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Proceedings of the regional peer review of Reference points consistent with the fishery decision-making framework for Arctic Char in Cambridge Bay, Nunavut

January 25-26, 2011

Winnipeg, Manitoba

Chairperson: R.F. Tallman
Editor: L.N. Harris

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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

This document contains the proceedings of the regional advisory meeting pertaining to the assessment of commercially fished anadromous Arctic Char (*Salvelinus alpinus*) stocks in the Cambridge Bay area, with emphasis on reference points consistent with the fishery decision-making framework and temporal variation in biomass index. This review occurred on January 25-26, 2011, in Winnipeg, Manitoba. It was held in response to a request from the Fisheries and Aquaculture Management (FAM) sector of Fisheries and Oceans Canada (DFO) in Central and Arctic Region for science advice on the current status and sustainable harvest levels for each of the current river systems in the Cambridge Bay commercial fishery, with emphasis on resolving precautionary reference points.

During the advisory meeting participants from DFO Science, DFO FAM, the University of Manitoba and an independent expert peer reviewed two working papers and a draft science advisory report. The first working paper was specific to the formulation of a biomass index and the second paper employed the biomass index to resolve precautionary reference points through a surplus production model. Participants agreed that given the lack of biological and catch-and-effort data that are often available for Arctic fisheries, the method used in this advisory process was a novel approach that will be useful for resolving precautionary reference points. This proceedings document summarizes the relevant discussions and presents the key conclusions reached at the meeting. The working papers presented at the meeting are published as Research Documents and the advice from the meeting is published as a Science Advisory Report on the Canadian Science Advisory Secretariat (CSAS) website.

Compte rendu de l'examen régional par les pairs des points de référence de précaution pour l'omble chevalier de la baie Cambridge (*Salvelinus alpinus*) au Nunavut, conformément au cadre décisionnel pour les pêches

SOMMAIRE

Le présent document comprend le compte rendu de la réunion de consultation scientifique régionale portant sur l'évaluation des stocks de l'omble chevalier anadrome destiné à la pêche commerciale (*Salvelinus alpinus*) dans la zone de la baie Cambridge, et met l'accent sur les points de référence conformes au cadre décisionnel pour les pêches et à la variation temporelle de l'indice de la biomasse. Cet examen s'est déroulé les 25 et 26 janvier 2011 à Winnipeg, au Manitoba. Il a eu lieu en réponse à une demande présentée par le secteur de la Gestion des pêches et de l'aquaculture (GPA) de Pêches et Océans Canada (MPO) dans la région du Centre et de l'Arctique en vue d'obtenir un avis scientifique sur l'état actuel et les niveaux de prises durables pour chaque réseau hydrographique concerné par la pêche commerciale dans la baie Cambridge, et l'on a mis l'accent sur la résolution des points de référence de précaution.

Au cours de la réunion de consultation scientifique, des participants du Secteur des sciences du MPO, de la GPA-MPO et de l'Université du Manitoba ainsi qu'un pair expert indépendant ont passé en revue deux documents de travail et un avis scientifique provisoire. Le premier document de travail portait sur la formulation d'un indice de la biomasse et le second utilisait cet indice afin de résoudre les points de référence de précaution grâce à un modèle de production excédentaire. Les participants ont convenu qu'en raison de l'absence de données biologiques ainsi que sur les prises et l'effort qui sont souvent disponibles pour les pêches dans l'Arctique, la méthode utilisée dans le cadre de ce processus consultatif est une approche novatrice qui sera utile pour la résolution de points de référence de précaution. Le présent compte rendu résume les discussions pertinentes et présente les conclusions importantes tirées de la réunion. Les documents de travail présentés lors de la réunion sont publiés à titre de documents de recherche, et l'avis formulé au cours de cette réunion est publié en tant qu'avis scientifique sur le site Web du Secrétariat canadien de consultation scientifique (SCCS).

