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I thank the Members of the Committee for the invitation to testify before you today. My name is Steven Cadrin. I am an Associate Professor of Fisheries Oceanography at the University of Massachusetts Dartmouth, School for Marine Science and Technology. I have over twenty years of experience as a quantitative fisheries scientist with expertise in fish stock assessment and fishery management. I was asked to address scientific aspects of fisheries management in New England.

In comparison to other fisheries management systems throughout the world, the system in the United States is relatively inclusive, transparent and science-based. However, the catch limit system specified by National Standard Guidelines (NOAA 2009) and NOAA's catch shares policy (NOAA 2010) are much more demanding than other alternatives, because they require greater transparency in catch monitoring, more extensive inclusiveness in fishery management decisions and more frequent and accurate scientific products. As detailed below, the current fishery science and management system in New England is not meeting those increased demands.

The New England fisheries management system has made great strides over the last decade to end overfishing and rebuild many stocks. However, there are several major deficiencies in our current fisheries science system that do not adequately support the requirements of catch limit and catch shares management policies. There are major deficiencies in the quality and frequency of stock assessments and fishery statistics, and National Standard Guidelines for implementing the Act pose unrealistic demands on the scientific system. The national strategy for fishery management needs to be reconsidered so that demands on the scientific system are more practically suited to the current scientific capacity and performance of the management system is more robust to the inherent uncertainties in fisheries science.

My view is supported by two recent reviews that were commissioned by the National Marine Fisheries Service. A recent national review on scientific institution building concluded that "*NMFS needs more*

national scientific leadership, and better management, information systems and organizational structures, to plan and implement national programs", and "*this problem has ramifications with respect to the science based roots of the agency and science as the foundation for policy and management*" (Sissenwine and Rothschild 2011). An independent assessment of the fishery management system in New England identified problems and challenges and formed recommendations including "c*onduct a comprehensive analysis of all NMFS data systems to identify areas that will improve data gathering, data management, data analysis and data use*" (Touchstone Consulting Group 2011).

New requirements of the 2007 amendment to the Act impose substantially greater demands on the fishery science and management system. The current scientific capacity was more adequate for meeting the requirements of the previous version of the National Standard Guidelines which focused on status determination (i.e., relative stock size, sustainability of harvest) and general management advice. Even state-of-the-art fishery science cannot fully support the risk-based catch limits with accountability measures suggested in the current Guidelines.

Several examples demonstrate that the failure to effectively adapt to new requirements negatively impact fisheries, fishery resources and the Massachusetts communities that depend on them. National Standard Guidelines suggest that catch limits should be based on an estimate of the catch associated with overfishing and uncertainty in the estimate of the overfishing limit, or the catch that will allow rebuilding of overfished stocks; and fisheries should be held accountable for exceeding catch limits. Such implementation of the catch limit mandate requires frequent and accurate stock assessments, comprehensive and real-time fishery monitoring, as well as risk analysis for each fishery. Although the Act establishes National Standard 1 so that "*Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry*", deficiencies in the scientific basis of fishery management decisions can result in either foregone yield or overfishing, both of which are costly to Massachusetts fisheries and fishing communities.

As implemented in the National Standard Guidelines, specification of annual catch limits requires frequent stock assessments and projected catch over a short period (e.g., one to three years). Stock assessment involves an update of the most recent fishery statistics and resource surveys to evaluate stock status and provide a basis for catch forecasts. Catch limits that are based on recent stock assessments and short-term projections take advantage of the strengths of conventional fishery science, in which catch forecasts are almost entirely based on a synthesis of updated fishery and survey observations. Conversely, catch limits based on longer-term predictions (e.g., greater than three years) are based largely on assumed population dynamics rather than on current data. Long-term predictions rely on the ability to predict annual recruitment of young fish and their future vital rates, which are the most challenging problems in fishery science.

