form by the SSC and Council and remains unused.) The Council recently adopted a motion to replace the methods for determining P* in Tiers 1 and 2 with an approach that assigns stocks to “bins” that are assigned fixed P* values on the basis of the status of the stock, presence of a rebuilding plan, productivity and resilience, and desirability of the stock to fishers.

**Management Uncertainty**

Management uncertainty in the Gulf of Mexico stems largely from difficulties in monitoring the large number of vessels that participate in the commercial fishery and from accounting for the significant recreational catch and effort that occurs over a large geographic region. To account for

management uncertainty in their specifications process, the Gulf Council employs an ACL/ACT control rule for data-adequate stocks and also relies on input from the long-standing Socioeconomic Committee to help set ACT buffers. This committee is tasked with providing analysis on economic and social impacts of potential ACT decisions at the back end of the specifications process. At the Fourth National SSC Workshop in Williamsburg, Virginia, participants expressed interest in incorporating such expertise earlier in the ACL/ACT specification process.

In 2012, the Gulf Council adopted a decision table-based ACL/ACT control rule as an optional tool to aid the Council during the specifications process. The control rule's spreadsheet format provides guidance to the Council when addressing management uncertainty and determining appropriate reductions in ACLs to yield ACTs. When an ACT is used, the ACL is typically set equal to ABC. When an ACT is not used, the control rules can also guide the Council in determining appropriate reductions in ABCs to yield ACLs. The ACL/ACT control rule relies on objective measures of management success, including the history of exceeded catch limits, the precision of landings data, whether the ACL applies to a single stock or a complex, and the status of the stock. Buffers resulting from the application of the control rule are typically 15% to 20% for non-ITQ managed fisheries. ITQ fisheries have stricter monitoring and reporting requirements, resulting in less management uncertainty, and thus are typically assigned buffers between 0% and 5%.

When the ACL or ACT is divided into commercial and recreational sector allocations, the control rule is applied to each sector individually. For example, in 2012, the commercial greater amberjack ACT was set 15% below the ACL, whereas the recreational greater amberjack ACT was set 13% below the ACL. Both sectors had experienced harvest overages in recent years, but the magnitude of the overages in the different sectors warranted the use of different buffers.

**Continuing Challenges**

The Gulf Council struggles with the frequency with which its stocks are assessed by the Southeast Data, Assessment, and Review (SEDAR) Team, especially for the majority of its 60-plus reef fish stocks classified as data-poor. Compounding this struggle is the fact that the Gulf, Caribbean, and South Atlantic Councils all rely on the region's limited resources to conduct requested stock assessments. Adhering to ACLs and applying AMs continues to be a challenge given the high management uncertainty in the Gulf's large recreational fisheries.

The Council is grappling with clearly incorporating risk and uncertainty into its specifications process and rectifying how these considerations affect the competing NS1 objectives of achieving OY while preventing overfishing. In particular, the Gulf Council is working toward explicitly noting tradeoffs associated with adopting specific P* values or other measures of acceptable risk for some fisheries. The ongoing discussions among the Council, SSC, and ABC Control Rule Working Group are valuable to helping the Gulf region address these challenges and refine its risk policy.

## CARIBBEAN FISHERY MANAGEMENT COUNCIL

The Caribbean Fishery Management Council (CFMC) administers FMPs for Shallow Water Reef Fish, Spiny Lobster, Coral, and Queen Conch. The region is uniquely challenged given the lack of quantitative stock assessments, basic life history data, and information regarding stock status for the majority of managed species. Given these challenges, the Caribbean region uses a qualitative approach to dealing with uncertainty and managing risk.

**Scientific and Management Uncertainty**
Lack of scientific information, catch accounting, and diffuse effort across the islands produces significant scientific and management uncertainty in the U.S. Caribbean. The region is also comprised of distinct island regions: the fishing cultures, management realities, and levels of information availability vary greatly among the four U.S. Caribbean islands. In recognition of these differences and to avoid managing to the lowest common denominator of data availability and stock status when specifying ACLs, the Council sub-divided the U.S. Caribbean EEZ into island-based components (St. Croix, St. Thomas/St. John, and Puerto Rico) and specifies ACLs separately based on that island's historical fishing activity.