INTRODUCTION

Arctic Char in the Cambridge Bay region of Nunavut have been commercially harvested since the 1960s (Barlishen and Webber 1973) from several local river systems under a variety of quotas (Day and de March 2004). Six main stock complexes in the vicinity of Cambridge Bay have primarily been targeted (Ekalluk, Ellice, Halovik, Lauchlan, Jayco and Paliryuak Rivers) and since the inception of the first commercial fishery over 2,000,000 kg of this species have been commercially harvested (Day and Harris 2013). Initially quotas for Arctic Char commercial harvest were established on an experimental basis (e.g., at the mouth of Freshwater Creek, Barlishen and Webber 1973). Later, the management of Arctic Char from these fisheries, including assessments on the health or status of harvested stocks, has relied on the analysis of trends in biological characteristic focussing on age, weight and, to a lesser degree, fork length (Day and de March 2004). More recently however, Fisheries and Oceans Canada (DFO) has adopted a more formalized precautionary approach to managing fisheries in which three stock status zones are prescribed based on abundance and biomass: the healthy, cautious and critical zones (DFO 2006). Typically, for most Arctic Char fisheries this management approach has yet to be put into practice because analytical and computational methods used to quantify harvest levels corresponding to each zone are lacking.

The purpose of this meeting, as described in the Terms of Reference (Appendix 1), was to do the following:

1) review accumulated information on historical harvest and status of exploited geographic stocks harvested from commercial waterbodies in the Cambridge Bay fishery;
2) critically review model selection, assumptions, prior specifications, and output analysis;
3) assess whether reference points can be established for Cambridge Bay Arctic Char (all waterbodies combined) and the potential for defining reference points for specific commercial waterbodies; and
4) provide science advice on model performance and harvest control rules for Cambridge Bay Arctic Char.

Meeting participants (Appendix 2) included DFO Science (Stock Assessment) and Fisheries and Aquaculture Management (FAM) sectors of the Central and Arctic Region, the University of Manitoba and independent experts (retired DFO biologists) with intimate knowledge of the Cambridge Bay fishery. The meeting generally followed the agenda outlined in Appendix 3 and was held at the Freshwater Institute in Winnipeg, MB, convening at 9:30 a.m. on 25 January 2011. This proceedings report summarizes the relevant discussions and presents the key conclusions reached during the meeting. Two working papers, which provided the technical details supporting the science advice, were discussed during the meetings and a draft Science Advisory Report (SAR) was reviewed and edited during the meeting. The working papers were later published as Research Documents, along with the SAR, on the Canadian Science Advisory Secretariat (CSAS) website.

DISCUSSION

After performing a round of introductions, the Chair provided a brief introduction to the meeting. Acknowledgements were given to the experts that were in attendance at the meeting, especially those who travelled a considerable distance to be there. The chair emphasized that stock assessment typically deals with the science of ensuring biological sustainability and involves a process of assessing a stock and offering advice. A summary of the request for science advice from FAM, with respect to the Cambridge Bay commercial fishery assessment, was then provided by the Chair. The terms of reference for the assessment were reviewed and finally the Chair provided an overview of the agenda.

Two presentations, each of which corresponded to a summary of one of the working papers, were given. Each was given in its entirety and once finished participants were solicited for questions and asked to provide comments and suggestions on the working paper as a whole. Participants were asked to focus on the general content of each section, the methods used for the assessment and the conclusions drawn from the assessment and not on editorial changes and suggestions. It was recommended that specific comments for each section and minor editorial suggestions be submitted to the author directly.

The first working paper was presented.

TEMPORAL VARIATION IN BIOMASS

Temporal variation in a population biomass index for Cambridge Bay Arctic Char, *Salvelinus alpinus* (L.), in relation to large-scale climate changes

Authors: Xinhua Zhu, A. Chris Day, Theresa J. Carmichael and Ross F. Tallman

Presenter: Xinhua Zhu

Presentation summary[1]

Arctic Char, *Salvelinus alpinus* (L.), is a coldwater circumpolar salmonid, extensively distributed over coastal estuaries and freshwater habitats around the northern high latitudes. Since 1960, Arctic Char from the Cambridge Bay area is an important target species for commercial and subsistence explorations. Fishers seek sea-run migrants in mid-July and sea-return migrants in August and September at the mouth of seven river systems. Accompanied with fisheries development and anthropogenic activities, a series of fish plant sampling and field experiments have been carried out by many researchers from Fisheries and Oceans Canada since 1972. Among these, abundance index, catch per unit effort (CPUE), was the research focus to measure the standing stock status, but sporadically-collected and never standardized. To effectively monitor the dynamics of these anadromous fish populations and manage the fisheries in Cambridge Bay, Nunavut, the current study aims to;