New England groundfish, our nation's oldest commercial fishery resource and one of its most productive, serves as an example of the inadequate frequency and quality of stock assessments provided by NOAA for fishery management decisions. NOAA concluded that it did not have the capacity to provide annual stock assessments for all northeast fisheries (Northeast Fisheries Science Center

2009). As a result of this deficiency in scientific resources, the planned approach for specifying catch limits for the groundfish fishery from 2012 to 2014 was medium-term catch forecasts, five to seven years from the 2008 stock assessments. The New England Fisheries Management Council's Scientific and Statistical Committee advised the Fishery Management Council that "*Projection of results from GARM III assessments to 2013-2014 were deemed to be too unreliable for setting ABCs*" (Acceptable Biological Catches). The Northeast Regional Coordinating Committee is in the process of revising its assessment and peer review process, and groundfish assessments are planned to be updated this winter. However, the process for updating groundfish assessments is still under development, and the current scientific basis for groundfish catch limits is insufficient.

In addition to the need for frequent stock assessments, accuracy is also required to determine appropriate catch limits. Only a small portion of stock assessments can accurately project catch associated with overfishing and its uncertainty, which is the technical basis of the National Standard Guidelines for deriving annual catch limits. Many assessments are data-poor, and are not informative enough to reliably evaluate stock size, fishing mortality, maximum sustainable yield reference points or catch projections to determine catch associated with overfishing. National Standard Guidelines suggest that Councils should be more precautionary in the face of such uncertainty, leading to lower catch limits and potential economic impacts as a result of scientific uncertainty. Despite the obvious deficiencies of data-poor stock assessments, the National Standard Guidelines require annual catch limits for all stocks, with few exceptions.

The New England skate complex offers an example in which fishery landings cannot be identified by species. Mixed-species catch limits are required to meet separate-species management objectives for ending overfishing and rebuilding overfished stocks. In such data-poor situations, catch limits are largely based on expert opinion, and their performance for meeting fishery management objectives is unknown. Requiring catch limits for data-poor stocks can result in fisheries constraints that are not consistent with the objectives of avoiding overfishing, rebuilding stocks or achieving optimum yield. For example, the two targeted species of New England skates rebuilt under a 20,000 lb trip limit, but implementation of the catch limit system required a reduction to 500 lb per trip after the stocks rebuilt.

Other stock assessments are more informative than those for data-poor stocks, but still have substantial uncertainties that cannot be quantified or used to determine catch limits. A troubling feature of many stock assessments in each coastal region of the U.S. is the lack of consistency from one stock assessment to the next. Retrospective inconsistency is the change in perception of previous stock size or fishing mortality when new data are added to the assessment. Managing a fishery based on an assessment with retrospective inconsistency involves setting an apparently appropriate catch that in retrospect caused substantial overfishing or foregone yield.

The fishery for Georges Bank yellowtail flounder, one of the principle groundfish stocks off New England, is an example of the frustrating and costly impact of retrospective inconsistency. From 1999 to 2006, the fishery caught less than the catch limit advised by the scientific process in each year. However, the 2011 stock assessment indicates that those apparently appropriate catches produced overfishing each year, in some years more than five times the overfishing threshold (Transboundary Resources

Assessment Committee 2011). Despite efforts to correct the stock assessment, the retrospective problem continues to obfuscate perceptions of stock status and obstruct attempts to manage the fishery or rebuild the resource. After decades of overfishing, in the face of severe restrictions to the fishery, the assessment indicates that the stock cannot rebuild within the desired time frame, even with no fishery.

Beyond the need for frequent and accurate stock assessments, scientific support for catch limits involves in-season fishery monitoring that is timely enough to inform future catch limits and support fishery-dependent business decisions in a catch share management system. Several transitions to electronic monitoring have improved the timely collection and reporting of landings from commercial fisheries. However, other components of total catch such as commercial fishery discards, recreational fishery catch, and location of fishing effort are not well estimated, and estimates are not available in a timely fashion. Uncertainty and slow delivery of catch statistics precludes in-season management or adaptive fishing decisions to optimize catch allocations, incurring considerable costs to fisheries and fishing communities. In addition, accountability for overfishing is being implemented in a way in which fisheries 'pay back' any catch that exceeds the annual catch limit in the form a reduced catch limit in the subsequent year. Such an implementation requires accurate in-season monitoring to allow fisheries to manage their own catch to avoid exceeding their catch limits and resulting accountability measures.