In the absence of sufficient information about recreational and commercial effort or landings to set scientific and management uncertainty buffers separately, a constant blended buffer approach is applied during the ACL specifications process. The SSC sets OFLs equal to an MSY proxy, which generally reflects average annual catch by species and island group. Then, the Council and SSC utilize expert judgment to reduce the OFL/ABC to an ACL based on an estimate of combined scientific and management uncertainty. Because managers do not have complete estimates of recreational or commercial catch, they use recent catch as a proxy for reference points comes at the cost of high levels of uncertainty. The United States Virgin Islands (USVI), for example, lacks any estimates of recreational catch. Differences in the scale (family groups versus species), consistency, completeness, and reliability of catch reporting across the USVI (St. Croix, St. John, St. Thomas) and Puerto Rico add additional uncertainty about the accuracy and validity of the existing data used to inform ABCs.

In Puerto Rico, expansion factors are applied to landings data to account for underreporting and non-reporting of catch. The expanded landings data provide estimates of annual catch, which serve as MSY proxies. To support the Council's 2011 ACL amendment, only reliable catch stocks (ORCS) methods were applied to scale these MSY proxies and determine OFL values (Berkson et al. 2011). The resulting scalar was 1.0 for all stocks; thus, the OFL was set equal to the MSY proxy for Puerto Rico's fisheries. This was the first time that ORCS methods have been used by CFMC; the Council will modify these methods for future application on the basis of the their initial experience. In the USVI, reported landings are used to determine MSY proxies directly. The Council sets ABCs equal to OFL for most stocks and accounts for the uncertainty associated with the use of landings data when specifying ACLs as described below. Although scientific and management uncertainty is high for many fisheries in the region, reductions from recent catch levels are likely to remain modest given the important social and economic role fisheries play in the survival of Caribbean communities.

**Eight-Scenario Model**
The SSC relies on the national eight-scenario model that corresponds to data availability for any stock or stock complex to set OFLs. Each scenario specifies whether the calculation of an OFL is possible and includes management advice corresponding with information availability. In the Caribbean, all stocks currently fall into scenarios 7 and 8, the most data-poor scenarios. As a result, the SSC does not calculate OFLs, ABCs, or ACLs directly for these stocks; rather MSY proxies are used to determine appropriate OFLs. For example, the SSC set OFLs for parrotfish and queen conch on the basis of expert judgment and utilized average landings to set OFLs for the snapper-grouper complex. Similarly, for stocks not judged to be undergoing overfishing, average landings over time are used as proxies of MSY to set OFL levels. Recently, ORCS methods have been utilized to establish proxies of recent catch to inform ABCs. The Council established a Risk Assessment Team to help implement and incorporate these data-poor methods into the specifications process.

**ACL Specification**
In general, ABCs are set equal to OFLs; where ABCs are not specified, the Council bases its specification of ACLs on the OFL. During the ACL specifications process, the CFMC applies a straight percentage reduction of OFLs or ABCs to set ACLs for stocks based on expert judgment from the Council, SSC, Southeast Fisheries Science Center (SEFSC), and local experts. This buffer accounts for a blend of scientific and management uncertainty, conservation, and optimum yield (OY) considerations. The Council selects one of three buffers to set ACLs:

ACL = OFL/ABC reduced 10% for stocks not undergoing overfishing
ACL = OFL/ABC reduced 15% for stocks undergoing overfishing
ACL = OFL/ABC reduced 25% for ecologically important stocks, including surgeonfish

The Council and SSC determined the size of the buffer in each category with significant input from non-governmental organizations (NGOs), NMFS, fishers, and politicians representing the U.S. Caribbean public. There are exceptions to the three buffer categories to address stock-specific concerns and differences in catch limits across island regions and to respond to new information as new or updated assessments become available. For example, a 15% buffer was applied to the parrotfish ABCs for all three island regions, and an additional reduction of about 5% was applied to the St. Croix stock to account for ecological concerns. To address differences in stock status across the islands, the Council and SSC specified catch limits for queen conch in federal waters off St. Croix while prohibiting harvest of queen conch in the federal waters of St. Thomas, St. John, and Puerto Rico.