1) summarize fishery development, including commercial and subsistence components,
2) establish individual- and weight-based catch per unit effort (CPUE) series from DFO-designed experimental sampling programs,
3) standardize the population biomass indices in combination with month and gear effects, and;
4) correlate climate covariates with CPUE to account for biological production variations under altering climate scenarios.

Historically, the maximum catch reached one hundred metric tonnes in the late 1970s. Along with the development of these fisheries, since 1972, a DFO-designed fishery-independent survey, which involves experimental gillnet and weir enumeration, has been conducted at traditional fishing locations in August and September. A population abundance index (weight-based catch per unit effort (CPUE)) was estimated using total numbers of individuals per census and length-weight relationships. Overall, a twelve year CPUE series is currently available.

[1] Later revised and published in Zhu et al. 2014a.

ANOVA found no significant differences in log-transformed CPUE between gear types (F=0.02, p=0.90) or months (F=2.96, p=0.08). August gillnet CPUE data was used for standardization because it showed a stronger temporal contrast in CPUE between months after CPUE data from the different gears was aggregated.

Three large-scale climate-related variables, the north Atlantic oscillation index (NAO), the Arctic oscillation index (AOI), and northern hemisphere sea surface temperature (NHSST), were included to estimate Arctic Char CPUE when enumeration information was not available. Significantly positive correlations between log-transformed CPUE and wintertime NAO (r=0.73, p=0.01) and AOI (r=0.78, p<0.005), with a five-year lag, were found. No significant relationship was found between CPUE and NHSST. Using posterior parameters in a robust normal regression model, estimates of CPUE from wintertime AOI were generated with contingent agreement between observed and predicted values ($\chi 2$=0.01, p>0.99). This approach is promising for further application of harvest statistics and the population biomass index to a population production model for Arctic Char integrating uncertainties from temporal variation in gear operations, stock status, and large-scale climate indices.

Discussion

The presentation described the biomass index calculated for Arctic Char in Cambridge Bay which was standardized by a single-mesh-sized (140 mm) gillnet in August and was used as an indicator of stock status to reflect interactions between human activities and ecosystem changes. Among several indices tested, the Arctic oscillation index (AOI), with a five-year lag was shown to be the best explanatory variable to linearly relate environmental change to log-transformed biomass-based catch-per-unit-effort (CPUE) for Arctic Char for the estimation of an unobserved CPUE series. Overall, participants indicated that, despite the limitations with the original data, the results present were plausible and could be used in setting preliminary reference points in this system.

Overall, participants had few concerns regarding the content presented in the Abstract and Introduction. Comments were made on the fact that most Arctic fisheries have very limited biological and catch-and-effort data associated with them. It was acknowledged by meeting participants that the work of the presenter was very novel and will likely be quite promising for guiding management decisions in subsequent years. The majority of comments and concerns raised by meeting participants dealt with the descriptions of the methods employed in the assessment and the results interpreted from those methods. The major concerns are described below.

CPUE concerns/clarifications

With respect to fisheries independent CPUE calculated from gill nets, several participants felt that better explanations are needed in the working paper about the data used to generate the CPUE information and how CPUE was calculated and incorporated into the assessment. For example, was fishing consistent from year to year with respect to location and time of year? It was also suggested that a description of how gill nets were specifically fished and the lengths of times these nets were fished needs to be described. For example, if gill nets, as indicated in the working paper, typically had a soak time of one day, does this mean they were fished for only one day? If they were fished for more than one day, or more than one gill-net was fished, were the catches combined over the interval used to produce a single estimate of CPUE per year per site?

Several participants also felt that a better explanation of exactly how CPUE calculated from a weir fishery was done. It was unclear if this is the entire catch/count of Arctic Char in a weir on a given day, or over a series of days, and if such an estimate really equates to the catch in a gill net. One participant felt that the weir is much more non-selective for Arctic Char size in comparison to a commercial sized (140 mm) gill net that would generally target larger fish.