Inadequate catch monitoring is demonstrated by estimates of discarded catch in New England. The Northeast Region adopted a Standardized Bycatch Reporting Method for commercial discards that is based on data from at-sea observers (Wigley et al. 2007). The stratification for observer sampling is stock area and fleet, which is too coarse to accurately estimate discards, often inferring 'phantom discards' (i.e., estimates of discarded catch that are artifacts of the methodology rather than a reflection of actual catch). Many groundfish sectors are charged with discards against their allocation based on the Standardized Bycatch Reporting Method, because the stock-wide estimators assume that each vessel in the sector has the same discard patterns. Some vessels have rare discards that have been documented by NOAA observers and the NOAA study fleet, but these vessels are charged the fleet-wide stock-wide discard rate, and the sector is accountable for exceeding its catch allocation, even if the overage is an artifact of an inaccurate discard estimate. Furthermore, the Standardized Bycatch Reporting Method removes any incentive for individual fishermen to reduce their bycatch.

The Standardized Bycatch Reporting Method for yellowtail flounder bycatch in the scallop fishery is both slow and biased. Final estimates of bycatch in the scallop fishery were not provided until seven months after the fishing year ended. The estimate of yellowtail discards in the 2010 scallop fishery was biased, because observers were more likely to sample off southern New England, where there are more yellowtail, than in the Mid Atlantic Bight, where there are fewer yellowtail. The Standardized Bycatch Reporting Method, which is more influenced by the southern New England bycatch rate, indicated that the scallop fishery had exceeded its yellowtail allocation. The accountability for such an overage in bycatch is to close large portions of the stock area for the entire year. By contrast, when updated observer data were appropriately stratified by region, the estimate of yellowtail discards was much less and led to the conclusion that bycatch was well within the limit. This example shows that the slow and

biased application of the Standardized Bycatch Reporting Method would have falsely triggered costly accountability measures in the nation's most valuable fishery.

Several aspects of scientific uncertainty exacerbate the mixed-stock fishery problem. When stock assessments underestimate stock size, catch limits are lower than they should be, and fishermen have difficulty avoiding the species that have artificially low catch limits. Furthermore, when some stocks are rebuilding, their catch limits remain relatively low while the stock rebuilds, increasing the challenge to avoid rebuilding stocks while targeting healthy stocks. These problems are intensified when accountability measures further reduce the catch limits on rebuilding bycatch stocks, thereby increasing the mismatch between the catch limit and the species mix on the fishing grounds. Therefore, scientific uncertainty and catch limits with accountability prohibit mixed-stock fisheries from harvesting their allocated catch limits and form a wasteful management strategy with huge economic losses.

The mixed-stock problem severely limits the New England groundfish fishery from landing its total multispecies allocation. For example, southern New England winter flounder are behind schedule in the agreed rebuilding plan largely because of scientific uncertainties in the stock assessment, and only incidental bycatch is allowed. If rebuilding is successful, the challenge of avoiding winter flounder will be exacerbated. Furthermore, if catch limits are exceeded, the fishery will be held accountable in the form of further reductions in catch limits of a rebuilding stock. The catch limit for southern New England winter flounder is based on an estimate of incidental bycatch, but the 2010 fisheries exceeded the catch limit, and accountability measures are being considered for the overage. The fishery is being held accountable because the observed incidental bycatch exceeded the projected incidental bycatch.

As a result of the mixed-stock problem, the groundfish fishery caught less than 40% of the allocated catch in 2010 (Kitts et al. 2011). If the catch limits were accurate, and discards remained low for these species, the groundfish plan appears to have successfully ended overfishing. However, preventing overfishing is only half the job that management plans are mandated to accomplish. The other half of the mandate is to achieve optimum yield. Landings of haddock, plaice, pollock and redfish in 2010 were less than half of the catch limit (Kitts et al. 2011b). Ending overfishing is a great accomplishment, but we need to refine fishery management plans to progress toward optimum yield.

