Report of the
Groundfish Assessment Review Meeting
(GARM III)

Part 1. Data Methods

By

Chairman: Robert O'Boyle

Review Panel: Victor Crecco, Lou Van-Eeckhaute, Desmond Kahn, Coby Needle, Brian Rothschild, Stephen Smith, Jon Helge Vølstad

Including Presentation Highlights for each Working Paper written by the lead Assessment Scientists

Report Date: December 27, 2007

Meeting Dates and Location:
October 29 - November 2, 2007
Northeast Fisheries Science Center
Stephen H. Clark Conference Room
Woods Hole, Massachusetts

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SUMMARY

During 29 October – 2 November 2007, a review of the seven types of data inputs (landings, discards, tagging, fishery independent and dependent surveys, ecosystem and recreational) was undertaken for the Groundfish Assessment Review Meetings (GARM). This was the first of a four part process, with the remainder focusing on models (25 – 29 February 2008), biological reference points (28 April – 2 May 2008) and the assessments themselves (4 – 8 August 2008). The overall GARM process has been designed so that each review can inform the subsequent ones.

A considerable amount of information on the GARM data inputs was considered in the meeting time available. Consequently, the review could only focus on the most important issues and highlight work that could be undertaken by the Northeast Fisheries Science Center to address these. This report provides a synopsis of each presentation along with the associated discussion, during which a number of specific suggestions and recommendations were made to address identified issues. Following this, a panel of seven reviewers provides its perspective on the activities required to meet the objectives outlined in the meeting's terms of reference. Many of the recommendations made can be implemented in time to be included in the next GARM in February 2008. However, a number will require longer-term actions which the Northeast Fisheries Science Center is encouraged to pursue.

Overall, the meeting successfully fulfilled its terms of reference and represents an important contribution to the remainder of the GARM III process.

INTRODUCTION

The chair (R. O'Boyle) opened the meeting by welcoming the participants (appendix 1) to the first of four GARM (Groundfish Assessment Review Meeting) reviews scheduled until August 2008. After introductions, he provided background on the GARM review, which is a peer review process developed in 2002 to provide assessments for the groundfish stocks managed under the Northeast Multispecies Fishery Management Plan. The first and second GARM reviews were held 8 – 11 October 2002 and 15 – 19 August 2005 respectively. The GARM process was initially intended to be distinct from the Northeast Stock Assessment Review Committee (SARC) process, which produces "benchmark" stock assessments. The initial purpose of the GARM was to provide assessment updates, using extant model formulations and data sources as well as to provide comments and recommendations regarding specific stock assessments and generic data collection and analysis procedures.

With this GARM III, the intent of the process has evolved. GARM III is to be the most comprehensive to date with the intent being the production of benchmark assessments and peer reviews of 19 groundfish stock assessments managed by the New England Fisheries Management Council (NEFMC). This process will take place over four meetings, with each having a different purpose:

- Data Methods (29 Oct – 2 Nov 2007) – this meeting
  - Review of the data inputs (commercial and survey) to be used in the stock assessments and the methodologies for analyzing
- Modeling (25 – 29 Feb 2008)

    - Determination of the most appropriate stock assessment methods and models for each of the 19 stocks
- Biological Reference Points (BRPs) (28 April – 2 May 2008)
    - Establishment of the BRPs for the 19 stocks
- Assessment (4 – 8 August 2008)
    - Application of the methods from the previous three meetings, along with survey and catch information through calendar year 2007, to estimate fishing mortality rates and biomass for each stock

The chair noted that the schedule has been established to allow time between meetings for scientists of the Northeast Fisheries Science Center (NEFSC) to address issues raised in each review. He noted that the GARM is a technical review of the science pertinent to assessments and would not be entertaining discussion on management issues, which is the purpose of the NEFMC. He also emphasized that the results of the meeting are confidential until its report has been released publicly.

The terms of reference (appendix 2) was then discussed. The meeting was to review the commercial and survey data that would be used in the stock assessments and identify appropriate statistical methods for analyzing those data (including bycatch and discard issues, changes in growth rates and other life history traits, issues related to merging databases, etc.). Other sources of data to be considered would be from tagging programs for cod and yellowtail flounder and from Industry-Based Surveys. Candidate sources of data relevant to ecological and ecosystem considerations would also be described. The draft agenda (appendix 3) had been structured to sequentially review the seven data types under consideration. It was noted that the agenda was exceptionally busy, with 34 working papers (appendix 4) to be considered and would be modified as needed. As it transpired, the working paper reviews were not completed until Thursday morning with the meeting adjourning noon on Friday.

The chair then introduced the GARM reviewers: Victor Crecco, Lou Van-Eeckhaute, Desmond Kahn, Coby Needle, Brian Rothschild, Stephen Smith, and Jon Helge Volstad who would be formulating the main recommendations of the meeting.

Regarding the conduct of the meeting, the chair noted that the presentation highlights and associated discussions would be recorded, the latter by the following rapporteurs:

A. Landings--Kathy Sosebee
B. Discards--Paul Nitschke
C. Tagging--Gary Shepherd
D. Surveys--Anne Richards
E. Industry Based Surveys--Lisa Hendrickson
F. Ecosystem indices--Laurel Col
G. Recreational Landings and Discards--Laurel Col

Following these comments, the meeting commenced.

The first section of this report provides the above mentioned ‘Presentations and Associated Discussion’. The presentation highlights are brief summaries provided by the authors of the working papers and do not provide many of the technical details. It is expected that the NEFSC will consider the recommendations of this report and produce working papers that are most appropriate as Center Reference documents. The discussion provides a synopsis of the main topics touched upon, as well as suggestions and recommendations, to inform the final session of the meeting in which the main conclusions and recommendations of the meeting were summarized.

The next section of the report, entitled ‘Progress towards Objectives’, provides the review panel’s recommendations and observations, structured by the meetings’ objectives as per the terms of reference. These are based upon the discussions held during the final session of the meeting and post – meeting reflections.

PRESENTATIONS AND ASSOCIATED DISCUSSION

COMMERCIAL LANDINGS

Working Paper A1: Wigley S E, Hersey P, Palmer J E. 2007. A Description of the Allocation Procedure applied to the 1994 to present Commercial Landings Data.

Presentation Highlights

The multi-tier trip-based allocation is designed to combine each mandatory reporting dealer (Dealer) trip with a vessel trip report (VTR) trip or a group of VTR trips of similar characteristics to obtain area fished and effort associated with the Dealer trip. Although the trip-based allocation and the single species proration yield similar results with regard to stock landings (Wigley et al. 2007), the trip-based allocation is an improvement over the single-species proration because it provides area fished at a fine level of resolution (statistical area rather than stock level) for all species. It also estimates effort associated with these landings. The trip-based allocation represents a comprehensive approach to determining area fished and effort in Northeast region’s commercial landings in order to meet scientific and fishery management needs as well as commercial data reporting requirements to Northwest Atlantic Fisheries Organization and supports economic and ecosystems research.

The multi-tier trip-based allocation has been developed to augment commercial landings data with area fished and effort; however, trip characteristics, species landings and price information will not change. All species on a given trip/subtrip will be assigned the same area and effort. The multi-tier trip-based allocation utilizes Vessel Trip Report data that have been aggregated into four levels: Level A, Level B, Level C and Level D. At Level A, Dealer and VTR trips are matched one to one. At Levels B, C and D, VTR trips are grouped together to form a pool of trips with similar characteristics which define the stratification cell within the level of aggregation.

A Dealer trip seeks an area match at Level A, and progresses through the increasing levels of aggregated VTR data until a match occurs. Area is obtained first then effort is obtained.

For each area level and stratification cell, a discrete probability distribution function is formed representing the proportion of trips which fished in a unique statistical area. A discrete cumulative distribution is formed using the statistical area probabilities. Each unique statistical area within the VTR group will have a cumulative probability associated with it. Before the allocation begins, every Dealer trip is assigned a random number between 0 and 1. The random number is compared with the cumulative probability associated with each area. The cumulative probabilities are in ascending order; when the random number is greater than or equal to the cumulative probability value, the statistical area associated with the cumulative probability is assigned to the Dealer trip. Thus, a single area fished is assigned to a Dealer trip on a probabilistic basis by sampling (with replacement) the distribution of VTR areas within the group.

Total effort is not known in the Dealer data; each Dealer trip will be supplemented with effort (days fished and days absent) taken directly from a VTR trip or estimated from the pool of VTR trips with similar characteristics. When a match occurs at Level A, days fished and days absent are transferred to the Dealer trip only when both effort metrics have values (both must be not null). If available, the number of hauls, haul duration, crew size, gear quantity, and gear size are also transferred. If a match occurs at Level B, C or D, then an estimate of days fished (DF) per trip and an estimate of days absent (DA) per trip are assigned to the Dealer trip. Both days fished and days absent are estimated by the median of their distributions, respectively, within the cell. The median was selected as the simplest statistic of central tendency for distributions of various shapes.

The allocation assumes the follow: 1) Dealer landings are a census of total landings; 2) vessels land only once per trip; 3) each Dealer trip that enters the allocation represents one trip; and 4) VTR data set is a representative subset of the Dealer set.

The proportion of Dealer landings entering the allocation range between 19% and 32%. Between 51% and 73% of the landings that enter the allocation to find area fished match at Level A (a one to one match of Dealer and VTR trips). Total commercial landings changed very slightly (< 1 mt) due to rounding of whole species pounds on split trips. An evaluation of input data for allocation revealed the VTR subset generally reflected Dealer data. An evaluation of the random component of the allocation indicated that the random component did not contribute to a wide spread in stock landings, indicating that the random component is not a large source of stock landings variability. Although some statistical areas on the biological samples associated with allocated trips changed, the majority of samples remained unchanged.

Strengths of the trip-based allocation include: 1) provides landings at a finer temporal and spatial resolution than the single species proration; 2) is a comprehensive approach to create a master dataset to support all analyses; 3) uses the same data sources as the single-species proration; 4) the multi-tier feature of the trip-based allocation is similar to the pre-1994 data where port agents conducted interviews or used their local knowledge to determine area fished and effort; and 5) the trip-based features maintains the link to biological samples. Weaknesses of the trip-based allocation include: 1) use of VTR data (self-reported data), however, this is the only data set containing the needed information; 2) VTR compliance and data auditing could be improved; and 3) examination of effort over the entire series is needed.

Discussion on Working Paper A1

There was discussion on the differences in the proportion of trips between the VTR and the dealer data particularly for invertebrate species and the large-mesh groundfish fishery. Part of the reason for this is that the not all of the lobster vessels are required to submit a VTR, and part is due to aggregation of trips in the dealer data for state landings information, resulting in a large number of single records which are actually multiple trips and/or vessels. In other words, trips may not mean the same thing in both databases.

The two algorithms used to prorate VTR data to statistical and stock area (old single-species vs new trip-based) were clarified and discussed. In the single species algorithm, proration for each species is undertaken separately (using port group, gear group, and market category, matched at permit month day, matched set by stock area, proportions applied to dealer landings). The trip-based allocation uses a similar approach but occurs at a finer scale and apportions the landings of the entire trip amongst statistical areas fished based upon a four level (A through D) allocation process. The first level (A) is considered the most detailed information which is used apportion the landings in the other levels. This allows for multi-species analyses and recreation of patterns on a consistent basis. It was noted that where latitude and longitude positional information is available, it is included in the database. The approach is meant to be similar to that of a port agent interview prior to 1994. It was noted that new and old systems produced landings allocations amongst stocks that were consistent. One of the advantages of the new system is the availability of intra-trip data on statistical area fished.

A small portion of the data is from smaller vessels that are grouped together and end up not allocated. It was clarified that the large amount of non-allocated data in Table 4 of working paper A1 are landings that did not enter the allocation process from fisheries that do not need to submit this type of logbook (i.e. surf calm, quahog, tunas) as opposed to data that required allocation.

It was noted that only one realization from the randomization simulation (different random number seed) was carried forward into the database. There is a potential for the selection of different areas assigned to Levels B, C, and D depending on the random number seed. This was tested and the distributions of the landings by stock area were generally fairly tight. The new database provides the potential to estimate the variance in the landings in the assessments due to stock area assignment.

Working Paper A2: Wigley S E, Legault C, Brooks E, Cadrin S, Col L, Hendrickson L, Mayo R, Nitschke P, Palmer M, Sosebee K, Terceiro M. 2007. Annual Comparisons of the trip-based allocated and the single-species prorated commercial landings, biological samples and numbers of landed fish at age

Presentation Highlights

Annual comparisons between the data used in the GARM 2005 stock assessments and the trip-based allocated commercial data were conducted for most GARM species for 1994 to 2003. These comparisons included: annual total species landings, annual stock landings, biological samples (lengths and ages), and the resultant numbers of fish at age.

There were negligible changes in annual total species landings between current landings (CFDETS) and trip-based allocated landings (CFDETS_AA) due to rounding in the trip-based allocation. There were minor changes in annual total species landings between data used in the GARM2005/TRC2007 and CFDETS_AA due to revisions and updates of the commercial landings. For multi-stock species, some shifts in stock landings occurred, the majority of biological samples retained statistical area (and stock area), and there were generally minor changes in landings at age. Statistical area changes of biological samples for single stock species are inconsequential.

Strengths of this analysis include: 1) comprehensive examination of GARM species with multiple stocks and most GARM species with unit stocks; 2) followed the estimation process all the way through to landings at age; 3) utilized the biological samples as much as possible; 3) includes estimates of uncertainty for landings at age and 4) landings at age do not change using the trip-based allocation. Weaknesses of this analysis include: 1) focused on GARM species, but invertebrates and other species should be examined as well; 2) unfair comparisons, in some cases, due to inclusion of lengths or ages from observer or survey sources in the GARM 2 but not AA calculations, making LAA comparisons difficult and 3) did not consider alternative to trip-based allocation schemes.

Discussion on Working Paper A2

The NEFSC's port sampling process was discussed and many clarifications made. Differences in the landings at age (LAA) for some species using the allocated data and samples were noted. Some of these differences may be due to low sample sizes in some years, resulting in even fewer samples after the allocation. It could also be due to the augmentation of port samples with samples from the observer program in the prior assessment. There is a need to examine the impact of these differences on the relevant assessments at the next meeting.

Working Paper A3: Nies T, Applegate A J. 2007. Accuracy of Self-Reported Fishing Locations in the New England Multispecies Trawl Fishery and
Working Paper A5: Applegate, A.J. 2007. Using VMS data to characterize fishing activity in the US yellowtail flounder *[Limanda ferruginea (Storer 1839)]* fishery

Presentation Highlights

Working paper A.3 investigated the accuracy of VTR location information that is used for several purposes in fishery analyses. With respect to the GARM TOR, this information is used to allocate landings to statistical area and ultimately stock area. The key points of the presentation were:

- VTRs did not accurately report area fished for 20% - 30% of a subset of observed trawl tows
- Impact of errors depends on spatial scale used (statistical area vs. stock area)
- Errors can affect allocation of landings to stock area; this may be important for some stocks
- Errors could affect other analyses: discard estimates, effort distribution, ageing, protected species interactions. Care should be exercised when assuming that the VTR locations are accurate at spatial scales smaller than stock areas.

Working paper A5 established that VMS speed profiles can be used to reliably predict trawl fishing locations. VMS positions from a random sample of trips landing large amounts of yellowtail flounder were classified as either fishing or non-fishing positions based on speed profiles. These positions were matched to observed tow locations for those same trips. A reasonable and statistically valid association between VMS positions tagged as fishing activity and observed tows was demonstrated.

Working paper A3 matched VMS or observer data to VTR records for subsets of trawl trips for calendar years 2003, 2005, and 2005. The assignment of fishing locations as determined by VMS speed profiles or observed haul locations was compared to the assignment of fishing locations from VTRs. The differences were reported by statistical area and stock area. This evaluates the errors in the distribution of fishing effort introduced through erroneous VTR reports. For the three years examined, between 20-30 percent of observed tows examined were assigned to the incorrect statistical area by the VTR. Most of the errors are caused by vessels fishing in more that one statistical area, but reporting only one area. The presentation highlighted that there are some statistical areas where erroneous VTR reporting is more problematic (e.g. SA 526).

In an additional analysis, the catch (landings and discards) of cod, yellowtail flounder, and winter flounder on the observed trips (matched to VTRs) was allocated to statistical area and stock area by the observed area and the VTR area. This illustrated how the VTR reporting errors can affect the distribution of catch for the data set used. The results showed that for some stock/year combinations the errors were minor, but for other stock/year combinations they were substantial. In particular, SNE/MA yellowtail flounder was identified as of particular concern. In a second analysis, yellowtail flounder catch on a different subset of trips was allocated to statistical area where VMS reports most fishing activity occurred. This is compared to the allocation reported by the VTR. This analysis also suggested that the VTR may over-allocate SNE/MA yellowtail flounder. Finally, the impacts of using VTR to allocate fishing effort were shown using observed haul duration as a measure of effort. The total effort assigned to statistical areas by VTR was shown to often be in error.

Strengths of these analyses are:

- The paper used methods to verify the accuracy of VTR location information
- The methods used allow an illustration of the magnitude of the errors and possible impacts.

Weaknesses of the analyses are:

- Observer coverage was directed to special programs in 2004 and 2005. Since some of these programs limited where vessels could fish on a given trip, this may bias the results to underestimate errors introduced by VTRs. At the same time, it makes it difficult to extend the results to the fishery as a whole.
- Because of a lack of observer and VMS coverage, the analyses cannot be extended to the full catch time series.
- While the paper suggests it may be possible to develop a way to use VMS to allocate catch in the future, there is no obvious correction factor that can be applied to existing data.

Working Paper A4: Palmer M C, Wigley S E. 2007. Validating the stock apportionment of commercial fisheries landings using positional data from Vessel Monitoring Systems (VMS)

Presentation Highlights

Vessel Monitoring System (VMS) positional data from northeast United States fisheries were used to validate the statistical area fished and stock allocation of commercial landings derived from mandatory Vessel Trip Reports (VTRs). A gear-specific speed algorithm was applied to 2004 – 2006 VMS data from the otter trawl, scallop dredge, sink gillnet and benthic longline fisheries to estimate the location of fishing activity. Estimated fishing locations were used to allocate the landings of eight federally managed species to stock areas: Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), yellowtail flounder (*Limanda ferruginea*), winter flounder (*Pseudopleuronectes americanus*), windowpane flounder *(Scophthalmus aquosus*), goosefish (*Lophius americanus*), silver hake (*Merluccius bilinearis*) and red hake (*Urophycis chuss*). Haul location and catch data from the

Northeast Fisheries Observer Program (NEFOP) were used to assess the relative accuracy of both VMS and VTR allocation methods.