**Continuing Challenges**
Other continuing areas of research include setting scientifically based buffers between OFLs and ACLs for stocks that are not currently undergoing overfishing. Given a large number of species and limited time and resources to obtain basic life history and other baseline information, prioritizing and conducting assessments is an ongoing challenge. Absent more reliable data and an improved data collection and monitoring program, the CFMC has little flexibility in implementing alternative specification processes or AMs for its fisheries. Despite these struggles, NMFS is putting significant effort into building relationships and trust with fishers to tap their local knowledge and to help reduce scientific and management uncertainty.

Though Caribbean fisheries have relatively low market value, they are extremely important to island communities and reef ecosystems. To address potential forgone yield of parrotfish and other reef species, the Council is discussing moving toward an island-based management scheme, akin to the Western Pacific's five fishery ecosystem plans. This spatial management approach could help address the issues associated with managing very different fisheries, cultures, and practices on the four main islands that make up the U.S. Caribbean region. This strategy may provide the Council more flexibility to allow fishing for under-utilized stocks in some areas, while preventing overfishing in others.

## SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL

The South Atlantic Fishery Management Council (SAFMC) manages more than 70 stocks through eight FMPs: Coastal Pelagics, Coral, Dolphin/Wahoo, Golden Crab, Shrimp, Snapper-Grouper, Spiny Lobster, and Pelagic Sargassum Habitat. The Pelagic Sargassum Habitat FMP is unique and was established to protect habitat for young commercially important and federally protected migratory species, including tunas, sea turtles, and marine mammals. The Coral, Spiny Lobster, and Coastal Pelagics FMPs are managed jointly with the Gulf of Mexico Fishery Management Council. Most of the fisheries in the South Atlantic region are characterized as data-poor, and a large proportion of catch is landed by the substantial recreational sector. As a result, the Council utilizes a broad tiered-approach that employs P* and a decision tree that allow the SSC and Council to decide on scalar reductions to set buffers from OFLs to ABCs.

**Scientific Uncertainty**
To date, assessments have only been performed on a fraction of South Atlantic stocks; a few of those utilize the P* approach to create buffers that account for scientific uncertainty. To gauge the reliability of assessment estimates, measures of parameter estimation uncertainty, process uncertainty, and explicit recruitment uncertainty are incorporated when characterizing scientific uncertainty. The SSC also considers sources of uncertainty that do not show up in assessments, such as different assumptions about current states of nature and different runs of the same model. The Southeast Data, Assessment, and Review (SEDAR) process, which includes input from fishers, biologists, Council members and Council staff, typically chooses a single assessment model that they think most accurately represents the stock, thus the probability density function (PDF) of the OFL is representative of only a single model run in an assessment. The SSC has noted that model-averaging tools could help with this issue.

The SSC is in the process of evaluating the applicability of the relatively new only reliable catch stocks (ORCS) methods to establish OFL and ABC values for data-poor stocks. At this point, both the ORCS methods and a "decision tree" approach (described below) are acknowledged in the control rule. The process for setting catch limits for data-poor stocks continues to evolve as new methods and updated assessment information become available.

**Four-Tiered Approach**
The Council and SSC employ the following four-tiered approach to specify ABCs on the basis of information available for each stock, from data-rich (Tier 1) to data-poor (Tier 4).

Tier 1: P* used to account for scientific uncertainty where possible; based on quantitative assessment of available data

Tier 2: depletion-based stock reduction analysis (DB-SRA) methods and P* utilized to determine ABC

Tier 3: depletion-corrected average catch (DCAC) methods used, does not provide OFL, only ABC; the analysis does not provide necessary details to inform a P* choice

Tier 4: ABC and OFL derived on a case-by-case basis

ABC specification for Tiers 1 and 2 are informed by four assessment dimensions, which reflect the critical characteristics of a stock: data and assessment information availability, characterization of uncertainty, stock status, and productivity susceptibility analysis (PSA). (PSA is an approach used to measure the relative risk or vulnerability of a stock to fishing activity.) Each dimension/risk factor is scored and weighted equally, though this can change with new information. Scientific uncertainty and PSA attributes are addressed and scored in a high, medium, or low qualitative fashion on the basis of the SSC's expert judgment. The sum of all these four dimensions, called adjustment factors, yields a "critical probability" value, which informs a downward reduction in the maximum P* value from 0.50. The Council then selects its preferred P*, which can be set equal to or below the revised maximum P* value. The resulting P* value does not necessarily correspond to a specific percentage reduction from the OFL to ABC; the actual reduction from OFL to ABC is based on applying P* to the PDF, which will yield different percentage reductions, depending on the shape of the PDF curve.