The presenter indicated that he would reword the research document and the SAR to better clarify these concerns regarding CPUE.

Statistical analysis of CPUE and climate indicator relations

Generally, it was felt among participants that many of the analytical approaches required clearer descriptions and also specific references pertaining too many of the analyses. The reviewer agreed to revise the descriptions for clarity and to provide references where appropriate.

Additionally, August gillnet samples were chosen to standardize the relative biomass index throughout the sampling series. This was because, despite the consistent sample size, the August CPUE data showed greater temporal variation in gillnet CPUE (median=0.1032, SE=0.0512) than weir CPUE (median=0.1287, SE=0.0423), which results in noticeable variability in the Arctic Char biomass index through the time series. Participants suggested that the explanation for why this was chosen needs to be improved.

Participants were concerned with the number of null results, but this was due to the small degrees of freedom (df) available for most tests and possibly the small sample sizes.

Several participants expressed concerns regarding issues with multicollinearity[2]. For example, it was suggested that the north Atlantic oscillation (NAO) is likely correlated with the Arctic oscillation index (AOI), therefore given the limited data available it is possible that the model presented is overfitting the data (i.e., the model is describing random error or noise instead of the underlying relationship). Although the presenter thought this was very unlikely, he agreed to provide better clarification in the working paper. Additionally, one participant noted that AOI was consistently shown to be one of the top models in Table 9 (the deviance information criterion (DIC) table). It was suggested that model choice should not strictly be based on the lowest DIC values as this may result in the loss of some important, and potentially biologically meaningful, information. For example, with respect to the DIC values, there is little to differentiate the first 6 models. The presenter agreed to explore model possibilities further, not basing model choices solely on DIC.

One participant raised concern regarding Table 5, the Analysis of Variance (ANOVA) table. Specifically, in this assessment, there were five rivers, 12 years, two gear types and two months included in the model(s) and an ANOVA was to be used to see if there was a difference in CPUE between gear types and between months. If only two months were used in the analysis, as per Table 4 (August and September), then the degrees of freedom (df) for month shown in Table 5 should have been 1 (i.e., 2 – 1 = 1 df), not 2 as shown. Additionally, given the total df was only 22, this again highlights the fact that there were very few data points included in the analysis which is consistent with the lack of data available for most Arctic systems. Furthermore, ANOVA found no significant differences in log-transformed CPUE between gear types (F=0.02, p=0.90) and marginal differences between months (F=2.96, p=0.08) which one participant thought could be the result of temporal autocorrelation. The presenter agreed to explore some of these ideas/possibilities and update the table as suggested.

One participant pointed out that several different months and lags were tried (e.g., as shown in Tables 6, 7, 8) in the model. By chance alone, one would expect 5% of them to be significant. For example, in Table 6 there are 12 x 11 = 132 pair-wise correlations of which 6.6 (5% of 132)

[2] Multicollinearity is a statistical phenomenon in which two or more predictor variables in a multiple regression model are highly correlated.

are expected to be "significant" by chance alone. Five "almost significant" correlations appear in Table 6 as well as the four identified as significant at the 0.05 level. As such, the results may not be as significant as initially assumed. It was suggested that the number of months and lags should be limited to those that are more biologically meaningful (e.g., spawning months or months important for growth), rather than trying them all. Given this, one participant, disagreed with the statement at the bottom of page 6 that states: "*… results explicitly demonstrated that the variability of Arctic Char population production has been significantly influenced by changes in hemispheric and synoptic scale atmospheric circulation."* The participant suggested that this was not evidenced clearly by these analyses. The presenter agreed to revise the working paper and SAR accordingly.

It was suggested that correlograms[3], instead of tables of significance and fit (r^2), would be an appropriate replacement for Table 6. The presenter agreed to explore this idea.