Overall, the mean VMS – NEFOP agreement rate was 86.4 ± 7.6 % compared to a mean VTR – NEFOP agreement rate of 58.5 ± 4.9 %. VTR's accurately record the identity of at least one of the statistical areas on a given trip, but exhibit a tendency to under-report the number of statistical areas fished when fishing occurs in multiple statistical areas. The VMS algorithm had a tendency (approx. 10 % of all trips) to overestimate the number of statistical areas fished such that when all fishing activity from a given trip occurs in a single statistical area, VTRs more accurately reflected the true fishing location. However, on trips where fishing activity occurred in multiple statistical area, the VMS algorithm showed pronounced gains (77.2 ± 11.2 % NEFOP agreement) relative to VTR reports (12.0 ± 5.9 % NEFOP agreement). The VMS method achieved distributions of stock landings closer to NEFOP estimates in 18 out of 24 instances (8 species over 3 years). The stock allocations from both the VMS and VTR-based methods were within ± 5 % for all stocks, suggesting that the impacts on total stock allocations are relatively minor. However, these small differences represent major relative differences for less abundant stocks such as southern New England/mid-Atlantic yellowtail where in 2005 the VTR-based method allocated 61.9 % more landings relative to the VMS-based method. The VMS-based method is not a replacement for the VTR-based method; however, it can, and should, be used as a tool to identify those vessels where targeted outreach activities would improve the accuracy of VTR statistical area reporting.

Discussion on Working Papers A3, A4 and A5

The impact of mis-reported statistical area(s) or the reporting of a single statistical area when fishing actually occurred in multiple areas on the allocation process was discussed. The impact on smaller stocks (SNEMA yellowtail flounder) may be greater than that on larger stocks and there may be a masking of trends in the relative fishing mortality (F) for index-based stocks. This could be examined in the assessment.

The statistical area reporting practices of fishermen on a trip were discussed. There may be predictable patterns in the reporting of statistical area by fishermen that could be used in the proration algorithm.

The value of using Vessel Monitoring System (VMS) data in verifying the statistical area fished was discussed, recognizing that these data also have issues. For instance, in Europe, some boats have been observed to slow down to develop fishing time in an area. There may also be issues with misreporting due to regulations (one area having a lower quota, etc). The need to communicate with and educate fishermen who have misreported the statistical area of fishing was highlighted as a means to improve the quality of the data on statistical area fished.

There was discussion on the difference between the conclusions of the main papers. Some of these were due to the number of vessels examined in each. One paper examined a subset of vessels (offshore vessels with a large catch of groundfish) whereas the other considered a wider range of vessels. Overall though, the papers were complementary, highlighted the need for caution in interpreting the statistical area fished data, and the future potential of the VMS data to supplement and verify the statistical area fished information in the VTR database.

Working Paper A6: Legault C, Brooks E, Seaver A. 2007. BioStat Bootstrapping for Estimating Uncertainty in Commercial Landings at Age

Presentation Highlights

Estimation of uncertainty for commercial landings at age is an important component for stock assessment, especially for use in forward projecting models which allow uncertainty in the catch at age. The bootstrapping process described in this working paper occurs at three levels: port samples, lengths within samples, and ages within lengths for that sample. This three tier bootstrap incorporates all levels of uncertainty in the data collection and then is treated in the same manner as the original sample to generate a bootstrap estimate of landings at age. Repeating this process many times produces distributions of landings at age which can be summarized by coefficients of variation as well as a variance-covariance matrix for landings among ages. The software is already developed and easy to use, typically taking only minutes to conduct 1000 bootstraps. An extension of the software to allow incorporation of an ageing precision matrix is in beta testing.

Results from specific application of the bootstrap method in BioStat show that uncertainty in landings at age are highest at the youngest and oldest ages and that there are often positive correlations among ages. These results showed high agreement with those of the model based estimates provided in WPA7, both in terms of the pattern of CV and the presence of positive correlations among ages, even though there are some slight differences in how the samples are expanded to the total catch. These positive correlations are not found in the typical assumption of a multinomial process for modeling error in the catch at age in forward projecting models. Preliminary exploration of using the variance-covariance matrix directly in the likelihood function of a catch at age analysis found different estimates of F than when the multinomial assumption was made.

Some additional uses of the bootstrap approach are to use the bootstrapped landings at age separately in virtual population analysis runs to produce distributions of stock and F matrices. Results can also be used to guide sampling requests and assist in determination of the plus group age. It is recommended that bootstrapping be performed regularly as part of the estimation of landings at age.

Working Paper A7. Miller T. 2007. Model-based estimation of numbers-at-length and(or) -age for commercial landings in the Northeastern United States

Presentation Highlights

Model-based estimates of numbers-at-age per unit weight are multiplied by the true total weight. An implicit assumption is made that the numbers-at-age per unit weight in the larger landings are the same as that in the unsampled smaller landings. The estimates are derived with respect to model-based inference, but are also appropriate for design-based inference using a specific type of stratified multi-phase design. Model-based inferences depend on the how closely model assumptions match the reality of the data-generating mechanism (Valliant et al. 2000).

The overall model reflects measurements with multiple sources of error. For example, the estimate of total number at length l for a given market category in a trip can be viewed as a measurement of the true total number at length l (in the market category) with error. Furthermore, this measurement error can be estimated with the data components used to make the measurement (the number of fish sampled in the trip with length l in the market category).

Similarly, the estimate of total number at length *l* at a port may be viewed as a measurement with error where the data used to make the measurement (the trip-specific total numbers at length *l*) are also measured with error and the precision of the measurements for each trip can be assumed to be different. As such, different measurement error components (trip- and port-levels) for an overall estimate (measurement) of the total numbers caught at length are produced.

Discussion on Working Papers A6 and A7

There was considerable discussion on the design of the NEFSC port sampling program. Questions arose on the definition of the sampling unit used. Sampling appeared clustered while the current analysis of the data assumes independence. It appeared that the current sampling procedure does not fit well into standard sampling theory. A request was made to develop a schematic of the bootstrapping sampling procedure. This was provided later in the meeting and led to the conclusion that bootstrapping below the port level was not required (see below)

It was considered that the model and design-based sampling approaches should produce similar results if both are based upon the same assumptions. The advantage of the modeling approach is that auxiliary information can be included. However, there was no discussion on what kind of auxiliary data would be appropriate.

COMMERCIAL DISCARDS

Working Paper B1: Blaylock J, Wigley S E. 2007. Summary of trips from the Northeast Fisheries Observer Program and Vessel Trip Report data

Presentation Highlights

The Northeast Fisheries Observer Program (NEFOP), which was implemented in 1989, has observed trips for a wide variety of gear types. During 1989 to 2007, the majority of NEFOP trips represent five main gear types: longline, otter trawl, shrimp trawl, sink gillnet, and scallop dredge. The number of NEFOP and Vessel Trip Report trips were summarized for 1994 to 2006 for those five gear types, stratified by area fished, mesh group, trip category and calendar quarter. Given that stock assessments need a time series of discard data, this inventory summary indicates that there are some stratification cells where there are little or no coverage. Issues of stratification, imputation and hindcasting will arise when estimating discards for stock assessments.

Working Paper B2: Wigley SE, Palmer MC, Blaylock J, Rago P J. 2007. A Brief Description of the Discard Estimation for the National Bycatch Report and Working Paper B6: Wigley S E, Rago P J, Sosebee K A, Palka D L. 2007. The Analytic Component to the Standardized Bycatch Reporting Methodology Omnibus Amendment: Sampling Design and Estimation of Precision and Accuracy

Presentation Highlights

Three methods and two ratio estimators (discard weight to kept weight of all species and discard weight to days absent) were examined in the Standardized Bycatch Reporting Methodology (SBRM) analysis. This analysis used 2004 Northeast Fisheries Observer Program (NEFOP) data to estimate sample sizes needed to achieve a desired precision and to evaluate accuracy in the NEFOP data. A broad stratification of calendar quarter, region (port of departure), gear type, mesh size, access area (open, closed) and trip category (general or limited) was used. The three methods and two estimators yielded similar results; the combined ratio of discard weight to kept weight of all species was determined to be the preferred approach.

For the National Bycatch Report, the combined ratio of the discard weight to kept weight of all species was used to estimate discards in 2005 for the 33 Magnuson-Stevens Act species from 25 fleets in the Northeast Region. Similar to the SBRM analysis, this analysis used a broad stratification; however, instead of port of departure, area fished was used. In addition to estimating discards and associated precision, this analysis also validated the estimation method and underlying data by estimating landings using the Northeast Observer Program data. For many of the species and species groups, the estimated landings based on NEFOP data compared favorably to the VTR landings, with the 95% confidence interval of the estimated landings encompassing the VTR landings, confirming that the method and underlying data provide sound estimates of discards. It is important to emphasize that discard estimates and the stratification used in this analysis may not necessary correspond to the discard estimates derived for individual stock assessments.

The strengths of this analysis include: 1) a wide variety of species were examined; and 2) validation of method and underlying data was undertaken. The weaknesses of the analysis include: 1) only examined a single year; 2) estimated discards and landings at species level, not stock level; 3) used a broad stratification with many cells containing large sample sizes.

Discussion on Working Papers B1, B2 and B6

The discussion raised a number of suggestions for NEFSC to pursue. The statistical methods for filling in missing data should be examined. Using nearest neighbor estimates for filling in missing years may also be appropriate. The impact of filling in missing cells or hindcasting for the results of the assessment should be investigated.

The National Bycatch report used a consistent method of estimating discards for many different species and fisheries. It was noted that a finer tuned stratification of the observer data will likely be developed in each species specific stock assessment which may result in more precise discard estimates. In addition, the use of allocated dealer data will allow for finer stratification in the discard estimates. However, the discard estimates used in the stock assessment should be on the same order of magnitude as the National Bycatch report estimates. The combined ratio method was validated by comparing estimated landings using expanded kept portion of the catch in the observer data to the actual report landing. The estimated landings appear to be in line with the reported total landings. Using kept weight of all species in the denominator of the combined ratio ensures that all the catch data were used in estimating discards.

Working Paper B5: Legault C. 2007. Discard Estimation using Observer Data

Presentation Highlights

Discards were estimated by six methods in four sample populations created using observer data. In each population, the total discards were known. Random samples of 10% of the population were selected and each of the six methods used to estimate the total discards. Bias for each method was estimated as the mean of difference between the 1000 estimates and the true value. There were two clear winners out of the six, the ratio of sums and the mean discard per trip. Both had zero bias, although individual realizations could still be relatively far away from the true value, plus/minus 50%. In contrast, the four clear losers were highly biased and almost always far away from the true value. These four poor performers were mean ratios of different types. Although only four sample populations were created, it was the use of actual observer data, with all of its inherent variability, which made this a reasonable test for the estimators and led to the poor performance of the mean ratio estimators. Use of all species kept as the denominator in the sum of ratios method appeared to produce less biased results than use of only the species of interest in the denominator.

Discussion on Working Paper B5

The discard simulation analysis using actual observer data showed a clear difference in the performance of the discard estimators. Discard estimators which use a mean of ratios were highly biased. Increased sampling did not make these estimates less biased. The ratio of sums (sum of discard weight over sum of kept weight) over all trips and the effort based estimator were unbiased and is the preferred ratio as there are difficulties in obtaining the total number of trips in the fishery for the effort based expansion. Although the combined ratio estimator preformed well, there was some discussion on whether landings of all species is a good surrogate for effort. The poor relationship between the discards of a species to the total landings was questioned. The simulation suggests that the estimator is invariant to the correlation between the numerator and the denominator. However, the effort based discard estimator may perform better at low sample sizes.

Working Paper B4: Terceiro M. 2007. Comparison of commercial fishery discard estimates for SNE/MA winter flounder

Presentation Highlights

The National Bycatch Report's combined ratio bycatch estimation approach (NBRD2) has been applied for comparison with observer (OB) and VTR discard rate estimation methods for 1994 and later years. Discard rates by half-year were calculated for trawls and scallop dredges, and applied to the corresponding landings (winter flounder landings for the OB and VTR rates; landings of all species for the NBRD2 rates). The OB discard rate estimates were higher and more variable (with some infeasible estimates), than discard estimates from the VTR and NBRD2 methods, which were generally of about the same order of magnitude. Coefficients of Variation (CVs) for the VTR estimates have not been calculated; CVs for the NBRD2 estimates for combined trawl and scallop fisheries ranged from 118% (1994) to 11% (2005), with a median value of 28% for 1994-2006. If the VTR and NBRD2 discard estimates are examined by gear, it is apparent that the scallop dredge estimates generally make up a larger part of the NBRD2 estimate total when compared to the VTR estimates. The scallop dredge fishery lands a small amount of SNE/MA winter flounder (less than 35 mt annually) compared to the trawl fishery (1,200-4,600 mt annually), and so even though the VTR scallop dredge discard rates can be high, the VTR discard estimates (based on expansion by winter flounder landings) area relatively low. In previous assessments, neither the OB nor VTR discard rate data were considered adequate for the estimation of discards specific to the scallop dredge fishery, due to sample size and inter-annual variability of the rates.

In contrast to the VTR estimates for scallop dredge gear, the NBRD2 scallop dredge discard estimates are quite variable and can be much larger than the trawl discard estimates, in spite of a low discard rate (discard of winter flounder to total landings of all species), because of the large magnitude of total landings in the fishery (used as the expansion factor) and the sensitivity of the discard estimate calculation to small inter-annual changes in the absolute discard rate. CVs for the NBRD2 estimates for the scallop dredge fishery ranged from 75% (1997) to 15% (2005), with a median value of 42% for 1994-2006. It remains unclear if the NBRD2 scallop dredge discard estimates for SNE/MA WFL are appropriate for use in the assessment.

Wigley et al. (B2) indicated that the NBRD2 estimate of landings for winter flounder (3,186 mt) was comparable to the Dealer reported landings (3,667) for 2005, with the 95% confidence interval (2,606-3,767 mt) encompassing both the Dealer landings and the VTR reported landings (3,477).

Discussion on Working Paper B4

The working paper described a real life example of estimating discards for a fishery that does not retain any catches of the discarded species. The working paper questioned how to estimate winter flounder discards in the scallop fishery. In this fishery, the combined ratio method produces very low ratios of discards to total landings but the expansion using total landing of all species was very large. The resulting discard estimates for the scallop fishery were relatively high compared to the trawl fishery discards and in years with low observer coverage, the estimates can be high and variable. The review panel suggested looking at other sources of information such as regulatory changes that could support a possible large discard event. It was noted that the trends appear to be similar among the different discard estimates from 1994 to 2003 but that there is some divergence between the trends after 2003.

Working Paper B3: Hendrickson L, Nies T. 2007. Discard and gear escapement survival rates of some Northeast groundfish species

Presentation Highlights

There are few studies that address discard and gear escape survival rates of the Northeast groundfish species that will be assessed during GARM III. No studies were identified for white hake, redfish, Ocean pout, and windowpane flounder. The working paper summarized important study design elements, factors affecting survival rates and survival rate estimates from existing studies. Most of the studies pertained to trawl gear but there were also a few longline studies for which the discard survival rates were estimated for haddock, Atlantic cod, and Atlantic halibut. Survival rates can be quite variable for the same species, gear type, and survival monitoring period because many factors affect the survivorship of discards and gear escapees. In addition, there are many important study design considerations that can affect survival rate estimates.

Survival rates are species-specific and may also be size-dependent. Some of the survival rate studies included in the review had design shortcomings such as: small sample size, lack of a control group, unrepresentative commercial fishing and handling conditions, and short holding times of caged individuals. Most of the studies did not include post-release mortality estimates attributable to avian predation, which can be a substantial source of discard mortality for some species. Therefore, it was recommended that a thorough evaluation of the adequacy of a particular study design be conducted before deciding to use the survival rate estimates in a stock assessment. Well-designed survival rate studies of Atlantic cod (longline and trawl), American plaice (trawl), and yellowtail flounder (trawl) were identified in the working paper. In general, discard survival rates were higher for flatfish (and highest for yellowtail flounder and winter flounder) than gadids and higher discard survival rates were reported for large fish compared to small fish. For example, trawl discard survival rates from one study were 0-25%, 17-37%, and 66-89% for Atlantic cod, American plaice, and yellowtail flounder, respectively. The same study estimated trawl escape survival rates for cod, American plaice and yellowtail flounder as 94-96%, 39-41%, and 68-90%, respectively. For haddock, gear escape survival rates are size-dependent with the lowest survival rates for fish < 15 cm. No precision estimates associated with survival rate estimates from any of the studies were presented. The Gulf of Maine and southern New England-Middle Atlantic winter flounder stocks are the only GARM III stocks for which a discard survival rate > 0 is used in the assessment (a value of 50% is used and is based on an average from two studies).

Discussion on Working Paper B3

There is limited information available on discard survival rates for GARM species in the commercial fishery. There is even less known about escapement survival. Escapement mortality is assumed to exist but is difficult to quantify. Escapement mortality estimates do not exist for GARM stocks. Gulf of Maine and Southern New England winter flounder are the only GARM stocks that assume greater than zero percent survival for commercial discards. The stress of capture or escapement can lead to higher predation mortality. However, the cod tagging study does indicate that survival in commercial gear is greater than zero. The question to the GARM was whether there is a basis to assume survival of discards greater than zero percent for a stock? It was recommended to use survival rates greater than zero percent if there are studies to support the higher survival rate estimates.

