Steven X. Cadrin

Associate Professor

University of Massachusetts Dartmouth, School for Marine Science and Technology

Testimony on

“NOAA’s Fishery Science: Is the Lack of Basic Science Costing Jobs?”

U.S. House of Representatives

Committee on Natural Resources

Subcommittee on Fisheries, Wildlife, Oceans, and Insular Affairs

oversight hearing

July 24, 2011

Washington DC

I thank the Members of the Subcommittee 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 am proud to have been an employee of NOAA for the fifteen years before I started my current position. Although I am not representing any organization, my testimony draws on my experiences as chair of the New England Fishery Management Council’s Scientific and Statistical Committee from 2008 to 2011, a member of the South Atlantic Fishery Management Council’s Scientific and Statistical Committee and associated interactions with Fishery Management Councils in all other coastal regions of the U.S.

I was asked to address how the 2007 amendment to Magnuson-Stevens Fishery Conservation and Management Act affects domestic fishery management, with a focus on the new role of Scientific and Statistical Committees and the new requirement for annual catch limits to prevent overfishing. More specifically, the Subcommittee requested my views on:

1) whether the data generated by NOAA is adequate for fishery managers to comply with the new requirements, and in the context of decreased funding, if the application of a precautionary approach using outdated information is affecting coastal economies and fishery-dependent jobs;
2) if NOAA’s reliance on using “best scientific information available” is a convenient excuse for defending outdated information; and
3) the adequacy of data-collection programs, including recreational fishery statistics, the inability to provide in-season catch information, and the effect of uncertain catch statistics on fishery-dependent business decisions.

1. Adequacy of Data Generated by NOAA

The current scientific information used to support fishery management decisions is inadequate to meet the NOAA's approach to implementing the Act. The problem is twofold: 1) there are major deficiencies in the quality and frequency of stock assessments and fishery statistics, and 2) National Standard Guidelines for implementing the Act pose unrealistic demands on the scientific system. In the context of decreased budgets, scientific resources need to be reprioritized. In addition, 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.

I will describe several examples to demonstrate that the failure to effectively adapt to new requirements negatively impacts fisheries, fishery resources and the communities that depend on them. Although the examples are primarily from New England, many of them exemplify similar problems or potential problems in other regions. 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 (NOAA 2009). 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 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 is one of the most challenging problems in fishery science.

Example 1 - New England groundfish, our nation's oldest commercial fishery and one of its most productive, serves as an example of the inadequate frequency 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). The Northeast Regional Coordinating Committee is in the process of revising its assessment and peer review process, because the requirements of the catch limit system far exceed NOAA's scientific capacity. As a result of this deficiency in scientific resources, the planned approach for specifying catch limits for the groundfish fishery from 2012 to 2014 is 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 NOAA and the Council that such medium-term projections would not be an adequate basis for specifying catch limits. The Council is now faced with the difficult task of specifying effective catch limits based on outdated assessments and unreliable catch projections, and the uncertainty will be reflected in precautionary catch limits.

In addition to the need for stock assessments to be frequent, 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.

Example 2 - 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. Despite these major uncertainties in the stock assessment of skates, the fishery is accountable for overfishing, and fishing communities are impacted from conservative catch limits in the face of scientific uncertainty. The fishing industry has incurred substantial costs in the form of lost jobs and income as a result of inadequate scientific information. Precautionary limits to the skate fishery caused 300 workers to be laid off from seafood processors in New Bedford (Whiteside 2011).

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.

Example 3 - 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 2006 to 2009, 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 stock cannot rebuild within the desired time frame, even with no fishery. Adequate scientific information would have prevented these fishery management failures.

The implications of uncertain, infrequent stock assessments and inadequate fishery monitoring create potential economic impacts on fishing communities. National Standard Guidelines suggest partitioning scientific uncertainty from management uncertainty so that fisheries are only accountable for the latter. However, that approach is only successful for data-rich assessments that are frequently updated and accurately quantify scientific uncertainty. The examples above demonstrate that inaccurate stock assessments, infrequent updates and unquantified uncertainties can hold fisheries accountable for scientific uncertainty.