A recent analysis of groundfish catch limits concluded that scientific information is available to support increased catch limits that do not undermine conservation mandates of the Magnuson Act (Massachusetts Marine Fisheries Institute 2010). The review of scientific analyses used to derive catch limits found that several decisions favored relatively low catch limits, and scientifically valid alternatives are available for direct estimates of the maximum sustainable yield reference point, alternative stock assessment models, smaller uncertainty buffers, and revised rebuilding objectives. Alternative scientific decisions support increases in catch limits for all New England groundfish stocks, with substantial increases for 'choke stocks.' Increased catch limits for 'choke stocks' would be more consistent with the availability of stocks on the fishing grounds and allow the fleet to achieve more of their allocation, thereby substantially increasing mixed-stock economic yield.

National Standard Guidelines suggest that catch limits should be based on each regional Fishery Management Council's desired risk tolerance for overfishing. However, such risk management decisions require evaluation of economic costs and benefits that are not routinely provided by the scientific process. Although some economic data are collected from fisheries, the information is not comprehensive enough to evaluate costs and benefits of alternative catch limits, and economic analyses are limited to impact statements that are completed after management actions are decided. A broader approach to informing risk tolerance would be management strategy evaluation, which has only been applied to few U.S. fisheries in a cursory way. Ignoring economic aspects of alternative catch limits poses unknown costs to fisheries.

Now that catch limit systems have been implemented, their performance should be retrospectively evaluated with respect to meeting all ten National Standards for fishery management (avoiding overfishing while achieving optimum yield, applying best science, managing unit stocks, fair and equitable allocation, considering efficiency, allowing for variations, minimizing costs, minimizing impacts on fishing communities, minimizing bycatch, and promoting safety). More specifically, each expectation of NOAA's catch shares policy (eliminating overfishing, achieving annual catch limits, producing more fish at lower costs, improving fishermen's safety and profits, and reducing the negative biological and economic effects) should be confirmed through analysis of fishery and resource monitoring information.

In the context of inadequate scientific information for supporting New England fisheries management, there are several potential solutions to help improve the scientific capacity for supporting annual catch limits. Solutions can address both aspects of the problem: the adequacy of scientific information and the implementation of the catch limit mandate.

1) Scientific resources can be increased or reprioritized to support more frequent and accurate stock assessments as well as more timely and accurate fishery monitoring data.
2) The peer review processes can be streamlined, using external expertise to solve scientific problems possibly by applying alternative approaches.
3) NOAA's scientific capacity can be expanded and improved by partnering with universities and research institutes that have the human resources and infrastructure to help bear the burden of the new requirements of catch limits.
4) Each regional Scientific and Statistical Committee can be empowered to help serve the necessary peer review role and more importantly help solve some of the major scientific problems in stock assessments.

The demands on fishery science can also be reduced in several ways.

1) Exemptions from annual catch limits should be considered for stocks and fisheries for which catch cannot be reliably monitored.
2) The mixed-stock exemption from catch limits and accountability measures should be considered for bycatch and rebuilding stocks to avoid the wasteful and costly consequences of applying those approaches to mixed-stock fisheries.

3) More strategically, alternative management procedures, such as data-driven catch limits that are regularly reconsidered through management strategy evaluation, should be considered that take advantage of the best of fisheries science rather than emphasizing the worst of it (e.g., Butterworth and Punt 1999).

In summary, I conclude that scientific information is insufficient to meet the needs of the catch limit system and catch shares policies in New England. Most stock assessments are too infrequent and too inaccurate to derive annual catch limits that avoid overfishing while allowing optimum yield. Major components of total catch, such as commercial fishery discards, recreational fishery catch, and location of fishing effort are imprecisely estimated and not monitored in a timely way to support in-season management and business decisions. Economic data and analyses are insufficient to evaluate risk-based catch limits. The scientific information required to support the fishery management system specified in the National Standard Guidelines and NOAA's catch shares policy is much greater than the current scientific capacity.

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