Fisheries and Oceans Canada / Pêches et Océans Canada
NOAA FISHERIES — NATIONAL MARINE FISHERIES SERVICE

CERT

Comité d'évaluation des ressources transfrontalières

TRAC

Transboundary Resources Assessment Committee

Comptes rendus 2009/02

Proceedings 2009/02

September 2009

Transboundary Resources Assessment Committee (TRAC) Eastern Georges Bank Cod Benchmark Assessment

Report of Meetings held
13-14 January 2009[1]
30 March – 1 April 2009[2]

[1]Hachey Boardroom
St. Andrews Biological Station
St. Andrews, New Brunswick, Canada

[2]Stephen H. Clark Conference Room
Woods Hole Laboratory
Northeast Fisheries Science Center
Woods Hole, Massachusetts, United States

Meeting Chairpersons

L. O'Brien
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts, USA

T. Worcester
Fisheries and Oceans Canada
Bedford Institute of Oceanography
Dartmouth, Nova Scotia, Canada

Ce document est disponible sur l'Internet à :
This document is available on the Internet at :
http://www.mar.dfo-mpo.gc.ca/science/TRAC/trac.html

FOREWARD

The purpose of these proceedings is to archive the activities and discussions of the meeting, including research recommendations, uncertainties, and to provide a place to formally archive official minority opinions. As such, interpretations and opinions presented in this report may be factually incorrect or misleading, but are included to record as faithfully as possible what transpired at the meeting. No statements are to be taken as reflecting the consensus of the meeting unless they are clearly identified as such. Moreover, additional information and further review may result in a change of decision where tentative agreement had been reached.

AVANT-PROPOS

Le présent compte rendu fait état des activités et des discussions qui ont eu lieu à la réunion, notamment en ce qui concerne les recommandations de recherche et les incertitudes; il sert aussi à consigner en bonne et due forme les opinions minoritaires officielles. Les interprétations et opinions qui y sont présentées peuvent être incorrectes sur le plan des faits ou trompeuses, mais elles sont intégrées au document pour que celui-ci reflète le plus fidèlement possible ce qui s’est dit à la réunion. Aucune déclaration ne doit être considérée comme une expression du consensus des participants, sauf s’il est clairement indiqué qu’elle l’est effectivement. En outre, des renseignements supplémentaires et un plus ample examen peuvent avoir pour effet de modifier une décision qui avait fait l'objet d'un accord préliminaire.

TABLE OF CONTENTS

ABSTRACT

The Transboundary Resources Assessment Committee (TRAC) met during 13-14 January 2009 in St. Andrews, New Brunswick, Canada, to review the stock structure, data inputs and survey indices for Eastern Georges Bank cod. TRAC met again 30 March 30 – 3 April 2009, in Woods Hole, Massachusetts, USA, to review possible assessment models. Results of both meetings will be used to establish a new benchmark for Eastern Georges Bank cod for use in subsequent TRAC assessments.

RÉSUMÉ

Le Comité d'évaluation des ressources transfrontalières (TRAC) s'est réuni les 13 et 14 janvier 2009 à St. Andrews (Nouveau-Brunswick), au Canada, pour étudier la structure du stock de morue de l'est du banc Georges ainsi que les entrées de données et les indices des relevés connexes. Le TRAC s'est réuni à nouveau du 30 mars au 3 avril 2009 à Woods Hole (Massachusetts), aux États-Unis, pour examiner les modèles d'évaluation possibles. On se fondera sur les résultats des deux réunions pour établir de nouveaux points de référence pour la morue de l'est du banc Georges, points de référence qui serviront pour les futures évaluations du TRAC.

A. DATA MEETING

A. Introduction

The Transboundary Resources Assessment Committee (TRAC) co-chairs, Tana Worcester and Loretta O'Brien, welcomed participants (Appendix A1). The TRAC receives its terms of reference from the Transboundary Management Guidance Committee (TMGC). The TRAC review process is two tiered, with annual assessment reviews undertaken between more intensive, periodic benchmark reviews. The benchmark for Eastern Georges Bank cod was last established in February 2002. At the June 2008 assessment meeting, concerns were expressed about this model formulation. In recent years the model results exhibit domed catchability for older ages in both the Department of Fisheries and Oceans (DFO) and the National Marine Fisheries Service (NMFS) spring surveys, as well as a domed fishery partial recruitment for older ages, generating 'cryptic' biomass that is not observed in the fishery or the surveys. This could potentially lead to an overestimation of fish at older ages.

The Terms of Reference and Agenda for the meeting are provided in Appendices A2 and A3, respectively. During the meeting, each working paper was presented by one of the authors and then followed by a plenary discussion of that paper. Rapporteurs documented these presentations and discussions for the Proceedings.

A. Stock Stucture

TRAC Presentation:	Gavaris, S. 2009. Background on Delineation of Management Units for Cod on Georges Bank. TRAC Working Paper 2009/02.
Presenter:	S. Gavaris
Rapporteur:	M. Showell

Presentation Highlights

A synthesis of the background for the delineation of management units of cod on Georges Bank and the vicinity was presented. Currently, for the purpose of developing a sharing proposal, agreement was reached that the transboundary management unit for Atlantic cod would be limited to the eastern portion of Georges Bank (DFO Statistical Unit Areas 5Zj and 5Zm; USA Statistical Areas 551, 552, 561 and 562) (Figure A1). For USA domestic management purposes, the multi-species management plan treats cod in the Northwest Atlantic Fisheries Organization (NAFO) Div. 5Z and Subarea 6 as an operational stock unit.

The delineation of fishing areas for the purpose of collecting and reporting fisheries statistics pre-dates the designation of management units. Agreement on the first geographically defined areas in the northwest Atlantic was reached in the early 1930s. A finer scale statistical area grid was subsequently developed and has been in use by the USA and Canada since the 1940s. The primary scientific input to fishing area delineation was information on stock structure. In addition, convenience with respect to political and administrative boundaries and practical limitations of fishery monitoring and regulation also played a role in the delineation of areas. Due to the prominence of the haddock fishery at the time that fishing areas were being delineated, there are indications that the placement of statistical area boundaries was strongly influenced by knowledge about haddock fishing grounds and stock structure, particularly the line separating what is now Subarea 4 and Subarea 5. A fine scale grid system would permit aggregation of fishery information on varying scales. However, at present, the designation of management units is constrained to the resolution of the statistical area grid.

A management unit is a geographic area defined for regulatory purposes. With the introduction of quota management in the 1970s, three management units were designated for cod in this area. These were 'offshore' 4X, 5Z, and 5Y. Since 1982 the entire Div. 4X has been treated as a management unit due to difficulties in distinguishing catches from the 'offshore' and 'inshore' components. In 1977, based on similarities in demographics, 5Z + 6 were designated as the operational management unit. The Canada/USA maritime boundary was established by the International Court of Justice in 1984. Following a re-examination in 1989, Canada designated cod in DFO Statistical Unit areas 5Zj and 5Zm as a management unit.

Numerous studies have been conducted to determine cod stock structure on Georges Bank and vicinity. While these studies include investigations of morphometrics, meristics, parasite prevalence and other characteristics, analyses of tagging results play a prominent role. Two important commonalities among the results from these historical studies are noteworthy in relation to management units for Georges Bank cod:

- Cod along the coasts of Nova Scotia, New Brunswick and Maine appear to belong to localized coastal components with limited connection to offshore areas.
- There appear to be components on Georges Bank (east of about 68W), Great South Channel/Nantucket Shoals and Browns Bank with some exchange between Georges and Browns Banks and lesser exchange between Georges Bank and Great South Channel/Nantucket Shoals.

It is desirable for the management unit to encompass a unit stock. However, this is not always practical and a stock complex may be treated as the management unit. This approach may have implications on management, as measures must be taken so that individual components are not subject to over-exploitation. To reduce bilateral transaction costs, it is advantageous to keep trans-boundary management units as small as possible. Arguments can be made to support either 5Zjm or 5Z+6 as management units. The status quo, using 5Zjm as the trans-boundary management unit and 5Z+6 as the USA domestic management unit, is acceptable, so long as the results of the two assessments are harmonized. Concord between the two assessments is most effectively achieved by conducting reviews concurrently. The status quo is considered the least disruptive option for management, but it is not the only approach.

Discussion

It was noted that data collection issues exist, as DFO and NMFS survey strata and current statistical areas do not match all imputed cod concentrations. Post-survey stratification is possible, but finer division of the data can create problems, with some areas inadequately sampled.

A strategy to separate commercial landings data between Nantucket Shoal and Northeast (NE) Georges Bank based on longitude 68^{o}W was discussed. However, for much of the time series, positional data associated with the landings is insufficient to make this separation. As well, this may create problems with length information collected through shore sampling, as some months/areas may be inadequately sampled.

Genetic studies corroborate the separation of the three offshore areas. However, the degree of 'distinctiveness' from these studies is low, probably as a result of mixing between the areas.

Industry observed that parasite loads were very different between NE Georges Bank and 4X. This was seen as inconsistent with tagging results, which suggest appreciable exchange between the two areas. However, parasite loads differ between east and west 4X. Recent parasite counts on NE Georges Bank provided by Industry are closer to those of western Browns Bank/Bay of Fundy, suggesting that exchange may be limited to that half of Div. 4X.

Given differences in growth rates between various areas, the question was raised as to whether these differences might be a result of differences in parasite load. This was seen as potentially possible, but studies on cod parasite levels in the Gulf of St. Lawrence did not support this. It was recognized that parasite infestation may produce higher mortality on older ages.

Information on cod egg distribution collected by the USA was presented. Eggs were generally distributed across the bank, with localized areas of higher density. Spawning was seen on Nantucket Shoals and NE Georges Bank, as well as coastal areas. It was noted that spawning on Browns Bank occurs on the SW corner, close to Georges Bank, primarily in winter. Egg distribution data tends to support tagging and other studies.

Additional information on egg distribution was brought to the attention of the meeting. Based on a split at 68^{o} longitude, Author #1 reported most eggs were seen on the eastern portion. This difference was relatively small in the 1980s but higher in recent years. A second paper by Mountain based on a 67^{o} split showed similar results, with 50 to 60% in the eastern portion in the 1980s, but 80 to 90% more recently.

Another potential source of egg distribution was identified. Hanke published a re-analysis of Scotian Shelf Ichthyoplankton Program (SSIP) data in a technical report. In addition, some years ago, M. Buzeta presented information in a working paper on otolith features which might be useful. It was unclear if this report had been published.

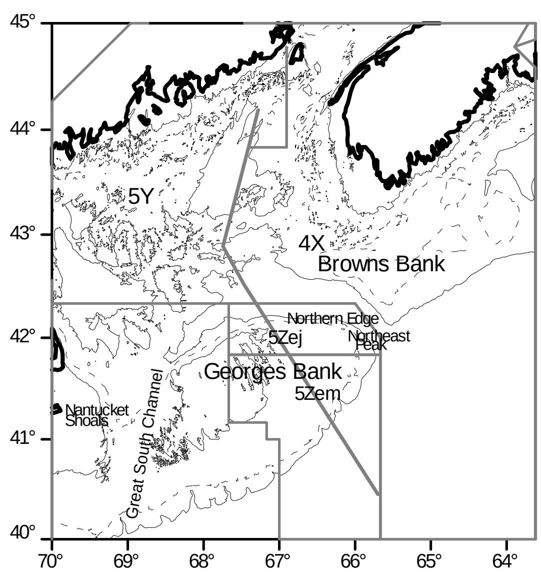

Figure A1. Georges Bank and vicinity.

A. <u>Tagging and Growth</u>

TRAC Presentation:	Cod Tagging of Relevance to the Gulf of Maine / Georges Bank Area, Including Historical Tagging on the Western Scotian Shelf and Bay of Fundy and the Northeast Regional Cod Tagging Program.
Presenters:	D. Clark and S. Tallack
Rapporteurs:	T. Worcester and C. Legault

Presentation Highlights

A significant amount of cod tagging has been conducted within the Gulf of Maine (GOM) and Georges Bank (GB) areas. For example, a large tagging program was conducted in the 1980s in NAFO Division 4X and Georges Bank, and, in the mid-1990s, there was an effort to conduct a joint Canada/USA tagging study. Approximately 300 cod were tagged on the USA side of Georges Bank, and a couple hundred were tagged in 5Zo; however, there were very few returns from this program. Additional Canadian tagging work was conducted in the 1990s around Halifax, Cape Sable Island, and the Bay of Fundy (BoF), and again in 2001/2002 in NAFO Division 4X and Georges Bank. Subsequently, a major USA tagging program (the Northeast Regional Cod Tagging Program) was initiated in the Gulf of Maine, including some coverage in Canadian waters.

The Northeast Regional Cod Tagging Program (NRCTP) tagging program was described to highlight its goals, approach and data. The NRCTP database comprises >114,000 tagged cod releases and >6,500 recaptures for the period 2003-2008. Additional tagging datasets are available for inshore western Gulf of Maine waters, Georges Bank and inshore Canadian Maritime waters.

A suite of descriptive and visualization analyses have been undertaken to tease apart the mass of cod movement data collected. From these, core movement corridors observed in the tagging data can be presented visually (Figure A2). Challenges of interpreting cod movements from conventional tagging data were summarized as:

- Tagged fish need to be both recaptured and reported and the non-reporting rate is difficult to calculate accurately.

- Recapture information collected is highly influenced by fishing effort distribution, tag release locations and the timing of releases (and recaptures).

- The presence of tagged fish in closed areas or any area with reduced/no fishing are under-observed.

- Time at large is highly variable and can result in highly varied observations of movement.

- Inter-annual variation in movement patterns can be high.

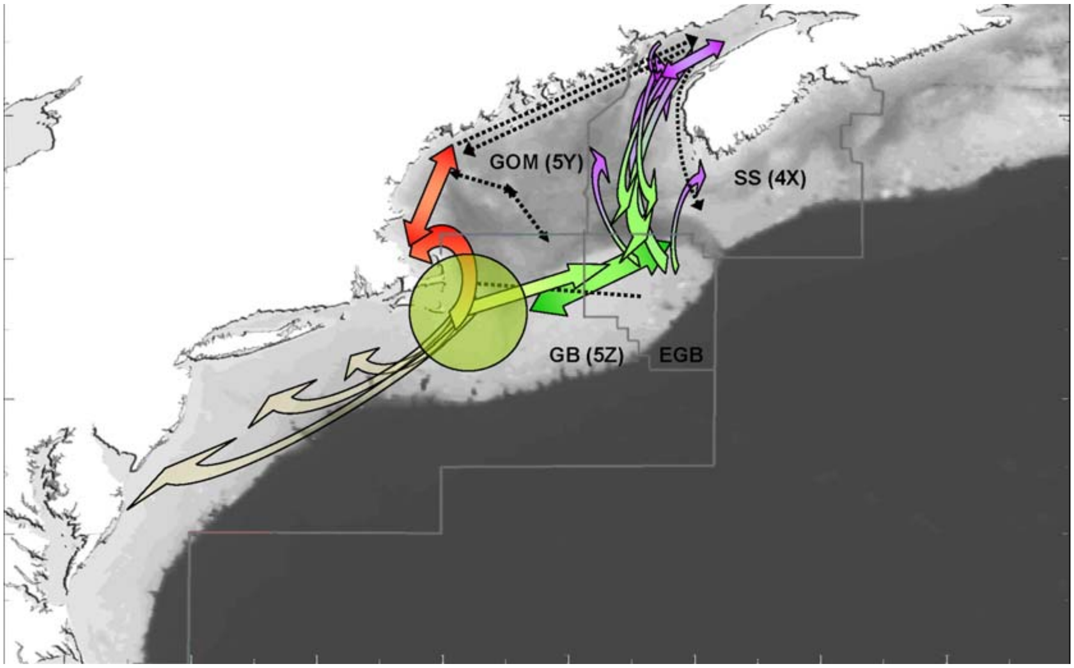

Figure A2 – Movement corridors as indicated by the raw tagging data.

