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Proceedings of the regional peer review meeting of the framework for Atlantic herring (*Clupea harengus*) and reference points for Capelin (*Mallotus villosus*) in the Newfoundland and Labrador Region

November 19-21, 2013
St. John's, Newfoundland

Chairperson: Bill Brodie
Rapporteur: Carissa Currie

Science Branch
Fisheries and Oceans Canada
P.O. Box 5667
St. John's, NL A1C 5X1

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

The Department of Fisheries and Oceans (DFO) conducted a regional peer review process meeting November 19-20 in St. John's, Newfoundland to conduct a scientific peer review of alternative approaches for stock assessments of Atlantic herring from southern and eastern Newfoundland. A science peer review of SA2+ Div. 3KL capelin was also conducted on November 21, 2013 to develop limit reference points for the stock. Participation included personnel from DFO Science and Fisheries Management Branches (Newfoundland and Labrador Region), representatives from the fishing industry, Provincial Department of Fisheries and Aquaculture, and academia. This Proceedings Report includes an abstract and summary of discussion for each presentation, and a list of research recommendations from this meeting.

Compte rendu de la réunion régionale d'examen par les pairs du cadre pour le hareng de l'Atlantique (*Clupea harengus*) et des points de référence pour le capelan (*Mallotus villosus*) dans la région de Terre-Neuve-et-Labrador

SOMMAIRE

Pêches et Océans Canada a tenu une réunion du processus régional d'examen par les pairs les 19 et 20 novembre à St. John's (Terre-Neuve-et-Labrador) afin de mener un examen scientifique par les pairs d'autres approches pour les prévisions à long terme de l'abondance des populations de hareng de l'Atlantique du sud et de l'est de Terre-Neuve. Un examen scientifique par les pairs du capelan de la sous-zone 2 et des divisions 3KL a également été effectué le 21 novembre 2013 pour élaborer des points de référence limites pour le stock. La participation incluait le personnel de la Direction des sciences et de la Direction de la gestion des pêches de Pêches et Océans Canada (région de Terre-Neuve-et-Labrador), des représentants de l'industrie de la pêche, du ministère provincial des Pêches et de l'Aquaculture et du milieu universitaire. Ce compte rendu comprend un résumé et un sommaire des discussions liées à chaque présentation ainsi qu'une liste des recommandations relatives à la recherche découlant de la réunion.

INTRODUCTION

A regional peer review process meeting was held from November 19-21, 2013, at Admirals Green Clubhouse in St. John's, Newfoundland to assess the best option to incorporate the changes in abundance of Atlantic herring stocks in the southern and eastern coastal waters of Newfoundland, and to examine limit reference points for capelin off Newfoundland, SA2 + Div. 3KL. Terms of reference, the list of participants at the meeting and the agenda are provided in Appendices I through III, respectively.

Atlantic herring is a key forage species in the marine ecosystem off the coasts of Newfoundland and Labrador. In the past the herring in this region have been composed largely of spring spawners. Within the last decade the catches of spring spawners have been decreasing while the catches of fall spawners have been increasing. The main goal of the herring framework was to address these changes and determine how they can best be incorporated into future assessments.

Capelin plays a primary role as a key forage species allowing energy from primary trophic levels to higher trophic levels in the marine ecosystem. The recent abundance and biological indicators used to inform management on stock status were low and the resulting advice was to manage the stock with caution. However, without reference points, it is difficult to equate this information with management objectives. Consequently, the main goal of the capelin framework was to propose approaches for identifying reference points and to apply to the method to estimate a limit reference point(s) for Newfoundland and Labrador capelin stocks.

HERRING FRAMEWORK

STOCK STRUCTURE, INFORMATION USED IN ASSESSMENTS, BIOLOGY AND CHANGES IN ENVIRONMENT

Presenter: C. Bourne

Herring Stock Structure and Assessment Methods

Abstract

There are 4 stock complexes of Atlantic Herring on the south and northeast coasts of Newfoundland which are currently assessed: White Bay-Notre Dame Bay, Bonavista Bay-Trinity Bay, St. Mary's Bay-Placentia Bay and Fortune Bay. These complexes were defined using tagging studies conducted in the late 1970's and early 1980's; it is not clear whether stock structure and migration patterns have changed significantly in the years since. All stocks are composed of both spring and fall spawning herring and until recently, spring spawners comprised more than 80 % of the catch. It was recognized during the 2011 assessment that the proportion (catch numbers) of spring spawners has declined significantly in most areas during the past decade and that in most areas fall spawners have increased. As these stocks have always been assessed based on their former composition of largely spring spawning fish, it was determined that a framework meeting was required to examine the impacts of changing stock structure on assessment outcomes and to propose potential methodology changes. Data currently collected for assessments includes fisheries data from commercial landings (including biological samples), bait and discard estimates from telephone surveys. In addition, indices of abundance are obtained from logbooks, telephone surveys and the long-running research gillnet program, to which there was significant reduction in 2013. Potential new data sources are being

explored, including herring caught in offshore multispecies Science surveys and samples collected during summer months.

Discussion

The funding for the research gillnet program has been reduced and as a consequence only provides funding to operate the program in two stock areas out of the four that were being covered previously. Since the peak timing of spring spawning is now being observed in the summer in some areas, and the research gillnet program and commercial fisheries do not extend into this time period, samples are inadequate to properly assess the magnitude of the change in spawning times. It was suggested that one stock from the Northeast coast and one from the south coast be assessed using the funds that are currently available.

It was suggested that size selectivity of gillnets in the research gillnet program may be an issue due to changes in herring size over the time series of the index. Therefore further investigation is needed to clarify that the index is adequately capturing the age and size distribution of the population over time.

In the illustrations of the results, purse seine indices did not correlate with the fixed gear indices. Although they are both useful indices it was suggested that they should not be compared directly as they are so different.

Recent Trends in Herring Abundance, Biology and Stock Composition

Abstract

Return rates of fixed gear logbooks continue to be low where in comparison, the fixed gear telephone survey has a larger samples size and significantly different estimates of bait catches by gill net fishers. The cumulative abundance indices derived from both sources are comparable, with the perception of abundance decreasing sharply in 2011 on the northeast coast, then increasing in 2012. There was no perceived change in abundance in recent years in St. Mary's Bay-Placentia Bay and a continued declining trend in Fortune Bay. Response rates in the purse seine telephone survey continued to be high, with the cumulative abundance index indicating an increase on the northeast coast and no change in St. Mary's Bay-Placentia Bay. The commercial catch was composed of 50% or more fall spawners in 2011 and 2012 in all areas except Fortune Bay, where spring spawners still dominate but catch rates are low and the age distribution is highly skewed toward older fish. Data from the research gillnet program showed similar trends. In addition to a change in spawning stock composition, the timing of spring spawning seems to have changed over the past decade, now occurring into July and August. The research gillnet program and commercial fisheries do not extend into this time period and samples are inadequate to properly assess the magnitude of the change.

Discussion

It is unknown whether the two spawning components of spring and fall spawners are genetically different; this is currently being assessed at Dalhousie University.

There is potential that the spring stock is changing its time of peak spawning and could now be considered a summer stock.

Bringing back the acoustic survey was discussed. It was originally dropped in favor of keeping the research gillnet program due to funding limitation and because herring school sizes were small and there was an issue with detectability. Potentially if schools are now larger in the spring or fall there will be a greater chance of detection. An acoustic survey would allow biomass and exploitation estimates of the stock(s). An acoustic survey has been recommended since its cancellation in 2000.

The research gillnet program and commercial fishery do not get samples of the spring spawning component during the summer months, so spawning times cannot be properly assessed. The timing of the research gillnet program needs to be re-assessed or samples need to be collected from other sources during July and August. Concern was raised regarding the program running during the summer months due to possibility of salmon bycatch.

Otoliths should continue to be investigated. In the past otoliths of the spring and fall spawning components were distinct and now the spring spawners are showing some characteristics of the fall spawners.