TAGGING DATA

Cod

Working Paper C1: Tallack S. 2007. A description of tagging data from the Northeast Regional Cod Tagging Program (WP3A) and preliminary applications of weighting and mixing analysis (WP3C)

Presentation Highlights

During 2005, it was recognized that the Northeast Regional Cod Tagging Program's (NRCTP) large, quality-controlled database had the potential for real management application, particularly with regard to stock identification through estimates of mixing and growth. Between April 2003 and July 2005, over 114,000 cod were T-bar tagged on over 100 commercial and recreational vessels, during dedicated tagging trips in both US and Canadian waters. The size range of fish tagged was 29-134cm, with 41% (n=46,613) being sublegal (<53cm) at the time of release. Different tag combinations were used to enable estimates of tag shedding (n=18,305 double-tagged) and reporting rates (n=2,240 high reward releases). Tag release data is detailed, quality controlled and downloadable as an MS Access relational database (the master database is built in SQL). By October 2007, recapture information has been received by GMRI (Gulf of Maine Research Institute) for over 5% of the tagged cod releases (n>6,500).
By December 2007, release and recapture information for an additional 67,554 cod tag releases during 2000-2003 will be available. These fish represent recent cod tagging efforts undertaken by the University of New Hampshire, University of Massachusetts' School of Marine Science

and Technology and Fisheries and Oceans Canada. The GMRI is currently auditing, error-checking and collating these three datasets into the same format as the larger, NRCTP dataset, ready for inclusion into the NEFSC multi-species tagging database (currently still in development). In total, 182,029 cod tag releases and >10,157 tag recaptures will be available for future movement analyses for the time period of 2000 onwards.

There are two core assumptions when defining a stock, namely that the stock is self-sustaining and that neighboring stocks exist in isolation. As the bank of recapture data has increased, a descriptive depiction of "passages of travel" for Atlantic cod in the Gulf of Maine region has become possible. These migration patterns may violate both core stock definition assumptions, as indicated through the quantification of movements using a model. Of the movements observed, some were anticipated; e.g. exchanges of fully recruited cod between the Bay of Fundy (Canada) and Georges Bank (US). However, a more surprising split in migration patterns has been observed where smaller cod appear to recruit from the Cape Cod nearshore waters and migrate either: 1) northwards into the inshore Gulf of Maine waters, or 2) eastwards out onto Georges Bank. This divergence in migration patterns is not currently accounted for in the current stock assessment models and it is recommended that cod movements and exchange rates feature in future stock assessment methods.

Working Paper C2: Loehrke J, Cadrin S. 2007. A Review of Tagging Information for Stock Identification of Cod off New England

Presentation Highlights

Recent observations of cod movement across stock boundaries are generally consistent with historical tagging data as well as information from other stock identification approaches. This working paper provided an historical context in which to consider recent tagging data for spatial delineation of cod stock assessments. A review of cod stock identification approaches, focusing on tagging investigations, was presented and organized chronologically. Four conclusions were made with special consideration to transboundary movement:

1. Movement across boundaries is documented in all relevant investigations.
2. The primary direction and magnitude of movement varies between studies.
3. The current stock management boundaries are defined for operational purposes.
4. Evidence suggests that it may be appropriate to reevaluate stock boundaries, particularly in the vicinity of the Great South Channel where there is considerable mixing and growth rates are intermediate between those observed in the Gulf of Maine and Eastern Georges Bank.

Working Paper C3: Miller A. 2007. Estimating instantaneous rates of regional migration and mortality from conventional tagging data and
Working Paper C4: Miller A. 2007. A finite-state continuous-time approach for inferring regional migration and mortality rates from conventional and archival tagging experiments

Presentation Highlights

A finite-state continuous-time approach for inferring instantaneous migration and mortality rates from different types of tagging studies including tag-recovery are the subject of recent work by Miller and Andersen (in review). Here we apply the statistical method to data from tag-recovery experiments by the Gulf of Maine Research Institute (GMRI) on Atlantic cod, but expand the set of states to allow estimation of tag reporting probabilities, tag shedding rates and account for incomplete mixing of newly released individuals.

The main concern with the results so far is the unexpectedly high estimates of natural mortality. Potential causes for positive bias in natural mortality include 1) movement of fish to areas inaccessible to fishing or outside of the study area, 2) heterogeneity of size of released fish when there are differences in fishing mortality with size and 3) less than 100% reporting of high reward tags. The first potential cause is not readily dealt with using any tagging study, but the second cause could perhaps be treated by allowing fishing mortality to change with length and assuming a model for growth of tagged fish. Finally, the third cause is probably contributing substantially to the results here because tagged fish may just not be seen in large trawl catches. Non-reporting of high-reward tags does not appear to be a treatable problem, but if we can assume that this occurs equally across regions, the estimates of migration rates would be unbiased even though the natural mortality rates would be positively biased.

Discussion on Working Papers C1, C2, C3 and C4

It was noted that catch and effort scaling by statistical area in the cod movement paper was from NEFSC dealer data pro-rated and then combined for stock area. The selection of the cod model by Miller (C3 & C4) was not unduly influenced by the number of model parameters as it was based on a likelihood ratio test criteria and would be same choice even if AIC were used.

The suggestion was made to evaluate alternative tagging models such as the Brownie or MARK models. However, it was noted that in this situation these models may have to make some undesirable assumptions and the confounding of migration and mortality may create misleading fishing mortality estimates. A simple model of the number of recaptures divided by number of releases was also suggested.

The assumption of 100% reporting of high reward tags may not be reasonable. Lower possible rates should be considered. The majority of cod tagged were small (less than 53 cm). The model was parameterized with a constant natural mortality but it may be higher on smaller fish due to predation.

A sensitivity analysis of the Miller model was suggested. It was suggested that some rates be fixed such as exchange rates, natural mortality, reporting rate, etc. The possibility that tag return rates differ by gear type should also be investigated. In particular, differences in gear composition for the different areas may result in area - specific differences in estimates of fishing mortality. Also, if possible, the fully recruited fishing mortality using only legal size fish should be estimated. It was noted that size distribution affects probability of capture (for sensitivity issues).

The question was raised as to whether the tag return data supported the current stock definitions. The large exchange of cod between Georges and Browns Banks was noted. It is possible that permanently closed areas may have reduced tag release and recaptures (~20,000 tagged cod were released in closed areas (Cashes, CAI, CA II, WGOMCA)), because recaptures in those areas are limited to tagging trips and recreational recoveries. This may affect parameter estimates because of refuge effects. It was assumed that all fish are available and have equal probability of capture, whether tagged or untagged.

It was suggested that an analysis be conducted to examine the impact of net movements among areas. Also, it was suggested that the differences within Georges Bank be examined. If movement rates were taken at face value, would net loss be similar to having a higher natural mortality? It was noted that the results have to be conditioned on biomass by region and would be a function of the size or age of fish tagged. Incorporating additional parameters into the model to address this would be difficult but is possible.

It was concluded that the tag analysis represented a first look at sensitivity for bias. Additional work could go beyond the tag results to consider the implications of the higher natural mortality in the assessment models (e.g. VPA).

There was discussion on how much movement was needed before the current view of stock definitions was invalidated. This could be examined through the modeling presented at the meeting including expected equilibrium distributions of abundance and biomass across stocks under different migration rate scenarios and the impact of different stock boundaries on these distributions. It was unclear how much of these explorations could be done during this GARM.

Yellowtail

Working Paper C5: Cadrin S, Westwood A, Alade L, Moser J' Martins D. 2007. Yellowtail Flounder Tagging Data

Presentation Highlights

New England fishermen and staff at the Northeast Fisheries Science Center tagged over 45,000 yellowtail flounder in all three New England stock areas. The study was designed to charter commercial fishing vessels to tag yellowtail flounder with conventional disc tags and data-storage tags with the objectives of estimating movement among stocks areas and mortality within stock areas as well as providing growth observations. Preliminary results indicate frequent movements within the Cape Cod and Georges Bank stock areas with a less frequent movement among stock areas. Results are expected to provide information for yellowtail flounder stock assessments and management decisions. This report provides supporting technical information for preliminary estimates of movement and mortality to be reviewed for yellowtail flounder stock assessments (TOR C).

Working Paper C6: Cadrin S. 2007. Movement-Mortality Analyses of Yellowtail Flounder Tagging Data

Presentation Highlights

The objective of this working paper was to provide updated analytical results from the cooperative yellowtail tagging study and demonstrate potential utility of the data for future stock assessments (TOR C). However, the tagging study is still in progress and these data are preliminary. More importantly, these analyses are presented to illustrate developmental methods and are not intended for stock assessment purposes. Background and introductory information about the yellowtail flounder tagging study are described in GARM Working Paper E3.

Working Paper C7: Alade L, Cadrin S. 2007. Evaluating the Precision and Accuracy of the Yellowtail flounder Movement-Mortality Model via simulation

Presentation Highlights

In this study we begin to address the uncertainty of the yellowtail flounder movement-mortality model by simulating a population that emulates the yellowtail flounder population and tagging study. The results in this paper only provide a snapshot of the several possibilities for simulation and analyses. Based on the presented simulations, recapture data with coefficients of variation of 10% - 25% tend to provide the most accurate estimates of fishing mortality and movement rates. While exploratory simulations will continue to be used to determine the general properties of the model, the results in this paper should be viewed as demonstrations. Future directions involve evaluating the effect of sample size on variance estimates, simulating a design that assumes proportional releases, time varying mortality rates and stock-specific reporting rate.

Working Paper C8: Wood A, Cadrin S. 2007. Can survival be estimated from the yellowtail tag-recapture database? A preliminary analysis.

Presentation Highlights

The analysis of the yellowtail data was based on the suite of Brownie models using the Mark program. Multi-period tagging models were applied. The model require a host of assumptions such as the representativeness of the tag releases, proper accounting of returns, catchability of tagged vs untagged fish, etc. Final model selection was based on an adjusted AIC value. Estimates of over-dispersion were higher than acceptable for these kinds of models. Four basic models were explored. Recaptures were fit to yearly, monthly and seasonal models. The general seasonal model likely best but still overparameterized. The model is considered preliminary and, once the models and the data are refined, the overall fit and the resulting parameter estimates will be greatly improved.

Discussion on Working Papers C5, C6, C7 and C8

Suggestions were made to improve the MARK model. It may be possible to limit releases to one release area and do separate MARK analyses for each stock. Other suggestions were made regarding the Cadrin model, including use of a sex disaggregated model and a model based on historical changes in regulations. Since fishing effort generally is generally related to aggregations of species, use landings instead of effort for specific auxiliary information could be considered. It was also suggested to explore alternative simple models such as the 'catch equation' method to examine natural mortality in SNE yellowtail.

The model estimated survival to be very low but with a great deal of inter-monthly variation. The mortality estimates were very high except in SNE yellowtail. The lack of tag recaptures for this stock created estimation problems in the Cadrin model. In both the MARK and Cadrin models, estimates of fishing mortality (F) were around 1.0 with natural mortality (M) around 0.2. The VPA also estimates high F which may be from high levels of discarding. There was then discussion on the level of discarding. Is SNE really a discard fishery? Discarding is high in two of the three stocks. It was suggested that with F being as high as estimated, the population couldn't persist. Recoveries in 2003 from Georges Bank, for instance, relative to the number released (an R/M or Peterson model) implied that exploitation was quite low. It was noted that R/M is commonly used for continuous fisheries, despite the intended 2-sample design of the

Peterson model and the implicit assumption of a closed population in the period between the two samples. It was mentioned that application of a Peterson model to a continuous fishery makes a logical inconsistency of recapturing tags over a period that is assumed to be closed to any losses. There could be other issues for the low exploitation in the early years (tag loss, etc.). The Miller model implies low dispersal of cod which is likely the case with yellowtail. Low dispersal rates may produce unreasonable values of the other parameters.

The low fitted reporting rate in the Cadrin model (13%) was noted. It was pointed out that even though it seems extremely low, in this fishery, there is an incentive to ignore tags (scallop fishery) and not report. It was suggested that tag returns be examined by vessel to determine the expected returns due to magnitude of vessel landings. This could also be done by fishery.

It was recommended that the Cadrin model was compared to the Miller model to examine the impact of the assumptions made in each. A suggestion was made to apply the Miller model to yellowtail but it was felt that the Miller model needed further evaluation using sensitivity analysis, although it was noted that some sensitivity analysis (sample size, etc.) was presented in the working paper. A caution was raised to avoid integrating results of tag model into VPA. The preference was to keep them independent as a means of checking conclusions. The tag models should move to integrate other information such as catch at length or catch at age. However, it was cautioned that results can be driven by the auxiliary data.

It was asked if the tag data and analyses support the current stock definitions. The reviewers concluded that nothing new resulted from this tag data, particularly boundary issues. What was known about the SNE-GB border was confirmed with tagging. Some Georges Bank fish move to Nantucket shoals seasonally. Diagonal results in the model for Cape Cod and Georges Bank are similar to tagging results from the 1940s (during WWII when F was presumably lower). This implies that the Cadrin model estimates of movement between these areas may be legitimate.

A question was asked on whether migration among stock areas can be quantified. It could but only if conditioned on a model derived F. Perhaps other methods for total mortality (survey data, etc.) would be more appropriate for use in the tag model.

Further discussion considered if it could be concluded that there was limited movement between Cape Cod, Gulf of Maine and Georges Bank. If F were high, then fish wouldn't survive long enough to migrate far. A suggestion was made to consider what process would be needed to make off-diagonals (stock movement) higher. It may be possible to use the Cadrin model to do sensitivity of this hypothesis.

The short time series of returns was thought likely to hamper analysis of mortality rates. The results may be most useful for migration and stock structure information. It was concluded that the mortality models are works in progress but not yet ready for use in assessment. It was noted that the tagging results could possibly be used as confirmatory estimates of survival in time for the final GARM meeting.

FISHERY – INDEPENDENT SURVEYS

Presentation: Rago P. 2007. NEFSC Bottom Trawl Surveys - Overview

Presentation Highlights

A brief overview of the NMFS trawl survey series was presented noting that it provided a synoptic view of the fish populations from Cape Hatteras to Scotian Shelf using a consistent stratified random design over the whole series. Of the three series, the oldest was initiated in 1963 while the newer series (winter series) was discontinued after the 2007 survey. In addition to numbers, weights and size composition for many species, ancillary data on food habits, growth and maturity are collected in addition to some basic oceanographic data (e.g., temperature, salinity).

Discussion on Presentation

It was noted that it was not possible to address the meeting terms of reference on fishery independent surveys (FIS) due to the lack of working papers on each issue. There are many issues to consider and it is important to prioritize work at the NEFSC to address those which are most relevant to the assessments. It was suggested that the Center hold a one to two day internal session as soon as possible to discuss FIS issues. It was suggested that the review panel provide its suggestions on the issues most pertinent to be discussed.

The choice of estimators for survey indices was discussed. With respect to delta distribution vs. zero-inflated distributions, auxiliary variables are needed to distinguish real and sampling zeroes, e.g. side scan or multi-beam sonar, bottom type or depth. Previous work suggests maximum likelihood estimates are not stable and Bayesian approaches may be best (and can incorporate the sampling scheme). Investigating estimators is a long-term research project beyond the scope of the current GARM. A quick approach to examining the usefulness of auxiliary variables would be to evaluate the gain in precision with a perfectly-known auxiliary variable. The auxiliary variable must be known everywhere to be used in this kind of analysis.

Issues with survey catchability (q) were discussed. Suggested methods for dealing with possible density-dependence in conversion coefficient estimates included (1) ignoring possible density effects when there are no estimates over a range of densities, (2) re-estimating the coefficients when density changes, (3) evaluating the empirical estimates by letting conversion coefficients be estimated as parameters in models, (4) comparing index trends over time with other ongoing surveys in same area (e.g. DFO survey on Georges Bank vs. Albatross and Bigelow) to validate trends produced with conversion coefficients, and (5) eventually considering data before and after the change in gear as separate time series.

The importance of tow duration effects was noted. For some species (strong swimmers, e.g. cod), larger individuals may be able to out-swim the net for relatively short tows. The effect may depend also on fish density or behavior pattern (schooling vs. individual swimmers); it is thought that schools are less likely to escape. NEFSC surveys for this GARM used 3.8 kt tow speed, so fish are likely to tire within the 30-minute tow time. Most studies show no difference in short vs. long tows; extensive Norwegian experiments on 15 vs 30 minute tows have shown no indication of an effect on q.

Working Paper D1: Jacobson L, Correia S, Blaylock J. 2007. Potential environmental and spatial effects on survey data and assessments for GARM stocks

Presentation Highlights

The purpose of this paper was to examine environmental and spatial factors that may affect NEFSC bottom trawl survey catchability parameters and interpretation of survey trend data used in GARM stock assessments. Mechanisms that might change survey catchabilities and assessments for multiple species were of particular interest.

Results show that GARM species respond to temperature and depth in complex ways that depend on species, stock, season and fish length. Spatial distributions (latitude, longitude and depth) have changed relative to survey strata sets used in stock assessments, potentially changing survey catchability. In many cases, trends appear to be occurring still. Some stocks (e.g. GBK yellowtail flounder) have spatial distributions that shifted towards closed areas after closed area management was implemented in 1994.

Effective area swept by NEFSC bottom trawls probably changes with depth but there is little effect on trends in survey abundance, length composition or abundance at age data.

Survey catchability coefficients for young haddock, Pollock, and white hake may be affected by the presence of large numbers of recruits in strata outside of the strata sets used for assessments during some years, although more investigation is required.

Changes in mean size at age of GBK haddock appear to have changed fall survey catchability at age, but results are preliminary and more work is required.

The conclusions and recommendations in this report are intended to be robust to the underlying mechanism and would hopefully help improve GARM stock assessments under a wide range of conditions. Assessment scientists and experts should evaluate recommendations on a stock by stock basis, but alternate approaches to handling or modeling survey data may benefit GARM stock assessments. In particular, use of relatively large survey strata sets (including additional offshore and particularly inshore strata where possible) would probably make survey data trends more robust to changes in environmental and spatial factors. Consider expanding survey strata sets for age structured assessments to include additional inshore and offshore strata sampled consistently since (but not before) the first year with survey age data. Survey "holes" (years of missing data for some survey strata) should be filled using some sort of statistical model so that additional strata can be used in assessment strata sets and to facilitate interpretation. Database management software should include procedures for post-stratifying survey data by splitting large strata that overlap stock boundaries or other regions of particular interest (e.g. closed areas). Given potential changes in survey catchability at age associated with changes in size at age, it would be useful to consider stock assessment modeling approaches that use survey length composition.