Quantitative movement analysis: all quantitative movement analyses presented here were RAW data, i.e., no weighting was undertaken on the data to correct for fishing effort, biomass present (relative to tag releases and recaptures), reporting rate etc. Weighting methods are available (e.g., Tallack, 2007; Miller and Tallack, 2007; Hunt et al., 1999), but it was agreed that this step would not be taken at this stage in the TRAC benchmark. A variety of matrices were presented showing proportional movements of cod between management areas, though it was reiterated that the presence or lack of fishing effort has a strong impact on these calculations.

Linkages between areas:

- Strong interactions are seen between Georges Bank fish (522, 561, mostly east of 68 degrees) and 4X (Bay of Fundy (466, 467), Georges Basin (464) and 511, 465.

- Strong interactions are seen with smaller Cape Cod (521) fish moving into inshore GOM (514, 513).

- Cape Cod fish also contribute/recruit to Georges Bank (525, 562).

- Little interaction is seen between 4X and 5Y.

Older Canadian cod tagging studies (1984-2003) were also described, highlighting goals, approaches and data. In general, most Canadian tag releases from the Scotian Shelf have been from cod caught on hook and line, while most from the Bay of Fundy have been caught by otter trawlers. In 2002 and 2003, cod were tagged from lobster pot releases (3291 fish released by 60 fishermen).

Those cod released in the Bay of Fundy appear to have gone to Grand Manan or the GOM, but most remained within the BoF. Few were recaptured on Eastern GB or the Scotian Shelf. There have been more returns from Eastern GB of cod released from southwestern Nova Scotia. Of cod released from lobster pots near Halifax, there was only one return from GB. Cod released from western Browns Bank tended to stay west, while cod released on eastern Browns Bank tended to move further east (with a few from GB). Of historical releases from western Browns Bank, a fair number were returned from GB. Cod released from GB in 2001 were all recaptured on GB (over a period of 4 years).

The pattern of movement of cod from more recent tagging on GB appeared to be somewhat different from patterns observed form historical tagging, though this may be due to differences in the location or timing of release and the potential for different components of the population. For example, small fish tend to stay on bank while large fish are more mobile.

In general, Canadian tagging results indicate that there is limited movement of cod between the Scotian Shelf and the Bay of Fundy. Georges Basin appears to be a mixing area for large cod from a variety of origins. There is little movement from the Bay of Fundy or eastern 4X to Georges Bank, but there is significant movement between Browns Bank and coastal Nova Scotia to Georges Bank. The management of Georges Bank cod must be considered within this context.

Discussion

One of the key limitations of the tagging studies was that fish were not tagged in proportion to abundance. This makes interpretation of movement patterns difficult. Additionally, because fishing effort is not known in all areas and times, the return rates cannot be used as direct indicators of movements. For example, there is much less effort in Closed Area II than in Cape Cod Bay and so there could be many more returns from Cape Cod Bay than Closed Area II even if more fish are located in Closed Area II. It was mentioned repeatedly that one must keep in mind what is happening with the fishing fleets when interpreting the tagging results. Reporting rates in different areas or fisheries could also influence the interpretation of tagging results. Similarly, if tagged fish are not released in a given area then it is difficult to estimate movement rates from that area. However, as long as these limitations are acknowledged, tagging programs still provide some of the strongest information regarding stock structure and should be examined in detail for cod.

Data were collected to determine whether a fisherman or a processor returned each tag. The initial concern was difference in precision of positional information, but this turned out to not be a problem. Most Canadian tag returns were from processors due to the fishing process whereby the fish are put in the hold at sea without much handling and then worked up at the processing plant. USA fishermen tend to handle fish more at sea and so have a higher reporting rate than USA processors because they see the tags on the fish during handling.

It would be interesting to compare the proposed “passages” of cod travel presented by the authors to historical hypotheses of cod migrations, especially taking into account seasonal movement patterns.

Analyses of movement by size classes are still underway. Preliminary indications are stronger for recapture of big fish in the area they were released, but more analyses need to be completed. A difficulty for analysis of small fish is that they are typically not caught until they are above the minimum size and thus are behaving like bigger fish at the time of recapture.

It was suggested that the tagging data could be used to make inferences about the usefulness of surveys at different times of the year as indicators of abundance of Eastern Georges Bank cod. However, discussion among participants showed that different interpretations were readily made of the data to indicate that either the spring or fall surveys were good or bad. It was agreed that all current surveys should continue to be used in the assessment.

The applicability of recent movement rate estimates to previous time periods was discussed. It was noted that the movements observed during the recent tagging studies varied by year. Of more concern for stock assessment would be a trend in change of movement rates. This means that historical tagging studies should be analyzed with modern approaches similar to the recent tagging studies to account for possible differences in effort and reporting rates by season and area. This would allow a more direct examination of whether a trend in movement patterns has occurred over time or not.

There appears to be approximately equal relationship between Eastern Georges Bank and both the Western Georges Bank and Division 4X in terms of tagging returns from fish released and recaptured in these areas. Although there were no releases in the Canadian portion of Eastern Georges Bank and there are differences in fishing effort and possibly reporting rates by fleets, this result would indicate that there are a number of possible area aggregations for stock assessments: all of Georges Bank plus 4X, all three areas separately, and Eastern Georges Bank with either Western Georges Bank or 4X. The relatively high movement rates observed in the raw data indicate that management measures in all areas will need to be harmonized to ensure a high probability of achieving management targets. All lines in the water to distinguish stock assessment areas will be wrong to some extent due to fish movement and concentration or homing.

The additional data (from cod tagging studies undertaken by the School for Marine Science and Technology (SMAST), the University of New Hampshire (UNH), and DFO) being added to the current datasets may fill some gaps in the current database, by providing additional observations of, e.g. spawning cod movements, cod from fishing areas not targeted by the Northeast Regional Cod Tagging Program, e.g. Brown’s Bank, and also by expanding the time series of the data to 2000-2009. However, data holes relative to the question of stock delineation within or among Georges Bank and 4X will still remain.

TRAC Presentation: Information on Growth from Tagging Results
Presenter: S. Tallack
Rapporteur: C. Legault

Presentation Highlights

There is some indication for similarity in growth patterns between USA-GB and USA-GOM, but it is possible that the sample sizes and also size structure of fish sampled are compromising the estimates for 4X and Eastern Georges Bank (EGB). Growth rates at smaller fish sizes may be fairly comparable across all areas.

Discussion

The size distribution of tagged fish was not directly compared to the size distribution of the commercial fishing fleets, but since most tags were applied from commercial boats they would be expected to be approximately the same.

The growth analyses suggested large differences in maximum size among the areas. However, the differences in sample sizes could influence the likelihood of observing large fish in some areas and not in others leading to false impressions of growth differences. The two areas that show the most different growth have the lowest sample sizes. Given the similarity among growth increments at small sizes, it would be difficult to distinguish growth pattern differences at young ages. Age readers have suggested there is a mix of growth patterns in Division 4X which could confound the growth estimation as well. Data collected at the ports could be compared to the tagging results to determine if the results are due to sample size differences or true growth differences.

From W. Stobo's tagging database, cod tag returns are consistent up to 90 cm but drop off significantly after that. Tagged cod seem be to caught at small sizes but they are not recaptured again at larger sizes. It was suggested that very large fish may not survive when you tag them, but this was based on experience with tagging and not from double tagging experiments. If cod are caught the first time (i.e., to be tagged), one would assume that they could be caught again (i.e., recaptured), which would suggest that the lack of recapture is not a catchability issue, if the gear used for tagging resembles the gear used for fishing.

A. <u>Landings and Discards</u>

TRAC Presentation:	Nies, T.A. 2009. Issues to Consider when Estimating USA Cod Catches from the Eastern USA/Canada Area (Statistical Areas 561 and 562). TRAC Working Paper 2009/03.
Presenter:	T. Nies
Rapporteur:	L. Brooks and T. Worcester

Presentation Highlights

Since May 1, 2004, USA fishing on Georges Bank has been tightly controlled. The only vessels that can fish are required to have a groundfish permit. There have been few violations (though a few report during closed times). Management measures have changed substantially over time. These changes can affect both landings and discard estimates.

The discard to kept ratio has increased significantly since May 2004, but sample size is not large. Peaks in the beginning of the fishing year became dramatic in 2005, 2006 and 2007. For 2004-2007, discard estimates are sensitive to temporal stratification. There was an unexplained exception in 2007. Kept catch was mostly in June, but observed catch was more distributed. Observed trips didn't capture focus of fishery.

When looking at discard estimates, we should be aware of the management measures that were in place at the time. Since the allocation of landings to statistical areas was reviewed and approved at the Groundfish Assessment Review Meeting (GARM), there is no further debate on the process that is used; however, there is important contextual information that needs to be considered. When assigning catch to stock area, accuracy is pretty good. Below stock area, however, caution is warranted. TRAC uses something in the middle.

Catch allocation is pretty accurate in 2005 and 2006 because of the limitations in fishing location. In 2007, however, one could start fishing in eastern GB and then go elsewhere. It is important to continue monitoring these types of things so estimates don't get progressively worse. In 2004-2006, dealer records weren't all assigned to an area, but this seems to be getting better now. Fleet level assignments started increasing in 2004.

There is another source of data available. Vessel Monitoring Systems (VMS) can be used for quota monitoring. Limited number of trips in statistical areas 561 and 562 allows almost all declared trips to be matched. There is no evidence of extensive fishing in the GB area on undeclared VMS trips.

Efforts have been made to compare quota monitoring with the landings database (CFDERS). Quota monitoring is more accurate for locations, as CFDERS summarizes more.

Discussion

It was suggested that discard estimates should be investigated for sensitivity to temporal stratification. It was unclear how much work would be involved in tailoring it to management measures. It was agreed that there were not enough trips to do the analysis on a quarterly basis, as you quickly get into sample size issues. In the analysis for Eastern GB, there were lots of years with no samples in some quarters, which is why it was done semi-annually. There was some discussion on the number of trips that would be sufficient (e.g., three or six?). It was agreed that it wouldn't be possible to do the analysis by month. It was suggested that the analysis would have to be done separately for each year using the lowest resolution possible within that year. Alternatively, the analysis could be done only for the last years where it's important. It is expected that the difference would lie within the bounds of variation. It was not expected to impact the determination of status, but it may have an impact on quota management. It won't be possible to estimate discards to the last ton.

It was suggested that the accuracy of the Vessel Trip Report (VTR) positions be monitored as it may influence the choice of the assessment model. It was also suggested that quota monitoring data be compared to CFDERS data to determine if differences are persistent and significant.

The changes in management measures over time were discussed. Implementation and duration of management measures overlap calendar quarter and vary between stocks, i.e., different catch limits, special access programs (SAPs), delayed opening of fisheries. These differences may have an effect on the estimate of the d:k ratio on a calendar quarter.

The reason for the mismatch between the landings database and the quota monitoring was discussed. Fishermen are supposed to provide a new page every time they shift areas, but they don't always.

Problems with identification of fishing location may not necessarily result in an over-estimate of discards from the landings database (CFDERS). It could equally result in an underestimate depending on the year or management measure. A comparison of 2005 and 2006 should match up better, as fishing was only supposed to be occurring in this area.

This type of analysis may provide a good estimate of the error in the catch estimate. There were a number of suggestions as to how it could be used more quantitatively. For example, it could be incorporated into the model. However, there was caution expressed about incorporating it as random error if there may be bias.

It was noted that we are currently in a period of a small USA fishery. It was suggested that this might be a small problem if there was a larger fishery, as it may be the low catches that are magnifying the error.

It was agreed that the results for 2007 should be checked first to make sure the analysis is correct. If so, then it could be determined whether it was considered to be enough of a problem to use another procedure.

TRAC Presentation:	Wang, Y., L. O'Brien, and S. Gavaris. 2009. Survey and Fishery Data Review of Eastern Georges Bank Atlantic Cod. TRAC Working Paper 2009/01.
Presenter:	S. Gavaris
Rapporteur:	L. Brooks and T. Worcester

Presentation Highlights

Updated Canadian fisheries landings for 1978-2007 revealed no appreciable differences compared to the data used in the 2008 assessment. Canadian landings were taken primarily by longliners and otter trawlers during June to December on the northern edge of Georges Bank. Dating back to the early 1970s, fishing has been restricted from March through May on spawning grounds. Between 1995 and 2004, fishing by the Canadian groundfish fishery has not been permitted during January and February. Catches in the fourth quarter have become more important in recent years. Discards of cod from eastern Georges Bank have been attributed to Canadian groundfish and scallop fisheries. The estimated discards from the groundfish fisheries (1997-1999, 2005-2006) and the scallop fishery (1978-2007) were used for this benchmark assessment.

Updated USA fisheries landings for 1978-2007 resulted in minor adjustments to the data used in the 2008 assessment. Almost all USA fisheries landings were taken by otter trawl, primarily during the second quarter. Discards of cod from eastern Georges Bank have been attributed to USA otter trawl and scallop fisheries. The estimated discards (1989-2007) were used for this benchmark assessment. In 2005-2007, the amount of discards were almost the same as landings and most are from the otter trawl fisheries.

Combined Canada/USA catches, which averaged 17,508 mt between 1978 and 1992, peaked at 26,463 mt in 1982, declined to 1,684 mt in 1995, fluctuated around 3,000 mt until 2003, and subsequently declined again. Catches in 2007 were 1,796 mt, including 472 mt of discards. Prior to 1996, discards were only 1% of the total catch. Since then, the proportion of the total catch accounted by discards ranged from 2% to 15%.