In several locations within the document (e.g., Abstract, paragraph three) it was stated that results were marginally significant even when the null hypothesis was not rejected (e.g., p-value of 0.08). In those cases ($p \leq 0.05$), the result is one of non-significance and not marginally significant. Additionally, it was noted that many of the correlations (as indicated by the coefficient of determination: r^2) were very weak (even those that were significant) and therefore should be interpreted with caution. These were acknowledged by the presenter who agreed to revise the documents for those cases.

HIERARCHICAL BAYESIAN MODELING

Hierarchical Bayesian Modeling for Cambridge Bay Arctic Char, *Salvelinus alpinus* (L.), incorporated with precautionary reference points

Authors: Xinhua Zhu, A. Chris Day, Theresa J. Carmichael and Ross F. Tallman

Presenter: Xinhua Zhu

Presentation summary[4]

The second presentation focused on hierarchical Bayesian state-space models (HBM) that were employed to reconstruct historical trends and harvest removal series of population production dynamics. Essentially, maximum surplus production (MSP) and biomass at MSP (B_{MSP}) were estimated by a hierarchical Bayesian model (HBM) as 92 and 522 metric tonnes annually, respectively. The harvest report rate, which amounted to 31 metric tonnes and mainly accounted for subsistence uses, was estimated to be 34% of MSP. These methods were then used to resolve the corresponding reference points: the Limit Reference Point (LRP) is located at a standing biomass of 208 metric tonnes, representing the lowest stock status (0.0544 t/gillnet), the Upper Stock Point (USP) is at a standing biomass of 417 metric tonnes (0.1087 t/gillnet) and the Target Reference Point (TRP) is located at a stock status of 0.1359 t/gillnet, which is equivalent to a standing biomass of 522 metric tonnes. It was deduced that the fishing mortality rate at MSP is 0.1761 per year. The presentation highlighted the fact that given the lack of available data for these fisheries these reference points should be re-examined and revised as new information is obtained. There is a need for future research to address some of the gaps in knowledge.

Discussion

[3] A correlogram is an image of correlation statistics that is commonly used for checking randomness in a dataset.
[4] An abstract was developed after the meeting and published in Zhu et al. 2014b.

Similar to the first presentation, participants had few concerns regarding the content presented in the Abstract and Introduction. The majority of comments and concerns raised by meeting participants dealt with the descriptions of methods employed in the assessment and the results interpreted from those methods. The major concerns are described below.

As with the first presentation, it was generally felt among participants that many of the analytical approaches required clearer descriptions and also specific references pertaining to many of the analyses. For example, one participant suggested much more information on model construction is needed (e.g., why certain burn-ins were chosen, a figure of prior probabilities (Chain Plot) would be valuable to show how the priors changed throughout the model exercise). The presenter agreed to revise the descriptions for clarity and to provide references where appropriate.

Following the presentation, the chair provided a brief summary of the three zones of risk (critical, cautious, healthy) and noted that if a fishery falls within the critical zone, there is nothing legally that FAM can do to close the harvest. If this scenario was to take place, it was suggested that alternative locations, specifically Perry and Ellice rivers (Figure 1), should be considered for commercial fishing.

Similar to first presentation, participants indicated that better explanations are needed in the working paper about the data used to generate the CPUE information and how CPUE was calculated and incorporated into the assessment. The presenter indicated this would be done.

One participant pointed out that the models were run with the beta parameters greater than one and questioned whether the model should be run with a beta parameter of less than one, indicating hyperstability which is quite likely in this system. The participant questioned what the output of the model would be if the model were run across a range of beta values. The presenter agreed to explore running the model across a range of beta values and would update the working papers accordingly as required. Additionally, subsistence harvest for the model was held constant at 50% of the commercial harvest. Participants suggested that the model be run at varying rates of subsistence harvest (e.g., 25%, 75%) to explore how the output of the model would change (if at all). It was mentioned that subsistence harvest is likely not constant and will vary yearly depending on a variety of factors. The presenter agreed and indicated he would explore these ideas.