Discussion on Working Paper D1

During the discussion, several clarifications relating to the working paper were made, including the following: (1) catchability (q) was from N=qS where S is the survey index (as opposed to tow efficiency discussed in the overview for this session); (2) catch-weighting used number (not kg), as is done in assessments; (3) door/gear/vessel conversion coefficients were not used because the analysis was done on an annual basis; (3) changes in time of sampling among years was not accounted for; however, this is more of a problem in the early part of the time series and this analysis only used 1979-2006; (4) the analysis did not include sampling in Canadian waters.

Discussion was then pursued on each hypothesis:

Hypothesis 1: Shifts in distribution vs. depth and bottom temperature

Shifts in bottom temperature may be systematic, but if size-groups react differentially due to different preferences, the pattern of shift will be complicated. Suggestions for improving the analyses included: (1) include tests for interactions (e.g. depth * temperature), (2) use a plus group for plots (e.g. age vs. depth) because sample sizes are small for older ages, (3) follow the methods of Perry and Smith (1994) to refine the analysis and construct hypothesis tests, (4) evaluate how annual random station selection may affect estimated distribution with respect to temperature and depth (e.g. if all stations fall in deep water within a stratum in a given year, this may produce a spurious year effect).

Hypotheses 2 and 4: Distribution of GARM stocks has shifted relative to standard strata sets, possibly affecting survey catchability

The importance of addressing these issues depends on (1) the proportion of the stock that falls within the standard strata sets. The higher the proportion within the sets, the more resilient are the estimates to a shift in distribution, (2) the stability of the proportion within the strata set over time – if the proportion is relatively constant over time, then impacts would be minor, and (3) the tradeoffs of being more or less inclusive.

Suggestions for the analysis of changes in the proportion of a stock in a standard strata set included (1) plot stock abundance vs. abundance from the whole area (proportion of stock in each stock area) to look for indications of change in q, (2) consider using different sets for different seasons because distribution of stocks may be different between seasons, (3) do not include areas in the analysis that have been excluded for biological reasons. The goal is to set up analyses that minimize the risk of measuring a different population between years. It isn't possible to have a quantitative summary of how much distribution changes over time if fish are distributed in areas that aren't sampled. Apparent (spurious) changes may be observed if the fishery is changing and causing shifts in distribution (this is not the same as a change in q).

The importance of inconsistently-sampled (and therefore ignored) strata (e.g. inshore strata) was discussed. A simple exercise to evaluate the importance of incomplete coverage would be to start with a time series from the consistent strata set (strata sampled in all years), then sequentially add strata that are sampled less frequently, ignoring holes, and look at effects on the estimates. If data are imputed for missed strata, the uncertainty in the imputations needs to be taken into account or overall uncertainty may be underestimated. Standard imputation methods exist, e.g. small area methods, model-based Bayesian approaches.

Basic biology must be considered when distribution is evaluated. The habitat where fish occur may not be where they survive well (e.g. haddock may be swept off Georges Bank rather than retained in an area favorable for survival). This is different than an environmental shift causing fish to move into a new habitat where they can now survive.

It was pointed out that other weaknesses of survey sampling may be as important as size of the strata set, e.g. rough bottom types are more poorly sampled, yet some species are primarily associated with these habitats. The list of hypotheses in the working paper did not cover all possibilities – human effects may be important, e.g. small cumulative changes in survey practice over time may have an influence that can't be quantified.

Hypothesis 3: Changes in depth distributions causes changes in q due to area-swept-depth relations

In addition to changes in q with wing and/or door spread, changes may come about through effects on overall net geometry, e.g. the relation between wing/door spread and headrope height.

Hypothesis 5: Changes in mean size at length has altered age-specific q's

Although it was asserted several times that this is the most important issue for the assessments of GARM III, it received relatively little discussion. However, it was noted that each analyst should consider the possible importance of this issue in their respective assessments. For instance, if there is a change in size at age in the population, survey results could be biased due to selectivity with size. This is an issue of particular concern for Georges Bank haddock which has recently shown large declines in size at age, where haddock at age are now the size of the previous age observed before the year 2000. It was noted that the impact on TAC advice should be examined, especially as this decline in size at age appears to be carrying through to subsequent year classes. Density-dependent effects on estimates of relative catchability at age are possible and should also be considered.

It was commented that it may not be appropriate to use average growth curves to convert selectivity-at-age to selectivity-at-length if size-at-age is shrinking over time. To help with model selection in the assessment, it would be useful to have an estimated prior for age-specific q.

INDUSTRY-BASED SURVEYS

Working Paper E1: Legault C, Keith C, Johnston R. 2007. Comparison of the Southern New England Yellowtail Flounder Industry Based Survey with the Northeast Fisheries Science Center Bottom Trawl Survey: Annual Trends and Distributions

Presentation Highlights

The comparison between the fine scale resolution of the Southern New England Yellowtail Flounder Industry-Based Survey (SNEYT IBS) and the Northeast Fisheries Science Center Bottom Trawl Survey (NEFSC BTS) clearly demonstrates the need for dense station locations to resolve fine-scale abundance issues. Once domain estimation was used to allow direct comparison between catch rates from the two surveys, the absence of yellowtail flounder in some NEFSC strata in the NEFSC BTS despite relatively high abundance found in the SNEYT IBS was a clear indication of the inability of the NEFSC BTS to measure fine-scale distributions. However, the long time series and comprehensive spatial scope of the NEFSC BTS makes it the preferred index of stock abundance over time. Trade-offs in density of stations, area coverage, and biological sampling must always be made in surveys, making some surveys better for specific topics than others. Some of the difficulties encountered in this analysis highlight the problem of cooperative research projects that are funded to collect data but are not funded to analyze the data.

Working Paper E2: Chouinard C, Beutel D, Legault C. 2005. Consensus Report of the Technical Review of the Maine Department of Marine Resources

Presentation Highlights

Since the fall of 2000, an inshore trawl survey has been conducted in the spring and fall of each year in coastal waters of Maine and New Hampshire. The "Maine-New Hampshire Inshore Groundfish Trawl Survey" project has been funded by the Northeast Consortium and NOAA Fisheries, Northeast Regional Office and is led by scientists at the Maine Department of Marine

Resources. The main objective of the survey is to provide abundance indices of marine species in coastal waters that could be useful in stock assessments conducted by NOAA Northeast Fisheries Science Center. The data are also of use to the New England Fishery Management Council and the Atlantic States Marine Fisheries Commission. The presentation summarized the findings of a 2005 review panel on this survey.

As one of the major sources of information available concerning the coastal waters of the Gulf of Maine, it was imperative that all aspects of the surveys be formally assessed. The goals of the review panel required an extensive examination of survey design, data processing, and survey results to inform and improve future work and to assess the viability of using the data in the management of the resource. Overall, the survey was considered by the panel to be a valuable project with high scientific standards. It felt though the objectives of the survey needed to be clarified. As well, there was a need to adjust the design of the survey (random and fixed stations issue) to ensure achievement of the survey's objectives. Minor modifications and suggestions for improvement in survey operations, biological sampling and data collection were also suggested. The panel considered the survey to be an excellent example of a cooperative project with extensive outreach work and good data accessibility and that the data collected had a high potential for use in stock assessments, ecosystem analysis and increased understanding of coastal waters of Maine and New Hampshire. The panel made a number of recommendations for next steps and use of the data including 1) securing long-term funding, 2) implementing adjustments to sampling design, survey operations, biological sampling and data collection as soon as possible, 3) conducting small scale experiments to help resolve issues with the survey operations (e.g. towing in tide, depth-warp ratio) and a comparative fishing experiment if a second vessel becomes available, 4) detailed analysis of the data collected to date to help identify issues relating to the survey and illustrate its value and 5) developing closer contact with the NMFS stock assessment analysts who are likely to be important users of the data.

Working Paper E3: Chouinard G, Weinberg K, McGovern J. 2006. Peer Review of Industry-Based Survey for Gulf of Maine Cod

Presentation Highlights

The presentation summarized the findings of an August 2006 review panel on a cod industry-based survey initially designed to examine the distribution and demographics of the Gulf of Maine cod stock. The survey design utilized a standardized grid as well as randomly selected locations provided by fishermen. An additional objective of the survey was to provide information on the age and length structure of cod within rolling closure areas. The panel undertook a comprehensive review of the technical aspects of this survey and considered that it represented an enormous amount of work for the investigators, cooperating fishermen, and the NCRPP. The care taken in the development of the survey design and gear was noted as well as the outreach program designed to keep the fishing community and general public aware of survey activity. The panel considered that the survey provides valuable information on cod in the Gulf of Maine when no other sources of data are available, particularly high resolution information on the spatial and temporal distribution, size composition, maturity and potentially age of cod which augments information from existing surveys. There is concern that the lack of sampling of cod in water deeper than 75 fathoms may not provide a complete picture of cod distribution particularly during the winter although the survey data are useful in determining the location and timing of cod in spawning condition as well as the coincidence of spawning cod with rolling closures. The panel assumed that the efficiency of the four commercial vessels providing data is the same, noting however that inter-vessel comparisons would be desirable. It considered that the data provide a qualitative spatio-temporal view for a number of parameters but further statistical analyses are required. It concluded that while it may be possible to use the data collected to derive indices of stock abundance for specific species, a significant number of issues would first need to be examined and resolved.

Working Paper E4: Chouinard, Martin M, Sowles J. 2007. Peer Review of the Southern New England Yellowtail Industry-Based Survey

Presentation Highlights

The presentation summarized the findings of a February 2007 review panel on the technical aspects of the Southern New England industry-based survey for yellowtail flounder. The main objective of the survey was to assess the temporal and spatial abundance, distribution and size composition of yellowtail flounder (and associated species) within the Nantucket Lightship closed area, other proposed closed areas and adjacent areas. The survey also had a number of secondary objectives. The survey utilized a stratified random design based on strata defined by 30 minute latitude by 30 minute longitude rectangles and an equal number of fixed stations selected by the fishing industry. The panel noted the survey's high sampling intensity and the significant amount of effort by the team conducting the survey. It concluded that the survey had collected sufficient information to suggest that the Nantucket Lightship closed area does not meet the objective of protecting juvenile yellowtail. It recommended that analysis of the efficacy of the closed area be formally conducted and documented, noting that the survey dataset would be useful to identifying alternate closed areas. The panel was satisfied with the vessel selection process to minimize inter-vessel differences as well as the selection of the most appropriate trawl gear. It noted that the age samples have been very useful in complementing the age-length tables for the assessment of yellowtail flounder. However, the panel considered that the utility of the survey in tracking changes in abundance was low due to the shortness of the time series. Further, the mixed design of the survey (stratified random and fixed station) posed particular analysis difficulties, such that the survey estimates using all stations may be biased. Given the high sampling intensity, the panel felt that it should be possible to obtain unbiased indicators of the trends in yellowtail abundance by analyzing stratified random and fixed stations separately and that, if it were continued in the future, consideration should be given to using a unique sampling design, guided by the knowledge gained during the 2003-2005 surveys. As well, procedures and protocols (e.g. towing speed, guidelines for declaring null sets, swept area, fishing station standardization and analyses) need to be further documented to ensure that data are correctly interpreted and repeatable methods are used if the survey were to be resumed. It recommended that funding be made available to complete the documentation and development of metadata for this dataset to preserve its integrity and usefulness, noting the wealth of information available for analysis which would provide new knowledge on the biology of yellowtail flounder in the area. To the extent possible, it encouraged project team members, NEFSC scientists, and others to analyze these data. However, due to the single-species nature of the survey, the panel considered that the integration of this survey as it now exists with the NMFS survey, would be difficult and not cost effective. While the Southern New England industry-based survey was considered a good example of a cooperative project that provides valuable information on yellowtail flounder in the area, it, as well as other like surveys, are considered more appropriate to address short-term issues than to conduct long-term monitoring.

Discussion on Working Papers E1, E2, E3 and E4

Summaries of the peer-review panel reports (E.2, E.3 and E.4) were presented for each of the surveys. The surveys included a Maine/New Hampshire inshore groundfish trawl survey (spring and fall, 2000-2006), southern New England yellowtail flounder trawl survey (spring and fall, 2003-2005), and a Gulf of Maine cod trawl survey (November-June, 2003-2006). The designs of the yellowtail flounder and ME/NH surveys included stratified random sampling as well as sampling of fixed stations. The Gulf of Maine cod survey employed a fixed-station grid design. Due to the specificity of survey objectives, sampling during each survey occurred within a limited area and sometimes involved multiple vessels and gears for which conversion factors do not exist. Data from all three surveys have been audited and the yellowtail and cod survey data are available in the NEFSC research survey database. The ME/NH survey data are also available at the NEFSC but in a different format.

It was recommended that the NEFSC scientists consider using data from the three IBS surveys on a case-by-case basis. It was suggested that biological data might be the most useful data to examine for the cod and yellowtail surveys. As a result of the short time series and design issues pertaining to the yellowtail and cod surveys, these surveys were not considered useful for providing relative abundance indices. It was also noted that there is no conversion factor available for standardizing catch rates of the four vessels used to conduct the cod survey. However, the review panel suggested that the cod maturation data and size frequency data, in comparison to similar data collected during NEFSC surveys, might be useful ancillary information for the Gulf of Maine cod assessment. It was suggested that data from the yellowtail survey might be useful as a weighting factor with respect to analysis of the yellowtail flounder tagging study (C6). An attempt to use data from the yellowtail flounder survey was conducted whereby stratified mean catch per tow indices were computed and compared with those from the NEFSC research trawl surveys for a similar strata set, season, and year (E1). The review panel provided recommendations for the refining the analysis. It was concluded that such IBS surveys would be more useful in addressing management issues that require fine-scale sampling (i.e., closed area evaluations).

ECOSYSTEM DATA

Working Paper F1: O'Brien L, Jacobson L, Rago P J, Traver M, Col L. 2007. Trends in Mean Length and Weight at Age for Selected Groundfish Stocks.

Presentation Highlights

If trends in growth are significant and persistent there would be potential ramifications for stock assessments that involve stock projections or calculation of biological reference points. Randomization tests and linear regression were used to test for significant trends in mean length at age and mean weight at age for seven GARM stocks: Georges Bank (GB) cod, GB haddock, GB yellowtail flounder, Gulf of Maine (GM) cod, GM winter flounder, American plaice, and witch flounder and three other stocks: fluke (summer flounder), mackerel, and northern GB silver hake. Mean values were converted to Z-scores and presented, along with mean number per tow, as quintiles using Visual Report (NEFSC Toolbox) to display year and year class effects and possible density dependence.

No significant trends in mean length or weight at age were detected for GM cod. No significant trends in mean length at age were detected for GM winter flounder and only significantly increasing trends in mean weight at age 2 and age 3. GB yellowtail flounder showed significantly increasing trends in mean length at age for most ages and significantly increasing trend in mean weight at age 2 and age 3 only. Significantly declining trends were observed for mackerel mean weight at age but not mean length at age, whereas GB haddock showed significant trends in mean length but not mean weight at age. Silver hake showed significantly increasing trends younger ages and significantly decreasing trends in older ages for both mean length and weight at age. The remaining stocks (GB cod, American plaice, witch flounder, and fluke) generally showed significant declines in mean length and mean weight at age. These results indicate that fish condition is declining in mackerel, which may be related to competition or otherwise limiting resources. For all other stocks, mean length and weight at age generally trended together indicating that a different mechanism is influencing somatic growth. Further analyses will be conducted to explore what biological or environmental variables may be correlated with these trends.

Discussion on Working Paper F1

It was noted that the validity of the model assumption that somatic growth is constant over time needs to be examined since changes in growth could significantly affect spawning stock biomass and stock status determination. Persistence or transience in growth trends over time need to be determined so that an appropriate temporal interval for average growth can be made. Slower growth in young fish could also lead to higher predation, and these changes in natural mortality rates would violate the assumption of equilibrium. Changes in growth also have implications for reference points, and the causes for these changes are important to determine. If the changes are determined to be due to environmental factors, there may not be a need to change the reference points. However, if the growth changes are due to genetic shifts, then reference points should be altered accordingly. It was noted that there have been similar noticeable changes in condition factor of Canadian haddock stocks. Mackerel is the only stock that directly shows a decrease in condition for this analysis of U.S. stocks, with weight decreasing without corresponding decreases in mean length. However, decreases in length at age over time seen in many stocks could be an indirect effect of sustained poor condition.

It was discussed that non-linear relationships such as a quadratic equation should be explored to determine whether there are additional trends and to characterize these relationships. Splitting the time series further was also discussed to account for management changes such as closed areas etc. Auto-correlation of length and weight variables was raised as a concern, and it was suggested that a Durbin-Watson analysis be conducted to account for these correlations. It was also discussed that variance needs to be determined since the actual trends over time may not be significant given the confidence intervals. This could be done by bootstrapping the survey lengths and weights; however this is unrealistic given the time constraints of the GARM III. Another recommendation was to include the scale of trends in addition to the quintile divisions (e.g. range divided by the mean) since the divisions may be irrelevant if the magnitude of the change is small.

Working Paper F2: Sutherland S J, McBride R, O'Brien L, Mayo R K, Pregracke S E. 2007. Recent Trends in Weight-at-Age of New England Flatfishes

Presentation Highlights

This analysis sought to determine whether recent changes have occurred in weight-at-age among nine flatfish stocks from the Northwestern Atlantic. Data from NEFSC survey cruises (1992–recent) were used to generate estimates of weight-at-age (WAA), length-at-age (WAA), and length-weight (L/W) parameters for these stocks. Trends within these measures were tested with correlation analysis by age, sex, and stock. Of the 51 tests conducted, only 2 (age-6 females for American plaice and witch flounder) showed significant ($P < 0.001$) decreases in WAA during the study period. These decreases were supported by changes in LAA and the L/W regressions as well. Sex ratios were also examined for each stock, as changes here could create an artificial change in WAA, but only summer flounder exhibited a significant correlation between the percentage of males and time ($P = 0.0001$).