The size and age composition for the Canadian groundfish landings from 1978-2007 were derived for all principal gears and seasons using port and at-sea observer samples. For the derivation of size and age composition, a weight-length relationship based on 1995-2000 observer samples was used to calculate numbers caught from weight caught. The length samples from the three principal gears, otter trawlers, longliners and gillnetters, were grouped separately by month and then by quarter. Catch at length was obtained by prorating length frequency by the catch from the corresponding fishing gear within each quarter. Where there were gaps, samples from adjacent quarters were used rather than from different gear types in the same quarter. Quarterly age length keys were applied to the catch at age to estimate age composition. Age at length information from the USA commercial fishery in 5Zjm and from the DFO survey was used to supplement age-length keys in some years. The size and age composition for the USA landings were estimated by market category from length frequency and age samples pooled by calendar quarter. In some years samples were pooled semi-annually, or annually due to an insufficient number of samples within a quarter. Combined USA and Canadian age samples for 1978-2006 were applied to length frequencies from Eastern GB (some years, primarily mid-1990s, combined Eastern and Western GB). At-sea observer information from the Canadian scallop fishery was used to derive discards at length for recent years. For earlier years, discard length composition was derived from surveys – spring surveys for first half of year and NMFS fall survey for the second half of year. For estimating groundfish discards at age, the age and length samples from the Canadian otter trawl landings were used while survey and commercial age data were applied to the USA commercial discard length samples obtained from at-sea sampling.

The combined Canada/USA fishery catch at age was obtained by pooling Canadian landings at age, discards at age from groundfish fishery and discards at age from scallop fishery with USA landings at age and discards at age. The number of fish captured by the fishery for all the ages has declined substantially since 1995. The proportion at age has tended to decrease for ages 2-3 and increase for ages 4-7. Both number and proportion caught at ages 9 and older are lower. In previous years, larger fish were caught in the first quarter. The decline of landings in the first quarter is thought to have impacted changes in catch composition.

Discussion

There was some discussion about other fisheries that might catch cod on Georges Bank. There is a very small offshore lobster fishery, but cod catches were not considered to be appreciable. There is limited observer coverage. Until the mid 1990s, the Canadian groundfish fishery focused on cod but has since focused more on haddock. On the USA side of eastern GB, there is limited lobster, longline, and gillnet effort, but this will be confirmed at the model benchmark meeting.

There was some concern about how individual weights were determined from the observer data. A spring scale was used, which is different from the survey. Differences are expected but only in the variance. The mean trend line was not expected to be significantly effected.

It was noted that during 2001-2007, cod over 100 cm were not observed in the fourth quarter. This is related to the ongoing question about the unexplained absence of large fish. The fishery is not fishing in winter. At present low population abundance, it could be that with fewer fish in the population, there are fewer to survive to large sizes.

A question was asked about the amount of observer coverage that is used to estimate cod discards from the scallop industry. There used to be 12 observed trips a year, but now there are 25 observed trips a year.

Possible reasons for a reduction in the proportion of young cod in the fishery catch were considered. The majority of the 2-year old cod that were landed prior to the early 1990s were caught with otter trawl. Prior to 1989, the majority of the Canadian quota was allocated to mobile gear vessels >65 feet. Subsequently, both the fixed gear and mobile gear vessels <65 received a higher allocation. Otter trawl mesh type and size changed by 1991, and when square mesh was initiated, the industry considered that their catch of 2-year olds declined. Since the majority of cod are caught with fixed gear, there was doubt whether the effects of square mesh would be dominant. Further, the DFO Research Vessel (RV) survey also caught fewer 2-year olds after 1995. There may have been concurrent effects impacting the decline in the proportion of younger cod in the fishery catch associated with a change in gear, a change in growth and weaker year classes at the same time.

It was agreed that cod length composition at age for the different seasons should be investigated, though perhaps not pooled across all years. In addition, evidence to support the various hypotheses for the lack of old fish should be examined for the next meeting. It may be possible to try D. Hart’s method (examining partial recruitment of the 5Z cod stock using tag return data) on Eastern GB cod. CVs for the discard estimates should be reviewed. Size composition for catch with and without separator panel should also be investigated.

A. <u>Survey Indices</u>

TRAC Presentation:	Wang, Y., L. O'Brien, and S. Gavaris. 2009. Survey and Fishery Data Review of Eastern Georges Bank Atlantic Cod. TRAC Working Paper 2009/01.
Presenter:	S. Gavaris
Rapporteurs:	T. McIntyre and T. Worcester

Presentation Highlights

Surveys on Georges Bank have been conducted by DFO (February) from 1986-present, and by NMFS each fall (October) from 1963-present and each spring (April) from 1968-present. The DFO survey on Georges Bank started near the end of the overall decline in cod. The trawl doors used on the NMFS spring and NMFS fall surveys were changed in 1985 and a conversion factor was derived and has been applied. In the past assessments, the population abundance index was the mean catch per standard tow; however, for this analysis it is the total number per standard tow, which has the same trend, but is scaled to swept area. All three surveys show a decline in cod abundance since the mid 1990s. Survey abundance indices at younger ages declined substantially for all three surveys since the early 1990s, In contrast, the abundance indices for ages 4-6 fluctuate without trend since the early 1990s and their proportion at age increased compared with before the early 1990s. Abundance indices for ages 9 and older is currently very low. There is no indication that cod age composition is different in Closed Area II, which has been closed to fishing since 1994.

The mean length and weight at age data from DFO spring, NMFS spring and NMFS fall surveys indicate a decreasing trends for all ages since the early 1990s. No decrease in weight at length was observed in the NMFS surveys, but there was some indication of a modest decrease in weight at length from the DFO survey for recent years. Since the DFO survey is conducted closer to the beginning of the year and has good sample size, it was suggested that the DFO survey be used to calculate the beginning of the year weight at age from 1986-present. It was proposed that a weight-length function derived from the DFO survey from 1986-1993 be applied to the NMFS spring survey length at age for earlier years.

Length at maturity from the DFO survey data was analyzed for 2 time periods: 1987-1993 and 1994-2008. Results indicate that both male and female cod appear to be maturing at a smaller size in the recent time period, with length at 50% maturity decreasing from 42-45 cm to 36-39 cm for males and from 42 cm to 39 cm for females. No appreciable change was detected in the age at maturity except that 2-year old males showed a slight increase of proportion mature. Female maturity ogives were estimated from the NMFS spring survey, which has been collecting cod maturity information since the 1970s. There appears to have been a decline in female age at maturity from the 1970s to the late 1980s), but it increased again recently and they now seem to be almost fully mature at Age 3.

Discussion

The catch at age from each of the surveys seemed to show stronger year classes in earlier years. Since these passed through the population, there have been fewer older fish observed. It was noted that there may have been a year effect in the NMFS 2004 surveys.

Below 50 cm, cod are not fully recruited to fishery. Last year, the Individual Transferable Quota (ITQ) survey in NAFO Division 4X didn't catch a lot of cod, but they were all within the 20-25 inch range.

For the model meeting, it would be useful to compare results for the whole of Georges Bank with those of EGB, as well as possible incorporation of NAFO Division 4X, to examine any differences in trends and also variability in the whole versus the part.

There was some discussion of how to deal with large tows, particularly how this was dealt with in the past. If they are included in the model, they lead to large residuals. It was asked whether tows had ever been left out in the past. It was suggested that they may have been left out in the early years but are all included at present.

It was noted that all available data has been used to evaluate changes in mean length at age. Older data is not available, and it is not possible to determine what is “normal”, i.e., what it would have been prior to fishing or under different environmental conditions. Results need to be described in the context of the productivity regime that we have now. The results from the NMFS spring survey from 1995-2000 were questioned given the small sample sizes at this time.

There appears to be some movement of small fish move into EGB from Nantucket Shoals and Browns Bank, but in general there is limited information available on small fish. More small fish tend to be caught in the NMFS surveys than the DFO surveys in the same areas; however, all surveys use large rollers.

A decrease in mean size may be due to an increased abundance of young fish in the population and not necessary due to the loss of large fish.

A question was asked about any changes in staff doing cod ageing. It was noted that there had been changes in readers, but the exact timing was not known. Changes may have occurred in 1991, 2003, 2004, and 2005.

The 2003 year-class appears to be smaller at age on EGB. Before 2000, there was no change in size at Age 2, though it is hard to tell from the scale. Nonetheless, it does not appear that there has been sufficient change to explain a change in gear selectivity.

At GARM III, mean length and mean weight at age was estimated for many stocks but the reason is not known. Similar declines were seen among stocks, but not all. Declines were seen in flatfish stocks but not for yellowtail. Similar declines in mean weight at age have been noted for 4X haddock, but not cod.

Survey information shouldn’t be relied upon as an index for very young fish. Efforts should be made to get more information on Age 7+ fish from the fishery. The surveys appear to provide the most useful indices of abundance for cod aged 3-7.

Various approaches for determining beginning year weights at age were discussed. The influence of cod sampling before and after spawning on their weights was an issue of interest. It was suggested that cod sampled in pre-spawning condition would be heavier than later in the year. While this seemed logical, it was not always consistently observed. The recommended approach of generating beginning of year weights at age from the DFO survey was supported as the sample size is better and the survey is conducted earlier in the year.

A question was asked about how maturities observed on the surveys compared to those observed in the fishery. It was noted that on GB, fisheries observers were checking to see if fish were spawning and did record maturities stages.

A. Management Unit Options

Evidence pertaining to stock structure was summarized at the meeting as follows:

Tagging	historically, releases in coastal areas of Maine, New Brunswick and Nova Scotia were largely recaptured in the local vicinity
	recently, releases in coastal SWNS also recaptured offshore
	Historically, releases on Nantucket Shoals were largely recaptured on Nantucket Shoals (spring/summer) or to the southwest (fall/winter)
	Recently, releases on Nantucket Shoals have been recaptured inshore in the GoM (5Ye) and also to Georges Bank (5Zgh), as well as continuing to be recaptured to the southwest of Nantucket Shoals
	releases on Georges Bank east of 68W were largely recaptured on eastern Georges Bank with some recaptures from both Div. 4X and Great South Channel/Nantucket Shoals
	releases in Bay of Fundy largely recaptured in Bay of Fundy and Canadian Gulf of Maine basins with some recaptures on Georges Bank
	releases on eastern Browns Bank to Emerald Bank largely recaptured in eastern part of Div. 4X
Spawning	occurs on Bay of Fundy, Browns Bank, eastern Georges Bank/Northeast peak, western Georges Bank/Great South Channel, Nantucket Shoals and coastal bays with different peak spawning times
	percentage of eggs in Div. 5Z coming from eastern Georges Bank varies over years. In recent years (90s), relative abundance of eggs from EGB higher than in the past (80s) compared to Western Georges Bank (WGB)
Genetics	Bay of Fundy, Browns Bank and Georges Bank distinguishable but degree of separation was nominal
	more heterogeneity between Georges Bank and Nantucket Shoals than between Georges Bank and Browns Bank
Parasites	prevalence different between Gulf of Maine, Georges Bank and Southern New England. Industry representatives at the meeting noted increases in sealworm densities from EGB to western 4X to eastern 4X
Growth	size at age of western 4X, eastern Georges Bank and Great South Channel/Nantucket Shoals was similar but different from Gulf of Maine and eastern Div. 4X

Summary of current understanding of cod stock structure in the Gulf of Maine / Georges Bank area:

- Cod along coasts of Maine, New Brunswick and Nova Scotia belong to local coastal components with some, but limited, connection to offshore areas.
- Four offshore components occur in the area:
    - Great South Channel/Nantucket Shoals,
    - Georges Bank east of about 68W,
    - Bay of Fundy/Western Browns Bank, and
    - Eastern 4X banks.
- Some exchange occurs between Georges Bank east of about 68W and both Bay of Fundy/Western Browns Bank and Great South Channel/Nantucket Shoals.

Management Unit Options (preferred option highlighted)

In order to effect regulatory measures at the resolution of management units, status determination must be provided at the scale of management units. Status determination may initially be determined at a scale larger than the management units, but the assessment must include decomposition to the management units. At present, we are limited to defining management units at the resolution of statistical unit areas.

A. 5Z+6
   - assumes exchange with Div. 4X can be ignored
   - may result in concentration of exploitation on a component within 5Z+6, a potential conservation concern if exchange is low

B. 5Zjm and 5Z(-jm)+6
   - assumes exchange between 5Zjm and 4X and between 5Zjm and 5Z(-jm)+6 can be ignored
   - Fish between 5Zjm and 68 may be missed
   - ability to achieve management objectives may be compromised if exchange is appreciable

C. 5Z+6 (USA domestic) and 5Zjm (transboundary)
   - status quo – least disruptive to existing process
   - respective implications listed above apply
   - require concurrent assessment reviews to harmonize results

D. Statistical Units 561, 562, 551, 552, 522, 525
   - may captures too much of South Channel component (half of Wilkinson Basin)
   - potentially reflects more of tagging results
   - additional work with tagging results would be required

E. East of 68
   - splits statistical units 522 and 525 in half – cannot be done currently
   - best captures understanding of cod components

F. Inclusion of part of 4X (4Xp, 4Xq, 4Xr, 4Xs)?
   - difficulty in setting appropriate eastern boundary (which statistical/unit areas)?
   - e.g., 4Xp includes both western and eastern Browns Bank
   - survey issues – don't have a survey that covers the whole area at one time
   - would take into account observed exchange

A. <u>Action Items</u>

- Check to make sure that proceedings from last benchmark indicated that no survey sets should be excluded. At present, all sets are included.
- Weights at age for older fish for beginning of year biomass? Ages 10+ weights at age are quite variable. Will look at commercial fishery weights at age for these older fish. Will revisit this at the modeling meeting.
- Look at length composition in proportion to total catch at age by the different seasons – perhaps do not pool them across all years. For Canadian fishery in years when fishery did not occur in the winter.

- Support for / description of competing hypothesis for lack of old fish – For next meeting. Are there other sources of information to bring forward?
- Can we try D. Hart's (NEFSC) method for resolving domed partial recruitment for EGB? (she did for GB whole).
- Related to Tom's request: Investigate matching discard estimate with changes in management (only for last 2-3 years).
- Look at size composition for catch with and without separator panel from observer data. Note that there are lots of different configurations.
- Check effort is minimal from other fisheries (for which discards of cod are not estimated).
- CPUE indices? Agreed not useful to look at this.
- Look M. Buzeta's work for model meeting. Also Hanke overview of SSIP work.

A. <u>Concluding Remarks</u>

Presenters were asked to provide a summary of their presentations, and rapporteurs were asked to provide their draft notes, to T. Worcester for incorporation into the proceedings. The next cod benchmark meeting to discuss the assessment model would be held the week of 30 March – 3 April 2009. The cod/haddock/yellowtail TRAC assessment would be held the week of 8-12 June 2009.

The Co-chairs thanked the participants for a their participation. The meeting was then adjourned.

A. <u>References</u>

Hunt, J.J., W.T. Stobo, and F. Almeida. 1999. Movement of Atlantic Cod, *Gadus morhua*, Tagged in the Gulf of Maine Area. Fishery Bulletin, 97: 842-860.

Miller, T.J., and S.M.L. Tallack. 2007. Estimating Instantaneous Rates of Regional Migration and Mortality from Conventional Tagging Data. DRAFT REPORT: Submitted to National Marine Fisheries Service, Pre-GARM Working Group, October 2007. Northeast Fisheries Science Center, Woods Hole, MA, WP3D: 10 pp.

Tallack, S.M.L. 2007. A Description of Tagging Data from the Northeast Regional Cod Tagging Program (WP3A) and Preliminary Applications of Weighting and Mixing Analysis (WP3C). DRAFT REPORT: Submitted to National Marine Fisheries Service, Pre-GARM Working Group, October 2007. Northeast Fisheries Science Center, Woods Hole, MA, WP3A and WP3C: 60 pp.