A discussion regarding the validity of the Nunavut Harvest Study (Priest and Usher 2004) followed. Generally, it is believed that these data should be interpreted with caution as the information presented in the subsistence harvest study may not reflect true subsistence harvest but likely also accounts for some commercial and exploratory harvest. Therefore, the subsistence harvest data presented in the harvest study greatly overestimate the true subsistence harvest. Alternatively, one participant suggested that the harvest study may actually underestimate the true subsistence harvest due to fishers not reporting their subsistence catches. Participants agreed that for proper stock assessments to be conducted, there is a need to obtain accurate subsistence harvest information and programs need to be initiated in order to do so.

One participant pointed out that during the1960s, harvests were quite low and only the Ekalluk River was apparently fished. Additionally, after 1970, the catchability coefficient (q) was much more stable. They suggested running the model beginning in 1970 as results generated from this point in time onward would likely be more representative of the true fishery. Others in the meeting agreed this would likely be beneficial and the presenter indicated he would try this.

In the research document, it states that “Comparing the UKR, HCLNKR, and LNKRWQ model scenarios, the posterior median for B_{MSP} was 460, 490, and 522”. One participant asked exactly what the B_{MSP} values represent. The presenter replied that these values indicate the “standing biomass”.

One participant raised concern regarding the biomass at MSP (maximum surplus production). Percentiles of 2.5% and 97.5% are very wide and some acknowledgement of these wide intervals should be made in the text. The presenter agreed to do so.

Text for a section on sources of uncertainty was drafted by the participants later in the meeting for inclusion in the SAR.

In general, participants agreed that there was no fundamental problem with the approach employed by the presenter, especially given the available data. This novel approach to Arctic stock assessment will be valuable for the management of commercially harvested stocks and the information provided in this assessment will aid FAM in implementing management strategies. It is anticipated the model will undergo refinement as new data becomes available.

REVIEW OF THE SCIENCE ADVISORY REPORT

The participants reviewed the draft SAR. In general, most editorial changes related to clarity of the document and elimination of many technical analytical terms typically beyond the scope of a SAR. The Summary Bullets were revised and a new Sources of Uncertainty section was drafted to summarize knowledge gaps pertaining to the fishery. A paragraph of text was also added to the Other Considerations section to explain why the estimated mortality generated by the model is higher than that previously assumed for Cambridge Bay Arctic Char. Sections pertaining to model construction and performance were not revised as the presenter agreed to re-run the model(s) which will likely change the outcome of the results and subsequent interpretation.

Revised Summary Bullets

The Summary Bullets were revised to highlight only the main points in the document.

- The biomass index for Arctic Char in Cambridge Bay is standardized by a single-mesh-sized (140 mm) gillnet in August and used as an indicator of changing stock status.
- Among the environmental indices used to predict the abundance index (catch per unit effort), wintertime AOI with a five-year lag was selected as the best explanatory variable. Hierarchical Bayesian state-space models (HBM) were employed to reconstruct historical trends and harvest removal series of population biomass.
- Parameters of interest included virgin biomass or carrying capacity and the intrinsic population growth rate. Essentially, maximum surplus production (MSP) and biomass at MSP (B_{MSP}) were estimated by the model at 93 and 518 metric tonnes annually, respectively. The harvest report rate (HRR), which mainly accounted for subsistence uses, was estimated to 34%, which amounted to 31 metric tonnes on the basis of MSP.
- The Limit Reference Point (LRP) is located at a standing biomass of 207 metric tonnes, representing the lowest stock status (0.0539 t/gillnet). When the stock entered the critical zone, an immediate reduction in harvest should be taken for conservation, or the fishery should be closed to exploitation until it grew to a healthier stock status. The Upper Stock Point (USP) is at a standing biomass of 414 metric tonnes (0.1078 t/gillnet), where the exploitation rate should be gradually reduced. The Target Reference Point (TRP) is located at a stock status of 0.1348 t/gillnet, which is equivalent to a standing biomass of 518 metric tonnes.
- These interim reference points are specific to the combined Arctic Char populations in Cambridge Bay and its adjacent waters, and should be re-examined and revised as new

information is obtained. The lack of sufficient information regarding mixed-stock CPUE, the stock-recruitment relationship, age structure, discrete stock discrimination, vulnerability of fishing effort, and localized variations in productivity and environmental factors is responsible for observation uncertainties in the risk assessment. Future research to address these knowledge gaps would be substantially beneficial to the underlying fisheries risk assessment and precautionary management.