Information on Environmental Changes, Recruitment, and Offshore Data

Abstract

During the past decade the ocean climate has changed with a general trend of warming, increased salinity and decreased ice in the Newfoundland region. Changes have also been observed in plankton biology and phenology. A shift toward predominant fall spawners in Northwest Atlantic herring stocks has coincided with increasing temperature, which is likely an indicator of more complex environmental processes driving the change. In Newfoundland increasing temperature during the last decade has been correlated with increasing recruitment of fall spawners, while the variability of spring spawner recruitment has declined and seemingly stabilized at a relatively low level. The collection of offshore herring samples during Science multispecies surveys began in 2011 when it was recognized that herring occurrence in the survey had increased over the past decade. Preliminary analysis shows that most herring caught in the spring surveys in 2011 and 2012 were young spring spawners and mature fall spawners. The results indicated a potentially strong 2009 spring spawner year class.

Discussion

Some of the main copepod species are changing their production peak from spring to fall. Possibly these are the species herring larvae are feeding on, increasing the fall larval survival and decreasing the spring larval survival. Larval diets are being studied at Memorial University.

The impact of environmental variables should continue to be explored, as both the environment and stock components are changing.

OVERVIEW OF THE FISHERY AND EVALUATION OF STOCK

Current Fishery Management Practices and Considerations

Presenter: L. Knight

Abstract not provided

Discussion

If fishing dates are flexible, the dates could be adjusted based on the changing arrival time of the spring spawning herring. It was noted that there was flexibility in the fishing dates previously as the fishery has opened earlier in the past.

Another source of data that could be used to monitor fishing locations and times is the vessel monitoring system (VMS) on the fishing vessels.

Review of the 2011-2012 Fishery

Presenter: C. Bourne

Abstract

Landings were below average in all areas except White Bay-Notre Dame Bay in 2011, with 23% of the overall Total Allowable Catch (TAC) being taken. In 2012 landings increased and 39% of the TAC was taken. Purse and bar seines are responsible for the majority of the landings. In all areas, the percentage of fall spawners in the commercial spring and fall catch varied, showing no obvious pattern other than a general increase in most areas over the past 10 years. The commercial fishery in St. Mary's Bay-Placentia Bay has declined steeply in recent years, with little to no purse seine landings. In Fortune Bay landings have decreased over the past 3 years and the age structure of fish caught in both the commercial and research gill net fisheries is highly skewed, with the majority of fish being older (age 9+) spring spawners with no strong signs of recruitment. There have been concerns in recent years about the proportion of small fish being caught in the Northeast coast purse seine fishery and in 2013 a pilot project was implemented to collect small fish and evaluate the size at maturity. Results of this project were not available for this meeting.

Discussion

A cumulative abundance index is used to estimate abundance from fixed gear logbooks, fixed gear phone surveys and purse seine phone surveys. Questions are asked such as: on a scale of 1-10, how abundant were the fish this season compared to last season? The cumulative Index has a 1-10 scale, but due to the cumulative approach the plots can exceed 10. A re-evaluation of the way the three indices are presented was recommended.

It was agreed that a review and analysis of the results of the 2013 pilot project will be an important component during future assessments.

Evaluation of Stock Status

Presenter: C. Bourne

Abstract

Performance reports have been used since 2000 to report on stock status using a traffic light system. The measure of current stock status is based on a standardized evaluation of indices and age composition, and the weighting of this evaluation was changed to reflect recent recommendations. Logbook catch data was removed from stock status calculations due to the small sample size. Additionally, the cumulative abundance index was given less weight while more value was shifted to the results of the research gillnet program. A retrospective analysis showed that these changes had minimal effects on overall trends in stock status for the time series in each stock area. Stock status was calculated and reported for each stock area using this revised method, however this was largely for demonstrative purposes and to generate discussion about method revision for the 2014 Herring Assessment.

Discussion

The definition of status was discussed and in the case of assessing Atlantic herring it was defined as: the measure of the robustness of the population including various characteristics such as abundance, age structure, Spawning stock biomass (SSB), area of occupancy, etc…

A major question of presentation was: how can the indices be weighted to best assess the stocks? The only independent index is the Research gillnet program; the rest of the indices are opinion based. The program is currently weighted 80 %, but it was suggested that it should potentially be weighted 100 % and the other indices be used as industry perspectives.

Older fish (cohorts) should be explored in the current calculation. This will aid in understanding how many spawning adults are present in the population.

Harvesters like the traffic light system, it is easy to understand.

The fisheries landings are composed of both spring and fall spawners, which raises the question of whether stock components should be managed separately. Are they genetically distinct? (This is currently being investigated at Dalhousie University).

Recruitment is currently measured using herring at the age of 4 years, even though they have already been in the fishery at that point. There are no larval measurements. Possibly there is another way by exploring estimates at younger ages.

CONCLUSIONS AND RECOMMENDATIONS

The following overall conclusions regarding the Newfoundland herring stocks were made:

- There have been major changes in the spawning stock composition that have resulted in a decrease in the number of spring spawners and an increase in the proportion of fall spawners.
- The main influence of these changes appears to be the changing environment and consequently, changes in the ecosystem, e.g. zooplankton community composition and availability to herring, although further investigation is needed.
- The current changes in spatial-temporal distribution, stock component ratios and timing of spawning may affect the role of herring as a forage species.

Recommendations for addressing the spring-fall change in spawning components:

- Split indices where possible from the Research gillnet program. Advise FAM they should not be added.
- Adjust the timing and duration of the Research gillnet program to better capture the spring spawning component.
- Bring back the fall Research gillnet program to assess the fall component.
- Conduct research into otolith morphology/spawning group assignment
- Re-evaluate criteria for spawning group assignment
- Obtain samples from other sources in July and August

Recommendations for indices:

- Evaluate impact of changing research gillnet program timing on catch rate index.
- Reintroduce the fall acoustic survey, to obtain biomass and exploitation rates.

Recommendations for reporting:

- Keep the current summary format for areas with research gillnet program, except for fisher opinion surveys, which will be removed from calculation of stock status and included in industry perspective, or included elsewhere in the report.
- In areas with research gillnet program, current status will be based on research gillnet catch rates, number of cohorts above average (change), and mean catch rate of older fish (addition). These indices should be presented separately and the weighting scheme will be discussed at the next stock assessment.

- Catch rate from research gillnet program (mean ages 4-6) will be used to report short term prospects (2-3 yrs).
- Areas without the research gillnet program will use traffic light approach, with no weighted stock status. Where appropriate comment on trends in the adjacent stock areas.

Recommendations for future research:

- Examine implications of selectivity on the research gillnet program index by comparing catches across mesh sizes.
- Continue to explore estimation of total mortality rates through population modeling (e.g. SURBA, etc.).
- Explore other data sources such as offshore trawl surveys, VMS information.
- Re-evaluate reporting information from opinion surveys.
- Continue to explore the influence of environmental variables on herring stock structure and recruitment.

CAPELIN FRAMEWORK

LIMIT REFERENCE POINTS AND CAPELIN FISHERIES

Limit Reference Points: Purpose and Derivation

Presenter: P.Shelton

Abstract

The DFO Sustainable Fisheries Framework policy outlines “A Fishery Decision-Making Framework Incorporating the Precautionary Approach” which provides a basis for scientific advice on the management of Canadian fish stocks. An important element of this framework is the Limit Reference Point (LRP), which, in most cases is interpreted as the spawning stock biomass level below which serious harm, such as severe recruitment overfishing, is considered to occur. Consequently stocks are required to be managed such that there is a low probability of the spawner biomass falling below this level. In the case of a key forage species such as capelin, the biomass required to maintain trophic process up the food chain may also be a consideration in determining the LRP.