Discussion on Working Paper F2

It was discussed that the Bonferroni correction used in this analysis is conservative, and that if a 0.1 significance level is used as in the previous study, declines in weight at age are consistent in both methods. The results of sex ratio shifts in summer flounder were discussed, which could be related to mesh size or minimum size limit changes targeting the faster growing, larger female fish. It was suggested that Murphy's change (Murphy 1952) in sex ratio method be used to determine whether there are non-linear relationships.

Working Paper F3: Miller T, Jacobson L, O'Brien L, Legault C, Rago P J. 2007. A state-space approach for modeling maturity as a function of time and age

Presentation Highlights

In age-structured stock assessment models, an estimate of the vector of probabilities of maturity at age (for females in particular) is a necessary component of an estimate of spawning stock biomass. When maturity at age changes over time, it is also necessary to account for these changes. The state-space model is appealing because it directly accounts for changes in population attributes through time that are imperfectly observed from various ongoing data collection activities. More generally, the state-space model is useful for framing questions about any time series of data where the attribute of interest changes through time (Durbin and Koopman 2001). Other aspects of state-space models that are appealing from a more practical perspective include that predicted attributes at times where observations have large uncertainty due to either lower sampling or poorer information in the collected data can be improved by observations that neighbor the point in time with less uncertainty. Also, predictions can be made within the time series where observations may be missing or backward or forward in time beyond the available observations (i.e., hind- and fore-casting). As such properties are useful for projection of fish populations into the future, we propose the use of a state-space model for estimating maturity at age over time.

Given yearly estimates of any other population attributes such as mean weight at age or length at age and corresponding estimates of observation errors, the structural time series approach applied here for maturity could also be used to detect whether trends exist in these other population attributes. The structural time series approach can easily incorporate measured environmental covariates to improve predictions of the state through time and similar to GLMs the usefulness of various environmental covariates in prediction of the state can be assessed.

Discussion on Working Paper F3

The assumption that samples of individual fish are random was raised as a concern since the samples are clustered into tow groups. The review panel suggested using a quasi-binomial and/or generalized linear mixed effects models and coding the tows as groups to identify tow affect, however it was noted that this violation of independence applies to all methods. It was discussed that unlike previous analyses, there was no evidence for changes in maturity rates over time for Georges Bank haddock since the large confidence intervals indicate that apparent stanzas of maturity rates could simply be a random walk. Without taking into consideration the magnitude of the variability, mean maturity rates indicate stanzas of maturity patterns over time; however the model was stationary in the mean without a clear directional trend. It was questioned how large of a change would need to occur in order to acknowledge changes in maturity since it also cannot be definitively determined that there are no changes in maturity over time. Maturity rates are related to size, and previous size at age analyses could similarly have high uncertainty which would reduce evidence of trends. A further recommendation is to test the annual proportion mature instead of using the logistic relationship, and allow the model to fit the curve instead of fitting the model to an S-curve. Also, since length and weight variables are correlated, it was recommended that the age at 50% maturity be modeled over time rather than modeling the length-weight parameters.

The constant maturity rate used for forecasting projections was a concern, however since no trend was detected in the state-space model, this constant trend could be reasonable. It was noted that maturity can change with population size, and that the variability of maturity estimates have not been incorporated into spawning stock biomass. It was discussed that using a moving average of maturity rate would reduce variability, although there is no clear method for determining the appropriate bin for the moving average, and dampening the effect of the changes may overestimate or underestimate spawning stock biomass. Another approach to reducing uncertainty would be to use a length or age plus group that represents the mature fish in the stock, as used in Canadian stocks. This would incorporate the evidence that first time spawners are generally less fecund than older fish, and would eliminate the variability of the age at 50% maturity. Since this state-space model showed little trend over time, the average maturity rate over the time series could be used. However, this is not advisable since there are realized environmental and population changes over the time series which likely influence maturity. Covariates of biological and environmental variables should be incorporated to determine if trends in maturity exist.

The biological feasibility of inter-annual variation in maturity rates needs to be examined further. Knowledge of whether maturity is influenced greatest by genetics or conditions of individual fish which could exhibit considerable annual variability is important in determining realistic shifts in maturity rates. In assessments, pooling of maturity data over years is common since sample sizes are often too small to calculate annual 50% maturity rates, and the lack of pooling in the state-space model could be contributing to the high variability in the results. It was concluded that a moving window of average maturity rates should be used, and implications for using a smoothing method versus calculating maturity stanzas should be examined. Finally, it was commented that this model only examined one stock which is not necessarily representative of the other 18 GARM stocks, and that these stocks need to be examined individually.

Working Paper F4: Legault C, Blaylock J. 2007. Analysis of Recorded Sample Weight vs Length-Weight Equation Derived Sample Weight using Commercial Port Sampling and NEFSC Survey Data

Presentation Highlights

Comparison of recorded sample weight with the weight predicted by a length-weight equation applied to the length frequency of the sample demonstrated changes in the population length-weight relationship over time, but not in the commercial catch generally. This apparent discrepancy could be due to a number of reasons. The survey comparisons are believed to be a representation of the population and these results agree with other working papers that fish appear to be getting slightly lighter at length in recent years. In contrast, the commercial data, which is a measure of the fishery landings, did not in general show trends in the length-weight relationship over time. There are two possible reasons for this. The commercial data could be too noisy to detect the population trends due to accumulating catch over the entire year from many gears and the use of estimated weight for the sample. Alternatively, the commercial fishery could be targeting a specific size or condition of fish. An additional analysis, not presented in the working paper, confirmed the decreasing weight at length in the survey data using individual fish weights, although the magnitude of the decline was not large relative to the variability in the observed weights at length.

Discussion on Working Paper F4

It was noted that the lack of trends in commercial landings despite decreasing trends in survey weights at length could be due to the uncertainty in the estimation of commercial catch weight as well as the targeting of larger fish in commercial fisheries. Analysis of individual fish weights at length from the survey data show that variability is greater than any clear trends; however this analysis is limited to data since 1992. It was suggested that linear regressions or non-parametric analyses be preformed in order to determine objective trends in weight at length over time.

Working Paper F5: Hare J, Friedland K. 2007. Review of Environmental and Ecosystem variables relevant to assessments: *In-situ* Oceanographic Data and Remote Sensing Sea Surface Temperature and Chlorophyll Concentration

Presentation Highlights

The northeast U.S. continental shelf is changing (Friedland and Hare, 2007) and accounting for these changes may improve our understanding of the dynamics of fishery resources in the ecosystem. The NEFSC is currently working with a number of oceanographic data sets that describe the past and current state of the ecosystem. These data sets are separated into remotely-sensed and *in-situ* data. The remotely sensed data are derived from satellites and the NEFSC primarily is working with Level III processed-data. The *in situ* data sets are actual measurements of ocean properties and predominantly, but not exclusively, come from dedicated NEFSC monitoring activities.

The NEFSC is using these datasets to link environmental variability to ecosystem dynamics. For example, Friedland et al. (2003) estimated the distribution of winter Atlantic salmon habitat in the Labrador Sea and Denmark Strait using the OISST dataset and found that this habitat distribution was correlated with Atlantic salmon production indices. As another example, Kane (2007) linked the change in zooplankton community structure on Georges Bank to a recent shelf-wide freshening (Mountain 2004).

For the purposes of the GARM III, these environmental datasets would be included in an exploratory analysis with various stock parameters including weight-at-age. Maturity-at-age may also be included. This exploratory analysis would be an initial step in including environmental data in stock assessments. There is full recognition that mechanistic hypothesis regarding the effect of the environment on fishery population dynamics are needed, and it is hoped that the exploratory activities undertaken as part of the GARM can contribute to this broader need.

Discussion on Working Paper F5

Environmental data was discussed as potentially being important for assessments since changes such as melting arctic ice decreasing water temperature and salinity could cause changes in lower trophic level compositions and food availability. Traditionally, environmental variables are not incorporated into stock assessments and would instead be addressed as independent research questions. However, there are direct applications to assessments such as recruitment success and productivity, and there may be strong explanatory variables for recruitment other than stock size which could be incorporated as stanzas into stock assessments. Data for environmental variables need to be made more accessible to assessment biologists and synthesized into a model in order to incorporate productivity into stock assessments. It was concluded that changes in environmental variables indicate that the assumption of equilibrium is being violated, and that a comprehensive science plan should be made to determine which variables are important to assessments in order to prioritize facilitating the accessibility of these variables. It was suggested that the potentially important environmental variables be incorporated into a traffic light approach be reviewed during the biological reference point meeting.

Working Paper F6: Link J, Overholtz W J. 2007. Background Data Available for GARM3 Analyses of growth and Maturity

Presentation Highlights

The Northeast Fisheries Science Center of the National Marine Fisheries Service has had the Food Web Dynamics Program (FWDP) in one form or another since 1953. The FWDP is responsible for designing the collection of, sampling, processing samples, quality control and data auditing, database management, and analyzing food habits data for the major fish species in the northwest Atlantic. The food habits database contains more than 500,000 stomachs from over 130 predators and has more than 1,300 different prey items. For most fish species, diet can be adequately characterized with the examination of 500 – 1000 stomachs, which is the case for the 40-50 main species. The data have been collected quantitatively since 1973 to present (at the time of this report, 2007). These data serve as the basis for a plethora of multi-species, single-species add-ons, and ecosystem models. For the purposes of the GARM III, we will provide a set of food habits time series for the GARM species in appropriate strata sets, seasons, and size groupings.

Working Paper F7: Link J S, Overholtz W J, Fogarty M, Col L, Legault C. 2007. GARM3 System Capacity Analyses

Presentation Highlights

There has been some concern expressed (by numerous stakeholders) whether all 19 groundfish (and more broadly, the entire fish community and even all targeted species) can have biomass simultaneously at optimal levels (e.g., B_{MSY}). We propose four approaches to address this question. The four proposed approaches are: 1) Converted energy budget values will be calculated to provide context, compare to other ecosystems, and be rebalanced to see if simultaneous optimal biomass is even feasible; 2) a transfer efficiency calculation will apply the overall productive capacity of the system as a limit/constraint for fish stock production at their various trophic levels; 3) an aggregate production model will be fit using ASPIC or a similar production model for all 19 groundfish and commercially targeted species as one "mega" stock and associated fishery; 4) a multi-species production simulation model will be used to bound the sensitivities of the issue.

Discussion on Working Papers F6 and F7

The system capacity analyses will be important during the reference point meeting in providing an ecosystem level reference to addressing the question of whether there are limitations on production for rebuilding all groundfish species simultaneously. The concern was raised that if the ecosystem results show large discrepancies from the individual stock assessments, this could cause problems with advising management and needs to be considered prior to the meeting. It was noted that the ecosystem analyses will not be made on a species-specific level, avoiding potential problems of assessing negative impacts of one species being rebuilt in relation to another species. It was noted that environmental variables such as temperature and trophic effects could cause MSY to vary, especially for stocks such as cod which are at the southern edge of their habitat range. Since this is the first time that these environmental variables have been analyzed together with single species assessments, there will be problems with modeling these combined data sets, especially where high levels of data uncertainty exist such as foreign fleet landings and commercial discards. It was noted that the time series of the analysis could be restricted to time periods with reduced uncertainty, and that scenario analyses should be done to determine the effects of varying these areas of uncertainty.

The review panel noted the magnitude of the environmental information being analyzed and the progress towards incorporating ecosystem work into assessments. However, based on these system-wide analyses, it will be difficult to address which species will not be able to reach MSY based on ecosystem interactions. It was noted that trophic interactions can be significant, as seen for inshore Southern New England stocks, and that ideally changes in M over time, as indicated by ecosystem analyses, should be incorporated into assessment models for the modeling workshop. There are several instances of stocks either being highly responsive to management measures, initially responding and then declining likely due to predation, or showing negligible response, indicating a possible regime shift due to biomass collapse or reduction of genetic variation. Even if responses to management measures occur, the predicted rebuilding time could be significantly prolonged due to ecosystem interactions. Therefore, examining these variables is important to assessing the stocks and it is recommended that ecosystem effects be analyzed on a species by species basis.

In regard to the models used for these ecosystem analyses, it was noted that models such as EcoPath and EcoNetwrk often rely on changes in transfer efficiencies to balance the models, and these metrics need to be documented and discussed. It was also noted that these types of ecosystem modeling packages often do not incorporate appropriate links between the benthos and fish populations. In these ecosystem analyses, benthos has been incorporated and there could be interactions such as the recent increase in scallops reducing available prey for larval fish. It was recommended that the system be examined at differing levels of energy allocation to the benthos.

The concern was raised that although statistical areas or survey strata sampled twice a year on groundfish surveys may be acceptable for addressing trends in adult populations, this may be too coarse of a resolution for recruitment interactions with plankton since larval fish are often only in this life stage for a short temporal period and small geographic area. It was noted that plankton samples are available six times a year with finer resolutions from GLOBEC, although there may be limited analyses of direct fish larvae prey. The review panel concluded that although these resolutions are not optimal for detailed ecosystem analyses, these concerns should not inhibit the incorporation of ecosystem changes into assessments, and forecasts could be conditioned on environmental variables. However, it was cautioned that when a model becomes overly complex, it is difficult to have confidence in the results.

The concern was raised that the GARM framework is not intended to be an ecosystem control rule amendment, however it was noted that putting constraints on harvest rates based on ecosystem interactions is not a violation of the Magnuson-Stevens Act if these constraints would reduce effort. In conclusion, the review panel suggested that sensitivity analyses be preformed, and that important trophic interactions and environmental variables be included in the assessments since they can substantially affect recruitment and MSY reference points.

RECREATIONAL LANDINGS AND DISCARDS

Working Paper G1: Terceiro M. 2007. Magnitude and precision of Marine Recreational Fishery Statistics Survey (MRFSS) estimates of the recreational catch of winter flounder and Atlantic cod

Presentation Highlights

For the stocks considered in the GARM, only winter flounder and Atlantic cod have significant recreational catch. The magnitude of the landings (catch types A+B1) and live discards (catch type B2) of the recreational fisheries are estimated by the National Marine Fisheries Service's Marine Recreational Fishery Statistics Survey (MRFSS). These estimates have been revised since GARM II in 2005.

The PSE (proportional standard error) of landings in numbers of winter flounder has ranged from 8.2% (1990, 1992) to 28.3% (1993) while the PSE of landings in weight has ranged from 8.2% (1992) to 27.5% (2005). The PSE of the live discards in numbers of winter flounder has ranged from 9.0% (1990) to 45.3% (1989).

The PSE of landings in numbers of Atlantic cod has ranged from 9.0% (1984, 2001, 2006) to 37.3% (1985) while the PSE of landings in weight has ranged from 10.1% (1989) to 56.2% (1985). The PSE of the live discards in numbers has ranged from 7.5% (2006) to 57.7% (1981).

Discussion on Working Paper G1

It was noted that length-frequencies of recreational landings are generally sparse, and that the only GARM stocks that include recreational landings in the assessment models are Gulf of Maine winter flounder, Southern New England winter flounder, and Gulf of Maine cod. These stocks all use survey based age-length keys and have to occasionally borrow length data from neighboring years. Recent declines in recreational landings for winter flounder are considered to be realistic since they correspond to reductions in commercial landings; however survey indices are also declining, indicating that reduced landings are not resulting in population increases. Similar findings were noted in the Mid-Atlantic region for several inshore species which do not have useful trawl indices but have reasonable biomass trend estimates based on recreational landings. The recent appearance of haddock in the Gulf of Maine recreational landings was discussed, and was considered to be plausible since it has been previously documented with the 1973 year class that large year classes can produce substantial recreational haddock landings.

Recreational discards were discussed, and a survival rate of 85% is used for winter flounder. Discards are not included in the Gulf of Maine cod assessment, assuming 100% survival of discards. This is probably unrealistic since it has been documented that gadoids have lower survival rates than flatfish due to their swim bladders. Cod survival rates have been estimated at 35% for longline gear and about 50% survival for commercial jigs; however these may not be comparable to recreational catch survival. Since live cod discards can reach two to three times the recreational landings, the assumption of 100% survival should be reexamined especially since discarded fish have increased as minimum sizes have increased. Allocating discards to ages is particularly difficult since there are generally no length-frequencies for recreational discards. It was noted that state divisions of marine fisheries provide estimates on discard lengths for recreational fisheries; however these estimates may not be consistent across the time series. It was suggested that commercial discard length frequencies could be used to provide a scale of discard size ranges.

The concern was raised whether MRFSS data should be used since there have been critical reviews of the data (NRC, 2006), but it was concluded that there is nothing that can be done to correct historical issues in the recreational data, and the uncertainties do not warrant exclusion of the data. It was noted that the low proportion of recreational landings compared to commercial landings in most GARM species reduces the concern of using this data set. For stocks that include recreational landings in catch at age calculations, models other than ADAPT should be considered that do not violate assumptions such as aging being measured without error. It was suggested that a meeting be conducted to focus on discards and data issues by species.

The allocation of recreational landings was discussed. Massachusetts landings were determined to be somewhat problematic for allocation since the state is a dividing region for many stocks. Since recreational landings do not include information on the capture location, assessments for the last 25 years have allocated recreational landings based on the port of landing where the samples were taken. Recreational landings are not allocated based on effort since effort estimates are not considered to be reliable and provide inconsistent landing estimates compared to total recreational landings by port. It would be beneficial to implement a standardized recreational allocation, however landings prior to 1985 would be impossible to include since site registers have changed. Site registers are lists of landing ports.

The use of party charter logbooks was discussed and it was noted that the distribution of catch could be used to validate the allocation of MRFSS data. However, the quality of the data was noted to be unreliable in that recreational logbooks are often completed on a seasonal or annual basis with only very rough estimations of area fished.

PROGRESS TOWARDS OBJECTIVES

This section provides the review panel's response to the objectives of the GARM terms of reference. The volume of material presented and discussed at the meeting did not allow for an in-depth exploration of detailed technical aspects of the issues. The focus of the review was identification of the major issues and options for addressing these, which are reflected in this section.