Tier 3 stocks rely on the four-tiered DCAC methods described in MacCall's 2009 paper on methods for deriving reference points for data-poor stocks. These methods do not provide an OFL, only an ABC.

For Tier 4 stocks, which comprise a large portion of the Council's managed stocks, the SSC uses a decision tree to guide the case-by-case evaluations for initial OFL and ABC recommendations. Decision trees are stepwise decision-making tools that can be used to examine characteristics and trends of a stock and guide implementation of harvest control rules. The SAFMC Tier 4 decision tree was formalized in April 2012 and includes a set of questions and considerations to guide establishment of ABCs for Tier 4. The process of employing the decision tree also helps to build an administrative record to support SSC's decision.

The decision tree for Tier 4 directs the SSC to consider the following when setting catch levels for data-poor stocks:

Will current catches affect the stock?
Will increased catch lead to decline or other stock concerns?
Is the stock part of a directed fishery?

If the stock is mostly caught as bycatch, the decision tree also guides the SSC to consider trends in the fishery, including landings and effort.

The SSC is currently considering additional changes in Tier 4 to address recommendations from the ORCS report (Berkson et al. 2011). Many data-poor stocks in the South Atlantic are not targeted and/or are rarely caught, and thus lack the fishery-dependent data needed to apply Tier 4 methods. As a result, the SSC is also considering revising the above tiers or adding an additional tier to incorporate methods for setting OFL and ABC values for stocks without reliable catch histories.

**Management Uncertainty and Accountability Measures**

Management uncertainty in the South Atlantic is incorporated through the use of ACTs and accountability measures. ACTs are used largely in the recreational sector to address the precision

of catch estimates and to function as proactive AMs. Reactive AMs are in place for many fisheries and include fishery closures and payback mechanisms to account for ACL overages. Catches of many stocks in the South Atlantic region fluctuate widely from one year to the next. Given this variability, responsive monitoring is often used as a soft AM to investigate whether a sudden spike or drop in landings is related to overfishing, natural variability, or shifts in targeted effort. For commercial fisheries in the South Atlantic, the SSC has discussed the potential of a depletion threshold whereby targeted fishing ceases if stock biomass drops below 10% of its unfished (virgin) biomass.

**Continuing Challenges**

The South Atlantic Council continues to work on obtaining necessary life history information and assessments for its unassessed stocks and leveraging data-poor methods to inform specification of ABCs. The Caribbean, Gulf of Mexico, and South Atlantic councils all rely on the limited resources and capacity of the Southeast Fisheries Science Center (SEFSC) and SEDAR to conduct assessments on a prioritized and tight schedule. The South Atlantic Council cooperates with the Gulf of Mexico Council to manage several FMPs and stocks jointly, but this increases complexity, management uncertainty, and incentive to adopt less precautionary P* choices when the councils are presented with two conflicting P* choices by their respective SSCs.

Most of the focus in the South Atlantic region has been on dealing with scientific uncertainty; efforts to quantify or integrate management uncertainty into the ACL/ACT process have not yet been prioritized. The topic or management uncertainty remains challenging given the high level of diffuse recreational effort, lack of historical binding catch limits, and sensitivities around the equity of inter-sector allocation. The South Atlantic Council also struggles with explicitly managing risk during its specification processes. Even for assessed stocks, the Council is unsure how to incorporate the potential consequences of overfishing or forgoing yield into its decision-making frameworks. Like other councils, the SAFMC faces the challenge of managing stock complexes to the "lowest common denominator," a situation in which conservative ACLs for data-poor and/or overfished stocks can constrain harvest of other stocks in the complex. Alternatives to the ORCS methods for incorporating risk into the specifications process for data-poor stocks are also currently being explored. Conversations between the Council and SSC about a comprehensive risk policy that clearly distinguishes the concepts of risk and uncertainty are ongoing and remain a priority.

## MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

The Mid-Atlantic Fishery Management Council (MAFMC) administers seven FMPs: Atlantic Mackerel/Squid/Butterfish, Bluefish, Spiny Dogfish, Summer Flounder/Scup/Black Sea Bass, Surfclam/Ocean Quahog, Tilefish, and Monkfish. The Spiny Dogfish and Monkfish FMPs are managed in cooperation with the New England Council. In addition to the omnibus amendment addressing the ACL and AM requirements of MSRA, the Council voted to accept a formalized risk policy to apply to all managed stocks. The SSC uses a complementary ABC control rule that incorporates scientific uncertainty into catch level recommendations.