Both the Barents Sea and the Icelandic Capelin stocks are considered to be well managed based on scientific advice. The scientific advice comes from a complete acoustic estimate of absolute stock size and age composition obtained in the fall each year which is used to project the biomass that will result in the following year after the fishery is completed. Although the two management strategies differ somewhat, they both focus on achieving an escapement level of biomass after the fishery; thought to be necessary for the continued productivity of the stock and for sustaining trophic function in the ecosystem. The management strategies are detailed in explicit terms in the EU management plans (MP) for the stock. In the case of the Barents Sea capelin MP, the plan has been evaluated by ICES and found to be consistent with a precautionary approach.

The Canadian 2J3KL capelin fishery does not meet the standards established for capelin assessment for EU stocks. The partial assessment in spring does not allow absolute stock size to be determined and also does not provide a useful index of stock size. Even if the spring survey had complete coverage, projecting the stock post fishery in the following year would

require a forecast of more than one year and is considered to be problematical compared to one year forecasts from a fall survey.

The Integrated Fish Management Plan (IFMP) for capelin, although updated in 2011, is not publically available on the DFO website. In any event, the IFMP does not detail any scientific basis for adjusting the TAC and, based on the last 10 years; it does not appear that scientific information has had any direct effect on TAC adjustments. Contrary to the DFO Sustainability Checklist, there is no Harvest Decision Rule in place for this capelin stock.

While establishing a LRP for all stocks is desirable to denote the biomass level below which serious harm is considered to be occurring to the stock and/or the ecosystem, it is necessary to have an accepted stock assessment in place to which the LRP becomes an additional component. In the case of 2J3KL capelin, there is no accepted basis for this additional component. If the survey was considered to provide a reliable index of the whole stock, it may still be possible to defend a LRP value based on an empirical analysis (e.g. some percentile of past index values) however this is not the case for 2J3KL capelin. In conclusion, there is no defendable scientific basis for assessing the status of the stock, the impact of the fishery, or a LRP denoting serious harm.

It was noted that DFO has a policy specific to forage species, however this policy, which is very detailed, only applies to new forage species fisheries and therefore does not apply to 2J3KL capelin. It is unclear why there is detailed policy only for new fisheries for forage species, particularly when there are none currently, at least not in the Atlantic region (perhaps new fisheries may be considered in the Arctic in the future?), but no policy for ongoing forage species fisheries on mackerel, herring and capelin when these are major fisheries of considerable commercial importance and important in the ecosystem context, and known to be prone to overfishing and collapse.

Discussion

Speculations were raised: it used to be understood that if a population reached the critical zone of the Precautionary Approach (PA) Framework then fishing would be stopped, this is not always the case.

The suggestion was raised that capelin in the Newfoundland region could be managed similar to the Barents Sea and Icelandic capelin stocks. At the moment this may not be possible due to no biomass estimate for the entire stock. A biomass index is available for approximately one third of the stock from the spring acoustic survey in Division 3L and southern 3K. It was debated that one third of a stock estimate is not reliable to assess the stock, given changes observed in capelin distribution.

The current acoustic survey in the spring is used to estimate the surviving stock biomass after the next year’s fishery. Currently the May 2013 survey will project for July 2014. It is suggested the survey be done in the fall to estimate the stock biomass left after spawning and fishing effort for that year.

Capelin Fishery Management Strategies

Presenter: L. Knight

Abstract not provided

Discussion

The current fishery is based on pre-season at sea sampling and closures are based on reported landings and projected catch for the specific area. Questions were raised that the closures and

TAC is not based on science and more on what is being seen by managers at the time of the fishery for that year.

CAPELIN LIFE HISTORY AND CURRENT AND POTENTIAL MODELS

Consumption of Capelin Model

Estimating the order of magnitude of food consumption by the fish community of the Newfoundland and Labrador Shelves (2J3KL). Preliminary results from ERI-NEREUS and SPERA-funded projects:
Nadine Wells, Mariano Koen-Alonso, Jennifer Mercer, Denise Holloway, Brad Vaters, Fran Mowbray, Pierre Pepin, Robin Anderson, and Paula Lundrigan.

Presenter: N. Wells

Abstract

Order of magnitude estimates of food consumption by the fish community at large were produced for all fish including shrimp and crab. Species' biomass was derived from RV surveys from 1995-2012, with the assumption that the survey is representative of the entire fish community. These data were not corrected based on catchability of the trawl. Diet data, available for a few years for 5 key species, were used to fraction total consumption estimates into prey groups for these 5 species. Three approaches to consumption were used with estimates derived from: 1) a bioenergetic-allometric consumer-resource modeling framework, which is based on empirical allometric scaling relationships (Yodzis & Innes 1992); 2) a multivariate statistical model (Palomares and Pauly 1998) and; 3) by assuming daily rations as a percent fraction of body weight. Two daily ration scenarios of 1 % and 2 % based on typical literature reports (Macdonald and Waiwood 1987, Maynou and Cartes 1998, Richter et al. 2004) were assumed.

The annual total consumption by the entire fish community including shrimp and crab was computed using Model 1 and the daily ration scenarios. Data at the fish community level were not available for Model 2 because parameter estimates were not available for all species. The fraction of consumption by the entire fish community that can be attributed to 5 key predators – cod, turbot, American plaice, redfish and yellowtail flounder – was calculated and estimates from Model 1 show that these 5 predators contribute to 40-70 % of all biomass consumed by the fish community. The total annual food consumption (in tons) by the 5 key predators was computed using both models and the daily ration scenarios. A large range of values was seen; however, the actual amount of food consumed is likely to be within the envelope generated by these 4 estimates. Diet data from the last 5 years allowed us to estimate the amount of capelin consumed annually by the 5 predators using both models and the daily ration scenarios. In 2012, the amount of capelin consumed ranged from 200,000 to 1.3 million tons, depending on the method used. While the total amount of all prey species consumed over the last three years remained relatively stable, there was an increase in the amount of capelin consumed during the same time period, owing to both the availability of capelin in the system, as well as alternate prey. The proportion of capelin of the total consumption by the 5 key predators varied from 6 to 20 %, with the value for 2010 being the lowest in the 5-year time series (6 %). As the 5 key predators are responsible for a large portion of all biomass consumed, the mid-range of this proportion was applied to consumption by the fish community at large (excluding functional groups that are not known to consume capelin) to calculate an overall estimate of capelin consumption. For 2012, that estimate ranged from 0.5 – 1.0 million tonnes with a proportion of 10 %, or 0.7 – 1.6 million tonnes with a proportion of 15 %.

Discussion

When looking at the consumption rate of capelin by other species, further investigation could be done on other fish consumption, such as pelagic fish species.

Life History, Current Assessment Methods and Potential Limit Reference Point Candidates for 2J3KL Capelin

Presenter: F. Mowbray

Note: *Although it was planned that a Research Document would be produced describing the Limit Reference Point for Capelin, upon presentation of the methodology, it was determined that the methodology proposed did not meet the publication criteria: it must be scientifically sound and pass peer review. However, in order to retain a record of the work presented an extended abstract has been developed and is provided as APPENDIX 1.*

Abstract

The presentation included an overview of capelin including life history, species distribution, and key biological characteristics, and summarized historically used assessment methodologies and current recruitment and abundance indices. Models involving the latter indices were then presented and limit reference point candidates were discussed. A candidate methodology for determining ecosystem requirements for capelin using community consumption estimates and projecting survey biomass were also presented.

Discussion

The capelin are changing their distribution; further raising the question of whether the approximately 1/3 biomass estimate is enough. This distribution shift is also seen in the shrimp fishery, showing capelin as bycatch in areas not previously seen.

In the fall a bottom trawl survey takes place, but the capelin may not be near the bottom, making the survey unreliable.

There are many biological characteristics that have changed over the years but it is unknown at this time how to incorporate them into the management of the stock.

Is there enough spawning biomass left in the water to sustain the current TAC after the fish and mammal consumption? If the current biomass was available then it could be used to estimate a minimum biomass (B_{lim}) that should be left in the water.

A fall survey is needed in order to estimate the biomass and the specific ages, there is no projections for ages 4, 5, and 6.

The projection model is composed of abundance projections for the year and then it is compared to what is actually observed in the spring survey; but in the majority of the years the projected and observed abundances are not comparable.