Sources of Uncertainty

Several sources of uncertainty were identified and discussed in detail during this regional advisory process. Participants agreed they would be included in the Science Advisory Report and they are also summarized below.

Catch-per-unit-effort (CPUE)

The lack of a series of annual, historical CPUE data for Cambridge Bay Arctic Char fisheries means that cohort-based models cannot be employed to predict individual cohort abundance at the time of recruitment into the fishery or recruitment into the population at age 0+. This type of information is required to provide advice for DFO Fisheries Management on total allowable harvest (TAH). A sampling design and its implementation are needed for the collection of annual CPUE data. Furthermore, research is required to standardize CPUE for weirs and gillnets for all weir fisheries (e.g., the Halovik and Jayco rivers) which will require the simultaneous fishing of both gear types at weir locations.

Bycatch Concerns

Information on bycatch is needed as a component of an Integrated Fisheries Management Plan (IFMP) but none is currently available. A sampling design and its implementation are needed for collection of annual bycatch data. This could likely be collected through fishery-independent sampling of these fisheries.

Fecundity and Size and Age at Maturity

Fecundity information is needed for the improvement of the prediction of surplus biomass and TAH but is not currently available. Size- and age-at-maturity data are available but it has been collected in a strongly unbalanced manner with respect to sampling year and location. Like fecundity data, maturity rate information is needed for the improvement of the prediction of surplus biomass and TAH. Some meeting participants also questioned the reliability of maturity status assigned to Arctic Char sampled in earlier years since many large and old char were likely misclassified as immature at this time.

Genetic Stock Structure

The request for advice from DFO Fisheries Management for individual river-based quotas is noted but their prediction cannot be attempted until the proportional contribution of discrete genetic stocks to each mixed-stock fishery location is known. Newer genetic models for the analysis of mixed stock fisheries analysis employing genetic stock identification are now available and can be used after base line genetic profiles of known discrete stocks have been collected. This will likely take some time given the logistical constraints of collecting samples. It may be possible for the Fish Plant (Ktikmeot Foods) to assist with sample collection through the plant sampling program; discussions are currently underway. Additionally, it was noted that management units that incorporate more than one population may be resolved through the use of molecular assessments (e.g., the “Designatable Unit” framework of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)).

Subsistence Harvest

The harvest of Arctic Char by Cambridge Bay subsistence fishers is substantial but, with the exception of a recent four-year Nunavut Wildlife Harvest Study (NWHS), no data are available on the true subsistence harvest. Additionally, the accuracy of the NWHS is questionable. Subsistence harvest data must be collected and incorporated into all fisheries science modeling of this fishery to produce reliable predictions of surplus biomass and TAH and future reporting of subsistence harvests should be done by harvest location rather than by community. A log-book reporting program should be implemented in order to collect this information.

Potential Bias of Surplus Production Model Predictions Caused by Estimation Error of Subsistence Harvest

For all models, out of necessity given a lack of data, total harvest was predicted as the sum of reported commercial harvest and the predicted subsistence harvest. Based on limited data derived from the aforementioned NWHS, subsistence harvest was assumed to be 1/2 of the commercial harvest for each fishing year. This assumption may be false and the results of the models may be biased because subsistence harvest may be uncorrelated with commercial harvest. Participants suggested that the prediction of total annual harvest could be re-examined using historical trends of the Inuit population size of Cambridge Bay.

Aging Error

Cohort-based models may provide conservative predictions of abundance because the age reading methods used for all Cambridge Bay Arctic Char otoliths tend to underage fish designated as being greater than 12 years of age. Aging methods will continue to be refined to increase the accuracy of Arctic Char aging which, in turn, will help refine the model and associated outputs/predictions.

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APPENDIX 1: TERMS OF REFERENCE

Reference points consistent with the fishery decision-making framework for Arctic Char in Cambridge Bay, Nunavut

Central and Artic Regional Advisory Meeting

January 25-26, 2011

Winnipeg, Manitoba

Chairperson: Ross Tallman

Context

Canada is committed, both domestically and internationally, to conserving, managing, and exploiting fish stocks in a sustainable manner. Recently, Fisheries and Oceans Canada (DFO) has adopted a Fishery Decision-making Framework incorporating the Precautionary Approach to conserve and manage its fisheries resources. The framework includes the identification of reference points and stock status zones, and the development of harvest decision rules based on a harvest rate strategy.