**Scientific Uncertainty**
Both the MAFMC and the New England Fishery Management Council (NEFMC) rely on the Northeast Fisheries Science Center (NEFSC) to conduct stock assessments. "Benchmark" assessments, in which every aspect of the assessment process—including the model employed—is carefully examined, are conducted about every three years; updated assessments may occur on an annual basis. The SSC looks at several facets of "within" assessment uncertainty stemming from differences in life history, natural mortality estimates, modeling projections, calibration coefficients, and other factors to help specify OFLs and ABCs. The four-level approach described below utilizes a probability of overfishing (P*) and an OFL distribution with a coefficient of variation (CV) or expert judgment approach to inform ABC recommendations. The CVs are a product of stock assessments but can be modified by the SSC on the basis of specific stock status information and expert judgment. The SSC incorporates scientific uncertainty from data collection, modeling and observation error, and variance of $F_{MSY}$ and $B_{MSY}$ estimates or proxies to determine appropriate CV values.

**Four-Level Strategy**
Prior to the 2006 reauthorization of the Magnuson Act, the Council's Species Monitoring Committees specified catch and landings limits. The SSC, now explicitly tasked with setting OFLs and ABCs, relies on an ABC control rule that employs a four-level approach to characterize stocks on the basis of assessment quality and scientific uncertainty.

Level 1 – "ideal assessment": ABC is based on the distribution of the OFL as provided from the assessment model; P* is based on the Council's risk policy

Level 2 – "preferred assessment": uses an OFL distribution proxy provided from the assessment workgroup; P* is based on the Council's risk policy

Level 3 – "acceptable assessment": does not reliably incorporate scientific uncertainty; uses an OFL distribution proxy (with a proxy CV) or a default value of 75% of $F_{MSY}$ to set ABC

Level 4 – "unreliable assessment": lacks data on absolute abundance and fishing mortality rates; no reliable OFL proxy available; ABC set based on ad hoc, alternative approaches (e.g., adjustment to long-term catch history or survey index values)

Currently, all managed stocks in the Mid-Atlantic region fall under Levels 3 or 4; Levels 1 and 2 of the control rule have not been applied to date. Level 3 stocks use a CV of 100% for the OFL distribution; however, the SSC could choose another value in response to additional information. For stocks in Level 4, an ad hoc approach is used to set an ABC on the basis of the SSC's expert judgment. This multi-level approach to specification allows the Council flexibility to adapt to specific fishery conditions instead of relying on a blanket buffer for all stocks within a level. In practice, the buffers for stocks with "typical" life histories that are at or above $B_{MSY}$ provided by the 100% CV are equivalent to setting ABCs equal to about 81% of the OFLs. For stocks with "atypical" life histories that use a 100% CV and that are at or above $B_{MSY}$, the buffer is about 73% of the OFL. In general, as CV values increase, the buffer between ABC and OFL increases**.** When the SSC has insufficient information to determine OFL distribution proxies for Level 3 stocks, it may utilize a default control rule of ABC = 75% of $F_{MSY}$ (GMFMC 2012).

**Risk Policy Alternatives**

The MAFMC utilizes a risk policy to specify the Council's tolerance for overfishing a stock for all the Council's managed resources. The Council explicitly applies the control rule to stocks that fall into Levels 1 through 3. Before developing its risk policy, the Council considered multiple approaches, ranging from a constant P* to more elaborate matrices that include multiple risk factors and are based on scientific information and SSC judgment. The Council ultimately selected a single policy that applies to all the managed resources.

The MAFMC's risk policy is based on a linear reduction in catch as a stock declines in abundance per the methods laid out in Restrepo et al. (1998). The risk policy relies on a linear function that plots the current biomass to biomass associated with MSY ($B/B_{MSY}$) ratio on the x-axis and the P* options on the y-axis. Use of the function yields a linear reduction in probability of overfishing, which in practice translates to a reduction in fishing mortality (F). The Council employs a default maximum P* value of 0.40 for "typical" stocks with a $B/B_{MSY}$ ratio of 1.0 or greater. A more precautionary maximum P* value of 0.35 is used for "atypical" stocks because those are judged by the SSC to be more vulnerable to overfishing. For stocks with no $F_{MSY}$ estimate or proxy, catch levels cannot be increased without SSC recommendation. The NS1 guidelines state that the probability of overfishing may not exceed 50% (P*=0.50) and should be something lower.