The consumption model seems to make sense theoretically but it was agreed that more work needs to be done and the modelling framework needs further investigation.

Neither of the methods presented was accepted to provide limit reference points at this time and further investigation is needed.

The harvesters believe the quantities being taken as catch is minor compared to the consumption by predators in the ecosystem.

CONCLUSIONS AND RECOMMENDATIONS

It was concluded that the meeting did not provide the recommended limit reference points or methodology. There are a number of areas that need to be clarified before pursuing the proposed methodologies.

- The current acoustic survey only accounts for approximately one third of the stock area and may not be representative of the entire stock.
- The fisheries catch is minor compared to the present consumption by predators in the ecosystem.
- How is science advice being used to adjust and recommend the TAC for the fishery?

Recommendation

Capelin is a key forage fish species for the Newfoundland and Labrador marine ecosystem, and priority should be given to the development of Limit Reference Points necessary for the management of its fishery within the ecosystem-based management approach. Necessary for this objective is the implementation of a full scale acoustic survey covering the entire range of distribution, and providing the baseline data from which a time series of capelin stock biomass can be estimated.

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APPENDIX 1. LIFE HISTORY, CURRENT ASSESSMENT METHODS AND POTENTIAL LIMIT REFERENCE POINT CANDIDATES FOR 2J3KL CAPELIN

Life History

Capelin are a short lived species rarely exceeding 6 years of age. Historically these fish matured at ages 3 and 4, but have been maturing younger since the early 1990s. Capelin spawn primarily on beaches along the NE Newfoundland coast and Labrador although some coastal and offshore bottom spawning is known to occur. Larvae emergence occurs in July and August and survival of the larvae is highly variable. Larval survival has been shown to be largely dependent on environmental conditions surrounding emergence and the first few months of life. Capelin do not exhibit any predictable stock-recruitment relationship.

Juvenile capelin are found both in the major bays and in the offshore waters of the northern Grand Bank and Northeastern Newfoundland Shelf. Capelin generally mature at approximately 12 cm total length and can attain a maximum of length of near 23 cm, with males larger than females. Particularly during the fall feeding period there is a latitudinal cline in capelin size, with the larger and older fish feeding further to the north. Studies suggest that capelin experience a large post-spawning mortality with 100 % of males within 6 weeks, although a variable proportion of the females survive to reproduce the following year. Investigations of females during the mid-1990s estimated that between 40-60 % of females were repeat spawners. During the spring adults migrate along the shelf edge and across the bank, feeding en route before entering the bays to spawn. However the actual route and timing of this migration varies.

Historically capelin in Newfoundland were fished for bait, food and fertilizer. In the early 1970s a directed offshore fishery was started. This fishery closed in NAFO Division 3L in 1979, and in Divisions 2J3K in 1992. The 2J3KL stock is prosecuted by an inshore fishery with a TAC of 22,771 tonnes in 2013. Fishing effort and catch are largely market-driven. Closure of the offshore fishery in 1992 coincided with a disappearance of capelin in 2J3KL and a dramatic decline in overall abundance, changes in spawning behaviour, biological characteristics and distribution.

Distribution

Information on capelin distribution is available from spring acoustic surveys as well as fall bottom trawl surveys. Since the expansion of the spring acoustic survey area in 1996 the abundance and distribution of capelin has varied considerably with areas of highest density shifting from on top of the Grand Bank and coastally in the late 1980s, to the shelf break and areas immediately off Bonavista and Trinity Bays from 1999 to 2010, and back to the coastal areas again, as well as the northern portion in 2013 (Figure 1).

During fall acoustic surveys conducted from 1982 - 1994 the highest densities of capelin occurred in Division 2J, however starting in the early 1990s these concentrations shifted to the south. Since the discontinuation of the fall acoustic survey in 1994 only bottom trawl survey data are available to investigate fall distributions. Although bottom trawl data may not accurately reflect capelin abundance it can be used to investigate distribution. Therefore we examined the bottom trawl catch distributions from the bottom trawl survey from two periods: 1981-1994 which deployed an Engel highrise trawl; and from 1995-2013 which used a Campelen shrimp trawl fitted with rock-hopper footgear.

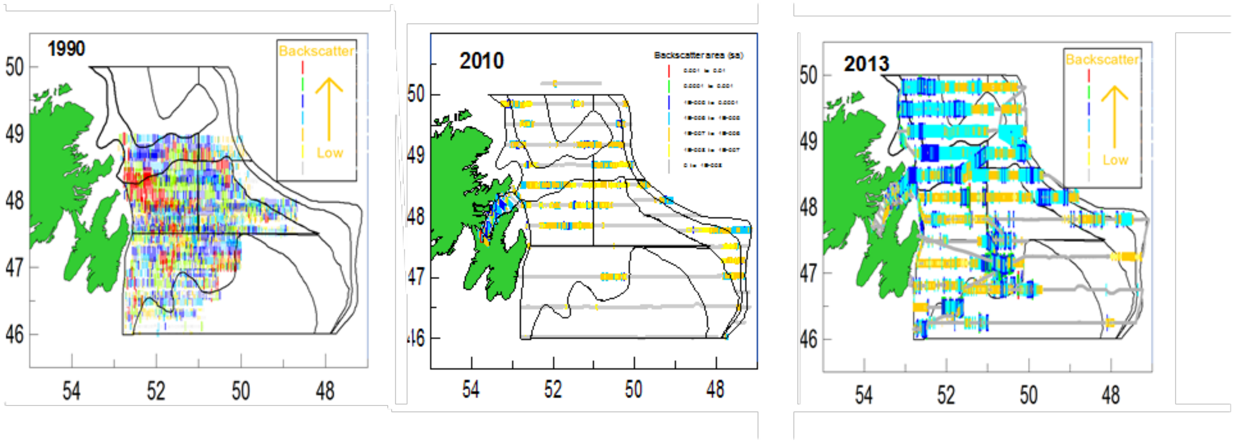

Figure 1. Distribution of capelin acoustic backscatter from surveys during a period of high abundance (5600 kt) in 1990 (left), low abundance (23 kt) in 2010 (middle) and currently (763 kt, right).

Due to selectivity differences between these two fishing gears, with the Campelen more suited to catching capelin, the two series are considered separate. In recent years (1995-2010) capelin were centered in Division 3K, with some fish in 3L. However starting in 2011, capelin distribution has shifted back to areas more typical of the 1980s with more of the surveyed biomass now centered in 2J (Figure 2).

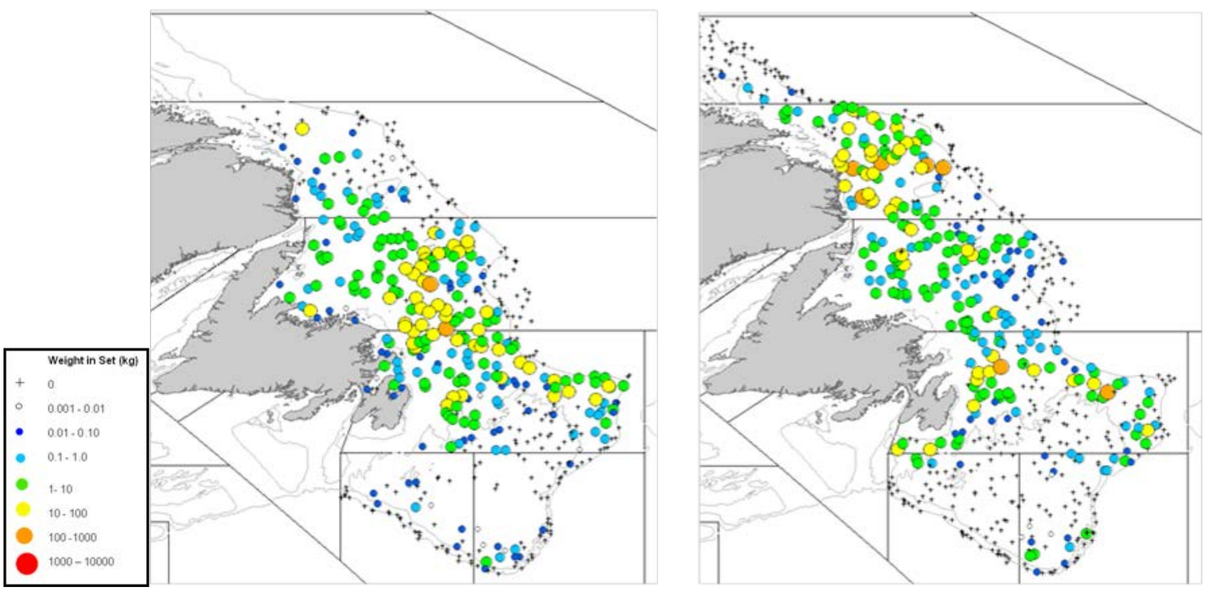

Figure 2. Distribution of capelin catch in the Campelen trawl during fall multi-species bottom trawl survey in 1995 (left) and 2012 (right). Symbol size is proportional to catch rates (kgs per standard tow).