COMMERCIAL LANDINGS

1. Proration Methods for allocating dealer landings and port samples to Statistical and Stock Areas

a. Evaluate algorithms used to estimate assignment of statistical and stock areas for dealer records, based on Vessel Trip Reports (VTR) for 1994-2006

The current Vessel Trip Report (VTR) system has been in place since 1994, when reporting changed from a voluntary interview system to mandatory submission of trip related information (area fished, effort, gear characteristics, etc). However, before 2004, matching of VTRs with Dealer Reports, which provide landings of a trip, has not been straightforward due to the absence of a linking identifier. The latter, VTR serial number, which is available since 2004, is not yet ready to be employed in this matching but is planned for future implementation. In lieu of this, matching has been done on a single stock and species basis (the 'single species allocation system').

Wigley et. al. (A1) described a four level, trip-based hierarchical algorithm which offers a number of advantages over the single species allocation system, including comprehensive and consistent approach across all species, continuity with previous interview system, common data source for all species and finer scale of spatial resolution than currently available. Also, the new system is well documented with all allocation decisions transparent. While suffering from some of the problems present in the single species system (e.g. based on VTR self reports, compliance issues), it meets reporting needs and allows a broader range of analyses (e.g. ecosystem and economic) than currently available.

The new algorithm matched the majority of trip records at level A with decreasing degrees of matching from level B through D (where area is assigned on a probabilistic basis). Multistock species (e.g. cod, haddock, yellowtail, winter flounder and windowpane flounder) are potentially most at risk of having landings reallocated amongst stocks, this particularly due to reallocations in Statistical Areas (SA) adjoining several stocks. Overall though, the highest percent of total landings that required matching at level B, C and D was 13% and thus inter-stock reallocations were not considered significant. While there is little impact on landings allocations amongst stocks overall, there could be issues in the case of small stocks adjacent to larger ones.

The new allocation system brought attention to the accuracy of the SA information in the VTRs. Nies et. al. (A3) compared the areas fished from observer and VMS information to areas fished by large offshore groundfish trawlers, which indicated that 20 to 30 percent of observed fishing activity was assigned to the wrong statistical area. Palmer et. al. (A4) determined that when all fishing activity from a given trip occurred in a single SA, the VTRs reflected the true fishing location. However, on trips where fishing activity occurred in multiple SAs, there was significant reduction in the accuracy of the SA in the VTRs. This raised questions as to how fishermen report SAs on multi-SA trips. For instance, is there a predictable sequence to the SA reported in the VTR e.g. the first SA fished? Further research on SA reporting practices by fishermen was encouraged. It was noted that the growing use of Vessel Monitoring Systems (VMS) provides an important source of the positional information of fishing, as illustrated by Applegate and Nies' (A4) examination of fishing trip records from the yellowtail flounder fishery. While interpretation of the VMS data is still required to identify the area of fishing, these can be used to verify and supplement the VTR statistical area of fishing information. It is recognized that there remain uncertainties with the SA assignments but the current assignments are an improvement over what currently exists. It was recommended that issues with uncertain area of fishing information in the VTR can best be addressed through outreach and communication with fishermen who have low levels of reporting.

Overall, the new trip – based allocation system has a number of advantages over the single stock allocation system and is recommended for adoption. Managers will likely be interested in the impact of the new allocation system on assessments. The GARM III assessments should provide a comparison of the results using the old and new allocation system. Further, the new system affords an opportunity to investigate the impact of uncertainty in reported stock area on assessments, particularly for those small stocks in which a potential problem may exist (SNE yellowtail, Southern windowpane, Northern silver hake). The implications of the new allocation system for these resources should be investigated through a sensitivity analysis which would be included in the relevant assessments. More generally, the new system affords an opportunity to generate many different realizations of landings allocation, thus providing a consistent means of reporting stochasticity in the assessment-management cycle in the longer-term. Indeed, an appropriate ultimate goal of the allocation system may be a holistic and robust scheme that utilizes sales notes (dealer records), observer sampling, log books (VTR) and VMS records to generate probabilistic catch estimates.

b. Consider implications of algorithm for use of biological samples to estimate Catch At Age (CAA) by stock area

The algorithm was designed to ensure maintenance of the link between the trip area of capture and the biological sampling information. Wigley et. al. (A2) determined that the majority of biological samples matched at level A and thus there was no change in SA designation. For the five multi-stock species (cod, haddock, yellowtail, winter flounder and windowpane, there were slight shifts in biological sample allocation to stock area but overall, significant changes to the stock landings at age were not expected.

It was noted however, that the allocation of non – GARM species, which was not investigated at the meeting, would require further investigation.

c. Compare results of revised algorithm with landings from GARM II

The algorithm resulted in small changes in the overall landings reported by stock due to rounding errors. These, reported by Wigley et. al (A1), are considered minimal. Thus, the landings are unchanged relative to those used in GARM II.

Evaluate uncertainty in CAA using information from the realized sampling design for port samples, the Age-Length Key (ALK), and overall sampling intensity

Legault et. al. (A6) and Miller (A7) explored a design (bootstrapping) and model – based approach respectively to the estimation of uncertainty in the landings at age. The bootstrapping was undertaken at three sequential levels - from port through length frequency to age within length. The model – based approach employed a correlation structure similar to that of the bootstrapping but allowed adjustment of the weighting given to each trip's sample. Both techniques produced similar results with high coefficients of variation (CVs) observed at the youngest and oldest ages. The ease of use of the bootstrapping approach was noted as an advantage. One advantage of the modeling over bootstrapping is that it allows the incorporation of auxiliary information and exploration of different assumptions to improve the estimates of uncertainty. Otherwise the approaches should provide similar results and either could be used.

A cautionary note on the bootstrap estimation procedures as currently implemented is warranted. Miller (A7) states: "Another complication is that there is a higher likelihood of sampling trips with larger landings. When this is ignored, biased prediction of numbers-at-age for the un-sampled trips will occur." As sampling generally has been a low percentage of the landings, the bias could be severe for estimates of total numbers at age and length. The bootstrap procedure assumes simple random sampling of trips within a region. A more appropriate approach would be to resample with probabilities that are modified to reflect a higher likelihood of sampling trips with larger landings. Also, it should be noted that since the sampling fractions are generally two percent or less, it is reasonable to assume sampling with replacement, thus eliminating the need for bootstrapping at the second (length samples within selected trips/market categories) and third sampling stage (subsampling of otoliths from selected lengths). Only bootstrapping at the first level only is required. The NEFSC was encouraged to undertake a comparison of bootstrapping at the first, port, level only with the results reported at this meeting to confirm this.

The above discussion highlights the importance of sampling rates at the port level and the importance of distributing sampling amongst more trips to ensure representative coverage of fishing activities. It was noted that the updated SA information in the VTR database affords an opportunity to check the sampling coverage of the spatial distribution of the catch. It was recommended that for each stock and fishery, the sampling rates be tabulated by market category and SA to guide sampling reallocation as needed and thus lead to improved estimates of the uncertainty in the landings at age. Further, it is recommended that the NEFSC explore the use of probability-based methods that are more in line with general survey practice (i.e., move away from opportunistic sampling) to safeguard against, possibly severe, biases in key estimates.

COMMERCIAL DISCARDS

1. **Evaluate methods for estimation of discards by stock area and measures of uncertainty**

a. Consider adequacy of sampling coverage by year and gear type and implications for measures of uncertainty

Blaylock and Wigley (B1) summarized the information available from the Northeast Fisheries Observer Program (NEFOP) in relation to the VTR database for 1989 – 2007 across a range of gears and seasons. It was pointed out that the NEFOP coverage was initially oriented towards marine mammals (mandated coverage) but since 2003, has not only increased but also been more representative of the activities of five primary gear types, although there are still stock and time specific gaps (e.g. less overall coverage in the Mid-Atlantic). Wigley et. al. (B2) provided an in-depth analysis of observer coverage for 2005 which showed where coverage was good and where imputation (assumptions from sampling of adjacent cells) was required and Wigley et. al. (B6) provided background on methodologies for estimation and imputation. Overall, while it was acknowledged that the adequacy of sampling coverage has improved over time, the analysis was undertaken at a coarse level. In order to adequately judge the adequacy of sampling, an estimate of precision beyond what was presented is required.

b. Test and apply model-based methods for estimating discards in strata without observer coverage

It was noted by NEFSC scientists at the review that the current practice of estimating discard rates in unsampled strata is to use data either from neighboring sample cells or from cells in which fishing activities were considered comparable to the cells in question. Decisions are made on a case by case basis. It was recommended that an analysis of the sensitivity of the derived discard rates to different sample selection assumptions be undertaken. Further, statistical techniques (e.g. Generalized Linear Models) should be applied to the data and the results compared to those of current practice, which should lead to improvements in the imputation of discard rates.

c. Compare and contrast alternative models for estimation of discards

The Standardized Bycatch Reporting Methodology (Wigley et. al, 2007) documents a number of estimators of discarding and validation of the combined ratio method was provided using the 2005 observer data set by Wigley et. al. (B2). VTR data were used as a surrogate for Dealer data to expand the NEFOP discard ratios to total discards. In most cases (95%), there was good correspondence between VTR and Dealer landings, adding confidence to the use of these data, although there were patterns in the data (e.g. surf clam / quahaug, hakes) that require exploration. Overall, the technique was synoptic, reasonably well validated and exhibited little evidence of bias.

Legault (B5) provided a comprehensive simulation study to test the overall performance of a number of discard estimation techniques with respect to bias and precision. Two were clearly superior to the other four techniques: combined ratio estimator (ratio of sums) and the direct estimator, based on mean discard per trip scaled up to all trips in the simulation datasets. The latter had been advocated by McAllister (2007) for the estimation of discards, and would be the preferred approach if there is no correlation between the numerator and denominator of the estimate (i.e. no correlation between discard weight and kept weight). However, the method only provides unbiased estimates of total discard if the total number of trips is known, which in the New England groundfisheries, is often not the case. Total landings estimates are considered more reliable than those of the total number of trips. The combined ratio estimator of mean discard based on observed trips has the advantage that it can be combined with known landings data to estimate total discards. This is a pragmatic solution to data deficiencies, and appears to provide estimates with similar precision as the direct estimator. The bias in the combined ratio estimator depends on the sample size (number of observed trips) and was negligible for the data being assessed in the simulation study. It is emphasized that the unweighted mean of discard ratios should not be used to estimate total discard based on landings. As was demonstrated in simulations by Legault (B5), the total discard estimates based on applying the simple mean of discard ratios from observed trips to the landings was biased even when 99% of the trips were sampled. The reason for this is that the individual fish observed on a trip are not a random sample of fish from the total catch.

The issue then is which landings to use in the estimation of discards. Two approaches were discussed. The first was estimation of discards produced during harvest of the target species, i.e. winter flounder discards produced from landings of winter flounder. The second was estimation of discards from trips that did not land the target species, either “all” trips, or possibly a subset of trips that land species associated with discards of the target species. For example, scallop dredges can produce high discards of various flounders, including winter flounder. Ignoring these discards would produce seriously biased low estimates of discard mortality. On the other hand, weighting by total landings appears to produce unreasonably high estimates of discards in some cases when the catch of all species landed is high, as illustrated by an analysis of SNE/MA winter flounder (Terceiro, B4).

Unbiased estimates of the discard rates for the total landings are crucial to obtain unbiased total discard estimates. Thus, it is necessary to estimate discard rates for the most appropriate components of the fishery before scaling up to total landings. A biased estimator from observer trips that misses a targeted fishery, for example, can yield very biased estimates of total discard if it is applied to total landings that include the targeted fishery. The observer database should be analyzed to develop a suite of harvested species that are associated with discards of the species of interest. Discards should then be estimated based on expansion of the observed discards as a function of the landings of this suite of associated species.

d. Consider methods to hindcast estimates of discards for years prior to start of Observer Bycatch program and

e. Comment on appropriateness of hindcast estimates and their implications for stock assessments

While no formal analysis to address these objectives was presented at the meeting, NEFSC scientists reported that hindcast or historical estimates of discarding have been based upon survey data to infer discard rates and assumed percent discard of the landings. Modeling of discard rates might be possible but would require building and testing hypotheses of how fishing behavior is influenced by regulations and markets to produce discards. The NEFSC was encouraged to undertake these explorations. Another approach to estimate discards is to use growth and gear selectivity models to determine the likely discard proportion in a given year, assuming that faster-growing fish reach marketable size more rapidly and are therefore less likely to be discarded. This can be valuable, either for stocks for which discards take place but there are no discard data, or for stocks for which all fish caught of a given species and size range are discarded (in which case the discard proportion cannot be estimated). Further, while not discard estimation per se, the examination of processor records to determine the total weight and number of fish entering the plants, to the degree that this is possible for the GARM species, could be used to estimate the extent of misreporting or under-reporting and thus provide verification of the total catch on which the discards are based. Both of these approaches are considered explorations that the NEFSC is encouraged to consider in the longer term.

f. Consider use of length samples from observer samples and "borrowing" of appropriate age-length keys from appropriate sources (eg. Research Trawl Surveys)

There was no formal presentation to address this objective. During the discussion, it was noted that, in principle, the same methods used to estimate the landings at age could be employed to estimate the discards at age. As well, as the intent is to use estimates of the variance of the landings in the assessment models, comparable estimates of the variance of the discard at age are required. The low overall sampling rates of the discards present significant challenges which again highlight the need to use sampling and analytical approaches that address the potential biases, as noted in the landings section above.

g. Consider measures of accuracy (bias) for discard estimates

There are two sources of unrecorded mortality related to the fishing process: 1) discard mortality (mortality of fish caught but discarded from the catch) and 2) escapement mortality (mortality of fish caught but which escape from the gear and subsequently die. Hendrickson and Nies (B3) reviewed estimates of both types of mortality available in the literature. Some general patterns in discard mortality were evident (e.g. highest survival for bladderless fish such as flatfish, lowest for juveniles). It was noted that the current assumption for most GARM stocks is that discard mortality is 100% except for the two stocks of winter flounder where, based upon a few studies, a discard mortality of 50% is used. No specific guidance can be provided other than to state that if well designed studies of discard mortality exist, these should be used on a case by case basis. Otherwise, a discard mortality of 100% should be assumed. It is recommended that the NEFSC conduct or arrange for gear-specific discard mortality studies.

In relation to escapement mortality, it was recognized that estimates of this are very difficult to obtain and would require a sustained monitoring and research program over a number of years. Although the estimates provided in the review are illuminating, it was considered that only qualitative statements on escapement mortality could be made at this time.

TAGGING DATA

1. Do results of tagging experiments support existing stock definitions for cod and yellowtail flounder?

Loehrke and Cadrin (C2) summarized the three major cod studies that have been conducted in the Gulf of Maine Area (GOMA: 4X-5Z-5Y) with the most recent in 2003 - 2005 being the most comprehensive. The analysis by Tallack (C1) of the latter tagging study in general corroborated the population movements as they are currently understood. As has been reported by earlier studies, there is a strong interaction between cod in 4X and 5Z and a less strong interaction between cod in 4X and 5Y. However, a split in migration patterns has been observed where cod less than 53 cm appear to recruit from the Cape Cod nearshore waters and migrate either: 1) northwards into the inshore Gulf of Maine waters, or 2) eastwards out onto Georges

Bank. It will be important to keep this interaction in perspective during the remainder of the GARM III process.

Cadrin et. al. (C5) reported the results of a large tagging study undertaken to describe the exchange amongst the Georges Bank and SNE yellowtail stocks. While they consider the results preliminary, they indicate high movement on Georges Bank but low movement between the Southern New England / Cape Cod and Georges Bank stocks. Overall, however, the study corroborated the location of the stock boundary between these components and the current stock structure of yellowtail in the GOMA.

It was noted that while tagging data is an important source of information to inform stock boundaries, other data such as that on growth also need to be considered.

2. Can migrations among stock areas be quantified?

For cod, a finite – state continuous – time (FisCot) model of migration and mortality processes in the GOMA was used to quantify cod migration rates (Miller, C3, C4). While the model could benefit from a number of improvements, it illustrated that cod migration rates could be quantified.

As noted above, the tagging data assembled by Tallack (C1) confirm apparently significant exchanges of cod among the management units in the GOMA, which are not included in current stock assessments, with a major locus of exchange occurring on the western boundary of the dividing line between 5Z and 5Y. The FisCot model computed exchange coefficients based on the current management unit definitions. It was suggested that the sensitivity of the current management unit definitions to these exchange rates be tested by simulating a movement of the western boundary. Overall, the FisCot model was seen as a valuable tool to examine the implications of management unit boundaries for the determination of key population parameters.

Cadrin (C6) also undertook modeling yellowtail tag recapture data using a formulation in which movement and mortality were considered separately. While the model showed promise, it did not adequately fit the tagging data, with significant trends in residuals in evidence. Simulations suggest that the model may not perform well when true movement rates are low, due to parameter correlations between morality and movement. It was suggested that auxiliary information, such as external estimates of fishing mortality or of movement inferred from biomass estimates from the NMFS surveys, be used to constrain model fitting.

It was concluded that while the model is a possible future application for yellowtail, the current model cannot currently provide quantified estimates of migration rates.

3. Develop appropriate analytical models for estimation of migration and fishing mortality

Three models were considered to estimate migration and fishing mortality rates for cod and yellowtail stocks in the GOMA, which have extensive tagging databases available. The first, used for cod, used a finite – state continuous – time process (FisCot) which allowed migration and mortality to occur simultaneously. It also incorporated double tagging information to allow estimation of tag shedding rates. The model allowed incorporation of a number of other processes (e.g. conventional and archival tags, exact time of tagging) which provides considerable flexibility in the analysis of tagging data. However, the current formulation does not include fish size or age, which would greatly enhance its utility. The model estimated high natural mortality (0.6) for all cod stocks and low fishing mortality rates, compared to the results of the relevant VPAs.

The second model, the movement – mortality model used for yellowtail, was an update of an existing formulation which modeled movement and mortality separately. It made a number of the same assumptions as the FisCot model but could not resolve model fit issues in relation to migration of yellowtail between Georges Bank and Southern New England. Thus, it was considered a preliminary formulation that required further development. An exploration of the sensitivities of this model to various assumptions on measurement and process error (Alade, C7) was instructive in identifying the model's strengths and weaknesses and guiding future work.

The third model, MARK, was also used to explore yellowtail migration and mortality processes. As with the second model, it too had difficulty fitting the yellowtail tagging data. Auxiliary data could also be useful in improving model performance. While promising, it too was considered preliminary and not yet ready for use in the assessments.