A. Appendices

Appendix A1. List of Participants

Name	Affiliation	Phone	Fax	Email
Loretta O'Brien (Co-Chair)	NMFS, NEFSC	(508) 495-2273	(508) 495-2393	Loretta.O'Brien@noaa.gov
Tana Worcester (Co-Chair)	DFO, BIO	(902) 426-9920	(902) 426-5435	WorcesterT@mar.dfo-mpo.gc.ca
Liz Brooks	NMFS, NEFSC	(508) 495-2238	(508) 495-2258	liz.brooks@noaa.gov
Chris Legault	NMFS, NEFSC	(508) 495-2025	(508) 495-2258	chris.legault@noaa.gov
Lou Van Eeckhaute	DFO, SABS	(506) 529-5938	(506) 529-5862	Van-EeckhauteL@mar.dfo-mpo.gc.ca
Stratis Gavaris	DFO, SABS	(506) 529-5912	(506) 529-5862	GavarisS@mar.dfo-mpo.gc.ca
Yanjun Wang	DFO, SABS	(506) 529-5893	(506) 529-5862	wangy@mar.dfo-mpo.gc.ca
Kirsten Clark	DFO, SABS	(506) 529-5891	(506) 529-5862	clarkk@mar.dfo-mpo.gc.ca
Tom Nies	NEFMC	(978) 465-0492	(978) 465-3116	tnies@nefmc.org
Jorgen Hansen	DFO, FAM	(902) 426-9046	(902) 426-9683	HansenJ@mar.dfo-mpo.gc.ca
Michael O'Connor	TMGC	(902) 482-7747	(902) 482-8146	MCOConnor@eastlink.ca
Claude d'Entremont	Inshore Fisheries	(902) 762-2522	(902) 762-3464	inshore@inshore.ca
Alain d'Entremont	Scotia Harvest Seafoods	(902) 648-4075	(902) 762-0167	alain@scotiaharvest.com
Tara McIntyre	DFO, BIO	(902) 426-2298	(902) 426-1506	McintyreTM@mar.dfo-mpo.gc.ca
Mark Showell	DFO, BIO	(902) 426-6083	(902) 426-5435	ShowellM@mar.dfo-mpo.gc.ca
Kent Smedbol	DFO, SABS	(506) 529-5976	(506) 529-5862	SmedbolK@mar.dfo-mpo.gc.ca
Heath Stone	DFO, SABS	(506) 529-5880	(506) 529-5862	StoneH@mar.dfo-mpo.gc.ca
Shelly, Tallack	Gulf of Maine Research Institute	(207) 228-1639	(207) 772-6855	stallack@gmri.org
Mark Terceiro	NOAA, NMFS	(508)495-2000 ext 2203		mark.terceiro@noaa.gov
Jamie Emberley	DFO, SABS	(506) 529-5887	(506) 529-5862	emberleyj@mar.dfo-mpo.gc.ca
Don Clark	DFO, SABS	(506) 529-5908	(506) 529-5862	ClarkD@mar.dfo-mpo.gc.ca

Appendix A2. Terms of Reference

Transboundary Resources Assessment Committee
Eastern Georges Bank Cod Benchmark Assessment

St. Andrews, NB (Data Inputs)
Woods Hole, MA (Modeling)

2009

TERMS OF REFERENCE

Context

The TRAC was established in 1998 to peer review assessments of transboundary resources in the Georges Bank area and thus to ensure that the management efforts of both Canada and USA, pursued either independently or cooperatively, are founded on a common understanding of resource status. While stock assessment results are needed routinely to serve the management system, it is not practical to evaluate the assessment approach each time the assessment is conducted. Instead, review of the assessment approach (benchmark assessments) are conducted periodically, generally at a separate meeting. The last TRAC benchmark for cod was conducted in February 2002.

At present, the USA assessment for the whole of Georges Bank is conducted independently from the TRAC assessment of eastern Georges Bank. There is some concern that differing assessment approaches may make reconciliation of results difficult. A benchmark that reviews the assessment approaches for both areas together would address this issue.

Objectives

1) To review the assessment frameworks Eastern Georges Bank cod management units (5Zjm). The agreed benchmark would be used in the June/July 2009 TRAC.

   Data Inputs
   - Review fishery landings and estimates of discards from all fisheries.
   - Determine most appropriate methods for calculating fishery landings at age.
   - Determine most appropriate methods for calculating discards at age from all fisheries.
   - Determine most appropriate methods for calculating weights at age for the fishery catch.
   - Determine most appropriate methods for calculating survey indices of abundance at age.
   - Determine most appropriate methods for calculating weights at age for the population.
   - Explore fishery catch per unit effort indices for use as tuning indices.
   - Examine tagging data for application in stock assessment.

   Assessment Methods
   - Explore full range of assessment methods for estimating current abundance and exploitation rate such as, but not limited to, catch curves, separable Virtual Population Analysis (VPA), index based approaches, surplus production, delay-difference, calibrated VPA, statistical catch at age models.
   - If required, update reference points for harvest strategy based on agreed assessment approach.

- Formulate projection procedures for harvest advice based on agreed assessment approach.

2) Review if an assessment of eastern Georges Bank can be reconciled with an assessment of Georges Bank as a whole.

   - Review the documentation on rationale for the current management unit.

Outputs

TRAC Proceedings, which will document the details of the benchmark

TRAC Reference Documents

Participants

DFO Maritimes scientists and managers
NMFS Northeast Region scientists and managers
Canadian and USA fishing industry
USA State and Canadian Provincial representatives
NEFMC representatives

Appendix A3. Meeting Agenda

Transboundary Resources Assessment Committee
Eastern Georges Bank Cod Benchmark Assessment

St. Andrews Biological Station, New Brunswick, Canada
Hachey Boardroom

13-15 January 2009

DRAFT Agenda

13 January 2009 – Tuesday

9:00 – 9:30	Welcome and Introduction (Chairs)
9:30 – 10:30	Review of Stock Structure
10:30 – 10:45	Break
10:45 – 12:00	Review of Stock Structure (con.)
12:00 – 1:00	Lunch
1:00 – 3:00	Results from Recent Tagging
3:00 – 3:15	Break
3:15 – 5:00	Results from Recent Tagging (con.)

14 January 2009 – Wednesday

8:30 – 10:00	Review of Fishery Landings and Discard Estimates
10:00 – 10:15	Break
10:15 – 12:00	Review of Methods for Calculating Fishery Landings, Discards and Weights at Age
12:00 – 1:00	Lunch
1:00 – 5:00	Review of Bottom Trawl Survey Distribution, Indices at Age Review of Methods to Calculate Beginning of Year Population Weight at Age

15 January 2009 – Thursday

08:30 – 10:00	Revisions, Discussion and Wrap-up
10:00 – 10:15	Break
10:15 – 12:00	Report Drafting
12:00 – 1:00	Lunch
1:00 – end	Report Review (as required)

B. MODEL MEETING

B. Introduction

The Transboundary Resources Assessment Committee (TRAC) co-chairs, Loretta O'Brien and Tana Worcester welcomed participants (Appendix B1) to the Benchmark Model meeting for Eastern Georges Bank Cod, held during 30 March – 2 April 2009. The Terms of Reference and Agenda for the meeting are provided in Appendices B2 and B3, respectively. During the meeting, each working paper was presented by one of the authors and then followed by a plenary discussion of that paper. Rapporteurs documented these presentations and discussions for the Proceedings.

B. Eastern Georges Bank Cod : Review of 2002 Benchmark

TRAC Presentation:	Wang, Y., and S. Gavaris. 2009. Eastern Georges Bank Cod. TRAC Working Paper 2009/04.
Presenter:	S. Gavaris
Rapporteur:	H. Stone

Presentation Highlights

For the purpose of the sharing agreement, the USA and Canada designated cod on eastern Georges Bank [5Zjm; 551,552,561,562] as the transboundary management unit. The USA has a requirement for management advice on Georges Bank cod. The status quo has been to use an assessment of cod on eastern Georges Bank for transboundary management advice and an assessment of cod in NAFO Divisions 5Z+6 for USA domestic management advice. This presentation deals with the assessment of cod on eastern Georges Bank.

The fishery catch at age, including discards, for 1978 to 2007 and the bottom trawl surveys conducted annually by DFO and NMFS that were reviewed during the data meeting (see section A above) are the information used to conduct the assessment. Evaluation of the state of the resource was based on results from an age structured analytical assessment (Virtual Population Analysis, VPA), which used the fishery catch at age. The VPA was calibrated to trends in abundance from three bottom trawl survey series: NMFS spring, NMFS fall and DFO.

For a basic VPA calibration, the annual natural mortality rate, M, was assumed constant and equal to 0.2 for all ages in all years. Fishing mortality on Age 9 for 1978 to 2007 was assumed to be equal to the population number weighted average fishing mortality on ages 7 and 8. The estimated model parameters were population abundance in the terminal year and survey catchability at age. The basic VPA calibration displayed notable age and time residual patterns. However, greatest concern was caused by the persistent retrospective patterns which indicated that contemporary estimates of biomass were consistently lower than previously estimated.

A benchmark assessment review was conducted in 2002 to address concerns about the residual patterns and the retrospective patterns from the assessment. The benchmark formulation was otherwise similar to the basic formulation except that it also estimated population abundance at Age 11 for 1999 onwards. The estimated model parameters for the consensus formulation from that meeting applied to the currently available data were population abundance in the terminal year, population abundance at Age 11 for 1999 onwards and survey catchability at age.

In recent assessments that applied the 2002 benchmark formulation, with the inclusion of information for additional years, the descending limb of the fishery partial recruitment became increasingly steeper and the survey catchability pattern at age displayed a notable dome shape. The resulting assessment generated appreciable 'cryptic biomass' at older ages that could not be observed by either the fisheries or the surveys. Preliminary exploration of alternative model formulations during the 2008 assessment review suggested that the benchmark formulation may be overestimating population biomass. A benchmark review was recommended.

Further, examination of the implications of eliminating the first quarter fishery indicated that the magnitude of those removals was not large enough to appreciably alter the annual size composition. Therefore, a marked change in fishery partial recruitment after the mid 1990s, a key feature of the 2002 benchmark model formulation, was not supported.

Important features of fishery and survey data include:

- The trends in survey abundance, coupled with the fishery catches, suggest that the relationship between survey abundance indices and population abundance changed during the mid 1990s, particularly at ages 4-6.
- Total mortality calculations indicate some decline around the mid 1990s, but total mortality remains high. Total mortality appears higher for ages 6+ compared to ages 4-5.
- Relative exploitation calculations, which assume survey catchability is constant over the time series, indicate a decline beginning in the mid 1990s.
- The indications for total mortality, coupled with relative exploitation (i.e. survey and catch data), imply that natural mortality (or aspects that might alias natural mortality, e.g., emigration) increased since the mid 1990s and that M (mortality) may be higher at ages 6+.

Discussion

The objective of this presentation was to provide some context for the modelling meeting. While the current 5Z+6 (USA Domestic) and 5Zjm (transboundary) assessment areas are considered to be the least disruptive to the existing assessment processes, the eastern GB assessment and whole bank assessment show contradictions in model results which need to be harmonized. The cryptic biomass generated by dome-shaped q in DFO and NMFS spring surveys in recent years is of particular concern. Not enough older fish are present in the Canadian fishery to account for differences in q.

The retrospective analysis for the 5Zjm assessment goes back to 1990, which may not be far enough back in time to determine when this problem starts to occur. A recommendation was made to examine differences in the retrospective patterns for whole bank vs 5Zjm assessments.

Most of the discussion focused on q changes in the survey and the fishery. Several comments were made regarding the differences in q between surveys (DFO, NMFS Spring, NMFS fall). These differences were thought to occur because of differences in gear, vessel, survey season, etc.

There was no support for the steeply domed PR occurring in the fishery since 1994. A comparison of the proportion of older fish now vs the past showed no difference because catches of older fish were quite low during first quarter. Longline fishery catch size composition by quarter was also examined to determine if more large fish were caught during the first quarter. This analysis was done, and more large fish were caught in some years but not consistently. Few port samples were available for the earlier years.

Several comments were made regarding the lack of older fish in the survey and fishery catch and the need to come up with an explanation as to how/why this pattern occurs. It was suggested that other things may be happening which are reducing the abundance of older fish. Catches are so low at present, particularly for the USA fishery, that we are not getting much information. Currently the discards are greater than the landings in the USA fishery and these tend to be comprised of small fish. The Canadian fishery is not presently directing for cod, and is actively trying to avoid them. This change in fishing practice could result in more small cod and fewer larger ones being retained. It was suggested that survey tow duration may have an influence on catchability; however, studies conducted in Norway indicated that larger fish are captured regardless of tow duration.

The position on survey PR (q at age) is that it is unusual for all indices to have a dome. Survey q should be flat-topped after Age 4; this is a basic premise which makes more sense biologically. Therefore, preference should be given to models with diagnostics which do not show dome-shaped q. There may even be a requirement to impose a flat-topped selectivity pattern. It was noted that there have been more changes in the fishery compared to the survey. A steep dome in the fishery PR can also generate the domed survey PR. This being the case, the main focus should be on the survey for PR changes.

It was noted that there is also a time pattern in the Georges Bank survey with a q change after 1994. Similar problems occur in the 4X cod assessment, which exhibits flat-topped selectivity in surveys up to the mid-1990’s then changes to a dome after that. Since there have been no changes in the survey design or procedures over the time series, selectivity should still be flat topped now.

The Georges Bank survey is currently catching more age 4-6 fish relative to the population. Why would ages 4-6 be more available to the survey gear? One explanation is that at higher levels of abundance there is more vertical distribution of cod in the water column. Therefore, a greater fraction is unavailable to the gear when abundance is high, while at lower abundance, more fish are available since they are more closely associated with the bottom. The result is a density dependent effect, i.e. increasing q with lower abundance.

There remains a need to identify potential mechanisms to support alternative model formulations i.e. use of power functions for some age groups, changing survey q (splitting survey time series), changing M. Canadian assessments for other cod stocks are using models with higher values of M; some of these areas have empirical evidence for higher M (i.e. where fisheries have been closed). For Georges Bank cod, there appears to be higher M for ages 7 and older.

Suggestions were made about using other models and approaches which may provide more insight as to how best to use the available data (i.e. estimate oldest age fishery PR with traditional VPA or try a catch error model (i.e. ASAP). The group may also want to explore age by age index weighting. This was actually done for the 2002 cod framework but was not found to be that useful (and may be hard to do if the time series is split).

While it was noted that we do not have to be concerned about random error in the catch at age, systematic error (i.e. unreported catches) could be a problem.