In order to quantify changes in distribution, the area of occupation was calculated for both trawl gear series.

Area of Occupation = $\sum_0^j A$

where j is the number of strata where mean capelin catch is > 0 and A is stratum area (km^2).

In both series the overall area occupied changed little as the occupied area of 3K and 3L tended to increase when the occupied area of 2J decreased, and vice versa. This suggests that capelin distribution tends to shift as opposed to expand and contract (Figure 3).

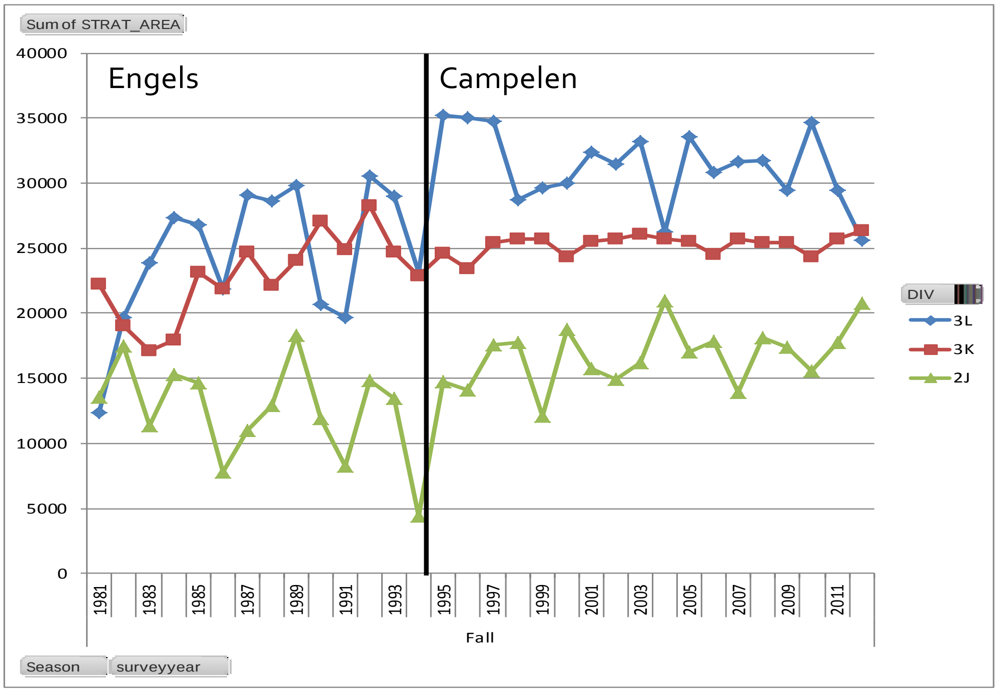

Figure 3. Area occupied by capelin during fall bottom trawl surveys of the core survey area conducted from 1981-1994 (Engels trawl) and 1995-2012 (Campelen trawl).

Biological characteristics

Size and age compositions of the capelin stock have changed over time. At the period of high abundance during the late 1980s stocks were composed of fish up to 6 years of age with the mean age of spawning capelin varying between 3.2 and 4 years. The age distribution of spawners declined rapidly in the early 1990s with the average age of spawners ranging between 2.4-2.8 years. This change was attributable to both a truncation in the ages present in the adult population and a decrease in the age of maturation. Prior to 1993 less than 10 % of age 2 fish were maturing, since 1999 it has varied from 38 to 80 %. This change coincided with an increase in the size of ages 2 and 3 fish and a decline in the size of ages 4 and 5 capelin.

The somatic condition of capelin also varied during the last 30 years with a general decline in the fall condition of all size groups. Spring condition information is only available from acoustic surveys conducted since 1996. These values are also quite variable, although it is noteworthy that better condition in the spring tends to coincide with more advanced gonad development, as reflected in the percentage of roe in maturing females.

There is some evidence that changes in condition, particularly that of older/larger fish may reflect changes in feeding success. Prey abundance and composition may be important for survival and growth of capelin as large prey items are less prevalent during the period of reduced abundance and smaller size.

All of these factors, length composition, age of maturity, condition and offshore distribution may be important for the timing of capelin spawning which has been delayed by 2 to 4 weeks since 1991.

Assessment of the 2J3KL capelin stock

Prior to 1992, capelin in NAFO Division SA2+3K and in Div 3L were treated as two separate stocks, both with regard to surveying and assessment strategies. However as a result of accumulated evidence it was recommended in 1992 that capelin in these two areas be considered as one stock complex, and survey and assessment methodologies were adjusted to reflect this change. Initial methods developed in ICNAF in 1975 used an estimation of capelin release from predation due to predator decline, proposing a harvest of 20 % of this number. This was a one-time estimate and was subsequently replaced by information from offshore trawl catch rates, acoustic surveys, and a Sequential Capelin Abundance Model (SCAM). This model, initially implemented in 1979, projected capelin abundance using a natural mortality estimate of 0.3, spawning mortality estimates for ages 3,4,5, partial recruitment estimates for ages 3 and 4 with ages 1,5 and 6 set to 1, numbers at age and CPUE from USSR BMRT –A class trawler fleet (1979-81). This CPUE index was replaced with Russian and Canadian acoustic estimates in 1982. The proposed TAC was not to exceed 10 % of the projected mature biomass estimated from the model.

Projections were completed for the SA2+3K and for the 3L stocks. For 3L, spring surveys were used with ages 1 and 2 projected 2 years until these surveys were discontinued in 1993. For 2J3K, ages 1 to 4 were projected 2 years, with the last fall Canadian acoustic survey conducted in 1994. Russian acoustic surveys were also discontinued in 1994. This coincided with the last absolute abundance/biomass estimate. Since then only indices of cohort strength have been available. A Canadian spring 3L acoustic survey was conducted again in 1996, and has occurred annually from 1999 to 2013, except for 2006.

In the absence of acoustic surveys from 1995 to 2000 a multiplicative model was introduced and first used to assess cohort strength in 1995. This model incorporated information from multiple indices of varying durations and covering different, sometimes overlapping time periods. Thirteen indices including spring and fall acoustic surveys, aerial surveys, an egg deposition index, purse seine catch rates, trap catch rates, bottom trawl by-catch, Russian Offshore commercial catch rates, Conception Bay sediment larvae counts, Bellevue Beach emergent larval counts, and offshore Div. 2J3KLNO 0-group and age 1 juvenile counts were considered . By 2001, so few of these indices were still available that this model was no longer scientifically valid. Recent assessments have relied on information from the spring acoustics series (re-initiated in 1999), recruitment indices (mostly from Trinity Bay) and various behavioral and biological indices.

Current Indices

Estimates from the spring 3L acoustic survey suddenly dropped from annual estimates of 2600 to 6 million tonnes from 1984 to 1990 to 116 thousand tonnes in 1991. This was followed by consistently low biomass estimates ranging from 23 to 300 thousand from 1992 to 2012. The preliminary biomass estimate of 762 thousand tonnes in 2013 was the highest since 1991 (Figure 4).