Central & Arctic Region (Fisheries Management and Science) are conducting a pilot to assess the feasibility of implementing the Fishery Decision Framework for Arctic Char fisheries. The Cambridge Bay Arctic Char fishery, consisting of fisheries in several commercial waterbodies, has been chosen for this pilot project because of the relatively long-term dataset.

A regional Science Advisory Process was held to update the assessment of the status of geographic stock complexes of Cambridge Bay Arctic Char in January 2010. At that meeting it was concluded that using traditional time series analysis of current data could not produce reference points for Cambridge Bay Arctic Char. Therefore, a Bayesian-based model has been applied to develop reference points for the combined river systems and the results will be presented and reviewed at this advisory meeting.

Objectives

- Review accumulated information on historical harvest and status of exploited geographic stocks harvested from commercial waterbodies in the Cambridge Bay fishery;
- Critically review model selection, assumptions, prior specifications, and output analysis;
- Assess whether reference points can be established for Cambridge Bay Arctic Char (all waterbodies combined) and the potential for defining reference points for specific commercial waterbodies;
- Provide science advice on model performance and harvest control rules for Cambridge Bay Arctic Char.

Expected Publications

- Canadian Science Advisory Secretariat (CSAS) Science Advisory Report (SAR)
- CSAS proceedings report summarizing the discussions of the science review
- Two CSAS research document providing technical support for the SAR

Participants

- DFO Science
- External experts
- DFO Fisheries and Aquaculture Management

APPENDIX 2. LIST OF PARTICIPANTS

Name	Affiliation
Darren Gillis[1]	University of Manitoba
Mike Power[2]	University of Waterloo
Tyler Jivan	Fisheries and Oceans Canada - Fisheries and Aquaculture Management
Allen Kristofferson	Fisheries and Oceans Canada - Science Emeritus
Theresa Carmichael	Fisheries and Oceans Canada - Science
Chris Day	Fisheries and Oceans Canada - Science
Brian Dempson	Fisheries and Oceans Canada - Science
Colin Gallagher	Fisheries and Oceans Canada - Science
Les Harris	Fisheries and Oceans Canada - Science
Kevin Hedges	Fisheries and Oceans Canada - Science
Kimberly Howland	Fisheries and Oceans Canada - Science
Muhammad Yamin Janjua	Fisheries and Oceans Canada - Science
Marie-Julie Roux	Fisheries and Oceans Canada - Science
Ross Tallman	Fisheries and Oceans Canada - Science
Melanie VanGerwen-Toyne	Fisheries and Oceans Canada - Science
Xinhua Zhu	Fisheries and Oceans Canada - Science

[1] Attended first day of meeting.
[2] Attended second day of meeting.

APPENDIX 3. AGENDA

Reference points consistent with the fishery decision-making framework for Arctic Char in Cambridge Bay, Nunavut

Central and Artic Regional Advisory Meeting

Room 3-55, DFO Freshwater Institute, Winnipeg, MB

January 25-26, 2011

January 25

09:00 Welcome and opening remarks by the Chair

09:05 Round table of introductions

09:10 Introduction, review of the agenda, RAP explanation, responsibilities of participants

09:15 Review of the terms of reference

09:30 Presentation by Xinhua Zhu – Temporal Variation in Arctic Char Biomass Index

10:00 *Break*

10:15 Discussion of first presentation

12:00 *Break for Lunch*

13:00 Continue discussion of first presentation

15:00 *Break*

17:00 Adjournment

January 26

09:00 Presentation by Xinhua Zhu – Hierarchical Bayesian Modeling for Precautionary Reference Points

09:30 Discussion of second presentation

10:00 *Break*

10:15 Continue discussion of second presentation

Review of the science advisory report

Closing remarks by the Chair

12:00 Adjournment Continue discussion of second presentation