B. Eastern Georges Bank Cod: Model Explorations

TRAC Presentation: Wang, Y., and S. Gavaris. 2009. Eastern Georges Bank Cod. TRAC Working Paper 2009/04.
Presenter: Y. Wang
Rapporteur: R. O'Boyle

Presentation Highlights

Model evaluation did not rely on a single criterion. The suite of diagnostics used to compare how well the models fit the data and how their results conformed to conventional perceptions of fisheries dynamics included:

- Residuals: age, time, cohort patterns.
- Fit statistics: residual sum of squares, Aikake Information Criterion (AIC).
- Survey catchability: age, time patterns.
- Fishery partial recruitment: age patterns.
- Fishing mortality with respect to catch: time patterns.
- Retrospective: time patterns.

The DFO and NMFS spring survey abundance indices for ages 4-6 increased in recent years, but not for the older fish, while the fishery catch for all the age groups has decreased greatly since 1994. The observation made above that total mortality remains high suggests that natural mortality might have increased in recent years. Model formulations with higher natural mortality after 1993 were investigated. Comparison of diagnostics confirmed the observation made above from data features that mortality appeared to have increased for ages 6+. Diagnostic comparisons favoured a value of M=0.7, close to the value obtained when M was estimated for the block of ages 6+ in years 1994-2007. Comparison between the estimated survey catchability and the calculated annual ratio of survey abundance index to estimated population numbers indicated that, for ages 4 to 6, most of the calculated points were below the estimated survey catchability for the early years and above for the recent years. This suggests that the survey catchability has changed.

The 'split survey' model formulations that were explored calculated separate catchabilities at age for surveys before and after 1994. A basic 'survey split' model with a constant M=0.2 was tried first. The resulting fishing mortality during 1997-2004 ranged as high as the fishing mortality during 1982-1990. This result is contradictory to the perception that effort decreased due to restrictive management measures introduced after 1994. 'Split survey' model formulations with higher natural mortality for ages 6+ after 1993 were investigated. Diagnostic comparisons favoured a value of M=0.5, close to the value obtained when M was estimated for the block of ages 6+ in years 1994-2007.

In summary, all three models can be supported or criticized. While a mechanism for large changes of survey catchability or M was not established, evidence suggests that both may have changed about 1994. The change in these parameters may not be well estimated because of the variability of survey abundance indices and the high correlation between survey catchability and M. The 'split survey' model with M=0.5 had the best AIC, no appreciable retrospective pattern and a fishing mortality time trend that is more consistent with perceptions of effort trends.

Discussion

The discussion commenced with a question on the difference in the 2008 estimated biomass between the Split / Increase M and the TRAC 2002 benchmark 'round-the-corner' model. The TRAC formulation generated domed shaped fishery partial recruitments (PR) for 1994 - 2000, which, while largely removing the retrospective pattern, produced 'cryptic biomass' – biomass that isn't observed either in the fishery or survey. The TRAC model produced an estimated 21,000 t biomass in 2008, which was at the upper end of the range for the three models considered at this meeting. The TRAC model also generated dome patterns in the survey catchabilities when the 2008 data were added.

This discussion clarified the main issues confronting the assessment. Stock abundance at younger age groups as indicated by the surveys was not producing expected fishery catches at older age groups. Thus, the options considered to reconcile the catch and survey data were 1) No Split / Increase M model - the cod were present but experienced higher natural mortality (M) than the presumed 0.2, 2) Split / Constant M model - the survey catchabilities (q) had increased and thus decreased cod abundance was more apparent than real, and 3) Split / Increase M model - combination of M and q changes.

There were a number of questions on the trends in the three models. The No Split / Increase M model (M = 0.7) produced monotonically increasing survey catchabilities which did not seem reasonable. The Split / Constant M (M = 0.2) model produced very high estimates of fully recruited fishing mortality (0.5 – 0.8) during 2001 – 2007, which could not be reconciled with the recent management efforts in the fishery. The Split / Increase M (M = 0.5) model did not exhibit these trends but exhibited an anomously high coefficient of variation (CV) in the 2004 terminal year of a retrospective analysis. It was recognized that changes in either M and q alone could address the residual and retrospective patterns but that these parameters are highly correlated and changes in both (the Split / Increase M model) could be occurring. It was emphasized that the Split / Increase M model should not be viewed as a middle option but rather that the three models formed a set that attempted to bracket the range of possibilities.

Clarification was requested on the model selection process. The first step was to split the three survey time series between 1993 and 1994 in an attempt to address patterns in the residuals. This had been used during GARM III as a proxy for an unknown process that may or may not be related to the survey. This produced the Split / Constant M model. The next step was exploration of the appropriate level of natural mortality (M) in the Split and No Split models using the minimum of the sums of squares of the residuals (SSQ) to select the starting age (6) of the group for which M would be changed and the value of M that would be used. For the Split / Increase M model, the selection of M = 0.5 was corroborated by an AIC analysis. Discussion ensued on the relative merits of the AIC and related BIC, which penalized use of an increased number of parameters differently. While this discussion clarified the overall model selection process, it was recommended that it be formally documented in the meeting report.

Discussion followed on hypotheses that may explain changes in M, q and/or both. In relation to M, it was asked if sealworm burdens, which have been increasing recently in Georges Bank cod, could be responsible. A study in Newfoundland (K. Clark, pers. comm.) indicated that cod mortality did not appear to increase with worm burdens. Seals were mentioned as a potential source of the natural mortality; however, seals are one predator of many which could be causing elevated M. It was noted that assessments of the Canadian cod stocks, which were reviewed at the end of February 2009, had assumed elevated Ms since the mid-1990s. A meta-analysis of

M trends in these assessments was made available to the meeting. A rationale for this was the continuing high total mortality estimated from the DFO surveys after a number of stocks were put under a fishing moratorium in 1992/93, implying increases in M. It was suggested that high M could also be a consequence of declining growth rates which have been observed since the mid – 1990s. Further exploration of these potential processes was encouraged.

In relation to changes in survey q, spatial changes in the resource were potential explanatory processes. For instance, as abundance increases, a relatively higher proportion of the population may occupy the water column above the survey trawl. Survey catchability thus may be a function of population size, which could be explored through use of a power parameter on abundance in the objective function. This has been employed in the examination of commercial catch rate – population abundance relationships. It was noted that the relationship could be different across ages. The survey qs on ages one and two had changed in an opposite direction (decreased) to those on the older ages. This was why an attempt had been made to relate size to survey catchability for these age groups. This discussion raised the benefits of a meta-analysis of survey q – population abundance relationships for cod stocks in the North Atlantic. If a relationship were to be used for 5Zjm cod, it could be expected in other cod stocks. Indeed, presence of the relationship more broadly would lend support to its application in any one stock.

As a consequence of the discussion, a number of additional analyses for the meeting were recommended:

- Description of the model selection process.
- Exploration of alpha term (Butterworth and Rademeyer, 2008) in the determination of the Age 10+ fishing mortality.
- Estimation of M on ages one to five for all years separate from M on ages 6+ before and after the survey q split year.
- SSQ profiling of M across age for the three model options.
- Exploration of M as a function of weight at age.

TRAC Presentation: ASAP Exploratory Runs
Presenter: L. O'Brien
Rapporteur: R. O'Boyle

Presentation Highlights

The ASAP forward projection model was run as an exploratory alternative model to the VPA. The ability of this model to include additional catch and survey indices when no age composition data is available can provide additional information on stock productivity. ASAP model runs were conducted for both EGB (5Zjm) and GB (5Z + Subarea 6) cod.

Three model formulations were run for both EGB and GB cod. The base formulation allowed the fishery selectivity, i.e., partial recruitment (PR) to be freely estimated, the 'flat PR' formulation imposed a flat topped PR pattern, and the 'dome PR' formulation imposed a dome shaped PR pattern. The selectivity for each fleet is by age, with two selectivity blocks within each fleet based on changes in management measures (quotas, mesh regulations, area closures) during those years. The selectivity blocks were between 1998 and 1999 for the USA western GB fleet, between 1994 and 1995 for USA eastern GB fleet, and between 1992 and 1993 for the Canadian eastern GB fleet. The times series of landings (1978-2007) and survey abundance indices, were the same as those used in the VPA. Landings and survey biomass estimates from 1964-1977, without age composition data, were also input to the model. The survey time series was not split as in the VPA.

EGB - The base and 'dome PR' formulations had a similar pattern in the survey catchability (q) at age. The fishery selectivity of the base run was generally flat topped for the early selectivity block, but exhibited a strong dome for the latter selectivity block. Trends in F and SSB estimates were similar for all three runs, with the 'dome' run estimating the lowest Fs and the 'flat' runs the highest. The opposite was observed in SSB, with the 'dome' run indicating the highest SSB and the 'flat' runs the lowest. All three runs exhibited a retrospective pattern in F, SSB and Age 1 recruits; however, the lowest magnitude occurred in the 'dome' run.

GB - The base and 'flat PR' formulations had a similar pattern in the survey catchability (q) at age. The base run fishery selectivity was generally flat topped for both the USA western and Canadian fleets, but tended to a dome for both selectivity blocks for the USA eastern fleet. Trends in F and SSB estimates were similar for all three runs, with the 'dome' run estimating the lowest Fs and the 'flat' runs the highest. The opposite was observed in SSB, with the 'dome' run indicating the highest SSB and the 'flat' runs the lowest. All three run exhibited a retrospective pattern in F, SSB and Age 1 recruits; however, the lowest magnitude occurred in the 'dome' run.

Further analyses would include splitting the survey time series as done with the VPA.

Discussion

It was noted that the ASAP runs were consistent with the observations made using the VPA. Use of a dome-shaped fishery partial recruitment reduces the size of the retrospective pattern but generates increasing population numbers in recent years.

There was discussion on the influence of the CVs used to weight the model data inputs. These are often difficult to determine and can significantly impact the model results. It was suggested that ASAP be used to explore the impact of variation in model components (e.g. catch at age, survey indices) on population status.

There were questions on the results of the ASAP run assuming a domed PR for the whole time series compared to those produced using the VPA 'run-the-corner' formulation. In VPA, the historically estimated PR is not influential on current estimates whereas it can be in ASAP.

Overall, there was agreement that the ASAP runs highlighted the same issues as encountered in the VPA. It was agreed that ASAP allows considerable latitude in testing different assumptions within one modeling framework and thus is a valuable exploration tool.

TRAC Presentation: Further Analyses for 5Zjm Cod Conducted During the Meeting
Rapporteur: R. O'Boyle

A number of further explorations of the 5Zjm cod assessment model were suggested based upon the discussions of the first day of the meeting. Additional analyses were undertaken during these investigations. Discussion of these analyses are presented according to the hypothesis that they are related to: Determination of fishing mortality, changes in survey catchability and changes in natural mortality. In addition, analyses were presented that pertained to the model selection statistics.

Determination of Fishing Mortality

Changing the weighting given to the survey indices in a Statistical Catch at Age model such as ASAP is equivalent to examining the relative importance of the catch at age and survey information. ASAP provides considerable flexibility in placing weight on those data perceived to be where uncertainty is lowest. A VPA model, such as presented at this meeting, assumes that there is negligible error in the catch at age. As more weight is placed on the survey data, the spawning stock biomass for the whole time series scales up. This is contrary to the VPA results, which has biomass declining more recently, this due to the weight that VPA gives to the recent catch, which has declined more than can be accounted for by the survey.

It was noted that in the ASAP retrospective results, the time series of spawning stock biomass and fishing mortality estimates were generally below and above zero respectively, which was unexpected. This prompted comments on the nature of generating retrospective patterns in a forward projecting model such as ASAP. There may be problems with how this is undertaken, which would require further exploration.

Problems with the reliability of the catch at age over years were raised. In the current analysis, survey coefficients of variation (CV) were adjusted by index, not by year. This led to a discussion on the determination of objective weightings, an issue discussed at the 2002 TRAC benchmark. It was acknowledged that this is a difficult issue to address.

This raised comments on the sampling associated with the catch at age. USA sampling protocols had changed in 1994 which could have influenced the precision of the catch at age. ASAP could be used to examine the impact of these changes.

It was noted that changing survey weightings addresses the influence of the precision of the catch at age on the assessment, but not bias such as misreporting and discarding.

After the additional analyses were presented, there was a more **general discussion on potential bias in the reported catch** and how this may have changed over time. Some of these comments echoed those made at the data inputs review. It was acknowledged that, for the model discrepancies to be addressed, recent catch would have to increase or earlier (prior to 1994) catch to decrease. While no analyses were presented at this meeting, work at the 2002 benchmark had suggested that recent catch would have to be in the order of thousands of tons to account for the model discrepancies. This led to a discussion on improvements to the catch monitoring systems in the USA and Canada. Significant improvements to Canadian dockside monitoring were introduced with ITQs in 1992 and reported catch since then is felt to be reliable. Some meeting participants felt less certain about recent USA catch reporting. Overall, however, it was felt that reporting by both countries in recent year was reliable enough that large unreported catches would not be considered likely.

The situation prior to 1994 is less clear. Discarding in the Canadian fishery during the early – mid 1990s could have occurred as there is no monitoring information available. There may have been over-reporting (reporting of catch made in another area into 5Zjm) by the fleets of both countries to stay within quota limits. Without information on these possibilities, they remain speculations.

This prompted discussion on downweighting of the catch and focusing on the reliability of the catch sampling information by both countries. The age structure of the catch was felt to be more robust to catch reporting issues. The possibility was tabled of conducting the population reconstructions using only the information since 1994. In response, it was considered that this approach would produce a terminal year population status the same as that of the split model approach. This was confirmed by an analysis conducted at the meeting. It was acknowledged that not including the historical information would have consequences for the determination of reference points.

Overall, while there may be issues with the recent catch, these are not likely to be the primary cause of the discrepancies between the catch and survey information.

Regarding the fishing mortality on Age 10 plus group, it was noted that the use of the alpha term (Butterworth and Rademeyer, 2008) produced VPA results similar to those of the 'corner' formulation. Abundance of the older age groups in recent years generally increased. Use of the alpha term over two time blocks did not change this overall result. The comment was made that, with little catch beyond Age 9, it is difficult to determine whether or not a domed fishery partial recruitment exists. The Age 10+ group fishing mortalities are likely not informative.

Notwithstanding these comments, it was acknowledged that the analysis corroborated the earlier conclusions made on fishery partial recruitment. The current analysis was not felt sufficient to support the presence of a domed partial recruitment.

Changes in Survey Catchability

During the clarification questions, it was noted that the survey – population abundance relationship, using a power term, was almost linear down close to the origin at which point it changed abruptly, this effect being age dependent.

It was felt that the formulation was not having the same effect as the split in the survey time series, which it was intended to do. It was speculated that this formulation would likely exhibit retrospective patterns.

Overall, the use of the power term in the survey – population abundance relationship in the manner undertaken here was not worth pursuing.

Changes in Natural Mortality (M)

R. Mohn presented an exploration of alternative population modeling approaches applied to 5jm cod. A VPA model written in ADMB which allowed random walks in M, q or both was presented for 5jm cod. The only index for tuning used was the NMFS spring survey for ages 1-9. A random walk model was used to get a clearer indication of the changes in M or q suggested by these data. It was emphasized this was not a candidate assessment model for benchmark consideration, but rather an exploration into some of the potential transients in assessment data.

When one M was estimated for all ages the time course was estimated as shown in Figure B1.