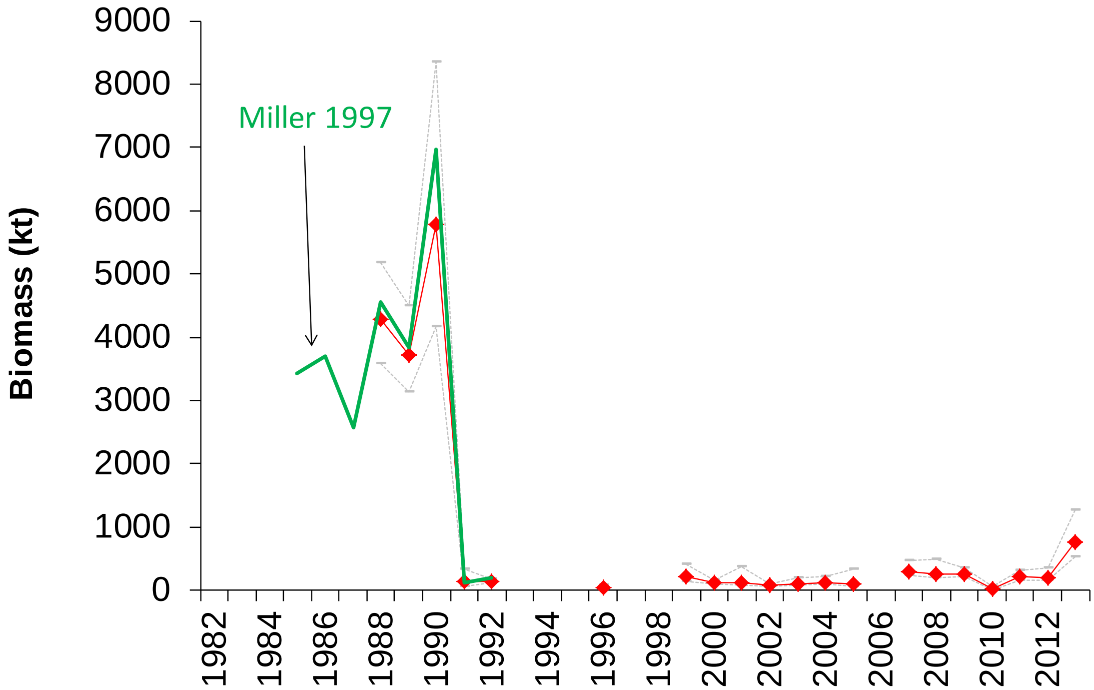

Figure 4. Capelin biomass index from spring acoustic surveys in NAFO Div 3L. Red line gives recent estimates calculated using a simulation approach (Mowbray 2012). Grey lines are confidence intervals of these estimates, and the green line is the former estimates as by Miller (1997).

Caveats to be considered when discussing this survey include the incomplete recruitment of age 1 capelin and older capelin (ages 3+) and the area coverage which constitutes approximately one third of the stock area. Age 1 capelin are not fully recruited to the survey fishing gear and may escape acoustic detection due to sub-threshold densities. Older fish may not be present in the survey area as they have typically already migrated inshore into the bays.

Recruitment indices are available for 2J3KL capelin covering three scales. The finest scale index monitors production at one beach (Bellevue) located at the bottom of Trinity Bay and furnishes two indices, one from emergent larvae (available since 1990, but terminated in 2012) and a second derived from surface tows off Bellevue which started in 2003. The second index commenced in 2002 and monitors production within Trinity Bay using a suite of stations in the middle of the bay. The third source comes from the spring acoustic survey and includes cohorts at ages 1 and 2. These five recruitment indices have tracked reasonably well over the last 10 years and are consistent in the identification of the stronger year-classes produced in 2007 and 2011 (Figure 5).

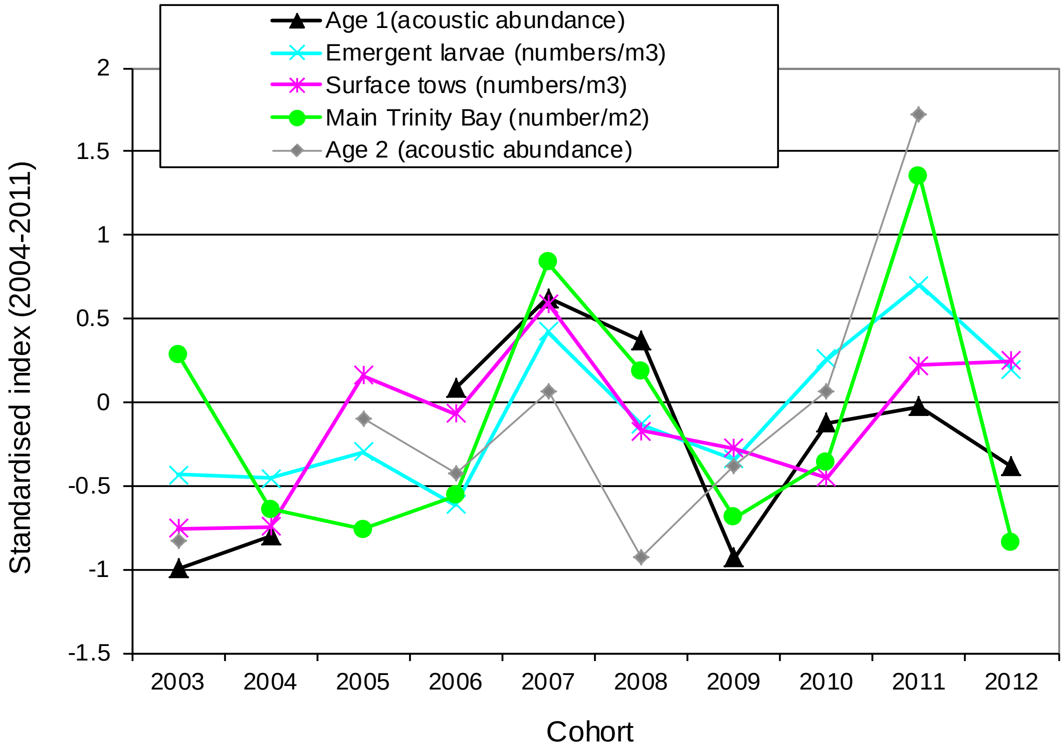

Figure 5. Relative strength of capelin cohorts from 2003 to 2013 standardised to the mean of their values from (2004 to 2011). Indices are emergent larvae from Bellevue Beach (tourquoise star), surface tows off Bellevue (magenta stars), September tows in Trinity Bay (green circles), age 1 abundance from spring 3L acoustic surveys (black triangles) and age 2 abundance from spring 3L acoustic surveys (grey diamonds).

Capelin Consumption, Production and Projections

An exercise was undertaken to explore the relationship between consumption estimates and system productivity. For this exercise capelin consumption by fish, seals and whales were considered. Consumption by fish was taken from estimates presented by Koen et al (this meeting) and ranged from 0.5 to 1.6 million tonnes. Consumption by seals was taken from modelled diet information along with population estimates as presented in Stenson (2012) and the estimates for whales was set at 0.5 million tonnes (pers. comm. G. Stenson). This gave an annual range of consumption (C) of 2.8 to3.4 million tonnes.

A crude estimation of capelin productivity rate (r) was derived using the round weight of age 1 and age 4 capelin during the spring acoustic survey and was calculated as:

$r = W_x – W_i / A_x – A_i$

Where r is the productivity rate, W is weight in grams, A is age in years, I equals 1 and x is 4.

For any given value of the standing stock (S), the annual production (P) was then calculated as

P = S + (S*r)

Post consumption production (E) was then calculated as

E = P-C

Using these relationships, values of post consumption production were explored for a range of standing stocks and annual consumption estimates (Figure 6).