Given the difficulties that these models have encountered to date, it may instructive to model the tag-recovery data from each stock area separately to compare to the multi-stock analyses. This is the approach used in analysis of tag data from striped bass, which also uses the MARK reparameterization of the Brownie models. Also, models built on a monthly time scale may be attempting to analyze a finer timescale than these approaches were designed for, as they have been applied most commonly on an annual scale.

The tag data can also provide Petersen estimates of exploitation rate (Ricker, 1975), which can be accompanied by sensitivity analysis of violations of the assumption that all recaptured high-reward tags are reported (e.g. test effect of a 90% reporting rate of high reward tags, etc.). A number of studies can be consulted which illustrate the approach, including Crecco (2003), which is currently the primary analysis applied by the ASMFC Striped Bass Tagging Subcommittee, Kahn and Helser (2005) and Hewitt et al. (2007) for applications to blue crab, and Pollock et al. (1991) who outline the approach and provide formulae for variances. It was noted that the models presented at the meeting can be reformulated to provide Petersen estimates. Insight on the implications of assumptions can be gained by comparing the results of different model formulations, which the NEFSC is encouraged to undertake as part of its analysis of the tagging data for this GARM.

Overall, of the models presented, the FisCot model showed the most promise in modeling migration and fishing mortality rates in cod and yellowtail stocks during this GARM. The sensitivity analysis of its performance presented at the meeting was instructive in developing a more comprehensive understanding of its behavior under different assumptions and uncertainties.

4. Consider sources of uncertainty, particularly tag reporting rates, and commercial fishing effort

The sensitivity analysis of the FisCot model highlighted a number of sources of uncertainty that need to be kept in mind. The model indicated that fishing mortality was highly correlated with reporting rate, which was in turn linked to the assumption of a 100% return rate for high valued tags. Another model input is the assumed initial capture rate. This is a measure of the rate of return, based upon the initial aggregation of tagged fish, within one month after release. These assumptions should be verified as they may explain some of the discrepancy between the FisCot estimates of exploitation rate (5%) and those from assessment models (50%).

The model also assumes that fish of all sizes behave the same. As fishing mortality is generally relevant to mature fish, it would be useful to reformulate the model for cod of greater than 53 cm.

An unresolved issue is the seemingly high natural mortality rate (0.6) estimated by the model compared to what is used in stock assessments (0.2). It was noted that natural mortality rates in cod stocks north of 4X have been estimated to be higher than 0.2. This will require further exploration.

5. Consider use of tagging data to "inform" stock assessment

The FisCot model was considered as having the most potential for informing the upcoming GARM assessments. As stated above, updates for the other two models would not be available in time for the February GARM meeting but might be for that in April. If these models become available then, they could be used to corroborate the findings of the GARM rather than being inputs to the process.

It was noted at the meeting that there is a trend in fisheries population modeling to fully incorporate tagging processes within stock models. However, there is benefit to maintaining the tagging models separate from the assessment models. They provide a means to potentially estimate mortality rates independent of assumptions about the level of natural mortality required in catch-at-age models. The two modeling approaches are independent views of the same underlying processes and differences can yield insight on the veracity of the assumptions used in each. Also, the tagging data series is short and inclusion of the tagging data directly into the population model would imply a relatively low contribution to the likelihood function of the stock models.

FISHERY – INDEPENDENT SURVEYS

There was only one paper presented to address some of the meeting objectives on fishery-independent surveys. Thus, many of the issues remain unresolved. Much of the discussion on this section referred to potential improvements that the NEFSC could consider based upon the review panel's understanding of the survey program. Reference was made to work by the March 2007 ICES Methods WG meeting, particularly on the treatment of zeros in surveys, which the NEFSC was encouraged to investigate at the working group's next meeting in April, 2008. In addition to the comments below, subsequent to the meeting during the review of this report, the review panel recommends two additional items:

- Evaluate the survey design efficiency for a number of species. This would be the first step towards deciding whether or not the design can be improved or if models with covariates are a way forward. It should be noted that some initial work on this has already been done for flounders (NRC, 2000)

- Many of the deeper survey strata are narrow and thin and may only be allocated one tow. This complicates estimates of standard errors and confidence intervals. The use of post-stratification to address this should be investigated.

It was recommended that the NEFSC conduct a one-two day focused session on fishery – independent surveys to explore survey improvements.

1. Consider methods for estimation of abundance indices and precision from stratified random survey designs

A complete set of estimation and analysis functions have been implemented either as part of the standard software for the survey data or in an R package (Smith, 2006) available to NEFSC scientists. This software also enables researchers to evaluate the efficiency of the stratified random design in terms of increase of precision benefits of the strata and allocation scheme for the number of tows assigned to each stratum. For instance, it was noted that while the sampling plan can be optimized for individual species being surveyed, when one considers all species together, proportional sampling has been found to be optimal. Indeed, one of the primary advantages of stratification is not only a potential reduction of variance but achievement of broad spatial coverage of the sampling. Having said this, the NEFSC was encouraged to undertake a comparison of the optimal and current sampling coverage using software that is available in the R package (Smith, 2006).

Confidence intervals for survey mean and total estimates can be calculated using the conventional normal approximation or the more robust bootstrap confidence intervals. However, there have been issues with using the bootstrap or the normal approximation when there are small sample sizes and particularly when there is only one sample as can be the case for some of the small deep water strata.

Work still needs to be done on evaluating potential gains in precision from post-stratification. There was no discussion on what would be the basis for the new stratification.

2. Evaluate effects of missing strata samples on estimation of spatially and temporally consistent indices of abundance and consider model based methods for imputation of missing strata

Jacobson et. al. (D1) presented six hypotheses and associated analysis to address how environment and other spatial effects may have affected the survey estimates. This working paper stated that it addressed the fishery independent surveys and ecosystem data terms of reference. However, the main emphasis of the paper was on the environmental aspects and no analysis was directed toward dealing with missing strata samples and imputation. The analyses presented were mainly graphical and exploratory in nature. If these analyses are to be developed more fully at a later time, there are established statistical methods available in the literature for analyzing associations between species and environments that should be considered. In addition, a number of these prospective methods incorporate the survey design which would address a shortcoming of the presentation, as acknowledged by the author.

The analyses were confined to the NMFS trawl survey series and the strata groups used by the stock assessment analysts for their respective stocks. Questions about the impact of not including inshore strata where for some species, juveniles may occur, were met by showing that the inshore strata from state and other surveys are included in many cases.

There was also discussion concerning the validity of the groups of strata that were used for specific species and stock. While no specific groupings were shown as being inadequate, the issue merits further investigation given the possibilities of changing distribution for some species given environmental changes. To that end, including strata now in response to changing distribution that may not have been covered every year in the past would necessitate some method of imputing past estimates for these strata. No specific methods have been used nor were any specified but the principle of including the uncertainty associated with the imputation in the estimates was acknowledged.

Potential impacts of changes in growth rates on catchability-at-age to the survey were also discussed as were possible density – dependent influences on survey catchability, both issues that require further examination.

3. Compare model vs design based estimators of abundance, including but not limited to geometric means, delta distribution, zero inflated Poisson, and zero-inflated negative binomial

At present, design-based estimates are being used for all GARM species. Improving the precision of design-based estimates usually involves improvements to the survey design. Given the multispecies nature of the survey, it is difficult to establish one survey design that is optimal for all the major target species of the survey.

An alternative approach for developing more precise estimates is to incorporate auxiliary covariates that are related to the distribution of specific species (e.g., depth). These types of estimates usually involve fitting a model to the data. Model-based estimates such as the Delta distribution has been used in the past for NMFS surveys. Generally, the small number of observations in each stratum has not allowed for the evaluation of the appropriateness of using the estimates defined for this distribution nor is it likely, based on theoretical work, that there will be significant gains in precision for sample sizes smaller than 30. Additionally, model-based estimates such as the Delta have not included auxiliary covariates explaining species distribution patterns.

Zero-inflated versions of the Poisson and negative binomial distribution offer the means to model the skewness noted for survey data as well as incorporate relationships with auxiliary covariates. These distributions have two kinds of zeroes, real zeroes possibly reflecting habitat where the target species is unlikely to occur and sampling zeroes as predicted by the Poisson or negative binomial distribution. Experience with these kinds of distributions is that auxiliary covariates (e.g., bottom type) are needed to differentiate between the two types of zeroes. Also, available maximum likelihood methods for estimating the parameters for the zero-inflated distributions have been found to be unstable but Bayesian MCMC approaches seem to be more useful.

The empirical likelihood approach of Chen et. al. (2004) combines design-based and model-based approaches, possibly allowing for incorporating a population model directly into the survey estimation.

There are a number of other design-based and model-based methods that allow for the incorporation of auxiliary covariates into the estimation to increase the precision but in all cases, the values for the auxiliary covariate needs to be known for the whole area and not just for where the trawl sampled. Surveys have collected auxiliary information on depth, temperature, etc. but usually at the sites where the tows were made and not over the whole survey area. Given that this kind of information is not available at this time, insights could be gained via simulation studies of the different kinds of estimates available in the literature based upon investigations of potential candidates for auxiliary covariates currently collected.

4. Consider implications of sampling design and age-length keys for estimation of CAA in surveys

Bootstrapping approaches were suggested by the NEFSC as being an appropriate method for characterizing uncertainty in CAA but little detail was provided. There was some discussion about making sure that the bootstrap structure replicated the sampling scheme. The review panel cannot comment further on this objective.

5. Consider implications of subsampling procedures for CAA and total survey effort for detection of "true" zeros and the use of multi-year ALKs. Consider implications of subsampling procedures for maturation rates, length-weight relations, and sex ratios

No projects were reported here and little was said about planned work.

6. Consider implications of D1-D4 for species with different catchability rates

No projects were reported here and little was said about planned work.

INDUSTRY - BASED SURVEYS

In reviewing the industry – based surveys (IBS), the review panel noted the level of effort and funding devoted to them. Recognizing that these surveys were undertaken for specific purposes, which were generally achieved, careful consideration needs to be given about continuing these surveys to provide stock indices of abundance. The latter requires a long-term commitment to their support and it is important to evaluate whether or not this is best provided on these surveys or elsewhere in the science program in support of management.

1. Summarize list of IBS and cooperative research projects to date and incorporate as appropriate into the stock assessments

Industry-based surveys (IBS's) and other cooperative or collaborative resource surveys are increasingly being implemented in the US and elsewhere; an example from Europe is the Scottish Science-Industry Partnership scheme, which thus far has yielded valuable information on anglerfish and megrim around Scotland. Such surveys are generally set up to address issues that may not be answered well by traditional, long-running scientific surveys that were designed to achieve other purposes – examples of such issues might include location of spawning areas, or the stock distribution of species for which catchability in standardized survey gear is low. This implies that these projects can be of short duration. Once the objectives are successfully achieved, the project can be terminated.

Three such surveys were discussed at the meeting - the Maine-New Hampshire inshore groundfish survey (E2), the Gulf of Maine cod survey (E3), and the yellowtail flounder survey in Southern New England (E4). These had been previously peer-reviewed and it was the reports of these reviews that were presented and discussed at the meeting. Although this was informative, it meant that the meeting was unable to make recommendations on the content, veracity and utility of the surveys, only possible after extensive analysis of the survey data, including evaluations of stock coverage, consistency with other stock indicators (such as NMFS surveys), and examination of survey variability. Specifically, the review panel could not comment on the potential suitability of the surveys for the generation of abundance indices, nor on their inclusion in any subsequent stock assessment, beyond a general statement that any time-series with less than five years is generally considered too short for these purposes, as is the case with the cod and yellowtail surveys but not the case with the Maine – New Hampshire survey which has been underway since 2000.

One other issue raised by the meeting was the multi-vessel design of the three surveys. Although efforts had been taken to standardize the sampling gear configuration, the use of several different vessels with different fishing characteristics was likely to have had an effect on the relative catchabilities of different parts of the survey.

2. Comment on use of IBS as measures of trend, scale, and/or relevant fine-scale biological information

Legault et. al. (E1) compared the stock dynamics suggested by two candidate surveys, the Southern New England yellowtail flounder IBS and the NEFSC bottom trawl survey. While the stock trends were broadly comparable, there were considerable differences at the level of individual strata. There are a number of possible reasons for this: the vessels and gear used may have different selection characteristics, the IBS gear was a trawl specifically designed to catch flatfish and set protocols were different from those of the NMFS survey. However, the most likely explanation for the differences is the higher density of tows in the IBS, which means that it is less prone to the effects of random noise.

While unable to comment on the surveys in detail, the review panel noted the types of information that IBS's are exceptional at providing. These include fish distributions, spawning areas, age-length keys, maturity and maturation rates, and other biological characteristics on a finer scale (in many cases) than that provided by more general NMFS surveys. The review panel encourages the further development of these surveys and considers further studies on their applicability to be valuable.

ECOSYSTEM DATA

1. Describe methods for detecting trends in average size, maturity and weight at length

The analyses by O'Brien et. al. (F1) and Sutherland et. al. (F2) examined temporal changes in gadoid lengths and weights at age of several GARM species. The first analysis employed a randomization test and the second a correlation analysis with Bonferroni adjustment. There was agreement in the observed trends for the flatfish stocks common to both studies. Many stocks exhibited long term declines in weights at age over time and, if persistent, have significant implications for biological reference points. Further, the analysis by Legault and Blaylock (F4) of a number of GARM species determined that the relationship between length and weight has changed in the population (fish are lighter recently) but not in the catch. While a number of suggestions were made to improve the above analyses, the broader concern remains that without hypotheses on the causes of these patterns, it will be difficult to determine how to respond to them.

In an analysis of long-term trends in maturity at age of Georges Bank haddock employing a state – space model, Miller et. al. (F3) determined that while there were patterns in the data series, these were consistent with a random walk. In order to determine whether or not there were biological or other processes causing these, it would be necessary to identify causative hypotheses (e.g. density dependent change in maturity, declining temperature) and redo the analyses using the appropriate covariates. It would be worthwhile determining whether or not the observed variation in maturation was biologically feasible. Improvements to the model to ensure that its conclusions were robust include investigating the impact of the clustered biological sampling, use of a generalized mixed effects model and use of a different functional model for the maturity ogive (e.g. Gompertz).

Given that the patterns remain unexplained, the review panel recommends the estimation of maturity at age using a multi-year smoothing average, referring to the influential biological processes of each stock when selecting the size of the window. This approach allows for slow change in the maturity at age which may be due to some as yet unknown process but also by using a smoothed average, recognizes the possibility that the observed patterns may be purely random.

2. Identify primary time series of extant environmental data and describe methods used to derive estimates on appropriate spatial and temporal scales

The review by Hare and Friedland (F5) of physical, chemical and biological information highlighted the availability of large amounts of data in the Gulf of Maine area that could be used to derive indices of environmental components and processes for use in the GARM stock assessments. To derive these, both temporal and spatial amalgamation is required but this is somewhat dependent upon the problem being studied. The examination of recruitment processes would require different analyses than those investigating processes, such as growth and distributional changes, occurring in the adult phase. There are a number of opportunities for inclusion of this information that would be worthwhile to pursue. Regarding recruitment, studies on the Scotian Shelf and Georges Bank have shown that haddock recruitment is influenced by phytoplankton productivity, which in turn is influenced by climate change. There is a need to explore potential environmental drivers of the observed trend in length, weight and maturity at age to resolve whether or not such trends have any biological basis. Certainly, changes in the ocean environment no doubt have an influence on the structure and function of the Gulf of Maine area ecosystem and need to be taken into account when considering stock specific reference points. There is a need to explore, on a case by case basis, how productivity might change and what adjustments to reference points would be required.

The intent by the NEFSC to include environmental processes in the GARM III is consistent with national and international efforts to more towards an ecosystem approach to fisheries (EAF). This will require the sustained effort of a coordinated science program to implement, elements of which were highlighted at the meeting. To profile these efforts with management authorities, it was suggested that the GARM III assessment report include a ‘Ecosystem Context’ section summarizing trends of a suite of pertinent environmental indicators, similar to efforts undertaken elsewhere e.g. Scotian Shelf (DFO, 2003). Further, trends in this suite could be summarized using multivariate statistical techniques which highlight the dominant changes in the ecosystem processes that have occurred. This approach might also allow identification of large scale changes, such as a regime shift from a groundfish to pelagic dominated ecosystem, which would have long term repercussions for ecosystem productivity and management.

3. Identify candidate measures of system-level productivity

Link and Overholtz (F6) and Link et. al. (F7) outlined a comprehensive program to integrate science on an ecosystem approach to fisheries into the GARM III. This consisted of four main elements: 1) estimation of the absolute abundance of the major species in the Gulf of Maine Area ecosystem, 2) the production potential of the fishery based on food chain processes, 3) estimates of Bmsy for exploited species (not just of GARM) in an ecosystem context and 4) modeling of the aggregate yield from the ecosystem. It is intended that the program will allow the GARM to comment on aggregate single stock yield projections in relation to overall ecosystem production and thus identify potential inconsistencies in single stock reference points with an EAF. For instance, it may be able to determine whether or not the rebuilding plans of many species are incompatible. Similar support for management decision making is already being provided to other regional councils (e.g. Pacific).

The initiative is ambitious and will require coordination of various science groups within the NEFSC prior to peer review at the April 2008 GARM. A number of the relevant datasets have never before been brought together in this manner and problems are to be expected. Indeed, each stock expert at the NEFSC is generally responsible for data collation, modeling, assessment and advice for his or her particular stock. Although this optimizes knowledge of one stock by the expert, it could hinder consideration of processes across stocks and thus calls for strong lab level coordination to fully address the ecosystem mandate of the GARM III. Notwithstanding this, the initiative was well received by the GARM and its efforts encouraged. Through it, the data needs of an EAF will be refined, including consideration of the required spatial and temporal scales of monitoring activities, uncertainties with historical fisheries statistics, and so on.

Many of the interactions amongst species occur during the early life history and are different from the processes that occur at the adult stage. As well, many of the current management issues involve the impacts of fishing on the benthic habitat. While efforts to model ecosystems have been underway for some time, the field is still relatively young and it is important not to ‘oversell’ its current capabilities. It is urged that ecosystem models be used within simulations to evaluate the relative performance of management strategies and to increase awareness and understanding of the implications of harvesting decisions.