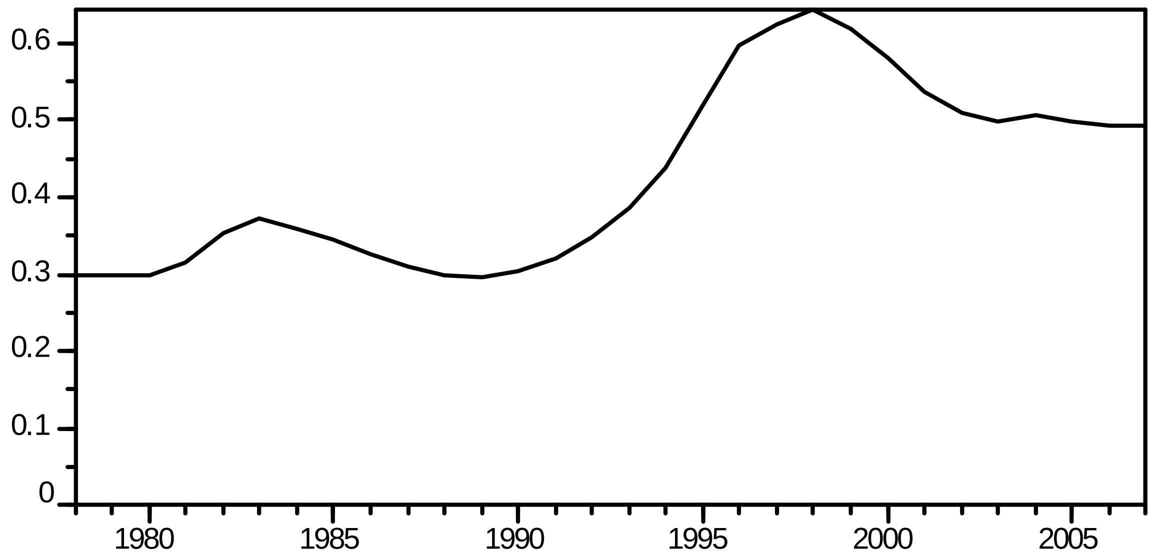

Figure B1. Moving window estimates of 5jm cod M for all ages.

If instead a coefficient of the estimated q at age was allowed to vary, its time course would be as shown in the red line in Figure B2 .And when both were allowed to vary with approximately the same flexibility (which is controlled by user-defined parameters) the results are as in Figure B3.

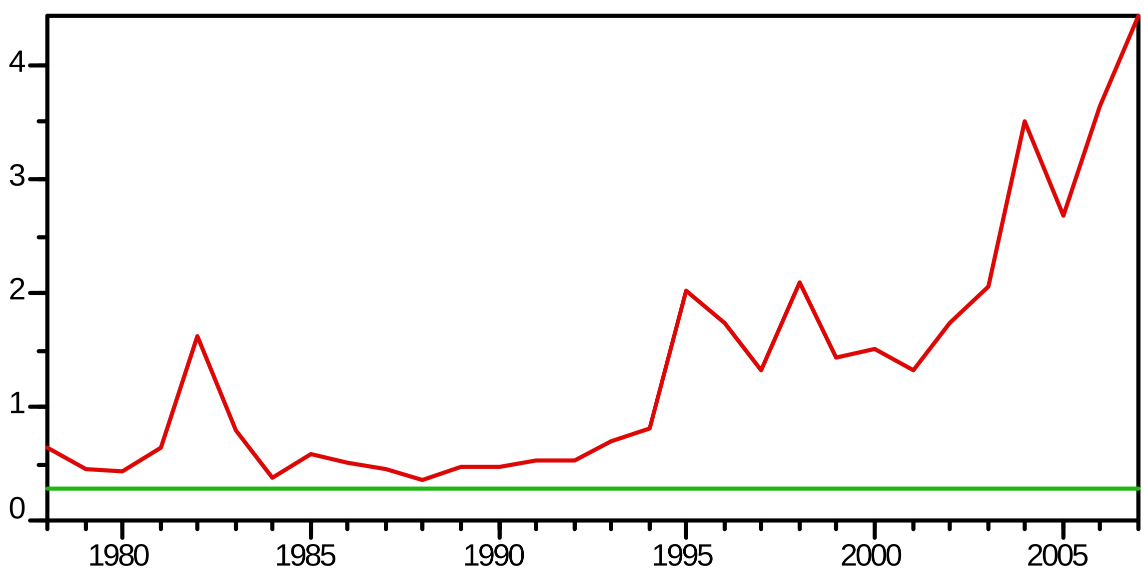

Figure B2. Moving window estimates of 5jm cod q coefficient (red line) and single natural mortality for all ages and years (green line;lower line).

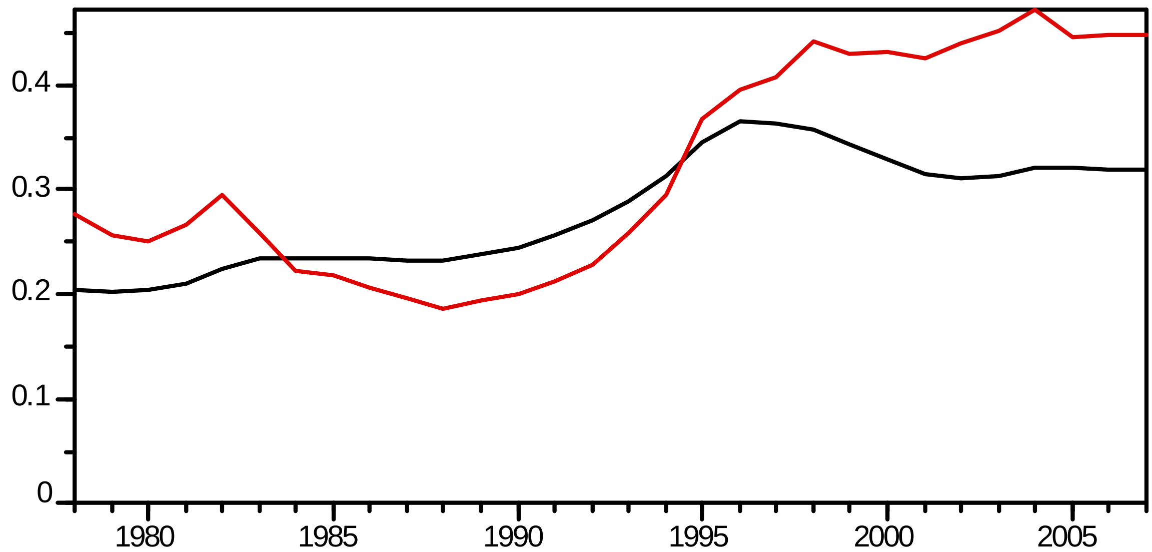

Figure B3. Moving window estimates of 5jm cod simultaneous M (black line;lower line in 2005) and q (red line, upper line in 2005).

A similar analysis was carried out for 5Z cod, again tuning only with the NMFS spring survey. It shows a similar time trend but lower M throughout. For comparison, random M's for 4X and 4VsW are also included in Figure B4. All show a similar time course but the intensity of the change increases from westerly to more easterly stocks.

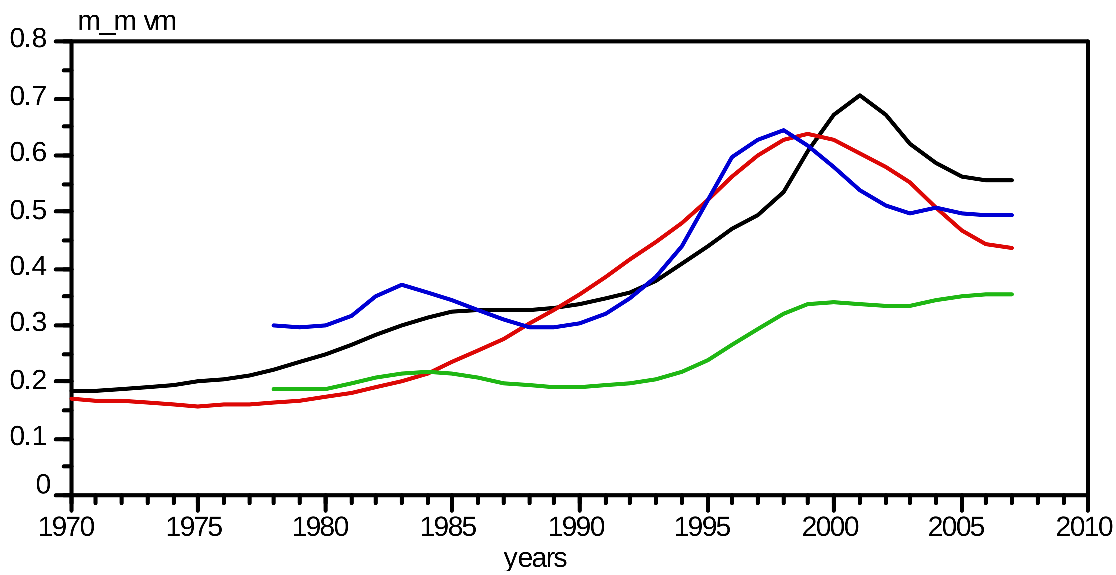

Figure B4. Moving window estimates of 4 northeast Atlantic cod stocks. 5jm is blue(2nd highest in 2007), 5Z green (lowest in 2007), 4X red (3rd highest in 2007) and 4VsW is black (highest in 2007).

This work agreed well with the magnitude and timing used in the benchmark investigations using blocks of time and age to assess changes in q or M.

Discussion

There was speculation that the western boundary of the 5Zjm management unit may be accounting for the differences in population trends between this and the 5Z management unit. The M trends in 5Zjm may be aliasing missing catch which is reported in the bigger management unit. This could account for the relative scaling of M up in 5Zjm compared to that in 5Z.

On the other hand, it was noted that the trends in M for ages 4 – 9 match similar trends for the other Canadian management units. All have been experiencing increasing M since the early 1990s, when fishing was closed. These trends have been the focus of much research on potential predators (e.g., seals) and ecosystem changes. It is, however, acknowledged that there may be different causes of M increases in different areas and these may be an alias for other processes in each area.

An attempt had been made at the meeting to explore the relationship between M and growth rate, as suggested on the first day of the meeting. The work was too preliminary to be considered.

It was noted that adjustments (e.g. split survey series) to seven of 14 GARM III assessment models were made to address significant retrospective patterns. There may be similar processes underway in more groundfish species than just cod.

Overall, it was recognized that the analyses highlighted longer-term trends in M that were consistent with those seen in more northerly resources and suggestive of recent increases in natural mortality.

It was confirmed that the starting **age (6) of the group which was experiencing increasing natural mortality** was based upon the AIC profile of the sum of squares of residuals (SSQ) along with flat partial recruitment and survey catchabilities on the older age groups.

It was acknowledged that the patterns observed with changing M were subtle. For instance, the SSQ changes by about two percent from M = 0.2 to M = 0.5. Notwithstanding this, the suite of diagnostics considered is suggestive of changes in M.

While it was acknowledged that the analysis indicated that increases in M could not be accounted for by **anomalous survey year effects,** the result was perhaps not unexpected as years with both low and high coefficients of variation were removed from the calibration. Further work on this was not indicated.

Model Selection Statistics

The analysis of the autocorrelation in residuals was informative in highlighting difficulties in interpreting residual patterns. Certainly, considering autocorrelations in residuals in this situation was not considered useful. A suggestion was made to attempt first differences, which could be pursued subsequent to the meeting.

Regarding **AIC and BIC model selection measures**, it was agreed that the analysis indicated that AIC and BIC criteria both corroborated the conclusion that natural mortality may be increasing. There was some discussion on the utility of these and other criteria that could be used as future diagnostics.

Reference Points, Projection, and Harmonization of the 5Zjm and 5Z Assessments

There was agreement that it was difficult to characterize the stock – recruitment relationship, although assuming that one exists leads to decreasing the fishing mortality reference point. On the other hand, based on yield per recruit considerations, the fishing mortality reference point would increase. Given the poor recent recruitment, slow growth and potentially increasing natural mortality, stock productivity is evidently low. Given indications that size at age has begun to increase and due to uncertainty about the increase in natural mortality, there was agreement that the current fishing mortality reference point should not be changed. This would apply regardless of the assessment model chosen. The fate of the 2003 year-class should be closely monitored to evaluate whether or not the natural mortality has increased, thereby requiring an update of the fishing mortality reference point.

There was agreement with the proposed projection procedure with no changes suggested.

Regarding the risk analysis, it was suggested that it could be presented to show the consequences of being wrong under the various modeling options.

There was agreement with the proposal on the harmonization of the 5Zjm and 5Z assessments.

B. Tagging Analyses

TRAC Presentation:	Cod Selectivity: Tagging Analysis
Presenters:	T. Miller, D. Hart, C. Legault
Rapporteur:	L. Van Eeckhaute

Presentation Highlights

Two types of analyses of a large scale Atlantic cod tagging experiment carried out by the Gulf of Maine Research Institute to assess whether there were decreases in fishing mortality at larger sizes (or older ages) were presented. The first analysis used a generalized additive model to assess whether there was a significant decrease in the probability of recapture with length at release while accounting for changes in the response due to reward type, number of tags at release and the date of release. The second analysis used a finite-state continuous-time model (Miller and Andersen 2008) to estimate yearly fishing mortality and natural mortality for 3 different size classes of release. The three size classes were constructed to contain three ranges of different selectivity found by Butterworth and Rademeyer (2008): low fishing mortality on younger fish, high fishing mortality on intermediate aged fish and low fishing mortality on older fish. The latter analysis also accounted for differences in reporting by reward type and allowed for different fishing and unobserved mortalities for a brief period after release. Both analyses did not find any statistical evidence for decreased fishing mortality at larger sizes nor did the latter analysis find evidence for increased natural mortality with size class.

Discussion

The analyses assumed constant selectivity for size, and tag return rates were needed over a range of fish sizes to determine if there was higher mortality on larger fish. For this reason, and also, to reduce noise, the analysis included all tagging data across several distinct areas in which cod were tagged. There were differences by area in numbers of tagged cod released and in the size structure. About 60,000 small cod were released but mostly off of Cape Cod. In 4X the fish were medium sized. No small fish were tagged in the GOM. All areas had to be included to incorporate small fish into the analysis. No given area, except the GOM, had enough sizes needed for a reliable estimate. To look at area differences, an analysis by D. Hart, similar to what was done for yellowtail flounder in the GARM, which used recapture rates by fish size to investigate support for domed PR, was presented by D. Hart and incorporated 3 areas, GOM, GB (including Cape Cod and the Great South Channel) and 4X.

There were many comments on aspects of T. Miller's analysis that could impact conclusions:

- Different areas had different reporting rates and differences in reporting rates could be seen between trips and fleets such as were seen in 4X. One industry reviewer felt that reporting rates were too low as, in his experience, workers in fish plants show a high tendency to return tags. More tags are found at fish plants than by fishermen. 4X had the highest reporting rates. Changes in reporting rates could change the picture. One reviewer felt the high reward-low reward system was the best way to estimate reporting rate. There would also be a discarding effect, in which case tagged fish would be lost.