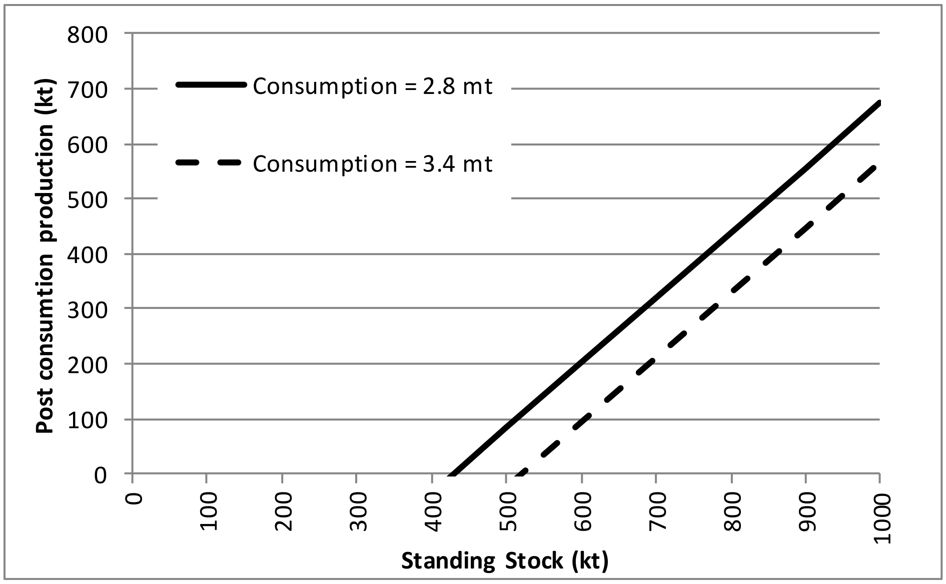

Figure 6. Post consumption estimates of capelin biomass at two annual consumption levels and various standing stock levels.

These calculations indicated that a standing stock of 425 to 525 thousand tonnes would be needed to meet consumption needs prior to the production of any surplus, given current levels of predation. This amount is nearly double the biomass estimated from the spring acoustic survey from 1999 to 2012 indicating that the survey captures approximately 50% of stock biomass, while surveying about one third of the stock's range. This suggests that if reasonable estimates of these parameters (consumption and production) were available, and the partial recruitment of the standing stock to the spring survey could be estimated then this type of model could be used to set target levels of the standing stock. Of course, in order to be useful to management, projections of next year's survey biomass would be needed.

While the results of this modelling exercise are reassuring as the order of magnitude of consumption and production appear to correspond, the production estimate is particularly crude as it implies that all fish in the standing stock will contribute at the calculated rate until the age of 4. However the majority of predation and other natural mortality occurs during younger ages hence this assumption would produce an overestimate. On the other hand this model does not account for the contribution of fish which do not survive, which in an r selected species such as capelin can be substantial. If only 1 % of the 30,000 eggs from a single 20 g female capelin survived for 5 months (to age 1), they would produce 2.1 kg of production (100 fold production). Consequently in order to refine these calculations age specific survival rates are required.

Given the proximity of the spring survey to the fishery, which occurs 4 to 6 weeks later, it is not possible to use current year data for current year management. Therefore the ability to forecast standing stock, or an index of standing stock is required. As a start towards this objective a method for projecting spring acoustic survey biomass was explored using empirical relationships from available data sources. Correlations between the larval indices (Bellevue surface tows and Trinity Bay) and ages 1 and 2 recruits were examined and the index (or combination of indices) explaining the greatest amount of variance was used for the projections. In the case of age 1 capelin, the surface tows at Bellevue Beach was significantly correlated and explained 53 % of the variance in numbers at age 1. For age 2 fish in the acoustic survey, the best fit was given by a combination of Bellevue surface tow larvae, the Trinity Bay larvae, and age 1 in the spring acoustic survey the following year. This formulation was not significant, but did explain 52 % of the variance in numbers at age 2. Age 2 fish in the acoustic survey were used to project numbers at age 3 (P=0.07, R^2=0.35). When Trinity Bay larvae were also included as an independent variable in the projection of age 3 fish, the explained variance improved (P=0.54, R^2=0.71, n=5) but the sample size of cohorts for which both these variables are available is small and it is unknown how it may perform over a time span incorporating greater variability, hence only age 2 abundance was used in the projection. Age specific projections were for ages 1 to 3 (2004 to 2013 year classes) and mean weights at age for the same period were used to produce a projected biomass at age and summed to give projected survey biomass (Figure 7).

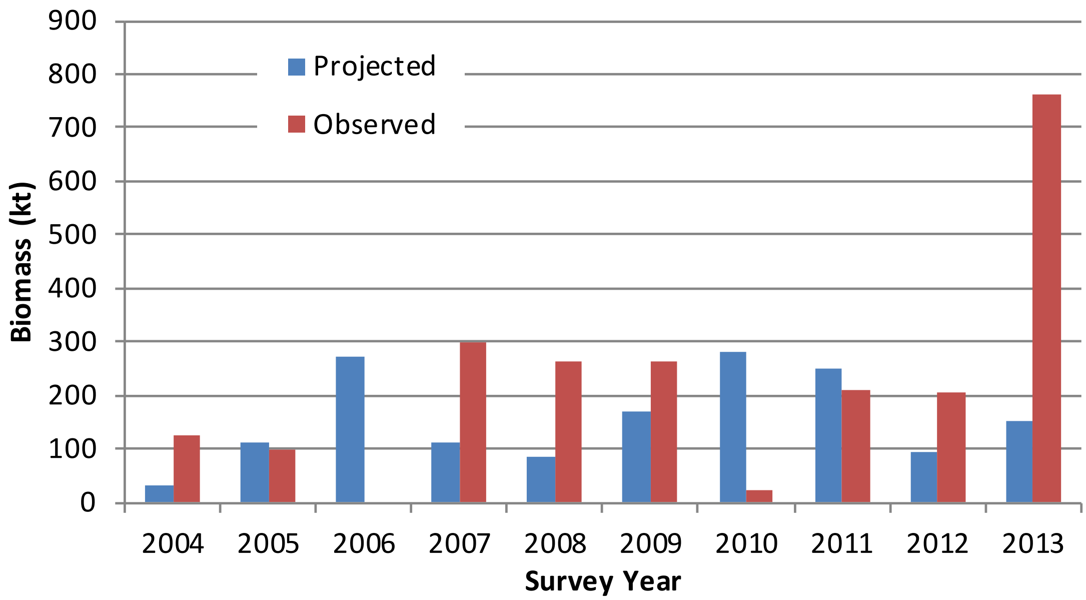

Figure 7. Spring survey biomass of ages 1-3 projected using age specific regressions (blue bars) and as observed during surveys (red bars).

The projected value corresponded poorly with the observed values, with an R^2 of 0.06. Consequently, despite some reasonable age specific fits and fairly good agreement among larval indices, the amount of capelin that will be picked up in the survey the following year cannot be accurately predicted using these metrics, and requires further investigation. It is likely that only through a fall acoustic survey can the goal of projecting next year standing stock be reliably achieved.

Candidate Limit Reference Point Data Sources

Is there enough spawning biomass left in the water to sustain the current TAC after the fish and mammal consumption? If the current biomass was available then it could be used to estimate a minimum biomass (B_{lim}) that should be left in the water.

A fall survey is needed in order to estimate the biomass and the specific ages, there is no projections for ages 4, 5, and 6.

Two models are suggested: the projections of the acoustic survey and the consumption model. The projection model is composed of abundance projections for the year and then what is actually observed in the spring survey. In the majority of the years the projections and observed are not comparable. The consumption model seems to make sense theoretically. It was agreed that more work needs to be done and the equation needs further investigation. Neither of the methods is accepted to provide limit reference points at this time further investigation is needed.

References cited

Stenson, G.B. 2012. Estimating consumption of prey by Harp Seals, (*Pagophilus groenlandicus*) in NAFO Divisions 2J3KL. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/156. iii + 26 p.