RECREATIONAL LANDINGS AND DISCARDS

The GARM raised a number of issues with the recreational fishery of which time at the meeting did not allow in-depth exploration. The management of recreational fisheries is growing in prominence and while GARM species are not generally implicated, it is urged that the NEFSC conduct a focused session on GARM species to explore comprehensively all recreational fishery related issues.

1. Retrieve relevant landings and discard information from MRFSS databases

It was noted that the Marine Recreational Fishery Statistics Survey (MRFSS) had undergone a national review (NRC, 2006) which had identified serious problems that required resolution. Given that there is a national initiative underway to redesign the system to address these concerns, the review panel did not comment on the MRFSS database.

Terceiro (G1) summarized recreational landings and discard information for cod (Georges and Gulf of Maine) and winter flounder (Gulf of Maine and Southern New England) which is available in the MRFSS database since 1981. It was noted that recreational reports on haddock have been increasing in recent years. While the winter flounder assessment appears to incorporate the recreational data in an appropriate way, the cod assessments seem to downplay such catches. While recreational catch may be a minor component, to be thorough, inclusion of recreational landings and discards is required in the catch-at-age matrix of these assessments.

It was pointed out that recreational catch per unit effort is used as important indices of abundance in other species and areas (e.g. striped bass in the Mid-Atlantic) and might be important to consider for relevant GARM species.

2. Report measures of uncertainty for each species

Estimates of uncertainty in the recreational catch for cod and winter flounder were reported. Concerns were raised regarding the merging of commercial and recreational landings, as the first is collected via a census while the second is based upon sampling. The major concern is not necessarily the precision of the recreational information but rather whether or not the sampling is biased. The NEFSC needs to evaluate the sampling design of the recreational fishery to determine its statistical properties.

Live discards are now significant part of the recreational catch of some GARM species. It is assumed that the survival of these discards, which are often below the minimum legal size, is 100%. Some discard mortality is to be expected, especially for species with swim bladders e.g. cod. On the other hand, discard mortality is likely not as high as in the commercial fishery. While the review panel could not recommend specific estimates of discard mortality for recreational fisheries, it felt that some level between zero and that for the commercial fishery was appropriate. The NEFSC was encouraged to consult published studies on recreational discard mortality for use in this GARM. In the longer term, the NEFSC will need to undertake field studies of recreational discard mortality.

3. Identify appropriate ALKs for estimation of recreational CAA

Both the Gulf of Maine cod and SNE winter flounder assessments use NMFS survey age – length keys to estimate the recreational catch at age. Recognizing that the collection of otolith material from anglers is difficult due to the need to ‘spoil’ the fish, this practice appeared appropriate but could not be fully evaluated at the GARM. It was noted that these keys should be supplemented by commercially derived aging material as appropriate (i.e. commercial aging available for size ranges in recreational fishery).

GENERAL COMMENTS

The intent of the NEFSC to quantify the precision of each of the datasets considered at the review is laudable. While it was recognized that the combination of datasets with different sampling objectives and plans will make this task difficult, the end product will ultimately allow examination of the costs and benefits of the contribution of the various types of information to the assessment and thus to harvest advice. It will be possible to consider which data types (e.g. port sampling, observer, survey) are most critical to the assessment and what sampling rates of each of these is optimal. This will then guide the NEFSC on how best to direct the funding of these programs.

CONCLUDING REMARKS

This report represents the review of the significant efforts of scientists at the Northeast Fisheries Science Center on the data inputs (landings, discards, tagging, fishery independent and dependent surveys, ecosystem and recreational) for the GARM III. A considerable amount of information was considered in the meeting time available and consequently the review could only focus on the most important issues and highlight work that could be undertaken to address these. Many of the recommendations made by the review panel can be implemented in time to be included in the next GARM in February 2008. However, a number will require longer-term actions which the NEFSC is encouraged to pursue. In a few cases (fishery independent surveys and ecosystem data), the NEFSC was encouraged to hold internal meetings to advance scientific investigation of the issues that were discussed.

Overall, the meeting achieved its objectives to review the data inputs for this GARM and represents an important contribution to the remainder of the GARM III process.

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APPENDICES

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Appendix 2. Terms of Reference

Purpose

Review the commercial and survey data that will be used in the stock assessments. Identify appropriate statistical methods for analyzing those data (including bycatch and discard issues, changes in growth rates and other life history traits, issues related to merging databases, etc.). Other sources of data to be considered are tagging programs for cod and yellowtail flounder, and Industry-Based Surveys. Candidate sources of data relevant to ecological and ecosystem considerations will also be described.

Emphasis will be placed on estimating precision and bias of data and derived quantities. Measures of uncertainty will be considered with respect to their implications for use in stock assessment models.

Objectives

Six (possibly 7) major sources of data will be examined:

A. Commercial Landings

1. Proration Methods for allocating dealer landings and port samples to Statistical and Stock Areas
    a. Evaluate algorithms used to estimate assignment of statistical and stock areas for dealer records, based on Vessel Trip Reports (VTR) for 1994-2006
    b. Consider implications of algorithm for use of biological samples to estimate Catch At Age (CAA) by stock area
    c. Compare results of revised algorithm with landings from GARM II
2. Evaluate uncertainty in CAA using information from the realized sampling design for port samples, the Age-Length Key (ALK), and overall sampling intensity

B. Commercial Discards

1. Evaluate methods for estimation of discards by stock area and measures of uncertainty
    a. Consider adequacy of sampling coverage by year and gear type and implications for measures of uncertainty
    b. Test and apply model-based methods for estimating discards in strata without observer coverage
    c. Compare and contrast alternative models for estimation of discards
    d. Consider methods to hindcast estimates of discards for years prior to start of Observer Bycatch program
    e. Comment on appropriateness of hindcast estimates and their implications for stock assessments
    f. Consider use of length samples from observer samples and “borrowing” of appropriate age-length keys from appropriate sources (eg. Research Trawl Surveys)
    g. Consider measures of accuracy (bias) for discard estimates

C. Tagging Data for Yellowtail Flounder, Cod, and Haddock

1. Do results of tagging experiments support existing stock definitions for cod and yellowtail flounder?
2. Can migrations among stock areas be quantified?
3. Develop appropriate analytical models for estimation of migration and fishing mortality
4. If possible, simultaneously estimate migration and fishing mortality rates for cod and yellowtail flounder from tagging data
5. Consider sources of uncertainty, particularly tag reporting rates, and commercial fishing effort
6. Consider use of tagging data to "inform" stock assessment

D. Fishery-Independent Surveys

1. Consider methods for estimation of abundance indices and precision from stratified random survey designs
2. Evaluate effects of missing strata samples on estimation of spatially and temporally consistent indices of abundance and consider model based methods for imputation of missing strata
3. Compare model vs design based estimators of abundance, including but not limited to geometric means, delta distribution, zero inflated Poisson, and zero-inflated negative binomial
4. Consider implications of sampling design and age-length keys for estimation of CAA in surveys
5. Consider implications of subsampling procedures for CAA and total survey effort for detection of "true" zeros and the use of multi-year ALKs. Consider implications of subsampling procedures for maturation rates, length-weight relations, and sex ratios
6. Consider implications of D1-D4 for species with different catchability rates

E. Industry-Based Surveys (IBS)

1. Summarize list of IBS and cooperative research projects to date and incorporate as appropriate into the stock assessments
2. Comment on use of IBS as measures of trend, scale, and/or relevant fine-scale biological information

F. Ecosystem Data for use in stock assessments

1. Describe methods for detecting trends in average size, maturity and weight at length
2. Identify primary time series of extant environmental data and describe methods used to derive estimates on appropriate spatial and temporal scales
3. Identify candidate measures of system-level productivity

G. Recreational Landings and Discards

Comment: Recreational landing of most stocks in the GARM have been negligible historically, but risen to important fractions of total removals for some stocks, particularly cod in the Gulf of Maine.   In recent years, the MRFSS data can be compared to VTR data for the commercial charter vessels.

1. Retrieve relevant landings and discard information from MRFSS databases
2. Report measures of uncertainty for each species
3. Identify appropriate ALKs for estimation of recreational CAA

Appendix 3. Agenda

Monday October 29

0900 - 0920 Welcome and Introductions
0920 - 0940 Overview of GARM and objectives of this meeting

A. COMMERCIAL LANDINGS

0940 - 1010 Methods for allocating landings to stock area (WP A1: Wigley)
1010 - 1040 Discussion
1040 - 1055 Break
1055 - 1105 WP A2: Wigley
1105 - 1125 Discussion
1125 - 1155 Accuracy issues VTR, VMS, Dealer data (WPs A3, A4, A5: Nies, Palmer, Nies respectively, 10 min each)
1155 - 1225 Discussion
1225 - 1325 Lunch
1325 - 1345 Commercial Landings—Estimation of total numbers landed at age and its variance Working Papers A.6, A.7 (Legault-10 min, Miller 10 min)
1345 - 1415 Discussion

B DISCARD ESTIMATION

1415 - 1425 Discard Estimates for National Bycatch Report (WP B1: Wigley)
1425 - 1445 Discussion
1445 - 1515 WPs B6 and B2: Wigley
1515 - 1530 Break
1530 - 1600 Discussion
1600 - 1610 WP B4: Terceiro
1610 - 1630 Discussion
1630 - 1640 WP B5: Legault
1640 - 1700 Discussion
1700 - 1710 WP B3: Hendrickson
1710 - 1720 Discussion
1720 - 1730 Wrap up and Adjourn

Tuesday October 30

0900- 0915 Progress review and Order of the Day (Chair)

C. TAGGING DATA

Cod Tagging

0915 - 0935 Cod Tagging Data (WP C1: Tallack)
0935 - 0945 Cod Stock Boundaries (WP C2: Loehrke)
0945 - 1000 Cod Data Analysis (WP C1: Tallack)
1000 - 1020 Cod Modeling (WP C3: Miller & Tallack with WP C4 as background)
1020 - 1035 Break
1035 - 1115 Cod Discussion

Yellowtail Tagging

1115 - 1130 Yellowtail Tagging Data (WP C5: Cadrin et al.)

1130 - 1140 Yellowtail Movement-Mortality Analysis (WP C6: Cadrin)
1140 - 1150 Yellowtail Simulation (WP C7: Alade)
1150 - 1200 Yellowtail Mortality Analysis (WP C8: Wood)
1200 - 1230 Yellowtail Discussion
1230 - 1330 Lunch
1330 - 1430 Discard Estimation (B)follow up issues

E. INDUSTRY-BASED SURVEYS

1430 - 1500 Industry-based surveys (WPs E2, E3 and E4: Johnston)
1500 - 1545 Discussion
1545 - 1600 Break
1600 - 1610 Comparison of RI IBS with NEFSC survey (WP E1: Legault)
1610 - 1730 Discussion
1730 Adjourn

Wednesday October 31

0900 - 0930 Progress review and Order of the Day (Chair)

D. FISHERY INDEPENDENT SURVEYS

0930 - 0945 Fishery Independent Surveys - Overview (WP D2: Rago)
0945 - 1000 Break
1000 - 1030 Fishery Independent Surveys – WP D1: Jacobson)
1030 - 1125 Discussion

G. RECREATIONAL LANDINGS

1125 - 1135 Recreational Landings and Discards WP G1: Terceiro)
1135 - 1200 Discussion
1200 - 1300 Lunch

F. ECOSYSTEMS

1300 - 1320 Trends in biological parameters, eg. ave size, maturity, L-W etc. (WP F1: O'Brien)
1320 - 1350 Discussion
1350 - 1400 Trends in Flatfish (WP F2: Sutherland)
1400 - 1410 Discussion
1410 - 1425 State Space model for trend detection (WP F3: Miller)
1425 - 1445 Discussion
1445 - 1455 Observed vs Predicted weights (WP F4: Legault)
1455 - 1510 Discussion
1510 - 1525 Break
1525 - 1535 Review of Environmental and Ecosystem variables relevant to assessments (WP F5: (Overholtz, Friedland, Link, Hare)
1535 - 1540 Discussion
1540 - 1550 Background data relevant to food web dynamics (WP F6: Fogarty)
1550 - 1610 Discussion
1610 - 1620 Proposed analyses for Ecosystem Capacity Issues (WP F7: Fogarty)
1620 - 1630 Discussion
1630 - 1730 Review and Discussion
1730 Adjourn

Thursday November 1
0900 - 0915 Progress review and Order of the Day (Chair)
0915 - 1030 Landings Proration—Revisit/Discussion
1030 - 1045 Break
1045 - 1230 Discard Estimation—Revisit/Discussion
1230 - 1330 Lunch
1330 - 1400 Tagging Data—Revisit/Discussion
1400 - 1430 Industry Based Surveys—Revisit/Discussion
1430 - 1500 Ecosystemt Data--Revisit/Discussion
1500 - 1515 Break
1515 - 1645 Fishery Independent Surveys—Revisit/Discussion
1445 - 1530 Recreational Landings and Discards—Revisit/Discussion
1730 Adjourn

Friday November 2
0900 - 0915 Progress review and Order of the Day (Chair)
0915 - 0945 Report development
1030 - 1045 Break
1045 - 1230 Report development
1230 - 1330 Lunch
1330 - 1530 Summary and Assignments
1530 Adjourn

Appendix 4. Working Papers

A1:. Wigley S, Hersey P, Palmer J. 2007. A Description of the Allocation Procedure applied to the 1994 to present Commercial Landings Data.

A2: Wigley S, Legault C, Brooks E, Cadrin, Col L, Hendrickson L, Mayo R, Nitschke P, Palmer M, Sosebee K, Terceiro M. 2007. Annual Comparisons of the trip-based allocated and the single-species prorated commercial landings, biological samples and numbers of landed fish at age

A3: Nies T, Applegate AJ. 2007. Accuracy of Self-Reported Fishing Locations in the New England Multispecies Trawl Fishery

A4: Palmer MC, Wigley SE. 2007. Validating the stock apportionment of commercial fisheries landings using positional data from Vessel Monitoring Systems (VMS)

A5: Applegate AJ. 2007. Using VMS data to characterize fishing activity in the US yellowtail flounder (*Limanda ferruginea)* (Storer 1839)] fishery

A6: Legault C, Brooks E, Seaver A. 2007. BioStat Bootstrapping for Estimating Uncertainty in Commercial Landings at Age

A7. Miller T. 2007. Model-based estimation of numbers-at-length and(or) -age for commercial landings in the Northeastern United States

B1: Blaylock J, Wigley SE. 2007. Summary of trips from the Northeast Fisheries Observer Program and Vessel Trip Report data

B2: Wigley SE, Palmer ME, Blaylock J, Rago PJ. 2007. A Brief Description of the Discard Estimation for the National Bycatch Report

B3: Hendrickson L, Nies T. 2007. Discard and gear escapement survival rates of some Northeast groundfish species

B4: Terceiro M. 2007. Comparison of commercial fishery discard estimates for SNE/MA winter flounder

B5: Legault C. 2007. Discard Estimation using Observer Data

B6: 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

C1: Tallack S. 2007. A description of tagging data from the Northeast Regional Cod Tagging Program (3A) and preliminary applications of weighting and mixing analysis (3C)

C2: Loehrke J, Cadrin S. 2007. A Review of Tagging Information for Stock Identification of Cod off New England

C3: Miller A. 2007. Estimating instantaneous rates of regional migration and mortality from conventional tagging data

C4: Miller A. 2007. A finite-state continuous-time approach for inferring regional migration and mortality rates from conventional and archival tagging experiments

C5: Cadrin S, Westwood L, Alade J, Moser, Martins D. 2007. Yellowtail Flounder Tagging Data

C6: Cadrin S. 2007. Movement-Mortality Analyses of Yellowtail Flounder Tagging Data

C7: Alade L, Cadrin S. 2007. Evaluating the Precision and Accuracy of the Yellowtail flounder Movement-Mortality Model via simulation

C8: Wood A, Cadrin S. 2007. Can survival be estimated from the yellowtail tag-recapture database? A preliminary analysis.

D1: Jacobson LS, Correia, Blaylock J. 2007. Potential environmental and spatial effects on survey data and assessments for GARM stocks

E1: Legault C, Keith C, Johnston D. 2007. Comparison of the Southern New England Yellowtail Flounder Industry Based Survey with the Northeast Fisheries Science Center Bottom Trawl Survey: Annual Trends and Distributions

E2: Chouinard C, Beutel D, Legault C. 2005. Consensus Report of the Technical Review of the Maine Department of Marine Resources

E3: Chouinard G, Weinberg K, McGovern J. 2006. Peer Review of Industry-Based Survey for Gulf of Maine Cod

E4: Chouinard G, Martin M, Sowles J. 2007. Peer Review of the Southern New England Yellowtail Industry-Based Survey

F1: O'Brien L, Jacobson L, Rago PJ, Traver M, Col L. 2007. Trends in Mean Length and Weight at Age for Selected Groundfish Stocks.

F2: Sutherland SJ, McBride R, O'Brien L, Mayo RK, Pregracke SE. 2007. Recent Trends in Weight-at-Age of New England Flatfishes

F3: Miller T, Jacobson L, O'Brien L, Legault C, Rago PJ. 2007. A state-space approach for modeling maturity as a function of time and age

F4: Legault C, Blaylock J. 2007. Analysis of Recorded Sample Weight vs Length-Weight Equation Derived Sample Weight using Commercial Port Sampling and NEFSC Survey Data

F5: Hare J, Friedland K. 2007. Review of Environmental and Ecosystem variables relevant to assessments: *In-situ* Oceanographic Data and Remote Sensing Sea Surface Temperature and Chlorophyll Concentration

F6: Link, J, Overholtz WJ. 2007. Background Data Available for GARM3 Analyses of growth and Maturity

F7: Link JS, Overholtz WJ, Fogarty M, Col L, Legault C. 2007. GARM3 System Capacity Analyses

G1: Terceiro, M. 2007. Magnitude and precision of Marine Recreational Fishery Statistics Survey (MRFSS) estimates of the recreational catch of winter flounder and Atlantic cod