**Coordination with other Bodies**

The MAFMC shares responsibility with the NEFMC for the Monkfish and Spiny Dogfish FMPs. Both councils must agree to and adopt the same specification of ACLs for shared stocks, which can be challenging and time-consuming. MAFMC collaborates with the Atlantic States Marine Fisheries Commission (ASMFC) on the Spiny Dogfish, Bluefish, and Summer Flounder/Scup/Black Sea Bass FMPs to reduce management uncertainty stemming from large recreational fisheries in the region. The ASMFC is a regional fisheries body and forum that establishes state harvest guidelines for specific interstate fisheries along the Atlantic coast. This cooperative management approach requires coordination between the Council and Commission to set consistent state and federal catch and landings limits as well as establish other fishing regulations. Representatives of the MAFMC and ASMFC meet twice a year and under "joint rules" cooperatively decide identical harvest specifications for the Summer Flounder/Scup/Black Sea Bass FMP. These meetings facilitate consensus building and consistency of management measures

between the two groups.

**Management Uncertainty**

Given the high level of inter- and intra-annual variability in the sources of management uncertainty, practical considerations, and the need for flexibility, the Mid-Atlantic Council delegates authority to the individual species monitoring committees to develop ACT control rules for stocks and to provide recommendations on implementing ACTs and regulations such as minimum fish sizes, seasons, and gear restrictions. These committees pre-date the MSRA and the expertise of the members provide in-depth knowledge of each fishery and the variable circumstances that could give rise to different levels of management uncertainty from one year to the next, particularly at the state level. The various species monitoring committees are typically comprised of representatives from the Council staff, Commission staff, NMFS staff, the Northeast Fisheries Science Center, and a representative of each state's fisheries agency. ACLs are set equal to ABCs for most stocks, and the various species monitoring committees are tasked with providing buffers to account for management uncertainty by reducing the ACL to a TAC or a TAL that acts as an ACT or other "soft target." For sources of management uncertainty that remain unquantifiable, such as unreported landings, unknown mortality sources, and illegal fishing, a default buffer may be selected for some stocks.

**Accountability Measures**

To account for management uncertainty, AMs and ACTs are in place for most managed stocks in the Mid-Atlantic region. The MAFMC utilizes two types of AMs: proactive and reactive. Proactive AMs include establishment of TACs and TALs as described above, adjustment of possession limits, in-season closures of directed fisheries, and modification of management measures to slow landing rates and prevent the ACL from being exceeded. Reactive AMs, on the other hand, are implemented in response to ACL overages and include modification of a subsequent year's regulations, such as trip or possession limits, or reductions in a subsequent year's catch or landing levels. Given variability in the availability of fish, fishing effort, and fishers' behaviors, setting long-term AMs is difficult. Most AMs are established and evaluated on an annual basis; however, AMs for some stocks may be set for multiple years and only modified if needed.

**Continuing Challenges**

Data limitations and the absence of robust methods for estimating, quantifying, and capturing management uncertainty in the specifications process are ongoing struggles for the MAFMC. In the case of fisheries for which data and methods afford explicit consideration of uncertainty, the species monitoring committees and the SSC remain unclear about which buffers should account for which specific considerations in the ABC and ACT specification processes. For example, accounting for discards is both a scientific and management uncertainty issue and thus bleeds through both the ABC and ACL-ACT specification processes. The Council and the SSC plan to address how to effectively characterize uncertainty so that stocks can be moved out of Levels 3 and 4 and into Levels 1 and 2. In addition, the SSC will continue to evaluate whether the 100% CV applied to Tier 3 stocks accurately reflects scientific uncertainty while not being overly precautionary when specifying ABCs. In an effort to build trust and engage stakeholders in a more proactive and forward-looking management approach, the Mid-Atlantic Council has undertaken a visioning and strategic planning project.