- The model included fish with different times at large as it included all recaptures.

- No growth model was used but during the period that the model covers, smaller size classes would have grown into larger size classes.

- The presentation did not show numbers nor was it shown how estimates were arrived at and diagnostics to determine how well the model fit the data were not examined.

- The study did not take into account spatial effects which appear to be an important factor. The study combined results for the whole area (i.e., 4X, 5Z and 5Y) but this meeting is only interested in EGB, an area where tagging was very limited and that did not have any tagging in the Canadian portion. Tagging took place in Closed Area II. The highest number of fish tagged were from the Cape Cod area and this is where most of the small fish were from. Other areas had medium to large fish.

- If tag induced mortality is higher for smaller fish there would be proportionately more larger fish left to recapture but the study did not take this into account and the analyst did not know how this would affect the results.

Other comments:

- The estimated tag induced mortality was very large and its believability was questioned. For example, high reward tags had a return rate of 25%, which, when compared to a tag induced mortality rate of 70%, indicates that this value is too high. In response, 50% to 60% mortality for discards has been estimated, however it was pointed out, that cod smaller than 14 inches were not tagged as past studies showed that fish smaller than this size showed a lower return rate and that the best condition fish were used. In analyses conducted by the project leader of the tagging study, a mortality rate of 10% was used. In comparison, a value of 30% was estimated by a study by Cadigan and Brady. Tagging mortality could have been greater for small fish due to, for example, warmer water.

- To support a domed PR, the fraction recaptured should decline at higher ages/sizes. The results showed no evidence of a reduced recapture rate as size increased. Similar results were reported during the GARM and were used to assume flat PR. These results could be used as the basis for a model without increasing M.

- Some high mortality estimates were determined but these may have been due to tagged fish being more catchable than non-tagged fish due to behaviour differences or where they had been tagged, such as in an actively fished area. Therefore, the magnitude of mortality rates should not be taken too seriously.

- This analysis says M does not change by size but Z is higher. Survey data indicates Z has not declined and is higher at older ages than at younger ages. The conflict is with catch data as we don't see older cod being caught by the fishery.

- No large fish were found on EGB, in contrast to the GOM where large cod were found to tag. This could mean that the GOM has lower mortality and EGB has higher mortality.

- Small fish wouldn't be expected to be recaptured for at least a year as fishing mortality on these would be lower. This translates into longer time for recapture.

- It was pointed out that the lack of a directed fishery for cod on EGB, due to fishermen avoiding catching cod would result in very low recapture rates.

- It would be helpful to see sample numbers and CV's for D. Hart's analyses.

In conclusion, it was pointed out that it is easy to accept corroborating conclusions, but, when faced with conflicting evidence, there is a need to examine analyses closely and look into the details. The group, therefore, wished to see more of the raw tagging data. Additional data on numbers tagged, size structure and numbers and percentages recaptured, all on an area basis (USA-GOM, USA-GB, EGB and 4X) were presented by D. Clark. In this case, a relevant question is how pertinent are these results, which are for the whole area (5Z, 5Y and 4X), for the present area of interest, which is EGB. The most that can be concluded is that composite tag recovery data, but largely based on returns of larger cod from the adjacent Gulf of Maine stock, did not show marked decline in percentage recovered by age, therefore not supporting a difference in M by age for recent years. The data for EGB are insufficient to allow for conclusions about M. An EGB only analysis would suffer from a lack of a broad size range.

The group also asked to see the results of the analysis presented by T. Miller at the GARM as this analysis took into account differences in areas. Results showed a marked increase in M for the larger size grouping which contradicts the results of the TRAC presentation which suggests that there was no increase in M with increasing size. However, the analyst reported that there were some problems with how the original analysis was done and the analyst cautioned reviewers not to put much reliance on the GARM analysis. These have been corrected for the current analysis prepared for TRAC. It was requested that the GARM analysis be repeated, for presentation at a later date, to address the lack of consideration of spatial aspects of the new analysis and to account for differences in tag induced mortality due to size at time of tagging.

There was a concern with including cod recaptured in less than 30 days in D. Hart's analysis. To address this, the analyst was asked to redo the analysis without these fish. The revised analysis for cod recaptured after more than 30 days from release (see Figure B5) showed essentially similar results as when they were included. A graph with all data combined was shown to illustrate the increase in selectivity of fishing gear as fish increased in size. A summary table of the GB/Great South Channel cod fraction recaptured by size class showed increasing return rates for 3 increasing size classes. It was noted by the analyst that all cod greater than 100 cm were from the GOM or 4X. It was commented that with the high rate of migration between Cape Cod and GOM fish, the cod from these 2 areas should show similar recapture patterns. The robustness of these results could not be evaluated during the meeting.

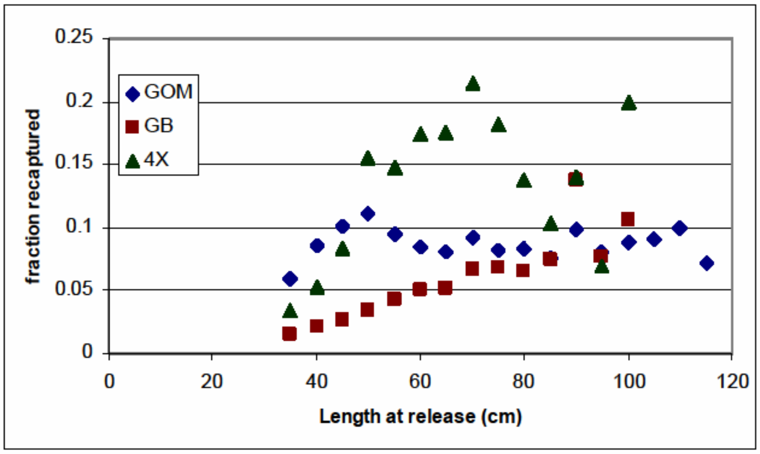

Figure B5. Fraction of tagged cod recaptured >30 days after release by region.

TRAC presentation:	Simulation Study of Estimating Stock Recruit Curves and Selectivity Patterns by Chris Legault, Tim Miller, Dvora Hart
Presenter:	C. Legault
Rapporteur:	L. Van Eeckhaute

Presentation Highlights

Four separate populations were created conditioned on the Gulf of Maine cod data and equations used in Butterworth and Rademeyer (2008), There were two stock recruitment relationships, Beverton-Holt and Ricker, and two forms of selectivity patterns for the commercial fleet and surveys, domed and flat-topped. Random noise was added to the survey indices, survey catch at age, and commercial catch at age to create 300 realizations for each of the four true cases. Each of these 1,200 realizations was assessed using the same model with estimation of either Beverton-Holt or Ricker stock recruit and estimation of either domed or flat-topped selectivity for a total of 4,800 assessments. For each realization of each true case, the best of the four possible models was selected based on maximum likelihood estimation.

In many cases, the model with best fit was not the model which corresponded to the truth (Table B1). There was a strong preference for domed selectivity over flat-topped selectivity in all cases. However, the estimated dome could be close to flat-topped in this specific model formulation. The Beverton-Holt stock recruit curve was strongly preferred over Ricker when Beverton-Holt was the truth while Beverton-Holt and Ricker were about evenly selected as the best model when Ricker was the truth. However, in all four cases, there was survey information available during a time period when spawning stock biomass was near unexploited levels. In many of the realizations, the best model had only a slightly better fit than the next best fitting model. Examination of two-way comparisons demonstrated this result, but also showed that there were some big wins, defined as >20 likelihood points, for the wrong model in every comparison.

Based on this study, it is clear that the wrong model can be selected based on maximum likelihood estimation. There are a number of details that prevent generalization of these specific results regarding domes versus flat-topped selectivity and Beverton-Holt versus Ricker stock recruitment relationships. However, the general warning holds that relying strictly on maximum likelihood to determine model structure can result in the wrong model being selected. Thus, it is recommended that external information be used when making decisions regarding model structure, for example tagging data to inform the selectivity assumption and biological characteristics to inform the stock recruitment assumption.

Table B1. Proportion of estimation models selected as best based on maximum likelihood estimation for 300 realizations of four separate true conditions.

			Estimated			
	SR curve		BH	BH	RK	RK
		Selectivity	dome	flat	dome	flat
True	BH	dome	84%	0%	15%	0%
	BH	flat	74%	9%	13%	5%
	RK	dome	45%	1%	53%	0%
	RK	flat	52%	5%	23%	21%

Discussion

It was noted that Maximum Likelihood Estimation, which was the method used to select the best model, was designed for parameter estimation and there is no theoretical basis to use it to determine between models. This analysis showed that there is a strong preference for domed selectivity over flat-topped selectivity and it was pointed out that it is true for highly parameterized models to favour domed selectivity. The recommendation to use external information, such as tagging information, to inform model selection rather than relying on fit was considered worrisome by one reviewer as there may be things going on that we don't know about. Another reviewer commented that this exercise was much like hypothesis testing and that the real world situation is much worse due to model mis-specification while in simulations, the model is correct. These results should be kept in mind when making decisions about model formulations and parameter estimates.

TRAC presentation: EGB Tag Returns Within Northeast Regional Tagging
Presenter: D. Clark

Presentation Highlights

A brief presentation was given on results of recent cod tagging to address questions that arose during the meeting.

Data on length frequency of releases showed that releases near Cape Cod were primarily small (< 55cm), while those released in Eastern Georges were large (>60 cm), complicating the interpretation of the influence of size at release on movement. Of the 952 recaptures recorded for fish released in 5Z which were <53 cm at release, all but 21 had been released in the vicinity of Cape Cod and Nantucket Shoals (Area 521).

The figures presented showed that almost all the tagging on Georges Bank took place near the boundary between Eastern and Western Georges Bank. Tagging in Eastern Georges Bank was primarily near the western boundary of the management area, with very little in areas 551 and 552 (the Canadian portion of Eastern Georges Bank). Tagging in Area 522 was also adjacent to this boundary.

Cod tagged in Area 522 were recovered primarily from Eastern Georges Bank. Roughly 66% of the cod recaptured from releases on Eastern Georges Bank were recaptured from within the management area. Of those which were recaptured elsewhere, few were recaptured in Area 521 (approximately 5%). The proportion recaptured in 4X (approximately 17%) was quite similar to the proportion recaptured farther west in the 5Z +6 management area (approximately 16%). While the proportion recaptured outside the Eastern Georges Bank management area was of concern, the results did not clearly suggest a stronger affinity with either areas further west or further east.

Tag return results showed that very few fish tagged in Area 521 were recaptured in Eastern Georges. Most were recaptured in the area of release, with 2% recovered in areas 551 – 562 (Eastern Georges Bank), 19% in areas 513 and 514 (the inner Gulf of Maine) and 7% in areas 522 and 525 (Western Georges Bank).

B. Benchmark Model Consensus

Management Unit

For the purpose of the sharing agreement, the USA and Canada designated cod on eastern Georges Bank [5Zjm; 551&552&561&562] as the transboundary management unit (Figure A1).

The USA has a requirement for management advice on Georges Bank cod. The status quo has been to use an assessment of cod on eastern Georges Bank for transboundary management advice and an assessment of cod in NAFO Divisions 5Z+6 for USA domestic management advice. While other options could be followed, this option is less disruptive to the existing processes. However, this approach requires concurrent assessment reviews of eastern Georges Bank and of NAFO Divisions 5Z+6 to harmonize results.

Consensus on Basis for Management Advice of Eastern Georges Bank Cod

A basic VPA calibration, where abundance at age in the terminal year is estimated and fishing mortality on the oldest age is calculated as the average of adjacent younger ages, displayed notable trends in residuals and an appreciable retrospective pattern. The current estimate of past biomass was consistently lower than previously estimated and the magnitude of that discrepancy was cause for concern.

A benchmark assessment review was conducted in 2002 to address concerns about the residual patterns and the retrospective patterns from the basic VPA calibration. The benchmark formulation was otherwise similar to the basic formulation except that it also estimated population abundance at Age 11 for 1999 onwards. This model formulation did not display any appreciable retrospective pattern but it resulted in a domed shaped fishery partial recruitment. At the time, this was not a concern because the decline in partial recruitment at older ages was modest and the survey catchability was relatively flat for older ages. The dome shaped fishery partial recruitment was thought to be the result of elimination of a fishery in the first quarter of the year when larger/older cod were more prevalent.

In recent assessments that apply the 2002 benchmark formulation, with the inclusion of information for additional years, the descending limb of the fishery partial recruitment became increasingly steeper and the survey catchability pattern at age displayed a notable dome shape. The resulting assessment generated appreciable ‘cryptic biomass’ at older ages that could not be observed by either the fisheries or the surveys. Further, examination of the implications of eliminating the first quarter fishery indicated that the magnitude of those removals was not large enough to appreciably alter the annual size composition. Therefore, a marked change in fishery partial recruitment after the mid 1990s, a key feature of the 2002 benchmark model formulation, was not supported. In principle, it is considered good practice to favour a flat age pattern at older ages for fishery partial recruitment and survey catchability unless there is compelling evidence to suggest otherwise.

Alternative models will be faced with accommodating challenging, and sometimes incongruent, data features.

- The trends in survey abundance, coupled with the fishery catches, suggest that the relationship between survey abundance indices and population abundance changed during the mid 1990s, particularly at ages 4-6.

- Total mortality calculations indicate some decline around the mid 1990s, but total mortality remains high. Total mortality appears higher for ages 6+ compared to ages 4-5.

- Relative exploitation calculations, which assume survey catchability is constant over the time series, indicate a decline beginning in the mid 1990s.

- The indications for total mortality, coupled with relative exploitation (i.e. survey and catch data), imply that natural mortality (or aspects that might alias natural mortality, e.g. emigration) increased since the mid 1990s and that M may be higher at ages 6+.

- Composite tag recovery data, extending from Bay of Fundy to Southern New England, but largely based on returns of larger cod from the adjacent Gulf of Maine stock with limited amount from Georges Bank, did not show a marked decline in percentage recovered by age, therefore not supporting a difference in either natural mortality or fishery partial recruitment by age for recent years. Analyses of the same tagging data resulted in similar estimates of natural mortality for three size ranges, but the robustness of these results could not be evaluated during the meeting.

While the 2002 benchmark model formulation did not display a retrospective pattern, this model was not supported due to generation of ‘cryptic biomass’. [Editor’s note: At the meeting, we discussed the approach of ‘assume the cryptic biomass doesn’t exist unless proved otherwise’ as was done at the GARM III]. The basic VPA model continues to display a strong retrospective. Alternative models that can remove the retrospective pattern will be challenged with discriminating between competing hypotheses about processes. Having ruled out a change in fishery partial recruitment as an option, the approaches considered for addressing retrospective patterns are changes in survey catchability, changes in natural mortality, and ‘missing’ or ‘extra’ catch. The effect of each of these options is often very similar and simulation studies have shown that determining the appropriate corrective measure needs to rely on corroborative information and expert judgement. It is possible, and even likely, that a combination of these options occurred. Specifying the appropriate ‘mix’ is even more challenging.