2. *NOAA's Reliance on "Best Scientific Information Available" as an Excuse for Inadequate Information*

The Act mandates that fishery management be based on the "best scientific information available", which is defined for application to fisheries by the National Research Council (2004) and Sullivan et al. (2006). Current practice and draft guidelines for National Standard 2 implement the "best scientific information available" mandate by adhering to official peer review processes for each region. Some regional peer review processes do not currently meet the other requirements of the Act, such as frequent status determination and specification of annual catch limits. The two aspects of stock assessments required by the implementation of catch limits (greater frequency and higher-quality) are competing needs that draw on the same scientific resources. A more efficient system of stock assessment and peer review is needed in all regions to increase the capacity of the scientific system.

Although independent peer review is an essential element of operational science, some regional peer review processes have produced inadequate information for implementing the catch limit management system, because it is not frequent enough and not reliable enough. Many regional peer review processes are slow to respond to new information and are generally unsuccessful for solving stock assessment problems. Some regional peer review processes focus on a few stocks each year and add a great deal of time to the fishery management system while adding little scientific value. A more streamlined peer review process that uses external scientific expertise to solve problems would be more suited to the catch limit system than some of the regional peer review processes.

Example 4 - The stock assessments produced by the Northeast Regional Stock Assessment Workshop in the last year illustrate the need for a more effective and efficient peer review system. The 51st Stock Assessment Workshop attempted to develop analytical assessments for silver hake, red hake and offshore hake (Northeast Fisheries Science Center 2010). Despite decades of fishery monitoring and survey data as well as months of work from dozens of scientists and support staff, the Workshop was not successful in developing stock assessments for any of those stocks that could adequately meet the requirements of the catch limit system. The 52nd Stock Assessment Workshop was similarly unsuccessful in developing an analytical assessment for Gulf of Maine winter flounder, a critical stock in the New England groundfish fishery. In each of these cases, the Council is faced with the difficult task of specifying a catch limit based on inadequate scientific information.

One provision of the Act offers a resource for efficient peer review and creative problem solving but is currently under-utilized. Each regional Fishery Management Council has established a Scientific and Statistical Committee to help develop, evaluate, and peer review scientific information for fishery management. Although catch limits are bound by the Committees' recommendations, some regional offices of NOAA and Councils insist on prioritizing the peer review process. The scope of Scientific and Statistical Committee responsibilities are often limited to applying results from the official peer review process without deviation from accepted methods and approaches. The defense of outdated science and problematic methods has precluded creative problem solving or responsive decision making.

Empowering Scientific and Statistical Committees would improve the scientific basis for fishery management while serving the role of checks and balances.

Example 5 - Recent management decisions for the New England sea scallop fishery provide an example of the limitations placed on Scientific and Statistical Committees and the resistance to deviate from the official peer review recommendations. In 2009, the New England Scientific and Statistical Committee recommended catch limits for sea scallops that were based on a stochastic estimate of the overfishing definition. The Northeast Regional Office of NMFS concluded that the Committee did not have authority to revise the overfishing definition, and catch limits should be based on the overfishing threshold recommendation from the most recent official peer review. Subsequent peer review of the sea scallop stock assessment by the 50th Stock Assessment Workshop confirmed that the stochastic estimate was the best scientific information available (Northeast Fisheries Science Center 2010). The cost of using outdated recommendations for managing the sea scallop fishery was estimated to be over $60 million and 500 jobs (Georgianna 2010).

3. Adequacy of Data Collection Programs

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. 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 and recreational fishery catch 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.

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 and avoid accountability measures. Therefore, in situations of slow or inaccurate monitoring, fisheries are indirectly accountable for scientific uncertainty.