APPENDIX 2. TERMS OF REFERENCE

NEWFOUNDLAND AND LABRADOR ATLANTIC HERRING FRAMEWORK MEETING AND FRAMEWORK FOR CAPELIN REFERENCE POINTS

Regional Peer Review – Newfoundland and Labrador Region

November 19-21, 2013
St. John's, NL

Chairperson: Bill Brodie

Context

There are five Atlantic herring stocks in the southern and eastern coastal waters of Newfoundland, namely (1) Notre Dame Bay/White Bay, (2) Bonavista Bay/Trinity Bay, (3) Conception Bay, (4) St Mary's Bay/Placentia Bay and (5) Fortune Bay. In all but one of these stocks current sampling regimes have shown an increasing contrast between abundance trends in spring and fall spawning stock components. Herring in Newfoundland and Labrador have traditionally been composed of largely spring spawners. However, in the last decade the proportion of fall spawners in research and commercial catches has been increasing. Assessment tools and techniques currently used to present information to stakeholders cannot transmit this important information which is crucial for the management of the fishery. A new framework meeting is required to examine how best to incorporate this information in future assessments.

During the Regional Advisory Process on the status of SA2+Div. 3KL Capelin in January 2013, questions were raised regarding the framework surrounding the stock status information provided to management. The current state of various abundance and biological indicators were low and it was advised that the stock be managed with caution. However without reference points it is difficult for mangers to equate this information with management objectives. Since there are no abundance estimates or exploitation rates available for this stock, the usual stock limit reference points cannot be derived. It was therefore recommended that alternative types of limit reference points be examined.

Objectives

1. Peer review of alternative approaches for conducting the long-term projections of population abundance to incorporate the recent changes in abundance trends in spring and fall spawning herring.
2. Peer review of approaches for the development of limit reference points for Capelin, including:
3. Review reference point methodologies and propose approaches for the identification of reference points for Newfoundland and Labrador Capelin stocks;
4. Apply the chosen methodology(ies) to estimate potential reference points.

Expected Publications

- Proceedings
- Research Document(s)

Participation

- Fisheries and Oceans Canada (DFO) (Science, Fisheries and Aquaculture Management, Policy and Economics)
- Provincial Department of Fisheries and Aquaculture
- Academia or Academics
- Fishing Industry
- Environmental non-government organizations (e.g.: WWF)

APPENDIX 3. LIST OF PARTICIPANTS

Name	Affiliation	E-mail	Telephone
Bill Brodie	DFO Science NL Region	Bill.brodie@dfo-mpo.gc.ca	772-3288
Jim Meade	DFO Science NL Region	James.meade@dfo-mpo.gc.ca	772-3332
Brad Squires	DFO Science NL Region	Brad.squires@dfo-mpo.gc.ca	772-5305
Craig Purchase	MUN	Craig.purchase@mun.ca	864-4452
Brian Nakashima	DFO Science NL Region	Brian.nakashima@dfo-mp.gc.ca	772-4925
Geoff Evans	DFO Science NL Region	Geoff.evans@dfo-mpo.gc.ca	772-2090
Carissa Currie	CFER-MI	Cjc016@mun.ca	740-7434
Martin Castonguay	DFO Science Quebec Region	Martin.castonguay@dfo-mpo.gc.ca	(418) 775-0634
Noel Cadigan	CFER-MI	Noel.cadigan@mi.mun.ca	778-0603
Dominique Robert	CFER-MI	Dominique.robert @mi.mun.ca	778-0499
Leon Slaney	DFO RM Southern NL	Leon.slaney@dfo-mpo.gc.ca	279-7624
Len Knight	DFO RM Eastern NL	Leonard.knight@dfo-mpo.gc.ca	772-5845
Robbie Green	Fish Harvester	Fiddlersgreen5@hotmail.com	685-8159
Gilbert Penney	Fish Harvester	gilbertpenney@hotmail.com	547-2439
Glen Newbury	Fish Harvester	gilbertpenney@hotmail.com	675-2506
Janice Ryan	WWF-Canada	jryan@wwfcanada.org	W: 722-9453 (ext.2224) C: 725-9337
Christina Bourne	DFO Science NL Region	Christina.bourne@dfo-mpo.gc.ca	772-2005
Loyola Sullivan	Ocean Choice Inc	lsullivan@oceanchoice.com	691-3264
Derek Butler	ASP	lsullivan@oceanchoice.com	726-3730
Shelley Dwyer	DFA	shelleydwyer@gov.nl.ca	729-3735
Karl Sullivan	Barry Group	ksull@barrygroupinc.com	W: 576-7292 C: 682-7293

Name	Affiliation	E-mail	Telephone
Fran Mowbray	DFO Science NL Region	Fran.mowbray@dfo-mpo.gc.ca	772-5542
George Feltham	FFAW	egfeltham@yahoo.com	765-8100
John Boland	FFAW	johnboland@nf.aibn.com	743-6063
Nadine Wells	DFO Science NL Region	Nadine.wells@dfo-mpo.gc.ca	772-4954
Peter Shelton	DFO Science NL Region	Peter.shelton@dfo-mpo.gc.ca	772-2341
Paula Lundrigan	DFO Science NL Region	Paula.lundrigan@dfo-mpo.gc.ca	772-6212
Hannah Murphy	CFER (MI)	Hannah.murphy@mi.mun.ca	778-0374
Timothee Govare	CFER(MI)	Timothee.govare@mun.ca	753-8564
Padmini Dalpadado	Institute of Marine Research Norway	Padmini.dalpadado@irnr.no	+4793634035
Luis Mello	DFO Science NL Region	Luis.mello@dfo-mpo.gc.ca	772-2060

APPENDIX 4. MEETING AGENDA

Tuesday, November 19		
9:00 – 9:30	Welcome, Introductions, Review of Agenda, Review Terms of Reference	Chair (B. Brodie)
9:30 – 10:45	Review of stock structure, information currently used in the assessment of NL Herring Stocks, and discussion of potential new data sources	C. Bourne
10:45 – 11:00	Refreshment Break	
11:00 – 12:30	Recent trends in abundance and biological indicators, with particular reference to spawning components and timing of spawning	C. Bourne
12:30 – 1:30	Lunch (Not Provided)	
1:30 – 2:00	Recent trends in oceanographic conditions	C. Bourne
2:00 – 2:45	Environmental Effects on Herring Stock Composition and recruitment, presentation of offshore data	C. Bourne
2:45 – 3:00	Refreshment Break	
3:00 – 3:30	Current Fishery Management Practices and Considerations	L. Knight
3:30-4:00	Review of the Fishery	C. Bourne
4:00–5:00	Review of current stock assessment results	C. Bourne
5:00	Adjournment	Chair

Wednesday, November 20		
9:00 – 9:15	Welcome, Review of Agenda	Chair
9:15 - 10:30	Review and discussion of stock summary information format	All
10:30 – 10:45	Refreshment Break	
10:45-12:00	Drafting of research recommendations	All
12:00 – 1:00	Lunch (Not Provided)	
1:00 – 2:30	Conclusions	All
2:30 – 3:00	Summary & Adjournment	Chair

Thursday, November 21		
9:00 – 9:15	Welcome, Review of Agenda	Chair
9:15-9:45	Limit reference points: purpose and derivation	P. Shelton
9:45-10:00	Capelin Fishery Management Strategies	L. Knight
10:00-10:15	Refreshment Break	
10:15-11:30	Review of capelin life history and assessment	F. Mowbray
11:30-11:45	Consumption of capelin	N. Wells
11:45-12:00	Candidate LRP data sources	F. Mowbray
12:00-1:00	Lunch (Not Provided)	
1:00-2:45	Discussion of lower LRP candidates	F. Mowbray
2:45-3:00	Refreshment Break	
3:00-4:30	Recommendations and Conclusions	All
4:30 – 5:00	Summary and Adjournment	Chair