Given an unexplained intervention occurred in 1994, the retrospective pattern indicates that any bias in catch reporting would have to be due to 'missing' catch post 1994 or 'extra' catch prior to 1994. Fishery monitoring systems are considered to have improved since the mid 1990s, though there may have been increased sampling bias during the transition. While some 'missing' or 'extra' catch is thought to have occurred, the large magnitude implied by the retrospective, for this option to be the sole factor, was not considered likely. Further, early 'extra' catch does not affect current estimates but may have implications for historical productivity. In conclusion, there was less support for this option. Therefore it was not explicitly explored, but it was recognized that incorporating changes in natural mortality could be interpreted as aliasing some 'missing' catch, i.e. the higher natural mortality could represent some non-reported fishery induced mortality.

Exploration of models that allowed M to change from 1994 onwards but did not split the survey time series gave better fits, flatter survey catchability at older ages, flatter fishery partial recruitment at older ages, fishing mortality time trends that were intuitively more consistent with effort regulations, and improvement of retrospective patterns when natural mortality for ages 6-10+ during 1994-2007 was set to 0.7. Fit statistics (AIC and BIC) also favoured natural mortality of 0.7 over 0.2 for this age/time block. Natural mortality between 0.6-0.8 accounted for about 99% of the probability in the fit statistics However, strong trends in annual survey catchability persisted and were considered problematic.

Splitting the survey time series in 1994 while keeping M fixed at 0.2 for all years and ages, appreciably improved the time trends in residuals and addressed the strong trends in annual surveys. The configuration gave better fits, flatter survey catchability at older ages, flatter fishery partial recruitment at older ages, and reduction of retrospective patterns as compared to the basic VPA.

Further exploration of models that split the survey time series as well as fixing M at 0.5 for ages 6+ during 1994-2007 gave better fits, flatter survey catchability at older ages, smaller changes in survey catchability at all ages, flatter fishery partial recruitment at older ages, fishing mortality time trends that were intuitively more consistent with effort regulations and reduction of retrospective patterns. Fit statistics (AIC and BIC) favoured natural mortality of 0.5 over 0.2 for this age/time block. Natural mortality between 0.4-0.6 accounted for about 80% of the probability in the fit statistics.

A model that incorporated 'random walk' for natural mortality and survey catchability was presented to examine the timing and magnitude of their changes. Results indicated that there were indeed abrupt effects at about 1994 and that increases in both survey catchability and natural mortality were estimated. Estimating both resulted in smaller changes than either estimated alone. In addition, if changes in catch were also incorporated, the expectation is that the change in each factor would be smaller still. The 'random walk' model was not presented as an assessment as it did not incorporate all the indices, but it corroborated the conclusion that the survey and catch data indicate a split in survey catchability and/or an increase in natural mortality at older ages.

There was consensus that splitting the survey time series addressed the strong time trends in annual survey catchability and residuals. Reliable estimation of natural mortality or even changes in natural mortality is challenging. Higher natural mortality for ages 6+ during 1994-2007 was favoured by the survey and fishery catch data and was reflected in the model selection. Tagging data, though not informative about a change over time did not support a difference in natural mortality by age for recent years. Models that split the survey time series did not display appreciable retrospective patterns regardless of whether natural mortality was set to 0.2 or 0.5. While models with higher natural mortality for ages 6+ during 1994-2007 were supported, persistence of higher natural mortality is questionable. Documenting the fate of the 2003 year class, the only year class above average since the 1990 year class, over the next few years should be informative about natural mortality at older ages.

Mechanisms that explain changes in either survey catchability or natural mortality could not be established. Possible differences in vertical structure of cod aggregations in relation to changes in abundance could cause changes in catchability. Changes in natural mortality could be aliasing 'missing' catch, particularly during the regulatory and reporting changes of the mid 1990s, and could also be aliasing emigration or imperfect designation of the boundaries for this component, though an excess of larger/older fish is not apparent in adjacent cod components.

A model with split survey time series and natural mortality of 0.5 for ages 6+ during 1994 to the current year is indicated by fit diagnostics as the basis for management advice. However, it is recommended that the results from a comparable model using a constant natural mortality of 0.2 also be considered. Until the fate of the 2003 year class has been documented (ages 6+) it will be necessary to use these two models to adequately account for uncertainty in the assessment. Doing so acknowledges that there is considerable uncertainty about selection of a single appropriate model. It is also notable that domestic USA management of NAFO divisions 5Z+6 will be based on a model with split survey time series and natural mortality of 0.2.

Reference Points for Harvest Strategy

The Transboundary Management Guidance Committee has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, F_{ref} = 0.18. When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

Inability to adequately characterize a stock-recruitment relationship and uncertainty about the magnitude and persistence of any changes in natural mortality and weight at age suggests that it is inappropriate to change F_{ref} until these model uncertainties are resolved. While stock recruitment data are not fit well by conventional models, the data suggest that chances of good recruitment are lower when biomass is less than about 25,000 mt regardless of what model was examined.

Procedures for Projection

Projections require specification of future fishery partial recruitment, weights at age and natural mortality. In principle, an average of a suitable time period, say the most recent five years, should be used to derive fishery partial recruitment and weights at age when there are no persistent trends. When trends are present, the time period may be reduced to three years or even the most recent observed value. In the case of extreme trends, it may be necessary to extrapolate the trend. The future natural mortality used for projection should be consistent with the natural mortality used in the model to determine stock status.

The outlook should be provided in terms of consequences with respect to the harvest reference points for alternative catch quotas. Uncertainty about standing stock generates uncertainty in forecast results, which can be expressed as the risk of exceeding F_{ref} =0.18 or the risk that biomass will not increase by a given percentage. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect stock dynamics closely enough. To address the uncertainty about selecting among plausible models, i.e. states of nature, the risk from alternative models should be presented and the consequences on basing actions on a 'wrong' model should be discussed. For this assessment, risk analyses for models that set natural mortality at 0.5 and 0.2 should be considered as plausible alternative states.

B. Concluding Remarks

Both the data and model cod benchmark consensus will be incorporated into the next Eastern Georges Bank cod assessment at the TRAC meeting to be held during June 8-12, 2009, in St. Andrew's.

The Co-Chairs thanked the participants and reviewers for their participation. The meeting was then adjourned.

B. References

Butterworth, D.S., and R.A. Rademeyer. 2008. Statistical Catch-at-Age Analysis vs. ADAPT-VPA: The Case of Gulf of Maine cod. ICES J. Mar. Sci. 65: 1717-1732.

Miller, T.J., and P.K. Andersen. 2008. A Finite-State Continuous-Time Approach for Inferring Regional Migration and Mortality Rates from Archival Tagging and Conventional Tag-Recovery Experiments. Biometrics 64: 1196-1206.

B. Appendices

Appendix B1. List of Participants

Name	Affiliation	Phone	Fax	Email
Loretta O'Brien (Co-Chair)	NMFS, NEFSC	(508) 495-2273	(508) 495-2393	Loretta.O'Brien@noaa.gov
Tana Worcester (Co-Chair)	DFO, BIO	(902) 426-9920	(902) 426-5435	WorcesterT@mar.dfo-mpo.gc.ca
Robert Mohn	DFO, Science	(902) 426-4592	(902) 426-1506	rmohn@mar.dfo-mpo.gc.ca
Kurtis Trzcinski	DFO, Science	(902) 426-9781	(902) 426-1506	trzcinskik@mar.dfo-mpo.gc.ca
Colin Millar	FRS Marine Laboratory, UK			cmillar@marlab.ac.uk
Bob O'Boyle	Beta Scientific	(902) 446-1301	(902) 446-1349	betasci@eastlink.ca
Liz Brooks	NMFS, NEFSC	(508) 495-2238	(508) 495-2393	liz.brooks@noaa.gov
Chris Legault	NMFS, NEFSC	(508) 495-2025	(508) 495-2393	chris.legault@noaa.gov
Ralph Mayo	NMFS, NEFSC	(508) 495-2310	(508) 495-2393	ralph.mayo@noaa.gov
Mark Terceiro	NOAA, NMFS	(508) 495-2203	(508) 495-2393	mark.terceiro@noaa.gov
Paul Rago	NOAA, NMFS	(508) 495-2341	(508) 495-2393	paul.rago@noaa.gov
Katherine Sosebee	NOAA, NMFS	(508) 495-2372	(508) 495-2393	katherine.sosebee@noaa.gov
Susan Wigley	NOAA, NMFS	(508) 495-2359	(508) 495-2393	susan.wigley@noaa.gov
Dvora Hart	NOAA, NMFS	(508) 495-2369	(508) 495-2393	deborah.hart@noaa.gov
Stratis Gavaris	DFO, SABS	(506) 529-5912	(506) 529-5862	GavarisS@mar.dfo-mpo.gc.ca
Lou Van Eeckhaute	DFO, SABS	(506) 529-5938	(506) 529-5862	Van-EeckhauteL@mar.dfo-mpo.gc.ca
Yanjun Wang	DFO, SABS	(506) 529-5893	(506) 529-5862	wangy@mar.dfo-mpo.gc.ca
Kirsten Clark	DFO, SABS	(506) 529-5891	(506) 529-5862	clarkk@mar.dfo-mpo.gc.ca
Don Clark	DFO, SABS	(506) 529-5908	(506) 529-5862	clarkd@mar.dfo-mpo.gc.ca
Heath Stone	DFO, SABS	(506) 529 8854	(506) 529-5862	stoneh@mar.dfo-mpo.gc.ca
Jorgen Hansen	DFO, FAM	(902) 426-9046	(902) 426-9683	HansenJ@mar.dfo-mpo.gc.ca
Matt Cieri	Maine DMR			matthew.cieri@maine.gov
John Pappalardo	NEFMC			johnp@ccchfa.org
Tom Nies	NEFMC	(978) 465-0492	(978) 465-3116	tnies@nefmc.org
Bill Gerencer	M.F. Foley Co., Boston, Ma.	(207) 761-0818	(617) 265-2548	gmorhua@aol.com
Alain d'Entremont	Scotia Harvest Seafoods	(902) 648-4075	(902) 762-0167	alain@scotiaharvest.com
Shelly, Tallack	Gulf of Maine Research Institute	(207) 228-1639	(207) 772-6855	stallack@gmri.org
Ben Martens	CCCHFA			bmartens@ccchfa.org

Appendix B2. Terms of Reference

Transboundary Resources Assessment Committee
Eastern Georges Bank Cod Benchmark Assessment

St. Andrews – January 13-14, 2009 (DATA)

Woods Hole - March 30- April 3, 2009 (MODEL)

TERMS OF REFERENCE

Context

The TRAC was established in 1998 to peer review assessments of transboundary resources in the Georges Bank area and thus to ensure that the management efforts of both Canada and USA, pursued either independently or cooperatively, are founded on a common understanding of resource status. While stock assessment results are needed routinely to serve the management system, it is not practical to evaluate the assessment approach each time the assessment is conducted. Instead, review of the assessment approach (benchmark assessments) are conducted periodically, generally at a separate meeting. The last TRAC benchmark for cod was conducted in February 2002.

At present, the USA assessment for the whole of Georges Bank is conducted independently from the TRAC assessment of eastern Georges Bank. There is some concern that differing assessment approaches may make reconciliation of results difficult. A benchmark that reviews the assessment approaches for both areas together would address this issue.

Objectives

2) To review the assessment frameworks for the two Georges Bank cod management units (5Z+6 for USA and 5Zjm for Canada). The agreed benchmark would be used in the June/July 2009 TRAC for 5Zjm cod.

   Data Inputs

   - Review fishery landings and estimates of discards from all fisheries.
   - Determine most appropriate methods for calculating fishery landings at age.
   - Determine most appropriate methods for calculating discards at age from all fisheries.
   - Determine most appropriate methods for calculating weights at age for the fishery catch.
   - Determine most appropriate methods for calculating survey indices of abundance at age.
   - Determine most appropriate methods for calculating weights at age for the population.
   - Explore fishery catch per unit effort indices for use as tuning indices.
   - Examine tagging data for application in stock assessment.

   Assessment Methods

   - Explore full range of assessment methods for estimating current abundance and exploitation rate such as, but not limited to, catch curves, separable VPA, index based approaches, surplus production, delay-difference, calibrated VPA, statistical catch at age models.

- If required, update reference points for harvest strategy based on agreed assessment approach.
- Formulate projection procedures for harvest advice based on agreed assessment approach.

2) Review if an assessment of eastern Georges Bank can be reconciled with an assessment of Georges Bank as a whole.

    - Review the documentation on rationale for the current management unit.

Outputs

TRAC Proceedings, which will document the details of the benchmark

TRAC Reference Documents

Participants

DFO Maritimes scientists and managers
NMFS Northeast Region scientists and managers
Canadian and USA fishing industry
USA State and Canadian Provincial representatives
NEFMC representatives

Appendix B3. Model Meeting Agenda

Transboundary Resources Assessment Committee
Eastern Georges Bank Cod and Spiny Dogfish
Benchmark Reviews

NEFSC Woods Hole Laboratory, Woods Hole, Ma. USA
Clark Conference Room

March 30 – April 3, 2009

Agenda

30 March 2009 – Monday: Eastern Georges Bank Cod

9:00 – 9:15	Welcome and Introduction (Chairs)
9:15 – 10:30	Review of Data Meeting Current Eastern GB cod model formulation
10:30 –10:45	Break
10:45 –12:00	Alternative Model Formulations
12:00 – 1:00	Lunch
1:00 – 3:00	Continue: Alternative Model Formulations
3:00 – 3:15	Break
3:15 – 5:30	Continue: Alternative Model Formulations Other Working Papers (e.g tagging)

31 March 2009 – Tuesday: Spiny Dogfish

8:30 – 10:00	Commercial Landings, Discard Estimates, & and Recreational Fishery
10:00 – 10:15	Break
10:15 – 12:00	Continue: Landings and Discards
12:00 – 1:00	Lunch
1:00 – 3:15	Research Bottom Trawl Surveys - inter-relationships among surveys - availability of spiny dogfish to survey gear
3:15 - 3:30	Break
3:30 - 5:00	Continue: Surveys
5:00 - 5:30	Review progress made on previous recommendations

1 April 2009 – Wednesday

08:30 – 10:00	Spiny Dogfish :Data Availability for Spatial Models (tagging, etc)
10:00 – 10:15	Break
10:15 – 12:00	Population level consumption estimates Reproductive Biology ; Rebuilding
12:00 - 1:00	Lunch
1:00 - 3:15	Revisit Cod models

3:15 - 3:30	Break
3:30 - 5:30	Continue: Cod models

2 April 2009 – Thursday

08:30 - 10:00	EGB cod : Reference points and Projection procedures
10:00 - 10:15	Break
10:15 - 12:00	Continue: EGB Cod
12:00 - 1:00	Lunch
1:00 - 3:15	Any follow up ; Start Report Writing
3:15 - 3:30	Break
3:30 - 5:30	Report Writing

3 April 2009 – Friday

08:30 - 10:00	Report Writing
10:00 - 10:15	Break
10:15 - 12:00	Continue: Report
12:00 - 1:00	Adjournment