Example 6 – Inadequate catch monitoring is demonstrated by estimates of discards in New England. The Northeast Region has 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 efficiently 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, but 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 their 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 bycatch.

The Standardized Bycatch Reporting Method for yellowtail flounder bycatch in the scallop fishery is both slow and biased. Estimates of yellowtail bycatch are not available on a timely basis, and the annual estimate of bycatch is not provided until months after the fishing year ends. The estimate of yellowtail discards in the scallop fishery is biased, because observers are more likely to sample southern New England, where there are more yellowtail, than the Mid Atlantic Bight, where there are few yellowtail. When the observer data are used for a stock-wide, fleet-wide estimate of discards, the estimate of discards is more influenced by the southern New England bycatch rate. When the same observer data are appropriately stratified by region, the estimate of yellowtail discards decreases. The Standardized Bycatch Reporting Method indicates that the scallop fishery substantially exceeded their allocation of yellowtail in 2010, which they will be accountable for in the future, but alternative stratifications that recognize regional patterns indicate that there was no overage or only a slight overage. This example demonstrates how fisheries are accountable for scientific uncertainty.

Example 7 - Recreational fishery statistics also demonstrate slow delivery of uncertain catch estimates and how the catch limit with accountability system implemented by the National Standard Guidelines poses unrealistic demands on scientific monitoring programs. For example, the recreational fishery has contributed approximately 20% to 30% of the total catch of cod in the Gulf of Maine over the last decade, and that portion is reported to have increased substantially since the last stock assessments. However, estimates of recreational catch are not available for the analysis supporting 2012-2014 catch limits for groundfish. Uncertainty in recreational fishery statistics negatively effects catch limit monitoring as well as stock assessments. Some components of catch are not being adequately monitored to determine future catch limits, and fishery-dependent businesses that are accountable for exceeding catch limits cannot plan according to timely catch statistics. Alternative management procedures (e.g., size limits, bag limits, gear restrictions, time/area closures) would be more suited to the properties of recreational fisheries and more robust to the problems associated with monitoring catch from recreational fisheries.

The fishery's accountability for scientific uncertainty is particularly a problem for bycatch species and rebuilding stocks. The catch limit system is most efficient when specific stocks can be targeted or the stock-specific limits reflect the mix of stocks available on the fishing grounds. When catch limits do not match the multispecies availability, catch limits for one stock constrain the ability of the fleet to catch the full allocation of healthy species. Several aspects of scientific uncertainty exacerbate the mixed-stock 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 other 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.

Example 8 - The mixed-stock problem, intensified by scientific uncertainties, 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 an incidental bycatch is allowed. According to the National Standard Guidelines, this restrictive approach to catch limits needs to be maintained until the stock is completely rebuilt. 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. This example shows that scientific deficiencies for meeting the the catch limit and accountability system implemented by National Standard Guidelines impose substantial costs to the fishery. As a result of the mixed-stock problem, the groundfish fishery only caught 35% of the allocated catch in 2010, and employment decreased by nearly 13,000 crew days from 2009 to 2010 (Kitts et al. 2011).

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.

Example 9 - The first iteration of the national catch limit system was implemented in 2010 and 2011, and catch limits have been largely driven by scientist's estimates of limits and recommended probability of overfishing, or expert judgment for the many stocks that have data-poor or problematic assessments. Implicit risk tolerance ranges from 10% to near-50% probability of overfishing, but most catch limits are not based on explicit risk decisions. More extensive risk management would include cost-benefit analyses, in which multiple utilities (revenue, profit, employment, etc.) and consequences of events (e.g., cost of overfishing, cost of triggering a rebuilding plan, cost of foregone yield) would be considered in the evaluation of risk tolerance. National Standard Guidelines need to be expanded to include these important scientific analyses as a routine aspect of deriving annual catch limits to help maximize benefits, minimize costs and achieve optimum yield.