## NEW ENGLAND FISHERY MANAGEMENT COUNCIL

The New England Fishery Management Council (NEFMC) administers nine FMPs: Multispecies Groundfish, Scallops, Small Mesh Multispecies Groundfish, Herring, Deep Sea Red Crab, Northeast Skate Complex, Atlantic Salmon, Monkfish and Spiny Dogfish. The spiny dogfish and monkfish fisheries are jointly managed by the Mid-Atlantic Fishery Management Council (MAFMC) and NEFMC; MAFMC takes the lead on managing spiny dogfish, and NEFMC takes the lead on monkfish. The Atlantic Salmon FMP protects the federally endangered salmon from bycatch or "take" in any non-target fisheries. Of the stocks for which NEFMC has established catch limits, only the deep-sea red crab fishery does not have an OFL in place due to lack of data. The New England Council utilizes different ABC control rules for each FMP and takes an ad hoc approach to setting ACLs. This approach provides the Council and SSC flexibility in managing diverse stocks and stock complexes.

**Scientific Uncertainty**
During its ABC specifications process, New England's SSC focuses its efforts on capturing scientific uncertainty around estimations of projected catch. The Northeast Fisheries Science Center (NEFSC) conducts stock assessments every two or three years for most stocks in a prioritized and staggered fashion. The New England region has struggled with obtaining consistent stock assessments from one assessment cycle to the next, which introduces considerable scientific and management uncertainty and anxiety among fishers. Since 2010, considerable attention has been paid to retrospective patterns in recent stock assessments, whereby older assessments are shown to be overly optimistic in their estimates of biomass. Despite overall increasing trends, the patterns across stock assessments show that biomass for most stocks is not as high as was estimated just a few years ago. As a result, many stocks are not rebuilding as quickly as initially projected.

Of the stocks managed by the NEFMC, only sea scallops and some of the multispecies groundfish species could be classified as data-rich; the rest fit with varying degrees into the data-poor classification. In the case of multispecies groundfish, a diverse fishery composed of 20 stocks, the SSC concluded that the uncertainty in catch projections is essentially unknown. This projection uncertainty, coupled with the possibility of a general productivity shift due to ecosystem and habitat changes, makes it difficult for the SSC to fully capture scientific uncertainty.

**ABC Control Rules**
Unlike tiered approaches adopted by many councils, the ad hoc ABC specification strategy of NEFMC is not constrained in a systematic way by the amount or quality of information available for a stock. Methods for determining ABCs for New England stocks are different for each FMP and range from a probabilistic approach for stocks with highly reliable stock assessments to data-poor approaches that rely on long-term average catch-based methods. Although the NEFMC mostly accepts levels of uncertainty included in the SSC's ABC recommendations, it has not provided the SSC with guidance regarding acceptable levels of risk for each stock.

In the case of data-poor fisheries such as deep-sea red crab and other fisheries such as monkfish, the SSC lacked confidence in the available stock assessments and opted to base the ABC on long-term average landings or other exploitation metrics with a buffer for scientific uncertainty. Small-

mesh multispecies groundfish ABCs are set based on percentiles of the OFL distribution. The SSC sets ABCs for the skate complex in response to $B_{MSY}$ proxies derived from survey data and median catch/biomass exploitation indices. The ABC for scallops, the most data-rich of NEFMC managed fisheries, is based on a P* approach as described in the next section.

The Northeast multispecies groundfish complex includes 15 species of groundfish, many of which are in rebuilding plans. To address ABC specification of healthy and rebuilding stocks, a multifaceted ABC control rule is applied. For healthy stocks, ABC is specified as 75% of the yield derived from applying the fishing mortality rate (F) associated with MSY to current biomass (75% of $F_{MSY}$); this practice is consistent with the Council's existing policy that OY be set equal to 75% of $F_{MSY}$ for species in the groundfish complex. For rebuilding stocks, the default 75% $F_{MSY}$ can be reduced to a fishing mortality level that meets rebuilding requirements ($F_{Rebuild}$). For stocks that cannot rebuild within the specified rebuilding period, even when directed fishing has ceased, the ABC is based on limited incidental bycatch. For stocks with unknown status, the SSC recommends interim ABCs on a case-by-case basis.

**Use of P* to Set ABC for Scallops**

The New England Council employs a P* approach for setting ABCs for the Scallop FMP on the basis of recommendations from the SSC and Scallop Plan Development Team (PDT). This approach is supported by the high quality of stock assessments and robust management measures in place for the fishery. Significant scientific and management certainty are conferred through a limited entry program, closed area rotations, observer coverage, strict reporting measures, and annual surveys performed by federal scientists as well as academic institutions working with the scallop industry.