In the context of inadequate scientific information provided by NOAA, 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 reprioritized to support more frequent and accurate stock assessments as well as more timely and accurate fishery monitoring data.
2) Peer review processes can be streamlined, using external expertise to solve scientific problems.
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 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 the scientific information provided by NOAA is inadequate to meet the needs of the catch limit system as currently implemented, and the inadequacy of science is costing jobs. 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 and recreational fishery catch, 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. In many cases, fisheries are accountable for scientific inadequacy, with major costs to fishing communities. The scientific information required to support the fishery management system specified in the National Standard Guidelines is much greater than NOAA's current scientific capacity.

In reply to the Subcommittee's specific questions, I conclude that:

1) The data generated by NOAA is inadequate for fishery managers to comply with the new requirements of the Act and associated National Standard Guidelines, substantially and negatively affecting coastal economies and fishery-dependent jobs;

2) NOAA’s reliance on using “best scientific information available” is an inappropriate justification for defending outdated information and avoiding creative problem solving; and
3) Data-collection programs are inadequate for providing in-season catch information, negatively affecting fishery-dependent business decisions and making the fishery accountable for scientific uncertainty.

References

Butterworth, DS and AE Punt. 1999. Experiences in the evaluation and implementation of management procedures. ICES Journal of Marine Science 56: 985–998.

Cuddy D. Herring fishery could catch a break. The Standard Times July 19 2011, New Bedford MA.

Georgianna, D. 2010. Short term economic impact of scallop framework 21. Massachusetts Marine Fisheries Institute Report. January 5 2010.

Kitts A, Bing-Sawyer E, McPherson M, Olson J, Walden J. 2011. Interim Report for Fishing Year 2010 on the Performance of the Northeast Multispecies (Groundfish) Fishery (May 2010 – January 2011). US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-07; 41 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

National Research Council. 2004. Improving the use of the “Best Scientific Information Available” Standard in Fisheries Management. The National Academies Press, Washington, D.C.

Northeast Fisheries Science Center. 2009. An Evaluation of Scientific and Assessment Needs to Support the Development of Acceptable Biological Catches (ABCs) and Annual Catch Limits (ACLs) for Managed Fishery Resources in the Northeast Region. A White Paper to the NRCC prepared by ACL Working Group with review and consultation with the NEFMC/MAFMC/NERO/NEFSC ACL Working Group, October 2009.

Northeast Fisheries Science Center. 2010. 50th Northeast Regional Stock Assessment Workshop (50th SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-17; 844 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

Northeast Fisheries Science Center. 2011. 51st Northeast Regional Stock Assessment Workshop (51st SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-02; 856 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

NOAA. 2009. Magnuson-Stevens Act Provisions; Annual Catch Limits; National Standard Guidelines; Final Rule. Federal Register 74 (11): 3178-3213.

Sissenwine M and B Rothschild. 2011. Building Capacity of the NMFS Science Enterprise. Unpublished report to NMFS, January 2011.

Sullivan PJ, JM Acheson, PL Angermeier, T Faast, J Flemma, CM Jones, EE Knudsen, TJ Minello, DH Secor, R Wunderlich and BA Zanetell. 2006. Defining and implementing best available science for fisheries and environmental science, policy, and management. American Fisheries Society, Bethesda, Maryland, and Estuarine Research Federation, Port Republic, Maryland.

Touchstone Consulting Group. 2011. A Review of the New England Fishery Management Process. Report to NMFS April 2011

Transboundary Resources Assessment Committee. 2011. Georges Bank Yellowtail Flounder. TRAC Status Report 2011/01.

Whiteside JF. 2011. Scientific and Statistical Committee's meeting April 12, 2011. Memorandum to J. Pappalardo, New England Fishery Management Council Chair, April 6, 2011.

Wigley SE, Rago PJ, Sosebee KA, Palka DL. 2007. The Analytic Component to the Standardized Bycatch Reporting Methodology Omnibus Amendment: Sampling Design, and Estimation of Precision and Accuracy (2nd Edition). US Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 07-09; 156 p.