During the specifications process, the Scallop PDT and SSC present the Council with a full decision analysis in table format to show results of Monte Carlo simulation, a computer modeling exercise that illustrates potential tradeoffs of yield that correspond to differing P* choices (Hart 2009 and Hart 2013). The flexibility of this simulation allows experts to run analyses with different management uncertainty percentage buffers from ACLs to TACs to provide the Council with several management alternatives. As a result of these measures and the data-rich nature of the fishery, the SSC endorses a risk-based approach that utilizes the lower value of either the harvest rate associated with a maximum P* of 0.25 or up to a 1% loss of yield (Hart 2009 in Appendix II of Amendment 15 to the Scallop FMP). This approach is both precautionary in the face of uncertainty and aims to optimize yield due to the high value of this fishery. The scallop fishery is the most valuable U.S. fishery by ex-vessel value and is worth over $500 million dollars annually.

**Management Uncertainty and ACLs**

Management uncertainty varies greatly from one fishery to another in New England, and thus the Council uses a number of approaches for specifying ACLs and ACTs. For each FMP, an Oversight Committee, consisting of Council members and a representative from the NMFS Northeast Regional Office (NERO), develops management alternatives for establishing ACLs and accounting for management uncertainty. These alternatives are forwarded to the full Council for approval before formal consideration. (In addition to the specification of ACLs and ACTs, the Oversight Committees play an integral role in all Council actions within each respective FMP.) The Council

also relies on its PDTs to provide input on ACL recommendations as well as guidance on allocation issues, closed areas, selectivity patterns, management areas, and assessment evaluations.

The Council utilizes a range of ACL and ACT specification options for its FMPs:

- Herring: ACL = 95% of ABC
- Monkfish - Southern Management Area: ACL = ABC; ACT = 93% of ACL
- Monkfish - Northern Management Area: ACL = ABC; ACT = 86.5% of ACL
- Small-Mesh Multispecies: ACL = 95% of ABC; TAL = ACL – discards – state landings
- Multispecies Groundfish: ACL = ABC; TACs include a 5–7% buffer for management uncertainty
- Northeast Skate Complex: ACL = ABC; ACT = 75% of ACL; TAL = 45% of ACT to account for catch in state waters and significant discards in non-target fisheries
- Sea Scallops: ACL = ABC

For most stocks, ACLs are set equal to ABCs. Fisheries thought to have low levels of management uncertainty do not require additional buffers in the form of ACLs or TAC/TALs.

Other New England FMPs have incorporated explicit buffers into their ACL-ACT specifications process for management uncertainty considerations, such as bycatch in the multispecies groundfish and Northeast skate complex fisheries. Total Allowable Landings (TALs) for the data-poor Northeast skate complex FMP are particularly precautionary due to high levels of bycatch in the groundfish fisheries and are based on estimates of stock biomass and median historical exploitation rate. The "sector" management program for the Multispecies Groundfish FMP is in its infancy, and issues of equity and management complexity complicate implementation of the program. Observers cover about a quarter of the vessel trips in the fishery, and a documented "observer effect" tends to skew reported catch data.

**Continuing Challenges**

The New England SSC struggles with incorporating sources of uncertainty that cannot be captured "within" stock assessments such as strong retrospective patterns across multiple assessments, environmental shifts, unknown sources of mortality for a stock, and variance among $F_{MSY}$ estimates or proxies. Retrospective patterns in stock assessments continue to complicate scientific uncertainty as well. Management uncertainty is unknown in the multispecies groundfish fishery due to a relatively new catch-share program and low observer coverage.

The tradeoff analysis performed during the specifications process for New England scallops is innovative. The SSC is interested in working with the Council in expanding this kind of thinking to be more explicit about potential implications of different levels of risk and more consistent across ABC control rules. It remains a priority in the region to explore the possibility of a more comprehensive approach that articulates a clear and transparent risk policy.

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**Personal Communications**

The Fisheries Leadership & Sustainability Forum acknowledges the time and contributions provided by council members, staff, SSC members, and NMFS experts in all eight regional fishery management council regions. Without them, this updated report would not have been possible.

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